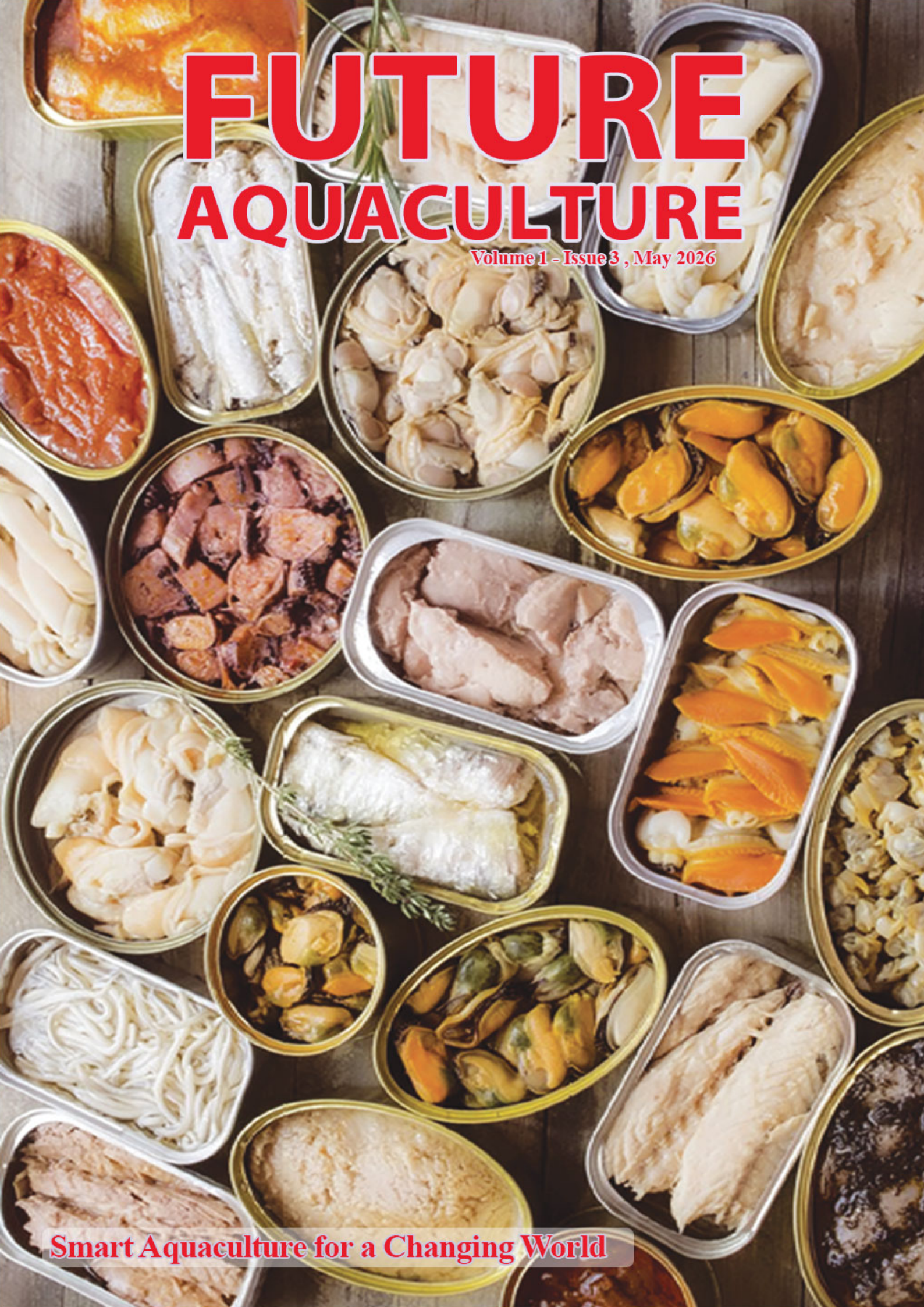




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Volume 1 - Issue 3 , May 2026

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ISSN: 3115-820X

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Email: info@gwapub.com

Future Aquaculture is published quarterly by Green Wave Publication (www.gwapub.com)

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Future Aquaculture in the Mirror of Analysis and Innovation

In a world where aquaculture is facing rapid change and increasingly decisive choices, the need for clear analysis and forward-looking perspectives has never been greater.

As aquaculture continues to evolve under mounting environmental, economic, and technological pressures, the role of informed dialogue and credible analysis has never been more critical. Future Aquaculture was founded to provide a platform where experience, evidence, and forward-looking perspectives converge. Each issue reflects our commitment to practical insight, critical thinking, and relevance to the real challenges facing the sector today.

With the valued support of our readers, and through the dedication of an experienced editorial board and contributing authors, we are pleased to present Issue 3 of Future Aquaculture. We invite researchers, practitioners, and industry experts to submit high-quality articles addressing emerging topics, innovative approaches, and future-oriented solutions in aquaculture. Your ideas, analyses, and experiences are essential in shaping informed progress, and we look forward to receiving your valuable contributions for upcoming issues.

Join us as we build the future of aquaculture, step by step!

*Editorial Director
Dr. Shahram Dadgar*





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Fulfilling the Promise of the Blue Revolution

Global aquaculture is expanding at an unprecedented pace, propelled by rising seafood demand, food security imperatives, and the urgent need to ease pressure on wild fisheries. Yet this remarkable growth is shadowed by mounting challenges—sustainability, fish welfare, and environmental impact chief among them. To truly fulfil the promise of the blue revolution, the sector must embrace transparency, certification, and consumer education. Only then can farmed fish strengthen their image in international markets while ensuring aquaculture remains a force for ecological balance and human nourishment.

Global Trends in Aquaculture

- **Rapid growth:** Aquaculture now supplies more than half of the world's seafood, with Asia—particularly China, India, and Vietnam—dominating production. Humanity has reached a historic turning point: farmed fish now surpass wild-caught as our primary protein source.
- **Diversification:** Beyond staples like tilapia, carp, and salmon, producers are expanding into shrimp, sea bass, and seaweed.
- **Technological innovation:** Systems such as Recirculating Aquaculture (RAS), Biofloc Technology (BFT), and Integrated Multi-Trophic Aquaculture (IMTA) are transforming farms into hubs of efficiency.
- **Regional focus:** Africa and South America are emerging as dynamic growth regions, positioning aquaculture as both a food security solution and an export engine.

Challenges Facing the Sector

- **Environmental pressures:** Intensive farming risks nutrient enrichment, water pollution, and biodiversity loss.
- **Aquaculture emissions:** Renewable-powered RAS and BFT within IMTA frameworks can position aquaculture as a climate-smart protein source.
- **Disease outbreaks:** Shrimp face White Spot Syndrome Virus, salmon battle sea lice, and tilapia contend with Tilapia Lake Virus. Addressing these requires resilient breeds, strict biosecurity, and climate-adaptive systems (see our feature, *Designing Genetics for the Pond – Lessons from a Rectangular Pizza* by Balasubramaniam Venkatachalam).
- **Resource conflicts:** Competition for land and water demands sustainable intensification—through RAS, BFT, IMTA, and Tank-by-Pond systems (see our feature, *Tank-by-Pond Systems: Rethinking Intensification Without Abandoning Ponds* by Danijel Gospić) and aquaponics (see our feature, *The Case for Aquaponics* by Leslie Ter Morshuizen).
- **Economic volatility:** Embedding nutrient circularity and strengthening local supply chains can transform volatility into opportunity.

Welfare & Environmental Concerns

- **Fish welfare:** Humane stocking, handling, and slaughter standards are vital to consumer trust.
- **Feed sustainability:** Alternatives—algae, insect protein, plant-based feeds—are gaining traction.
- **Climate change:** Rising temperatures and ocean acidification demand adaptive strategies.
- **Harmful algal blooms:** Early warning systems and land-based RAS can buffer impacts (see our feature, *South Australia's Algal Bloom Crisis: A Climate Change Challenge for Global Oyster Farming* by Janine Pierce).
- **Social concerns:** Labor conditions and community displacement highlight the need for stronger governance.

Improving the Image of Farmed Fish

- **Certification schemes:** Wider adoption of ASC, BAP, and GlobalG.A.P builds consumer confidence and counters “bluewashing” (see our feature, *Sustainability in Aquaculture: The Blue Economy and Bluewashing* by Andrew Leingang).
- **Improved flavour quality:** Tackling off-flavour taints in tilapia, carp, and Pangasius elevates reputation and unlocks premium markets (see our feature, *Tilapia: From the Nile to the World's Tables – A Success Story in Aquaculture* by Abd El-Rahman Khattaby).
- **Transparency:** Clear labelling, blockchain, and footprint disclosure strengthen consumer trust (see again *Sustainability in Aquaculture: The Blue Economy and Bluewashing* by Andrew Leingang).
- **Consumer education:** Outreach must highlight aquaculture's role in food security and reduced pressure on wild stocks.
- **Innovation in feed:** Insect protein, algae, and plant-based alternatives reduce reliance on wild fish.
- **Policy support:** Stronger governance and incentives for sustainable practices anchor aquaculture's legitimacy.

Lastly, as we reflect on the future of aquaculture, we also pause to honour the legacy of **David Fincham (1963–2026)**, a pioneer who transformed tilapia farming in Southern Africa. Through his vision at David Fincham Aquaculture and his development of modular recirculating systems, he championed accessibility for smallholder farmers and advanced sustainable practices that continue to inspire the sector. His mentorship, advocacy, and innovation leave an enduring imprint on the blue revolution we strive to fulfil.

Countering the challenges to fulfil the promise of the blue revolution

Aspect	Current Challenge	Improvement Strategy
Production Growth	Rapid expansion in Asia	Diversify species, expand RAS & IMTA
Environment	Pollution, habitat loss	Certification, eco-friendly systems
Welfare	Stocking density, handling stress	Welfare standards, humane slaughter
Emissions	GHG from feed & ponds	RAS, biofloc, low-carbon feeds
Nutrient Circularity	Waste discharge	IMTA, IAAS, recycling into co-products
Market Perception	“Cheap” or “low-quality” image	Branding, transparency, consumer education



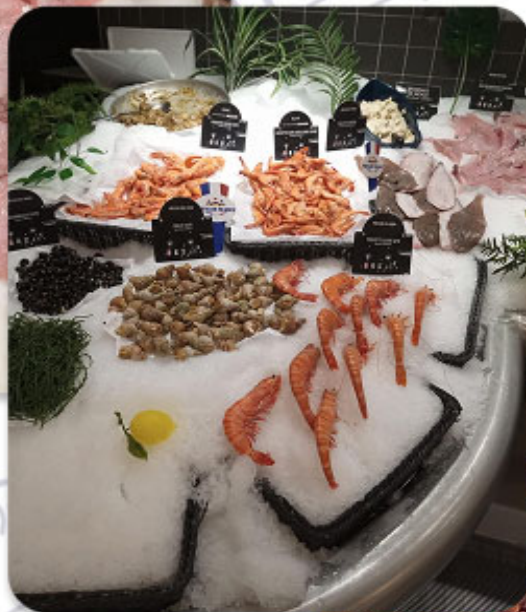
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SMART Aquaculture Technologies in Seafood Processing and Canning Industries

Summary

Advances in AI, IoT, and edge computing are transforming aquaculture, and these technologies are now finding applications in seafood processing industries. Real-time monitoring of critical parameters, combined with predictive analytics and computer vision, enables higher quality, safer, and more sustainable production of canned and processed fish products. This article reviews the latest innovations for integrating smart aquaculture technologies into industrial seafood

CORE TECHNOLOGIES FOR INDUSTRIALIZATION



AI, IoT Monitoring

Smart sensors networks measure processing predictive algorithms trigger alerts



Computer Vision for Quality Assessment

Machine learning models analyze fish size, color, and surface defects



Edge AI and TinyML in Factories

Low-power edge computing devices process sensor and image data on-site



Process Optimization and Precision Control

AI integration with PLC SCADA systems enables dynamic adjustments

PRACTICAL BENEFITS

- Enhanced Product Quality
- Food Safety Compliance

IMPLEMENTATION CHALLENGES

- Sensor reliability
- Data integration
- Model generalization
- Initial investment

FUTURE PERSPECTIVES

- Autonomous processing lines
- Hybrid edge – cloud architectures
- Expanded multimodal

Smart Aquaculture Technologies in Seafood Processing and Canning Industries

Abstract

Advances in AI, IoT, and edge computing are transforming aquaculture, and these technologies are now finding applications in seafood processing and canning industries. Real-time monitoring of critical parameters, combined with predictive analytics and computer vision, enables higher quality, safer, and more sustainable production of canned and processed fish products. This article reviews the latest innovations, practical applications, challenges, and future perspectives for integrating smart aquaculture technologies into industrial seafood processing.

1. Introduction

Seafood processing, particularly canning, faces multiple challenges: variability in raw material quality, microbial contamination, process inefficiencies, and inconsistent product characteristics. Traditional methods rely heavily on manual inspection, periodic testing, and fixed processing schedules, leading to **over-processing, waste, and safety risks**.

Recent developments in smart aquaculture technologies

offer tools to overcome these limitations. AI-driven monitoring, IoT-enabled sensors, and edge computing can provide **continuous real-time oversight**, optimize processing parameters, and reduce human error. These tools not only enhance product quality and shelf life but also support sustainability goals by minimizing waste and energy consumption.

2. Core Technologies for Industrial Application

2.1 AIoT Monitoring

Smart sensor networks measure temperature, pH, dissolved oxygen, salinity, and microbial activity throughout the processing and storage stages. Data is transmitted to edge AI devices for real-time analysis, enabling automated adjustments in sterilization, brine formulation, and cooking cycles. Predictive algorithms detect deviations from optimal ranges, triggering alerts before spoilage or contamination occurs.

2.2 Computer Vision for Quality Assessment

High-resolution cameras integrated with machine learning models analyze fish size, color, and surface

defects. This allows early detection of substandard raw materials and foreign matter in production lines, reducing recalls and ensuring compliance with food safety standards. Models can be trained on historical production data to predict optimal batch compositions and reduce variability.

2.3 Edge AI and TinyML in Factories

Low-power edge computing devices process sensor and image data on-site, minimizing reliance on cloud connectivity. TinyML algorithms can monitor critical points in real time—such as cooking temperature uniformity in retorts, brine concentration in tanks, or storage conditions—providing actionable insights instantly without latency.

2.4 Process Optimization and Precision Control

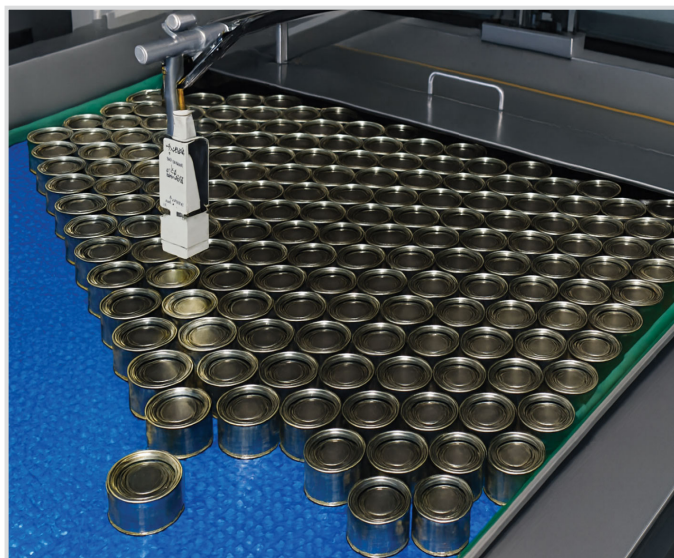
Integration of AI with PLCs (programmable logic controllers) and SCADA systems enables **dynamic process adjustments**. Feeding, brining, and sterilization cycles can be optimized according to real-time measurements, reducing over-processing and energy consumption while maintaining product integrity.

3. Practical Benefits

- **Enhanced Product Quality:** Continuous monitoring ensures consistent texture, flavor, and nutrient retention in canned seafood.
- **Food Safety Compliance:** Early detection of microbial growth and physical contaminants supports HACCP and ISO 22000 standards.
- **Sustainability:** Automated adjustments reduce energy use, water consumption, and raw material waste.
- **Operational Efficiency:** Predictive maintenance of processing equipment decreases downtime and labor costs.

4. Implementation Challenges

- **Sensor Reliability:** Harsh industrial conditions (steam, salt, vibration) can reduce sensor lifespan, requiring robust calibration protocols.
- **Data Integration:** Legacy control systems may not



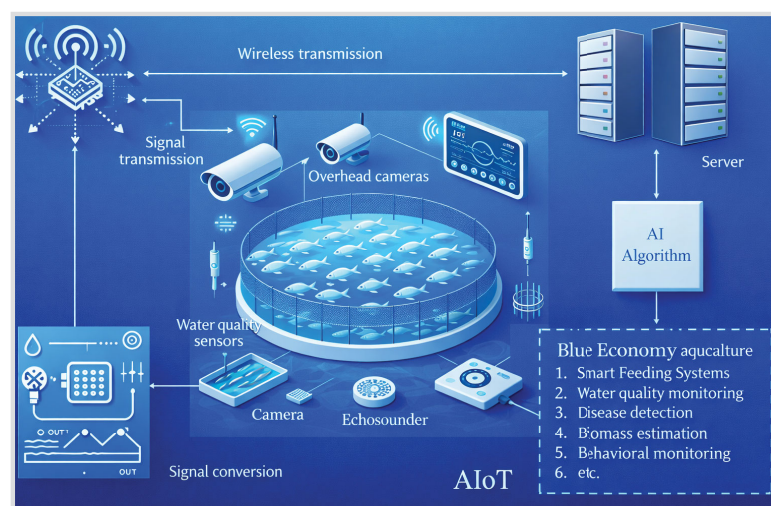
seamlessly integrate with modern AIoT platforms.

- **Model Generalization:** AI models trained in one factory may require retraining for another due to variations in equipment, fish species, or environmental conditions.
- **Initial Investment:** High upfront costs may limit adoption in small-scale facilities.

5. Future Perspectives

The next stage involves fully autonomous seafood processing lines, where AI systems monitor raw material quality, optimize cooking and canning, and manage storage conditions with minimal human intervention. Hybrid edge-cloud architectures, combined with **digital twins** of processing lines, will allow predictive simulations, early anomaly detection, and real-time optimization. Integrating blockchain technology could also enable transparent traceability from farm to shelf, strengthening consumer trust and regulatory compliance.

Research is ongoing to expand **multimodal AI**, combining computer vision, chemical sensors, and microbiome analysis, creating a comprehensive quality management system. Widespread adoption of these technologies promises a **revolution in seafood processing efficiency, safety, and sustainability**.



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4. AI in aquaculture and seafood supply chains, 2025 (sciencedirect.com)
5. IoT-enabled food processing and predictive maintenance, 2024 (mdpi.com)



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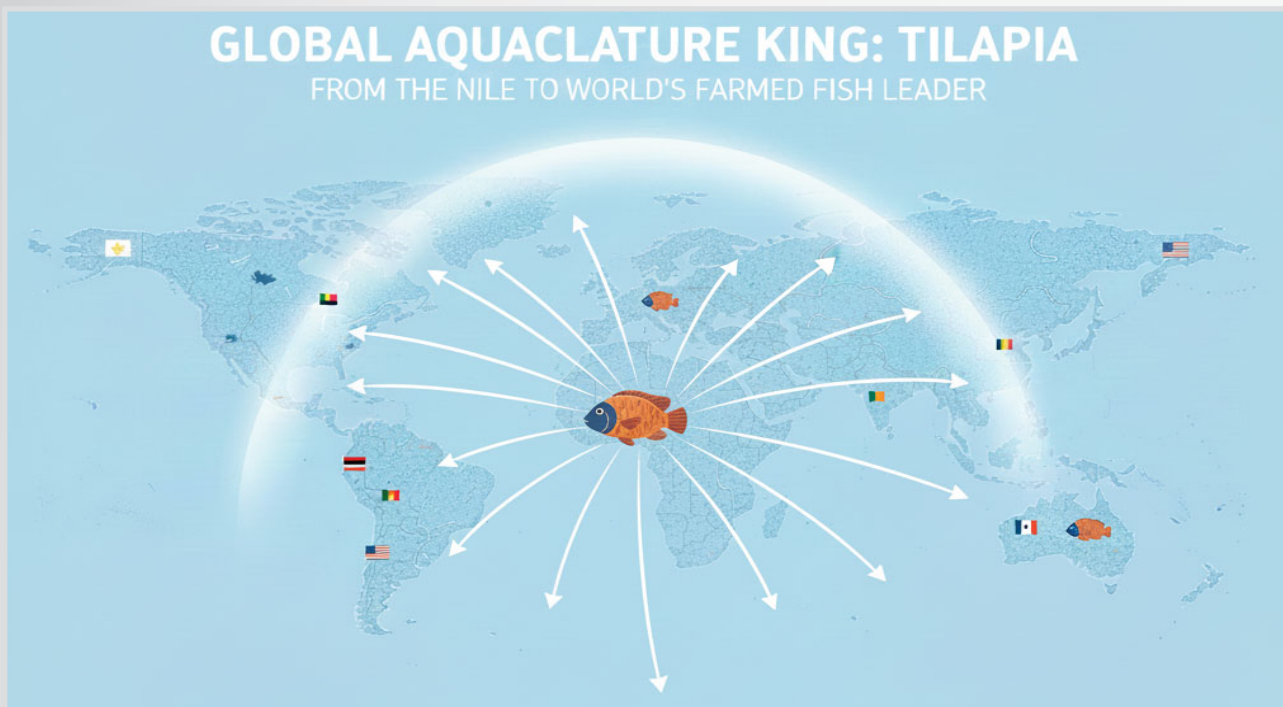
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GLOBAL AQUACULTURE KING: TILAPIA

FROM THE NILE TO WORLD'S FARMED FISH LEADER



Tilapia: From the Nile to the World's Tables – A Success Story in Aquaculture

Introduction

In a world witnessing increasing demand for animal protein, aquaculture (fish farming) stands out as one of the fastest-growing food sectors globally. At the heart of this revolution, tilapia (family Cichlidae, particularly the genus *Oreochromis*) shines as a star player and a key agent in bridging the food gap. Global tilapia production is expected to reach 9 million tonnes in 2030 with an estimated value of USD2.3 billion (Roderick, 2025). These fish, native to the freshwaters of Africa and the Middle East, are no longer merely a local food source but have transformed into a global commodity. This article traces the extraordinary journey of tilapia, from its native habitats to intensive farming systems on every continent, analyzes the reasons behind its success, its competitive interaction with local species, and looks ahead to its future growth prospects amidst the challenges of food security and sustainability.

Chapter 1: African Roots and Global Expansion

Tilapia originate from tropical and subtropical regions

of Africa, with some species found in the Middle East (such as Nile tilapia in the River Nile). Historically, these fish played a role in the economies and cultures of ancient communities. It has been found in the drawings of the ancient Egyptians in temples and papyri. Their global journey began in the mid-20th century, when they were transported for research purposes, aquatic weed control, and to provide a cheap, easily breeding protein source.

Mechanisms of Global Spread:

1- Colonial Transfer and Intentional Introduction: Governments and international organizations transferred species like Nile tilapia (*Oreochromis niloticus*) and Mozambique tilapia (*Oreochromis mossambicus*) to countries in Asia and Latin America in the 1950s and 1960s.

2- International Development Projects: Organizations like USAID and the UNDP promoted tilapia farming to combat poverty and malnutrition in developing nations.

3- "Informal" Spread by Farmers: Due to their hardiness and ease of farming, tilapia moved from official projects

to small farmers' ponds, often escaping into natural waterways, contributing to their spread as invasive species in some regions.

4- Trade and Global Demand: As the aquaculture industry grew, tilapia evolved from a subsistence fish into a commodity produced for export, driving the establishment of large-scale farms in countries with strong infrastructure like China and Brazil.

Tilapia have become an important commercial species in many developing countries for local consumption and export

Examples of Global Spread:

- **China:** The world's largest tilapia producer with first introductions of the genus in the 1970s. Today, China produces over 1.6 million tonnes annually, a significant portion for export.
- **Egypt:** The largest tilapia producer in Africa and one of the top global producers. Tilapia is the backbone of Egyptian aquaculture, supported by the Nile River and a suitable climate.
- **Indonesia and the Philippines:** These countries rank highly in production, with thousands of small and medium-scale farms relying on tilapia as a core part of the rural economy.
- **Brazil:** Introduced in the 1970s, tilapia became the dominant species in inland aquaculture, particularly in states like São Paulo and Paraná.
- **United States:** Although not native, the U.S. became one of the largest consumer markets. Tilapia are farmed in advanced systems in states like Mississippi and Idaho, with heavy reliance on imports from Latin America.

Chapter 2: Why Did Tilapia Forcefully Enter Aquaculture?

The tremendous success of tilapia in farming systems can be attributed to a unique set of biological and economic traits that made it the ideal candidate genus to support new aquaculture industries in multiples of nations.

1- Hardiness and Tolerance:

- **Environmental Resilience:** Tilapia tolerate a wide range of salinity (from freshwater to brackish water, and some species in seawater), temperature, and low dissolved oxygen levels compared to other farmed fish.
- **Disease Resistance:** Generally, tilapia have strong immunity, making them less susceptible to diseases



compared to other farmed species like salmon or shrimp, reducing antibiotic use and losses.

2- High Feed Efficiency:

- **Diet:** Tilapia are omnivores. They can consume a wide spectrum of feeds, from algae and plankton to agricultural by-products and cheap formulated feeds, keeping production costs relatively low.
- **Feed Conversion Ratio (FCR):** Tilapia are highly efficient at converting feed to flesh, with FCRs on complete feeds as low as 1.5:1 (1.5 kg of feed to produce 1 kg of weight), an excellent ratio.

3- Fast Growth Rate and Easy Reproduction:

- Tilapia grow quickly, reaching market size (400-500 grams) in 6 to 9 months under optimal conditions.
- They breed easily in captivity, even in suboptimal conditions. Females lay hundreds of eggs per breeding cycle and are mouthbrooders, ensuring high survival rates for fry.

4- Market Acceptance:

- **Mild Flavor:** Tilapia has a mild taste and firm texture, making it palatable to a wide range of consumers globally across different cultural tastes and affordable whitefish alternative to cod, haddock, Alaskan Pollock, hake etc.
- **Minimal Scales and Few Intermuscular Bones:** This facilitates processing and presentation, increasing its market appeal and value.
- **Affordable Price:** Due to its production efficiency, tilapia reaches consumers at competitive prices compared to other fish, making it a popular choice.

Chapter 3: Competing with Local Species:

Examples of Tilapia's Edge

The spread of tilapia has not been without challenge. In many regions, it found itself in direct competition with established local species, often outperforming them.

Example 1: Tilapia vs. Pangasius (Tra Catfish) in Vietnam

- **Background:** Pangasius (especially *Pangasianodon hypophthalmus*), known as “Vietnamese catfish,” dominates the aquaculture industry in Vietnam’s Mekong Delta. It is native to the region, boasts extremely fast growth, and yields large, boneless fillets.
- **Nature of Competition:** The competition is not direct in the same market. Pangasius is a massive export product (especially to Europe and the U.S.) with a strong brand. However, tilapia (known locally as Cá rô phi) is gaining ground because:
 - **Risk Diversification:** Vietnamese farmers culture tilapia as part of polyculture systems to reduce reliance on a single crop.
 - **Domestic and Regional Markets:** Domestic demand for tilapia is rising due to its reasonable price and taste.
 - **Flexibility in Farming Systems:** It can be raised in diverse systems, including river cages and earthen ponds, utilizing infrastructure that may not suit pangasius.
 - **Outcome:** While pangasius remains the “king” in Vietnam in terms of export volume and value, tilapia is establishing itself as a strategic option for diversification and meeting different market needs.

Example 2: Tilapia vs. Amazonian Fish in Brazil

- **Background:** Brazil possesses an immense wealth

of native freshwater fish in the Amazon Basin, such as tambaqui (*Colossoma macropomum*) and pacu (*Piaractus brachipomus*), which are large, high-value fish well-accepted locally.

- **Nature of Competition:** Here, tilapia’s dominance was more pronounced outside the Amazon region itself. In southern and southeastern Brazil (industrial and consumption hubs), tilapia outperformed native species because:

- **Adaptation to Intensive Farming:** Amazonian fish breed slowly in captivity and often require specific environmental conditions difficult to provide commercially. In contrast, tilapia breeds prolifically and grows fast in intensive systems.

- **Production Efficiency:** Tilapia’s feeding regimen and growth rate make its production cheaper and more predictable than that of Amazonian fish.

- **Creating a New Market:** The tilapia industry successfully built a massive domestic Brazilian market for the fish, while consumption of Amazonian species remained largely concentrated in their native regions or as a premium product.

- **Outcome:** Tilapia became the dominant species in Brazilian freshwater aquaculture, while Amazonian fish retain their cultural and ecological value, with ongoing efforts to improve their farming technologies.

Chapter 4: Hopes and Expectations for the Growth of Tilapia Farming

The sector looks toward a bright future for tilapia farming but simultaneously faces undeniable challenges.

Positive Trends and Expectations:



1- Continued Growth in Production and Consumption: FAO estimates indicate sustained growth in tilapia production, driven by rising demand from the middle classes in developing and emerging economies, and increased global health consciousness pushing consumers towards lean proteins like fish.

2- Technological Innovation: Technology will play a pivotal role in increasing efficiency:

- Integrated Farming Systems (e.g., Aquaponics): Combining fish farming with plant cultivation improves sustainability and economic returns.

- Marine and Brackish Water Aquaculture: Expanding tilapia farming into these waters will help alleviate pressure on freshwater resources.

- Genetic Improvement: Selective breeding for faster-growing, more disease-resistant strains will significantly raise farm productivity.

3- Focus on Sustainability and Certification: Consumer demand, especially in European and American markets, is increasing for products with sustainability certifications (like the Aquaculture Stewardship Council - ASC). This pushes large farms to improve practices in water management, feed sourcing, and environmental impact reduction.

4- Development of Value-Added Products: Production will shift beyond whole frozen fish towards value-added products; fillets, ready-to-eat meals, and appetizers, opening new markets and increasing economic value.

Challenges and Risks:

1- **Environmental Impacts:** Intensive tilapia farming remains associated with risks such as water pollution from waste, the use of wild fish in feed (for fishmeal/oil), and escapees competing with native species or spreading disease.

2- **Fluctuating Feed Prices:** Feed costs have escalated significantly in recent years account for up to 60-70% of production costs. Any volatility in grain (corn, soybean) prices directly affects farm profitability

3- **Disease:** As production intensifies, the risk of disease outbreaks, such as Tilapia Lake Virus (TiLV), increases, necessitating greater investment in biosecurity measures, animal health and preventive care.

4- **Marketing and Branding Issues:** In some markets, tilapia's image is still linked to being a "cheap fish," requiring marketing efforts to rebrand it as a healthy and sustainable product.

Conclusion

The story of tilapia represents a remarkable model of success in the global food sector. It has transitioned from a local resource in African rivers to one of the world's most important farmed fish, thanks to its exceptional biological resilience and superior economic efficiency. This fish has managed not only to spread but to compete successfully and sometimes outperform entrenched local species, as seen in Brazil, while carving a niche alongside industry giants like pangasius in Vietnam. The future of tilapia

farming is promising, but it hinges on the industry's ability to adopt technological innovations, address environmental concerns, and meet consumer demands for more sustainable and high-quality products. In its journey from the Nile to the world, tilapia has been more than just a fish; it has been a practical solution to food crises, a story of adaptation, and a model of globalization on the dinner table.

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Aquaculture without Frontiers (AwF)

AwF is an independent non-profit organization that promotes and supports responsible & sustainable aquaculture initiatives to provide fish for food and income in developing countries around the world.

Since 2004 AwF has been teaching poor families in some of the poorest countries in the world to raise fish for food and income through small-scale projects. AwF also assisted in tsunami relief work in 2005. AwF Volunteers work together to create long term networks enabling the transfer of skills, knowledge, experience and more.

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⇒ **AwF** is composed of volunteer professional aquaculturists from academia and the public and private sectors who have a wide range and depth of training, knowledge, and practical experience.

⇒ **AwF** represents the best of what the aquaculture community stands for and puts it into direct action to make a difference in people's lives daily.

⇒ **AwF** introduces and promotes practical techniques that are based on the best available science and technology.

⇒ **AwF** increases awareness of the importance of the aquatic environment, animal welfare, and the potential of aquaculture to provide food security and improve quality of life.



⇒ **AwF** trains women and young people to support themselves and their families.

⇒ **AwF** works for long-term stability, not just short-term relief.

⇒ **AwF** provides hope for a better future to people that society has forgotten.

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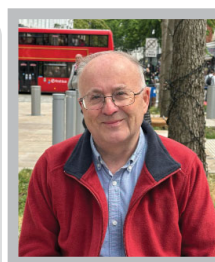




Interview with Professor Simon John Davies

Biography:

Professor Simon John Davies is an Emeritus Professor of Aquaculture Nutrition and Biosciences at Harper Adams University in the UK. He also serves as an Adjunct Professor at the School of Natural Sciences, Ryan Institute, University of Galway, Ireland. With over 36 years of experience in academia, his research primarily focuses on fish nutrition, sustainable aquaculture practices, and the development of functional feed additives for farmed fish species and shrimp. His work has significantly contributed to advancing aquaculture nutrition and promoting sustainable practices within the industry.



1. Could you elaborate on your recent work developing functional feed additives for aquaculture? What are the key innovations you're most excited about?

Recent advances in aquaculture nutrition have prioritized the development of functional feed additives and supplements that enhance both fish health and environmental performance. Additives such as bioactive compounds and probiotics are increasingly integrated into diets to support disease resistance and growth, while also reducing nutrient waste and the sector's ecological footprint. The increasing effort to develop functional feed additives that can enhance the immune system of

fish and shrimp allows us to expand the use of alternative ingredients from an array of sources to meet formulation demands and help fill the 'protein gap' in aquaculture diets for fish and shrimp. This is now deemed to be crucial for the aquaculture industry globally.

2. In your opinion, what are the most promising alternative feed ingredients that could reduce the industry's reliance on traditional fishmeal?

Several alternative ingredients—including insect meal (e.g. Black soldier fly larval meal), microbial proteins, and microalgae—are considered leading options to



either partially or fully replace fishmeal in aquafeeds. These alternatives provide sustainable protein sources, essential amino acids and essential fatty acids (omega-3s DHA and EPA), and additional bioactive components that contribute to both nutritional quality and fish welfare. The traditional use of soybean meal has also been questioned due to its sustainability issues with questions regarding deforestation, environmental footprint due to increasing production of soybean for animal feeds and also in aquaculture. Other terrestrial plant crops are being advocated such as pulses, beans like lupins, peas and faba bean for use in fish feed formulations with considerable success in many species of fish and in shrimp. Recently studies have shown how the spent processed grain from bioethanol production can be used as a well-balanced protein source for trout, salmon, tilapia, carp and marine species such as seabass, seabream and shrimp. Some specific animal byproducts can be used in aquaculture and can offer considerable nutritional value and high-quality sources in commercial diets. As such, poultry byproduct meal and blood meals are reemerging as viable ingredients to provide circularity within the bioeconomy for aquaculture production and processing of waste streams for future aquafeeds.

3. How do you approach balancing nutritional requirements with environmental sustainability in aquaculture feed formulations?

Balancing dietary needs with sustainability is achieved through precise feed formulation, waste minimization, and sourcing from renewable ingredients. Frequent assessment of digestibility and nutrient utilization, alongside inclusion of functional additives, supports optimal health outcomes and efficient resource use in aquaculture systems. Nutritional strategies can improve fish health and welfare and positively reinforce fish physiology and metabolism in terms of growth and development, gut integrity (microbiome) and promotion of higher nutrient assimilation and retention leading to better products at harvest.

The link between nutrition and product quality is or paramount concern and especially for the consumer. Aquaculture is increasingly being practiced in closed environmental containment such as RAS (Recirculation Aquaculture Systems). This now necessitates special nutritional strategies to produce diets of higher digestibility, less wastage of feed, lower release of Nitrogen and Phosphorous from feed to mitigate impact on biofilters and water quality criteria in closed containment systems. Diets designed for intensive fish production in RAS systems will become increasingly important as fish farming operations become land based. It is also imperative that we explore new candidate fish species for aquaculture that are more compatible with RAS operations and can be more receptive to novel diets.

4. How do you see the role of sustainable aquaculture in addressing global food security challenges?

Sustainable aquaculture is increasingly recognized as a viable solution for global food security challenges. Efficient feed conversion and bespoke resources enable this industry to supply high-quality fish protein with significantly reduced environmental burdens compared to traditional agriculture. Aquaculture plays a significant lead in the food sector and over 50% of global seafood consumption embodies aquaculture to varying extents of production from low to high intensity operations. It is expected that over 65% of seafood will be derived from aquaculture by 2035. This will need to be addressed through higher feed production, superior management of diseases and control employing prophylactic strategies.

5. What strategies do you recommend for aquaculture systems to adapt to the impacts of climate change?

Adaptive strategies in aquaculture rely on resilient production models, diversification of farmed species, and tailored nutrition to help organisms cope with elevated stress and disease risk under changing climate conditions.





Monitoring and technology adoption may further bolster system resilience and future-proof industry practices. Fish and shellfish will face elevated temperatures during their rearing as well as increased acidification in our oceans. Such factors will impact their physiology and metabolic processes, and we must research how to build resilience in our fish and shellfish stock to meet these emerging abiotic challenges.

6. What policy changes would you advocate for to support sustainable practices in the aquaculture industry?

Supportive policy frameworks are essential for accelerating sustainable aquaculture practices, incentivizing innovation in feed and welfare standards, and promoting responsible resource management will become critical in future years. Collaboration between industry, academia, and government enhances regulation and drives positive change across the sector. Such platforms of cross communications with stakeholders will ensure that safeguards and transparency are maintained to acquire biosecurity and an ethical and efficient supply chain. It is likely that with sophisticated AI technology, blockchain approaches will be utilized in practice to follow fish and shrimp from farm to plate to achieve biosecurity and product authentication.

7. How has your academic journey influenced your approach to aquaculture research and education?

A long-standing commitment to aquaculture research and education fosters multidisciplinary innovation and scientific rigor within the field. Exposure to diverse research methods and international collaborations encourages continuous learning and advancement of best practices in nutrition and welfare. The universities must continue to support the need

for nutrition scientists at postgraduate level attaining master and doctoral degree levels and beyond with postdoctoral fellowships. There is also a need to train veterinarians towards specialization and careers in fish farming that is now presently only partially addressed in their programs at veterinary college. Much more education is required, and even high schools should be addressing aquaculture and its benefits to our food supply chain. In this regard it would be wise to provide outreach and experiential opportunities for our high school students with stakeholders and fish farm operatives.

8. What areas of aquaculture nutrition do you believe require more research attention in the coming years?

Priority research areas include immune-modulatory feed additives and supplements, optimization of gut microbiomes, nutrient recycling technologies, and integration of advanced monitoring systems based on AI and machine learning technology. Future investigations should address how metabolic pathways, and immunological responses interact with environmental change for preventive measures.

The need for improving genetics and selection for fish to be responsive to changing diets, growth rates, feed conversion efficiency and nutrient retention is paramount. Increasing robustness and immune defenses to pathogens will become important in facing new feed formulations with lower fishmeal and higher in plant ingredients that may compromise fish and shrimp health.



A close-up portrait of a middle-aged man with thinning hair, wearing glasses and a black tuxedo with a white shirt and black bow tie. He is looking directly at the camera with a neutral expression. The background is plain white.

9. What advice would you give to young scientists aspiring to contribute to sustainable aquaculture research?

Emerging researchers are encouraged to be innovative, persistent, and open to collaboration within the global aquaculture community.

Networking, multidisciplinary engagement, and dedication to advancing sustainable nutrition and technology are highlighted as key elements for future success.

Young scientists should make every effort to attend workshops and international aquaculture events such as the World Aquaculture Society and European Aquaculture society and also the Caribbean, Latin America and African, Australasia chapters with their own conferences. Presentation of their research as posters or by direct oral talks is important to gain experience and to disseminate their work to their peers and to industry. The capacity to write articles, reports and to submit manuscripts for peer review in the best scientific journals for aquaculture and related biosciences is greatly encouraged for career advancement.

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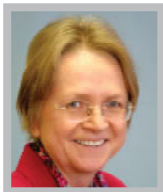
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How many people are employed in aquaculture?

Introduction

Aquaculture has expanded from roughly **0.5 million tonnes in 1950 to 126 million tonnes in 2021**, transforming into a major economic and food production sector. Growth has been driven by a focus on **market oriented species, improved breeds, feeds, health and farming systems, and stronger food safety and environmental regulation**, including trade measures. As production systems mature, the sector must shift equal attention to the **people** who operate, sustain and add value to aquaculture.

Why employment data lags behind production

The sector's rapid evolution has outpaced the capacity of both private and public organisations to collect the right data. In the 1990s, observers warned that **"much aquaculture activity is inadequately recorded because most countries have been unable to establish the necessary institutions and tools for monitoring the structure of the aquaculture sector"** (Rana, 1997, p. 1). That warning remains relevant: production tonnages are now well documented, but the workforce that produces them is not.

Early definitional and measurement challenges

Part of the problem has been definitional. In the 1990s fisheries authorities were still debating what to include under aquaculture—**were cultured ornamental fish counted? Should restocked fish be recorded under capture fisheries or aquaculture?** (SEAFDEC, 1994). Those debates mattered because they shaped what national systems recorded and what they ignored. At the same time, experts urged states to collect **sex disaggregated** worker data and to provide substantive guidance on gender information needs in aquaculture (van der Mheen Sluijter & Sen, 1994; SEAFDEC, 1994). Without clear definitions and guidance, national statistics remained partial and inconsistent.

The Current Situation on Employment Data in Aquaculture: better production data, patchy people data

By 2023, global production statistics for aquaculture were far better specified. Yet **much less attention has been paid to the people** who make the aquaculture revolution work (Brugere et al., 2023). Core workforce

metrics—basic counts of people employed across the value chain, their employment status, and their working conditions—are still incomplete. As FAO notes, employment statistics remain a work in progress, even in some of the largest producing countries (FAO, 2025a, p. 55).

Employment data has long posed challenges in fisheries, yet recent developments have set fisheries and aquaculture on diverging paths—offering potential lessons for aquaculture. FAO has been a common force for progress in developing improved employment data in both aquaculture and fisheries, working diligently with countries and experts in this challenging space.

In fisheries, grassroots initiatives aimed at reversing the decline of small-scale fisheries have helped close critical data gaps (FAO et al., 2023; World Bank et al., 2012). Through these efforts, experts devised and applied methodologies that generated employment estimates across all scales of fisheries, including small-scale and subsistence fishworkers (see Table 1).

By contrast, aquaculture employment data remain fragmented and incomplete. Global statistics provide only rudimentary estimates for primary production—essentially “fish farmers” (FAO, 2025a, p. 157). Employment figures for other segments of the value chain, such as processing, trading, and input services, are absent. Even within primary production, data are limited to a handful of top aquaculture producing countries, with some sex-disaggregated figures available. Global totals are presented only in aggregate form, with underlying components withheld (FAO, 2025a, p. 192). Gendered data appear solely in bar charts (pp. 58–59), restricting deeper analysis.

Table 1: Illustration of global employment data currently available for fisheries and aquaculture. Green cells indicate areas where some data exist, while other colors highlight gaps. For fisheries, both small-scale (SSF) and large-scale (LSF) employment have been estimated globally (FAO et al., 2023). Aquaculture, however, is represented far more sparsely, with limited entries

in FAO’s annual *Fishery and Aquaculture Statistical Yearbooks* (FAO, 2025a).

This lack of granularity leaves fundamental questions unanswered in aquaculture:

- Who is employed across different nodes of the value chain?
- Under what conditions do they work?
- Are jobs rooted in rural communities, offering local opportunities, or dominated by external expertise?
- Who controls the capital—farm licenses, company shares, and other assets?
- How do employment patterns vary across scales of aquaculture and along the value chain?

Who Needs Employment Data in Aquaculture and Why?

The **Guidelines for Sustainable Aquaculture** (FAO, 2025b) highlight *decent work and employment opportunities* as central to sustainability. Employment is also critical to aquaculture’s social licence to operate (Hishamunda et al., 2014; Olsen et al., 2024). Yet, responsibilities for collecting and using employment data vary across participants and observers, operating at different scales.

Two important elements are missing from the Guidelines:

- **Comprehensive employment data across the value chain.** This gap is explicitly addressed in the Shanghai Declaration (FAO et al., 2021, article J(1)), a participant statement from the 2020 Global Conference on Aquaculture.
- **Data on capital ownership.** Ownership structures shape enterprise operations, workforce size, employment types, and conditions. While some studies examine firm structures, ownership concentration, and performance impacts, comprehensive statistics remain unavailable. Resistance from powerful firms and coalitions often impedes transparency.

Who Needs the Data?

- **Policymakers and public managers** require reliable employment data to design policies, target interventions,

Table 1: Illustration of global employment data

FISHERIES				AQUACULTURE		
VC node	SSF	LSF	Total	Value Segment (all scales)	Chain Status	
Pre-harvest				Pre-harvest and farming services	n/av	
Harvesting				Farming		
Subsistence (pre-, post-harvest, harvesting)		n/app		Subsistence farming	n/av	
Post-Harvest Processing				Post-Harvest Processing	n/av	
Post-harvest Trading				Post-Harvest Trading	n/av	

VC = value chain; n/app = not applicable; n/av = not available

and coordinate across agencies (aquaculture, fisheries, labour, welfare, statistics). Fragmented responsibilities across value chains hinder comprehensive collection.

- **Private sector actors** use employment data for investment, planning, and benchmarking against industry or national averages. Enterprises often reduce staff through automation or adjust workforce skills to meet technical needs. In downturns, they may seek state support based on local employment figures.

- **Workers and communities** need recognition in economic statistics to claim rights. Emerging collective action, such as trade unions, pressures firms and policymakers to improve reporting, including occupational health and safety (Nuruzzaman, 2017; Watterson et al., 2020).

- **Advocacy groups**—environmental, animal welfare, human rights, women's equality, food safety, and industry associations—depend on employment data to track patterns and trends.

- **Women's groups and gender advocates** stress sex-disaggregated data across value chains (Harper et al., 2025). A gendered approach must also account for unpaid care and community work, disproportionately carried out by women, without which aquaculture cannot function.

- **Researchers** face major data gaps. In their absence, they reconstruct employment estimates through case studies or sampling, as in Phillips et al. (2016), which used nine country case studies to estimate global aquaculture employment.

- **Consumers and citizens** increasingly demand transparency on employment conditions. Certification schemes, however, remain weak on social data, outsourcing human elements and slowing progress.

Why It Matters

Employment data must go beyond primary production. Focusing only on farming obscures the broader workforce engaged across value chains. Shocks—whether disease outbreaks, climate disasters, or trade disruptions—affect workers at every stage. Conversely, technological advances or production leaps ripple through employment systems.

Accurate, reliable time-series data are essential to:

- Understand the diversity and scale of people engaged.
- Track conditions of work and how they evolve.
- Anticipate impacts of crises or innovations across the value chain.

Challenges

Improving employment data faces persistent obstacles:

- Historical neglect of social statistics.
- High costs and technical difficulties in system design.
- Social barriers, especially in reaching small-scale and under-recognised workers.
- Political resistance from powerful interests unwilling to expose questionable employment practices.

Global employment data estimates

The first global estimates of aquaculture employment appeared 15 years ago in the FAO Director General's statement to the 5th meeting of the Committee on Fisheries Sub-Committee on Aquaculture (Table 2). In

the *FAO Yearbook of Fish Statistics 2015* (published 2017), farmer numbers were reported from major producing countries and extrapolated globally.

The 2017 Yearbook also provided estimates for 1995–2015 at five year intervals. Subsequent editions revised historic figures, generally upward, as more data became available through FAO's leadership, with Table 2 presenting the latest estimates.

Scale of operations highlights the complexity of aquaculture employment data. The Big Numbers study on small-scale aquaculture (Phillips et al., 2016) found that farming, including hatcheries, employed more people than all other value chain segments combined. This contrasts with Bartley (2022), underscoring the need to address scale-related complexities—similar to those tackled in fisheries by Hidden Harvests and Illuminating Hidden Harvests (FAO et al., 2023; World Bank et al., 2012).

Sex and gender disaggregation adds another layer of complexity. For aquaculture, only 60% of employment data reported to FAO is disaggregated by sex, compared to 78% for fisheries. Women account for roughly a quarter of employees (~27% aquaculture, 24% fisheries) (FAO, 2025a, p. 55). FAO cautions, however, that regional gender patterns vary widely. Case studies by Hishamunda et al. (2014), Phillips et al. (2016), and Kruijsen et al. (2018, Table 1) confirm that women's employment differs significantly by industry, country, enterprise type, and value chain segment.

Employment is also vulnerable to shocks, particularly for small-scale operators and women. Maal (2013) documented “nearly jobless growth” in Norwegian salmon farming, where women's share fell from 20% in 1990 to 9% in 2010. Ownership changes and policy shifts transformed the sector from locally owned to large, industrialised, vertically and horizontally integrated companies. While economies of scale delivered profits, they severely reduced women's employment—a trend unchanged despite repeated recommendations for action (Karlsdóttir & Guðmundsdóttir, 2024).

The Way Forward on Aquaculture Employment Data

Without reliable data on employment, future aquaculture will not achieve its aspirations on decent work and employment opportunities, nor assure its social licence to operate. With the maturing of the aquaculture sector and the continuing dynamism in employment, now is the time to upgrade the data on employment. The global stimulus for this upgrade could be the Guidelines for Sustainable Aquaculture (2025), recently approved by the members of the FAO Committee on Fisheries and Aquaculture, alongside expert guidance and non-government commitments such as the Shanghai Declaration (2021).

Aquaculture has long focused on production data, while employment outcomes—who is engaged, under what conditions, and with what social impacts—remain poorly documented. Without attention to these dimensions, aquaculture risks repeating the trajectory

Table 2: Global estimates of employment in aquaculture, with sources.

Year	Estimates (millions of people)			Sources, notes
	Total Employment	On-Farm, Farmers, Primary Production	Off farm	
1995	n/av	11.17	n/av	FAO (2025a)
2000	n/av	13.40	n/av	As above
2005	n/av	16.17	n/av	As above
2010	n/av	19.90	n/av	As above
2010	30	21	9	DG's rep's statement to COFI-SCA#05 (Report, p. 69); fulltime equivalents
2015	n/av	22.04	n/av	Figures as cited in FAO (2025a)
2016	56.7	41.4	15.3	Phillips et al. (2016)
2018	59.51	20.53	38.98	Bartley (2022) citing FAO (2020)
2019	n/av	22.04	n/av	FAO (2025a)
2023	n/av	22.99	n/av	FAO (2025a)

of other industrial sectors, including fisheries, where growth in production masked labour losses alongside some opportunities, gender inequities, and exploitation. To avoid this trap, aquaculture must now build robust institutional data systems that capture employment characteristics alongside production.

Next Steps

Step 1: Obtaining Technical Agreement

- Secure broad, depoliticised consensus that employment data are essential.
- Stimulate global technical work to define aims and methodologies for setting up and maintaining the data systems at appropriate levels.
- Recognise challenges: entrenched legacy systems, resistance from stakeholders, and the inertia of long-standing data practices.
- Address the “two-edged sword” of data (Krieger, 2021): absence of data leads to neglect, while biased or incomplete data misguide action. Gender-disaggregated employment data exemplify this problem.

Step 2: Developing and Testing Methodologies

- Build on FAO and related work in aquaculture and

fisheries employment data.

- Use participatory approaches and new information technologies to design inclusive systems.
- Draw lessons from studies such as Illuminating Hidden Harvests (FAO et al., 2023) and Harper et al. (2025) on gender-inclusive data systems.
- Determine levels of detail required: national vs. industry-specific, enterprise scale, sex-disaggregated, and intersectional categories (e.g., migrant status, part-time/full-time work).

Step 3: Reaching Political Agreement

- Present demonstrated approaches to political bodies such as COFI, COFI-SCA, ILO, UNIDO, and UN Women.
- Recognise that employment data responsibilities extend beyond aquaculture agencies to national statistical offices, private sector actors, NGOs, and government registries (health, welfare, labour, etc.).
- Build bridges across institutional silos, leveraging integrative frameworks such as the Blue Economy and agrifood systems approaches.

Step 4: Implementation

- Roll out systems across countries, ensuring consistency

for comparison and aggregation.

- Mentor and train a new generation of experts to sustain progress, recognising that building robust social data systems may take decades, but aquaculture's dynamism could accelerate convergence.

- Link employment data to organisational objectives, education, and training to create demand and ensure uptake.

Call to Action

Aquaculture has reached a turning point. Production growth has been extraordinary, but without robust employment data, the sector risks undermining its own sustainability and social licence to operate. The evidence is clear: we cannot continue to measure tonnes of fish while leaving the people behind.

To move forward, all stakeholders must act:

- **Governments and policymakers** must commit to building comprehensive employment data systems that capture the full value chain, including gendered and community-level dimensions.

- **Industry leaders** must embrace transparency, reporting workforce figures alongside production metrics, and recognising that decent work is integral to long-term profitability.

- **Workers and communities** must be empowered to demand recognition, fair conditions, and inclusion in economic statistics that shape policy and investment.

- **Researchers and advocates** must continue to innovate methodologies, ensuring that employment data reflect the realities of diverse aquaculture systems and scales.

- **International organisations** must coordinate efforts, with FAO's leadership, linking aquaculture employment data to global frameworks on sustainability, labour rights, and food security.

The time for fragmented, partial statistics is over. Reliable, inclusive, and transparent employment data are not optional—they are essential. By acting now, aquaculture can secure its future as a sector that not only feeds the world but also sustains livelihoods, empowers communities, and delivers on the promise of decent work.

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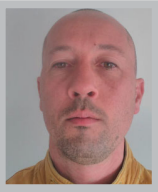
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Key merits of the Tank-By-Pond (TBP) System			
 Functional Separation for Efficiency 1. Ponds stop being the main production unit and instead act as biological backbones. 2. Tanks take over intensive growth, isolating fish metabolism from pond ecosystem respiration. 3. This separation prevents oxygen bottlenecks and stabilizes ecological processes.	 Higher Productivity Without Expansion 1. Achieves ~30 tonnes per hectare per year without routine freshwater exchange. 2. Tanks (e.g., 15 m diameter, 3 m depth) can replace an entire hectare of intensive pond production. 3. Enables intensification without increasing land or water demand.	 Diversification Potential 1. Tanks allow precise control over stocking and feeding, enabling species diversification. 2. Supports species poorly suited to open ponds (e.g., perch, sturgeon, African catfish). 3. Coexists with traditional pond production, spreading economic risk.	
 Natural Filtration & Lower Fragility 1. Ponds serve as living biofilters, replacing much of the mechanical filtration required in RAS. 2. Microbial communities, plankton, and low-density fish recycle nutrients naturally. 3. Reduces dependence on single-point mechanical systems, lowering fragility and capital intensity.	 Energy Efficiency 1. Consumes 2.5–3.5 kWh per kg of fish—more than extensive ponds but far less than RAS. 2. Energy demand scales gradually with biomass and can be tuned seasonally. 3. Oxygen supplementation is optional and modular, allowing stepwise intensification.	 Pragmatic Middle Ground 1. Balances between extensive ponds and high-tech RAS: • Intensification without new land. • Higher productivity without higher water abstraction. • Technological control without excessive complexity. 2. Builds on existing infrastructure and farmer expertise rather than replacing them.	
Why It Matters: The TBP system represents a scalable, resilient, and cost-effective innovation for aquaculture:  It respects ecological limits while enabling intensification.  It offers flexibility for farmers constrained by land, water, or regulatory limits.   It provides a pathway to sustainable growth without requiring full RAS investment.			

Tank-by-Pond Systems: Rethinking Intensification Without Abandoning Ponds

For decades, pond aquaculture has followed a predictable trajectory. When production stagnates, farmers add aerators. When aerators are no longer enough, they add feed, infrastructure, or more ponds. Eventually, the system reaches a point where every additional tonne of fish costs disproportionately more—in energy, labour, water, and risk.

At that moment, the industry usually turns its gaze toward Recirculating Aquaculture Systems (RAS). Full control, minimal water use, high densities. And equally: high capital expenditure, technical complexity, and narrow margins unless markets are premium.

Tank-by-Pond (TBP) systems propose a third path. Not by upgrading ponds, and not by replacing them, but by **reassigning their role**. See Figure 1.

The key innovation of TBP is deceptively simple: ponds stop being the main production unit and become the biological backbone of the system, while tanks take over intensive growth. This single shift changes how oxygen,

space, energy, and risk behave across the farm.

When ponds stop being the bottleneck

In traditional pond farming, intensification is limited less by feed quality or genetics and more by oxygen dynamics. As biomass increases, oxygen demand rises not only from fish, but from plankton blooms, benthic organisms, and microbial decomposition of organic matter. Aeration helps, but it does not isolate fish metabolism from ecosystem respiration.

TBP breaks this dependency.

By relocating most of the biomass into concrete tanks, oxygen consumption becomes focused and controllable. Tanks contain fish—but almost nothing else. No sludge accumulation, no benthos, no uncontrolled plankton growth. Sediment is continuously removed, and water movement is engineered rather than ecological.

The pond, meanwhile, processes what it is naturally good at processing: organic matter, nutrients, and



Figure 1: TBP system with 15 m diameter tank (Fish farm Žabnik (Slovenia), G2O d.o.o.)

suspended solids—without being pushed into oxygen collapse. Instead of fighting pond ecology, TBP uses it.

This is not intensification *against* nature, but intensification *through functional separation*.

Turning ponds into living biofilters

In RAS, filtration is centralized and mechanical. Solids removal units, biofilters, degassers, backup systems—each adds cost, energy demand, and points of failure.

In TBP, filtration is spatially distributed. The pond itself replaces much of the mechanical and biological filtration normally required in RAS. Microbial communities, plankton, and low-density fish stocks recycle nutrients and stabilize water quality.

This has two critical consequences:

1. **Lower system fragility.** There is no single filter whose failure collapses the entire operation.

2. **Lower capital intensity.** Existing ponds become productive assets rather than limitations.

This is why TBP systems are often easier to retrofit into existing farms than to build from scratch. They do not require redesigning the entire landscape—only adding production capacity where it matters most.

Productivity without expansion

One of the most compelling aspects of TBP is that it increases output **without increasing land or water demand**.

Operational experience shows total production levels approaching 30 tonnes per hectare per year, combining tank and pond output, without routine freshwater exchange. For many farms, this represents a two- to threefold increase over conventional intensive pond systems.

Crucially, this gain does not come from pushing ponds harder. It comes from removing the production pressure from ponds altogether.

A single production tank (for example, 15 m diameter and 3 m depth) can functionally replace an entire hectare of intensive pond production, while occupying a negligible fraction of that area. In regions where land prices, water rights, or environmental permits limit expansion, this changes the strategic options available to producers.

Energy efficiency in context

TBP systems consume more energy than extensive

ponds—but far less than full RAS. Typical energy use falls in the range of 2.5–3.5 kWh per kilogram of fish, depending on species and stocking density.

More important than the absolute number is **how energy use scales**.

Energy demand increases gradually with biomass and can be tuned seasonally. Pumps, blowers, and aeration intensity can be adjusted as fish grow, avoiding the front-loaded energy costs common in RAS facilities. See Figure 2 and 3 for the airlift column aerators.

Oxygen supplementation can be added selectively, not as a requirement but as an option—used only when market prices, species value, or space constraints justify it. This modularity allows farmers to intensify step by step rather than committing to a single high-risk investment.

Risk distribution instead of risk concentration

From a risk perspective, TBP systems behave very differently from both ponds and RAS.

In ponds, risk is ecological and weather-driven: oxygen crashes, algal blooms, predators, and water quality swings. In RAS, risk is technical: power failure, filter malfunction, or operator error can wipe out biomass in hours.

TBP distributes risk across components.

- Oxygen in tanks is stable and controllable.
- Pond ecology is buffered by lower biomass pressure.
- Mechanical complexity is moderate and forgiving.

As a result, mortality rates below 3% are consistently achievable under proper management. Disease pressure is reduced not by sterilization, but by **stability**—fewer stress events, fewer abrupt water quality changes, and more predictable feeding behavior.

For high-value species, juveniles, or diversification into sensitive fish, this stability often matters more than maximal density.

A platform for diversification

Another often-overlooked advantage of TBP systems is their ability to support diversification.

Concrete tanks allow precise control over stocking, grading, and feeding regimes. Species that perform poorly in open ponds—such as perch, sturgeon, or African catfish—can be integrated into farms that were previously limited to carp or similar species.

This diversification does not require abandoning



Figure 2: An aerial view of a newly constructed Tank-By-Pond (TBP) System where each tank is equipped with four airlift column aerators and a swirl separator

existing production. TBP systems coexist with traditional ponds, spreading economic risk across species, size classes, and market channels.

In volatile markets, this flexibility is not a luxury—it is resilience.

Why TBP matters for the future of aquaculture

Globally, aquaculture faces a paradox. Demand is rising, but expansion is constrained by land, water, environmental regulations, and social acceptance. Solutions that rely solely on building more ponds or fully enclosed RAS facilities will not scale everywhere.

TBP systems offer a pragmatic middle ground:

- Intensification without new land
- Higher productivity without higher water abstraction
- Technological control without excessive complexity

Most importantly, TBP does not ask farmers to abandon what they already know. It builds on existing pond infrastructure, existing skills, and existing ecosystems—while removing their structural limitations.

A shift in mindset, not just design

The true innovation of Tank-by-Pond systems is not a piece of equipment or a hydraulic trick. It is a change in how production is organized.

Fish grow best where conditions are controlled. Ecosystems function best when they are not overloaded. TBP respects both truths—and separates them.

As aquaculture moves into a future defined by constraint rather than abundance, systems that redistribute function instead of concentrating it may prove to be the most scalable of all.

Sometimes, the most innovative step forward is not to replace the system—but to let each part of it finally do what it does best.

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Figure 3: An aerial view of a newly constructed Tank-By-Pond (TBP) System where each tank is equipped with four airlift column aerators and a swirl separator



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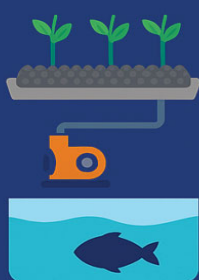
Market
Acceptance



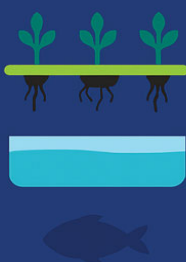
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TYOLOGIES OF AQUAPONICS SYSTEMS

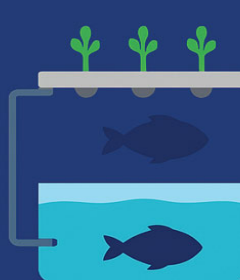
EBB AND FLOW
(FLOOD-AND-DRAIN)



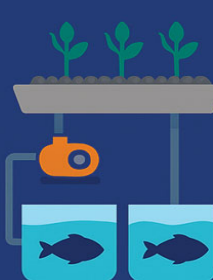
DEEP WATER
CULTURE (DWC)



NUTRIENT FILM
TECHNIQUE



DECOUPLED
AQUAPONICS
SYSTEMS



The Case for Aquaponics

Aquaponics is an ancient form of agriculture which has undergone a modern revival since the 1990s. It is born out of two industries, which give it its name: AQUAculture and hydroPONICS = AQUAPONICS.

Solid and dissolved wastes accumulate in the water within a recirculating aquaculture system (RAS) necessitating filtration for the regular removal of the solid wastes and continuous conversion of the dissolved wastes into a less toxic form (Timmons et al 2002). This results in water being discharged from the RAS daily as the filters are cleaned. However, both waste types contain nutrients that can be utilised by plants, primarily nitrate and phosphate, but also a host of micronutrients (Bernstein 2011).

Redirecting this wastewater stream to an area within the RAS that is planted, results in lush growth as these crops utilise the nutrients for their metabolic requirements. The plants in turn reduce the nutrients to the point that, in a correctly balanced aquaponics system, all the wastes produced by the fish are utilised by the plants, allowing the cleaned water to again return to the fish in a continuous cycle (Bernstein 2011).

Aquaponics offers several advantages over a fish-only system including the production of a second crop for minimal extra cost. The plant crop also commonly generates more sales than the fish do as the fish wastes supports large quantities of plants.

Plant crops also attain market size sooner than the fish, thereby improving cash flow during the start-up phase of the business. As aquaponics systems have no discharge, they are sustainable and environmentally responsible; well suited to areas where biodiversity concerns preclude the use of systems that discharge wastes into the environment.

Types of Aquaponics

There are different types of aquaponics systems of which the ebb and flow system is the mostly widely used (see Figure's 1 and 2).

In this instance a 300mm deep bed of 20mm diameter stones is placed inside a strong container and water flows into this growbed continuously. An automatic siphon device activates once the bed fills, causing it to empty, whereupon the siphon breaks allowing the bed to refill.

This continuous cycle of full and empty provides water and nutrients to the roots of the plants and desirable

table1: Pros and Cons of Aquaponics

Advantages	Disadvantages
Nutrients are utilised not wasted	Management requires two knowledge sets
Minimal nutrient addition required (only Fe, K, Ca)	Disease management options reduced due to potential impact on the other crop
Reduced labour requirement	Complete dependence on electricity
Reduced land requirement	
Reduced environmental impact	
Reduced water requirement	
Zero water stress results in healthy plants	
Reduced pest incidence	
Fish feed produces two crops	
Healthy produce due to gentle pesticides	
Constant production throughout the year	
Lower OPEX than field crops	
Faster crop growth than field farming	
Crop harvesting quick and simple	
Crop rotation not required	
No weeds	
Poor soils can become productive	

microbes living in the bed, alternated with abundant oxygen as the bed drains. The result is a super healthy environment for the microbes and the plant roots, and the solid and dissolved fish wastes are broken down by these microbes into elemental forms that are readily available for uptake by the plants. Consequently, these systems produce almost no waste. Ebb and flow aquaponics is suitable for producing virtually all crop types including the fruiting and leafy plants (Hargrove 2021).

An alternative form of aquaponics is the deep-water culture (DWC) method whereby polystyrene rafts are floated on a trough of 30cm deep water (see Figure's 3 and 4). Holes are cut into the polystyrene and plants are inserted into the holes so that the leaves are above the polystyrene but the roots are in the water. Heavy aeration below the sheets ensures that the dissolved oxygen concentration remains high for the plant roots. Although slightly cheaper to install than ebb and flow



Figure 1: Abundant plant growth in an outdoor ebb and flow aquaponics system

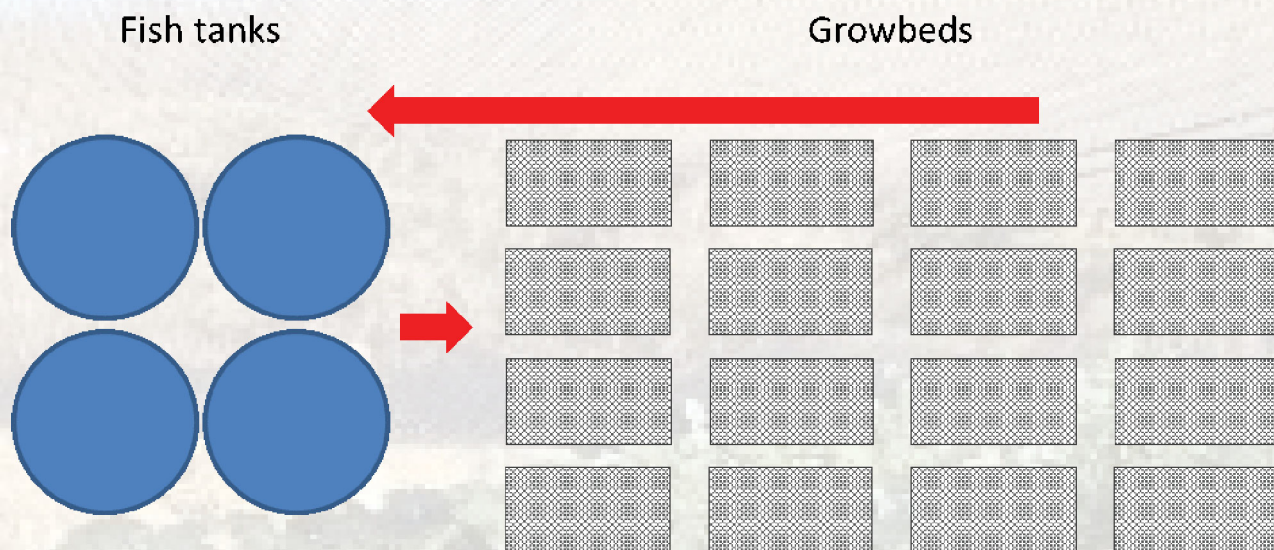


Figure 2: Schematic showing the components of an ebb and flow aquaponics system

systems, DWC aquaponics is only well suited to growing leafy greens.

The final form of aquaponics involves running a thin film of water inside a pipe. Plants are planted through a row of holes in the top of the pipe such that their roots dangle into the film of water, hence the name nutrient film technique (NFT) (see Figure's 5 and 6). Due to the disadvantages of the roots drying out rapidly during power failures, roots clogging the pipes, along with the heating or cooling of the thin film of water due to fluctuating air temperatures, this technique is not very

popular (<https://gogreenaquaponics.com/>).

The small stream of waste water generated by cleaning the mechanical filters in a DWC or NFT system can be treated and returned to the system, or utilised to fertilise soil grown crops.

A further development that has enhanced the efficiency of aquaponics is what is known as a decoupled aquaponics system (Aslanidou 2024). In traditional aquaponics the plants and fish are situated in a single system where the water flows directly from the fish to the plants and back. Given that the water cycles through the growbeds roughly



Figure 3: The DWC option is best suited for the production of leafy crops such as lettuce and basil

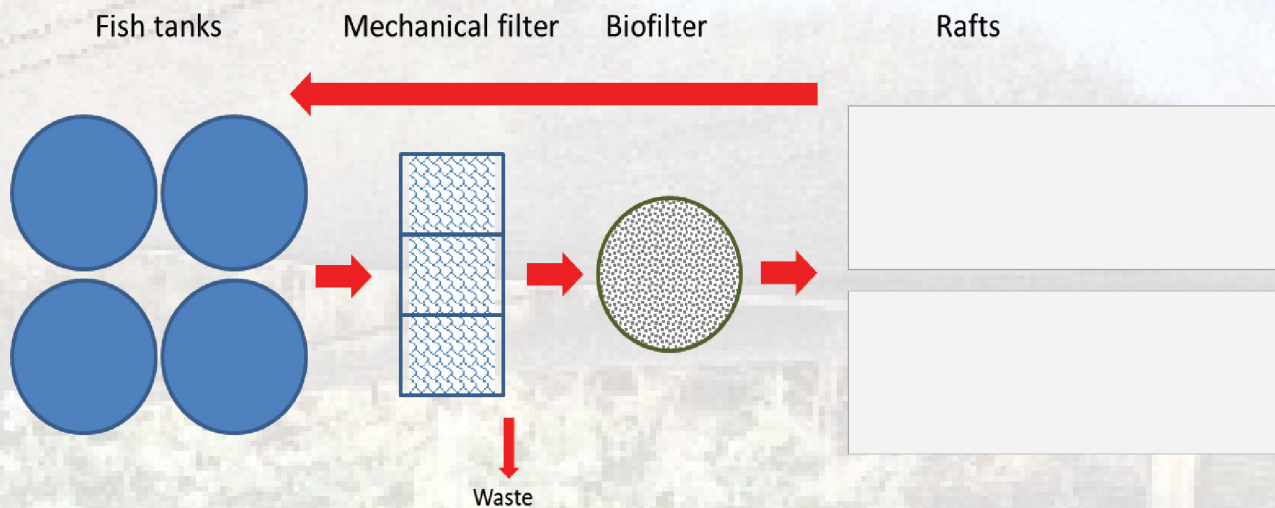


Figure 4: Schematic showing the components of a DWC aquaponics system

4x per hour, the temperature of the water in the plant and fish systems is the same.

Large scale installations, however, have the option of separating the two components (plants and fish) so that the wastewater from cleaning the fish filters is discharged into a highly aerated area known as a mineralisation tank, whereafter it flows to the plants at a slow rate of about 30% of the plant system volume per day. If the replacement is too slow the plants will reduce the nutrient levels to suboptimal concentrations for their optimal growth, but this 30% replacement avoids such nutrient depletion

within the plant growing area.

The cleaned plant water is directed to header tanks to replace the water lost when cleaning the filters. In this way about 10% of the volume of the fish system is replaced daily allowing for the fish and plant systems to be operated at completely different temperatures. A decoupled aquaponic system (See Figure 7) also allows for the establishment of multiple plant systems containing different plant species each held under their own optimal temperature regimes. Less than 10% of the total water volume in an aquaponics system is lost weekly due to evaporation and the harvesting of crops, and this needs to



Figure 5: NFT utilises pipes through which the plants grow

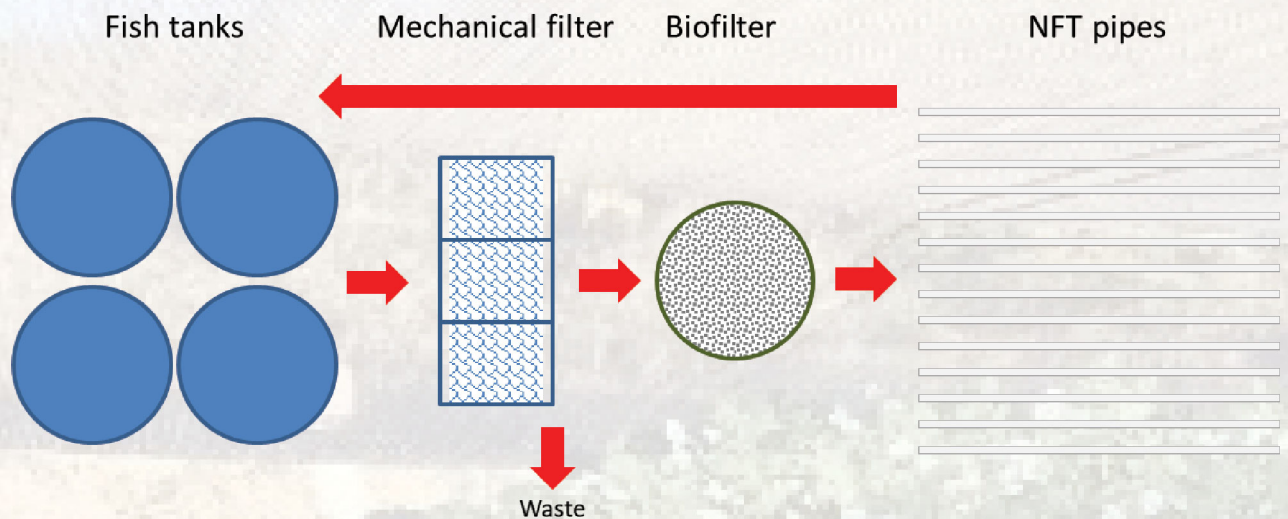


Figure 6: Schematic showing the components of a NFT aquaponics system

be replaced with clean water.

Indoor vs Outdoor Installations

These systems can be installed outdoors in places where the climate suits the temperature requirements of the fish and plants throughout the year, but more commonly, the infrastructure is erected inside a greenhouse for temperature control (du Toit 2022). Heat is trapped by day and heat loss at night is reduced. Crop quality is further enhanced by protecting the plants from rain and pests (see Figure 8).

Additives

Aquaponics is an amazing technology that allows for two crops to be produced on one primary input, fish feed. Depending on which plants are farmed, chelated iron will need to be added, and potassium (K) and calcium (Ca) are often also needed (Beem et al 2017). The pH of the water needs to be carefully managed to maintain the optimal 6.5 required by the plants, requiring buffer to be added. Normally the buffer is a K or Ca compound, leaving only the chelated iron to be added as a supplement.

Electricity

Aquaponics utilises pumps to circulate the water

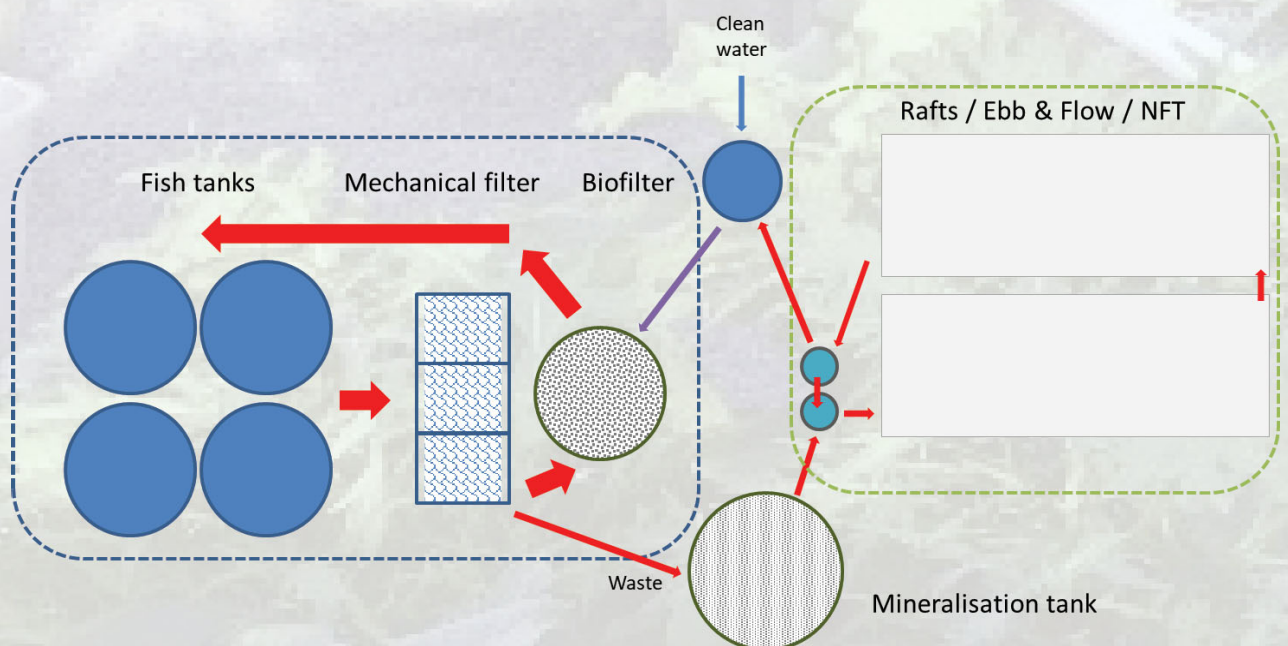


Figure 7: Schematic showing the components of a NFT aquaponics system



Figure 8: Aquaponics systems convert fish waste into valuable plant products

continuously and the fish tank is normally aerated to ensure adequate oxygen is available for the fish. Therefore, aquaponics is dependent on stable electrical supply. Solar systems, with battery backup for nighttime operation, are popular, but grid power can be used if it is reliable. Whichever power supply is selected an auto-start generator is an obligatory emergency accessory as with any form of RAS, including aquaponics.

In Summary

Where aquaponics becomes the agricultural method of choice is where the price of vegetables or plants is high, which typically corresponds to arid climates or areas where the soil is poorly suited to crop farming. Aquaponics is a scalable solution for the simultaneous production of plants and fish in a manner that is cost effective, light on the environment and produces crops with excellent flavour. Aquaponics stands out as a technology that we will see far more of in the future of aquaculture.

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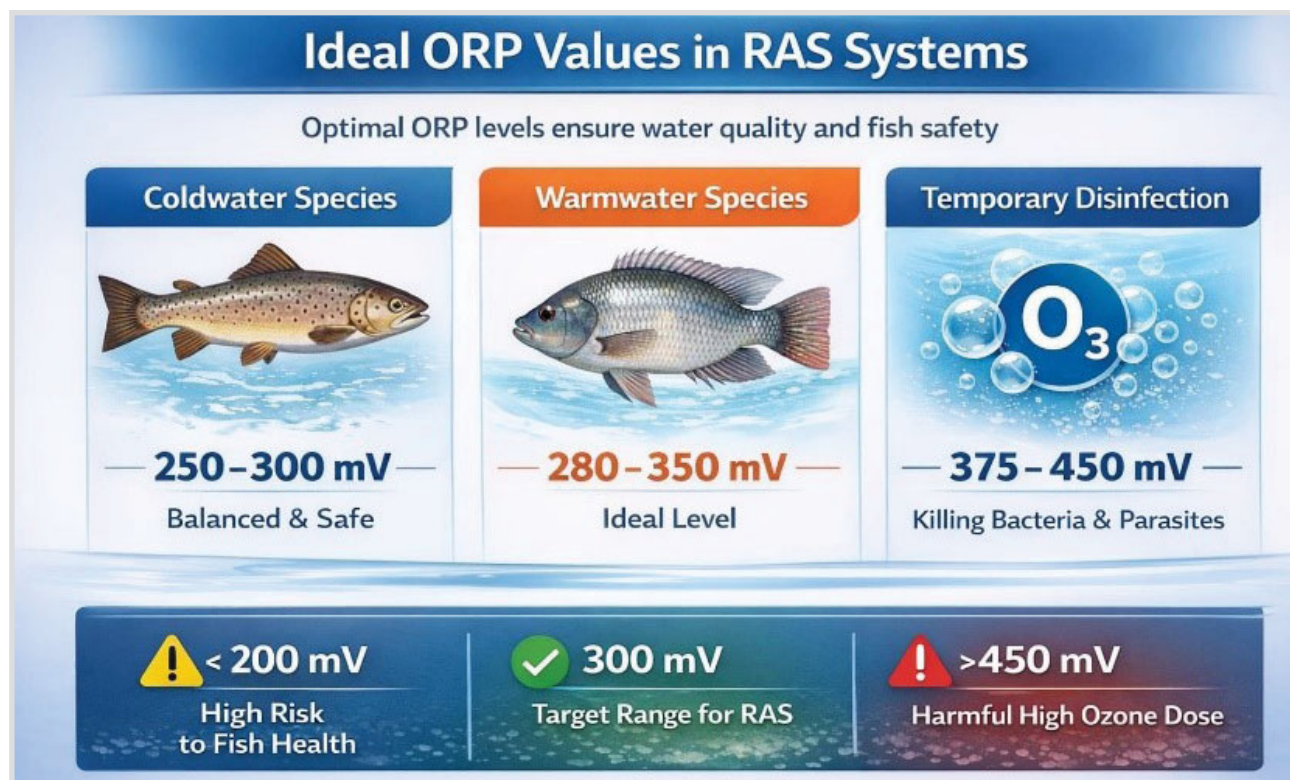
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Optimized Water Quality Management in Intensive RAS: The Integration of Oxidation-Reduction Potential (ORP) and Automated Ozonation

Summary

Recirculating Aquaculture Systems (RAS) face inherent challenges from the accumulation of Dissolved Organic Matter (DOM) and fine solids. This study evaluates the role of Oxidation-Reduction Potential (ORP) as a master control parameter for water quality. By integrating automated ozone (O₃) systems, RAS operators can achieve micro-flocculation of solids, reduce pathogenic pressure, and optimize bio filter performance.

This contribution outlines the physiological safety limits for fish, the chemical impact on Dissolved Organic Carbon (DOC), and the logistical requirements for automated redox management.

Introduction:

The bioorganic burden in intensive RAS aquaculture, where fish densities often exceed 50 kg/m³, results in high concentrations of metabolic waste. Traditional

mechanical filtration (e.g., drum filters) typically removes particles larger than 20-40 microns, but fails to address the “invisible” load of Fine Colloidal Solids (FCS) and Dissolved Organic Matter (DOM).

The Science of Oxidation-Reduction Potential (ORP)

ORP is a measure of the net thermodynamic “cleansing ability” of the water. It represents the ratio of electron acceptors (oxidizers) to electron donors (reducers like feces and ammonia).

Properly applied, ORP functions as an early warning system. A declining ORP value often signals system failure hours before a measurable rise in Total Ammonia Nitrogen (TAN) becomes evident. Healthy RAS environments typically aim for a range of 250–300 mV (Waller, 2024).

* Sub-optimal (<150 mV): Indicative of anaerobic

zones, potential H2S production, and high microbial load.

* Optimal (250–300 mV): Promotes health and bacterial resistance in species like European sea bass (Waller, 2024).

* Toxic (>350–400 mV): Risk of oxidative stress and gill damage.

Ozone (O3) Mechanisms in Water Treatment

Ozone is a powerful oxidant (2.07V) that acts through two primary pathways: direct oxidation and the formation of secondary radicals like hydroxyl (•OH) (Huang et al., 2025).

DOC Mineralization and Micro-flocculation

Ozonation effectively breaks down long-chain organic molecules (humic acids, proteins) into smaller, more biodegradable fragments. This process, known as micro-flocculation, increases the efficiency of foam fractionators and protein skimmers by making fine solids easier to trap (Waller, 2024).

Impact on Pathogens and Antibiotic Resistance

Recent studies show that advanced oxidation processes

using ozone can achieve complete degradation of common aquaculture antibiotics within seconds, reducing the risk of antibiotic-resistant bacteria in the system (Huang et al., 2025).

Physiological Thresholds and Fish Welfare

Toxicity and Safety Limits: The primary risk of ozone is the production of Total Residual Oxidants (TRO). In freshwater, this is largely ozone itself; in seawater, it includes toxic bromine compounds. Excessive ozone exposure damages gill lamellar epithelium, leading to osmoregulatory imbalance and death (Periyasamy, 2024). Examples include:

* Rainbow Trout: A safe chronic exposure limit is suggested at 2 µg/L, as levels of 5 µg/L have been shown to cause gill pathology and reduced feeding (Periyasamy, 2024).

* European Sea Bass: Research indicates that ORP levels above 320 mV can cause significant stress, decreased appetite, and mortality (Waller, 2024).

Engineering the Automated ORP Control Loop

To prevent the aforementioned toxicity while maintaining water clarity, an automated control loop is

ORP Dynamics in RAS:
A Research Syntlesis



Source: Experimental Data Analysis, 2023



mandatory.

6.1 Logic of the 4–20 mA Controller

The system utilizes a Proportional-Integral (PI) control logic. As the ORP probe detects a drop below the setpoint (e.g., 280 mV), the controller sends a signal to the ozone generator to increase output.

Proper degassing and a contact time of at least 2 minutes are required before water returns to the fish tanks to ensure all residual O₃ has decayed (Waller, 2024).

6.2 System Design & Best Practices for Ozone Integration

* Optimal Injection Point: Ozone should be introduced prior to the protein skimmer or within a dedicated contact chamber to ensure maximum efficiency.

* Required Contact Time: For effective disinfection and pathogen reduction, a minimum contact time of 2 minutes is necessary.

* Essential Degassing: To ensure safety, residual ozone destructors (such as UV sterilizers or Activated Carbon) must be utilized post-treatment to remove any remaining ozone before the water returns to the main system.

* Maintenance & Calibration: Sensors require monthly cleaning and calibration using 200mV and 400mV reference solutions to maintain reading accuracy.

Description of an Operational RAS System (Applied Case Study)

A recirculating aquaculture system (RAS) was implemented in a high-intensity production unit designed for marine fish culture, operating at stocking densities exceeding 40–50 kg/m³. The system consists of one or

more main culture tanks connected to a fully integrated water treatment loop operating under continuous recirculation.

System Components:

- Circular culture tanks designed with a central drain and rotational flow to facilitate solid waste collection
- Mechanical filtration unit (Drum Filter) for removal of particles larger than 30–40 µm
- Biological filtration unit (Moving Bed Biofilter) for nitrification and ammonia oxidation
- Protein skimmer / foam fractionator for the removal of fine organic particles
- Ozone generation unit integrated into the treatment loop
- Dedicated ozone contact chamber providing an approximate contact time of 2 minutes
- Residual ozone destruction unit (UV sterilizer and/or activated carbon)
- Online ORP probe connected to an automated PI control system

Operational Control Strategy:

Oxidation–Reduction Potential (ORP) is continuously monitored in the treated water line. When ORP values fall below the predefined setpoint (typically 270–280 mV), the control unit proportionally increases ozone output. As ORP approaches the upper safety threshold, ozone production is automatically reduced or shut down.

Ozone is injected upstream of the protein skimmer or within a dedicated contact chamber to ensure:

- Oxidative breakdown of dissolved organic matter

(DOM)

- Induced micro-flocculation of fine colloidal solids
- Enhanced removal efficiency by foam fractionation
- Operational Observations

Prior to the implementation of ORP-regulated ozonation: Water clarity appeared visually acceptable

However, signs of:

- Accumulated dissolved organic load
- Increased microbial pressure
- Instability in biological filtration performance were observed

Following the integration of automated ORP-controlled ozonation:

- Improved overall water quality stability
- Reduction of fine organic load
- Enhanced biofilter efficiency
- Stable fish behavior and feeding activity
- ORP maintained within the optimal and safe operational range, with no indications of oxidative stress

Practical Implications:

This applied case demonstrates that integrating ORP as a master control parameter with an automated ozone dosing system enables precise management of organic loading in intensive RAS operations. The approach mitigates risks linked to uncontrolled ozonation while maintaining fish welfare, biological stability, and overall system performance.

Perspectives

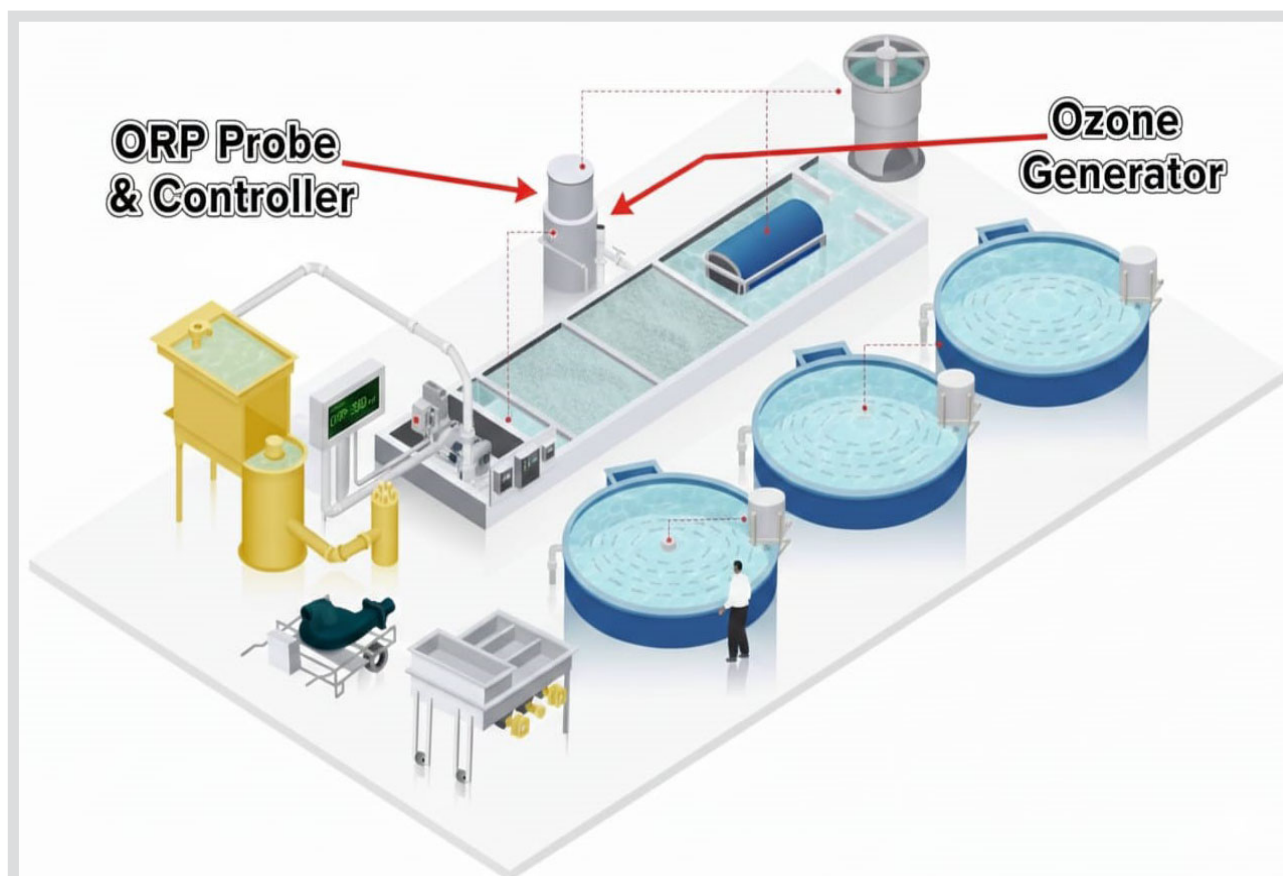
The integration of automated ozonation, regulated by real-time Oxidation-Reduction Potential (ORP) monitoring, represents a significant leap in the management of intensive Recirculating Aquaculture Systems (RAS). By addressing the “invisible” organic load—specifically Dissolved Organic Matter (DOM) and Fine Colloidal Solids (FCS)—ozone enhances the efficiency of mechanical filtration and foam fractionation through micro-flocculation.

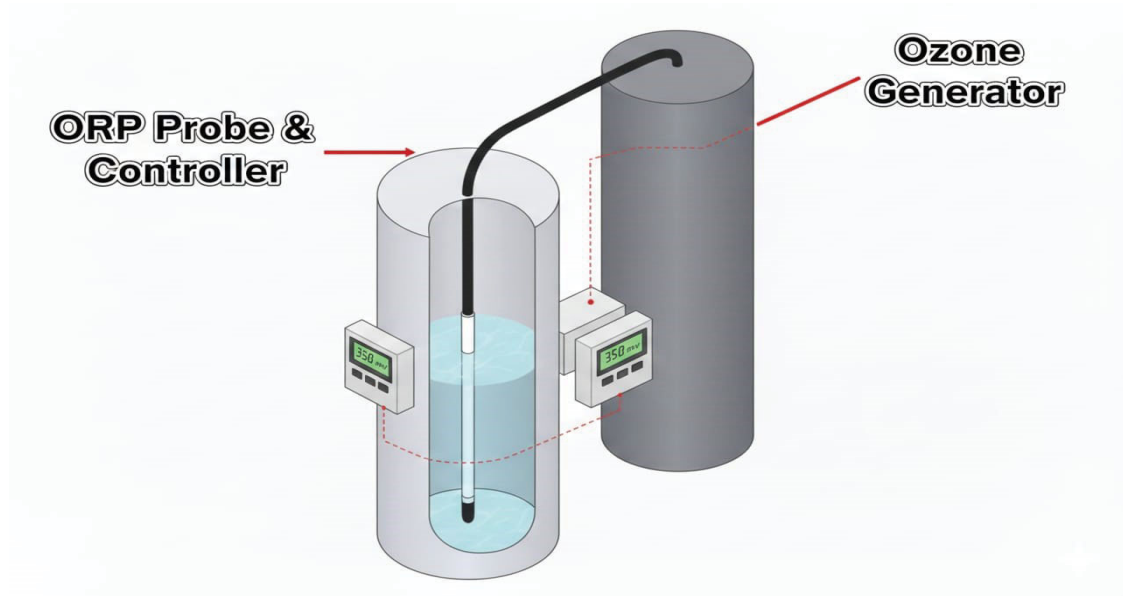
However, the narrow therapeutic window of ozone necessitates a rigorous engineering approach. The transition from a manual system to an automated PI control loop is not merely an efficiency upgrade but a fundamental requirement for fish welfare. Maintaining ORP within the 250–300 mV range provides a stable environment that fosters biofilter efficiency and reduces pathogen pressure without crossing the threshold into oxidative stress or gill damage. Future RAS innovations should prioritize refining TRO detection, particularly in seawater applications, to ensure that the pursuit of water clarity never compromises the biological integrity of the cultured species.

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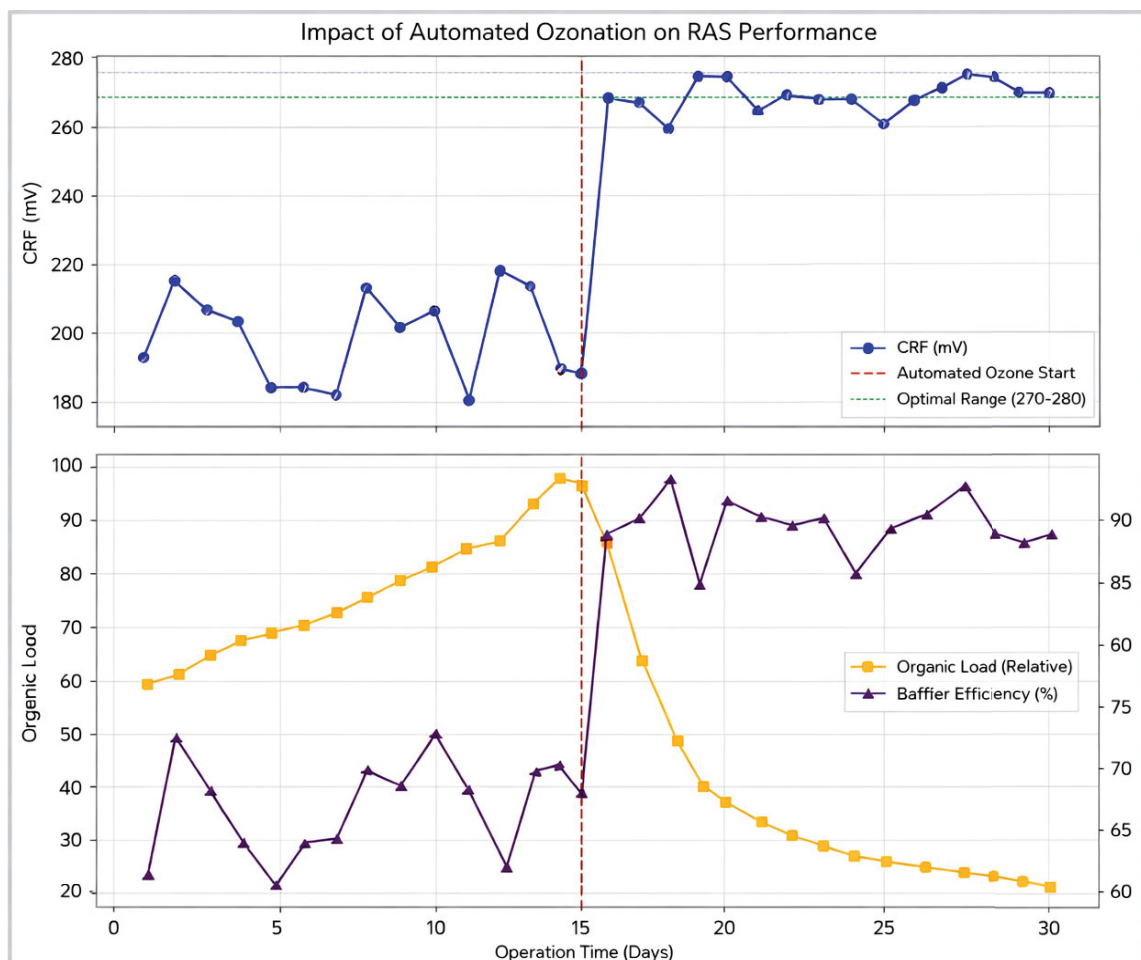


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Sustainability in Aquaculture, the Blue Economy and Bluewashing

Aquaculture, often referred to as the **Blue Economy**, represents a transformative shift in the global food system. As the demand for seafood increases due to population growth and changing dietary preferences, aquaculture has emerged as a critical solution to bridge the gap between supply and demand while alleviating pressure on wild fisheries. However, for aquaculture to truly succeed in the long term, sustainability must be at its core. This article explores the challenges, strategies, and innovations driving sustainable practices in aquaculture.

In the realm of environmental sustainability, **Bluewashing** has emerged as a significant concern, particularly in industries like aquaculture and marine resource management. Bluewashing refers to the act of misrepresenting or exaggerating the environmental or social sustainability of a product, company, or practice related to the marine or aquatic environment. Much like greenwashing in broader environmental contexts, bluewashing deceives stakeholders into believing that an organization or product is more eco-friendly or ethical than it actually is.

three decades, it has become the fastest-growing food production sector globally, now providing more than half of the seafood consumed worldwide. This growth has been fueled by declining wild fish stocks and increasing consumer awareness of the health benefits of seafood.

The Blue Economy mirrors the agricultural Green Revolution of the 20th century, aiming to increase food production to meet the needs of a growing population. However, aquaculture faces unique challenges, including environmental degradation, resource depletion, and social concerns that must be addressed to ensure its sustainability.

Environmental Challenges in Aquaculture

Aquaculture operations, if poorly managed, can have significant environmental impacts. Key concerns include habitat destruction, water pollution, and the overuse of wild fish for feed production.

One of the most notable examples is the conversion of mangroves into shrimp farms, which has led to the loss of critical coastal ecosystems. Similarly, nutrient-rich effluents from aquaculture ponds can lead to eutrophication in nearby water bodies, disrupting aquatic ecosystems.

The Rise of Aquaculture and Its Global Importance

Aquaculture is the farming of aquatic organisms, including fish, shellfish, and aquatic plants. Over the past

Feed production is another pressing issue. Many farmed species rely on fishmeal and fish oil derived from wild-caught fish, creating a paradox where aquaculture depletes wild fish stocks to sustain itself. This reliance undermines the very sustainability the industry seeks to achieve.

The Need for Sustainable Practices

Sustainability in aquaculture encompasses ecological, economic, and social dimensions. Ecological sustainability focuses on reducing environmental impacts and conserving biodiversity. Economic sustainability ensures that aquaculture operations remain viable for producers and accessible to consumers. Social sustainability addresses labor practices, community engagement, and equitable resource use.

Governments, industry leaders, and researchers have recognized the need to adopt sustainable practices to ensure aquaculture can meet current and future demands without compromising the environment or society.

Innovations Driving Sustainable Aquaculture

Several innovative strategies and technologies are driving the transition toward sustainability in aquaculture.

Integrated Multi-Trophic Aquaculture (IMTA)

IMTA combines different species within a single farming system to mimic natural ecosystems. For example, fish, shellfish, and seaweed can be farmed together, with each species playing a role in maintaining ecological balance. The fish provide nutrients for the seaweed, while shellfish filter the water, reducing waste. This approach enhances resource efficiency and minimizes environmental impacts.

Alternative Feeds

The development of alternative feeds is a game-

changer for aquaculture sustainability. Researchers are exploring plant-based proteins, insect meals, and algae as substitutes for fishmeal and fish oil. These alternatives not only reduce pressure on wild fish stocks but also lower the carbon footprint of feed production.

Recirculating Aquaculture Systems (RAS)

RAS is a closed-loop system that recycles water within the farming facility. By treating and reusing water, RAS minimizes water consumption and prevents the discharge of pollutants into the environment. This technology is particularly valuable for land-based aquaculture operations near urban centers.

Genetic Improvements

Selective breeding and advancements in biotechnology have improved the growth rates, disease resistance, and feed efficiency of farmed species. These genetic improvements reduce the resources required for production, enhancing sustainability.

Policies and Certifications Supporting Sustainable Aquaculture

Governments and international organizations play a crucial role in promoting sustainable aquaculture through policies and regulations. Environmental impact assessments, zoning laws, and strict effluent standards help mitigate negative environmental effects.

Certification programs such as the Aquaculture Stewardship Council (ASC) and Best Aquaculture Practices (BAP) provide consumers with assurance that the seafood they purchase comes from sustainable sources. These certifications incentivize producers to adopt environmentally and socially responsible practices.

The Social Dimension of Sustainable Aquaculture

Sustainability extends beyond environmental



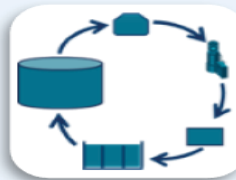
INNOVATIONS DRIVING SUSTAINABLE AQUACULTURE



INTEGRATED
MULTI-TROPIC
AQUACULTURE
(IMTA)



ALTERNATIVE
FEEDS



RECIRCULATION
AQUACULTURE



ALTERNATIVE
FEEDS

considerations to include the social well-being of those involved in aquaculture. Fair labor practices, equitable resource access, and community involvement are essential for building trust and ensuring long-term viability.

Engaging local communities in aquaculture projects can foster economic development, particularly in coastal and rural areas. Providing education and training opportunities ensures that these communities benefit from the Blue Economy.

The Future of Aquaculture Sustainability

The path toward sustainable aquaculture is not without challenges. Balancing production efficiency with environmental stewardship and social equity requires collaboration among stakeholders, including governments, industry leaders, researchers, and consumers.

Emerging technologies such as artificial intelligence, blockchain for traceability, and advances in aquaponics hold promise for addressing current limitations. As these innovations are scaled, they will further align aquaculture with the principles of sustainability.

Conclusion

The Blue Economy has the potential to transform global food systems and provide a sustainable source of protein for future generations. However, this promise can only be fulfilled through concerted efforts to address environmental, economic, and social challenges. By embracing sustainable practices, leveraging technological

innovations, and fostering global cooperation, aquaculture can continue to thrive while safeguarding the planet for future generations. Sustainability is not just an option for aquaculture—it is the foundation of its future.

Understanding Bluewashing: A Misleading Practice in Sustainability

In the realm of environmental sustainability, bluewashing has emerged as a significant concern, particularly in industries like aquaculture and marine resource management. Bluewashing refers to the act of misrepresenting or exaggerating the environmental or social sustainability of a product, company, or practice related to the marine or aquatic environment. Much like greenwashing in broader environmental contexts, bluewashing deceives stakeholders into believing that an organization or product is more eco-friendly or ethical than it actually is.

The Origins of Bluewashing

The term bluewashing stems from the symbolic association of the color blue with the ocean, water resources, and marine ecosystems. It has gained prominence as the global focus on ocean health, marine conservation, and sustainable seafood has increased. Companies and organizations often use sustainability claims as marketing tools to appeal to eco-conscious consumers. However, when these claims lack substantive action or accountability, they fall into the category of bluewashing.

How Bluewashing Manifests

Bluewashing can take several forms, including vague sustainability claims, misleading certifications, and superficial corporate social responsibility (CSR) initiatives. These practices can occur at various levels of the supply chain, from production to retail.

One common example is when companies label their seafood products as “sustainably sourced” without providing transparent evidence or third-party verification. Similarly, businesses may overstate their contributions to marine conservation efforts while continuing harmful practices such as overfishing, habitat destruction, or excessive carbon emissions.

In some cases, bluewashing involves the misuse of sustainability certifications. Certain labels and logos may appear on products to imply compliance with high environmental standards, even if the certification process is lax, outdated, or non-existent.

The Impact of Bluewashing on Sustainability Efforts

Bluewashing undermines genuine sustainability efforts by creating confusion and eroding trust among consumers, investors, and policymakers. When companies or industries falsely claim sustainability, they divert attention and resources from legitimate initiatives that genuinely contribute to ocean health and responsible aquaculture.

Additionally, bluewashing hampers progress by creating

a false sense of security. Consumers may unknowingly support unsustainable practices, believing their choices align with their environmental values. This disconnect can perpetuate harm to marine ecosystems and delay the adoption of truly sustainable solutions.

Key Drivers of Bluewashing

Several factors contribute to the prevalence of bluewashing.

Demand for Sustainable Products

The rising consumer demand for environmentally friendly seafood and aquaculture products has incentivized companies to position themselves as sustainable, even when their practices do not align with such claims.

Lack of Standardized Regulations

Inconsistent or insufficient regulations regarding sustainability claims and certifications allow companies to exploit loopholes. Without clear guidelines or enforcement, bluewashing becomes an easy tactic.

Marketing Pressures

Companies face significant pressure to maintain a competitive edge in the marketplace. By presenting themselves as leaders in sustainability, they can attract eco-conscious consumers, investors, and partners—even if the claims are unsubstantiated.

Complex Supply Chains

The global nature of seafood and aquaculture supply chains makes it difficult to trace and verify sustainability practices. This complexity provides opportunities for misrepresentation and obfuscation.

Combating Bluewashing

Addressing bluewashing requires a multi-faceted approach involving increased transparency, stronger regulations, and active consumer awareness.

Transparency and Traceability

Businesses must adopt transparent practices, providing verifiable data about their sustainability efforts. Traceability technologies, such as blockchain, can help ensure that claims about sourcing and production are accurate and accessible to stakeholders.

Third-Party Certification

Reliable, independent certification bodies with rigorous standards are essential in combating bluewashing. Certifications should be backed by scientific research and regular audits to maintain credibility.

Consumer Education

Educating consumers about bluewashing empowers them to make informed decisions. Awareness campaigns can help individuals identify genuine sustainability efforts and question vague or misleading claims.

Regulatory Oversight

Governments and international organizations should implement and enforce stringent regulations to prevent false sustainability claims. Clear labeling laws and penalties for misrepresentation can discourage bluewashing practices.

The Future of Bluewashing

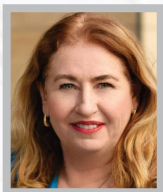
As global awareness of ocean health and sustainability

grows, there is hope that the prevalence of bluewashing will decline. Companies that engage in this practice risk damaging their reputation and losing consumer trust as scrutiny increases. On the other hand, businesses that prioritize genuine sustainability and accountability stand to benefit from long-term loyalty and support.

The fight against bluewashing is a critical aspect of ensuring the success of the Blue Economy. By exposing misleading practices and fostering a culture of transparency, stakeholders can drive meaningful progress toward sustainable marine and aquaculture practices.







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Tribute to David Fincham

Tilapia aquaculture pioneer in Southern Africa

Dave Fincham holding farm grown tilapia produced in one of the 450 Aquaculture Production Units (APU's) that he designed and built

David Fincham (c. 1963– 2026) was a leading aquaculture specialist whose practical innovations in tilapia farming transformed how smallholder farmers in Africa approach fish production. With over 30 years of experience in the sector, Fincham became known internationally for his deep understanding of tilapia biology, production systems, and the socio-economic barriers facing emerging aquaculture industries.

Born and raised with a passion for sustainable agriculture, Fincham's career in aquaculture began at a time when freshwater fish farming in Africa was largely underdeveloped. Early in his career he recognized that while tilapia has strong biological suitability for farming — being hardy, fast-growing, and highly adaptable — the continent lacked accessible, scalable production systems that could be adopted by both rural and urban producers. This perspective drove his lifelong mission: to simplify and demystify tilapia farming so that it could be a viable, profitable option for farmers rather than a niche commercial pursuit.

In 2014 Fincham founded **David Fincham Aquaculture (DFA)** in Muldersdrift, near Johannesburg, South Africa. Through DFA and with William Kelly, he developed the **Aquaculture Production Unit (APU)** — a modular, semi-intensive recirculating tilapia farming system designed for practical operation in diverse environments. The APU's one-tank design emphasizes affordability, ease of installation, and scalability, enabling farmers with limited capital or technical background to start producing tilapia with reduced risk. Over the following decade, Fincham's business supplied more than

450 APUs to farmers across Africa, making significant inroads in areas previously underserved by commercial aquaculture technologies.

Fincham also forged strategic partnerships with international breeding programs such as Til-Aqua International in the Netherlands to source genetically improved tilapia strains, including natural male lines with superior growth performance. This focus on better genetics, combined with his emphasis on training and farmer empowerment, helped raise production standards and productivity across projects where DFA was involved. Beyond technology provision, Fincham was an outspoken advocate for industry development and supportive government policy, frequently engaging with stakeholders to address structural challenges in the sector.

A respected speaker and mentor, Fincham shared his insights at international forums and workshops, emphasizing that tilapia aquaculture must transition from subsistence to commercially viable models if it were to meaningfully contribute to food security and economic growth in Africa. His work inspired a generation of aquaculturists and helped catalyse practical solutions that bridged the gap between high-tech research and grassroots farming realities. Fincham offered a practical “wet hands” training course, and trained over 500 people in the last 10 years, in person and online.

David Fincham's legacy lies in his relentless pursuit of accessible aquaculture — combining technical innovation with a grounded appreciation of the social and economic realities of small-scale farmers. His contributions to tilapia farming have left an enduring imprint on aquaculture development in Africa and beyond.

FUTURE AQUACULTURE

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Future Aquaculture introduces the Emerging Talent Award, a new international initiative designed to encourage students, young researchers and early-career professionals to contribute innovative ideas and industry-focused perspectives to the global aquaculture community.

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- ✓ RAS & Emerging Technologies
- ✓ Biotechnology & AI in Aquaculture
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- Industry-focused analysis
- 1,200–1,800 words
- Original and unpublished content

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Designing Genetics for the Pond – Lessons from a Rectangular Pizza

I first visited Ecuador in 2014. I returned again in 2024. On my second visit, I spent several days visiting farms, hatcheries and interacting with breeding companies, trying to understand what exactly they were doing differently.

One thing stood out clearly.

They do not talk about crop failure the way we do in India. Disease exists there. Survival may fluctuate. But large-scale mid-cycle collapses that wipe out a season's capital are not part of their regular conversation. Crops generally complete. In India, when a crop fails, it often means that the entire working capital for that cycle is gone.

After two long days of farm visits and discussions, we went out for dinner. The restaurant served rectangular pizza on trays, cut neatly for sharing.

At that moment, what I had been thinking about during those farm visits became very clear.

If you are serving pizza at the table, you keep it simple. You design it for how it will be eaten. You make it practical for the setting.

That is what Ecuador has done with shrimp farming.

They adapted their breeding philosophy to suit their farming systems and environment — very large ponds, continuous river water exchange and a practical reality where meaningful biosecurity, in the way we attempt in

India, is simply not possible. Water cannot be disinfected at scale. Complete exclusion is not realistic. So, the genetics had to suit the system.

That clarity stayed with me.

To understand this better, we need to go back to 2009.

The Early Vannamei Years in India

Before 2009, we were largely dependent on wild broodstock. Disease pressure was high. Production had fallen sharply in the late 2000s. Confidence was low.

The introduction of Vannamei changed the direction of Indian shrimp farming. It was not only because the broodstock were Specific Pathogen Free. It was also because they were domesticated and genetically selected. We received uniform, improved and pathogen-free seed.

At the same time, Indian farmers were already disciplined in pond preparation because of years of dealing with White Spot Syndrome Virus. Pond drying, liming, aeration and basic biosecurity were routine practices. Stocking densities were moderate.

Between 2009 and about 2014, survivals of 80–90% were common in many regions. Six to eight tons per hectare were achievable under proper management. The main constraint in many cases was working capital, not biology.

It worked because the animal suited the way we were

farming at that time.

What Changed in the Farming Environment

Over time, the farming ecosystem evolved.

Ponds aged. Organic load increased. Microbial pressure intensified. From around 2015 onward, EHP became entrenched in several regions. In the past couple of years, aggressive forms of Running Mortality Syndrome have added further uncertainty.

Most Indian shrimp farms continue to operate in open earthen systems. Complete exclusion of pathogens is not possible. Shared water sources and environmental exposure add to the pressure.

Over time, the shrimp we were stocking and the conditions in our ponds were no longer aligned.

Growth and the Balance That Shifted

Growth is important. Farmers want shorter cycles and markets reward faster turnover, so breeding companies respond to that demand.

But over the years, growth became the dominant selling point.

Selection for rapid growth is commercially attractive and, in many cases, technically more straightforward than developing tolerance to pathogens and resilience under field stress. As more emphasis was placed on faster growth, the balance between growth and robustness narrowed.

Excessive emphasis on accelerated growth reduces an animal's ability to withstand environmental stress and pathogen exposure under practical farming conditions. Faster-growing shrimp molt more frequently. In pond systems already carrying high organic load and complex microbial populations, this adds physiological stress. Under such conditions, even minor stressors can have larger consequences.

This has been seen in the field. Some fast-growing lines that were strongly promoted did not sustain commercial

acceptance beyond one or two seasons. In contrast, balanced and hardy lines continue to be sought after across regions. Companies that focused on resilience are able to command significant price premiums.

Growth is necessary. But growth without equal attention to tolerance and survival under real farming conditions creates fragility. The economic burden of that fragility has largely fallen on farmers.

Hatch India and the Move Toward Sentinel Trials

These concerns were openly discussed during Hatch India 2023, a premier conference organized by the All-India Shrimp Hatcheries Association (AISHA). The event brought breeding companies, hatcheries and farmers onto a common platform to discuss technical and practical issues facing the sector.

At that forum, questions were raised about repeated introduction of fast-growing lines that did not always match Indian field conditions. The idea of structured sentinel trials emerged — a system where breeding companies could test multiple family lines under Indian farming conditions before large-scale commercial introduction.

In Hatch India 2025, it became clear that the policy framework for sentinel trials was still not in place. At that stage, the Prawn Farmers Federation of India took up the matter with the Government of India to move the process forward.

The proposed framework allows empanelled breeding companies to bring approved lines through established quarantine systems and conduct structured trials under Indian farm conditions. These trials involve exposure to real pond conditions, local microbial environments and pathogen pressures — not just variations in salinity.

Sentinel trials are not a cure for disease, but they help bring some structure into how new lines are introduced. Instead of large-scale introduction first and learning later, lines can be assessed under realistic conditions before



Figure 1: Thoroughly prepared pond bottom before filling in water



Figure 2: Pond dried and ploughed and ready for culture. Note the bird fencing on top of the pond to prevent horizontal spread of diseases.

commercial rollout.

That way, farmers don't end up becoming the first testing ground.

The Structural Difference in Aquaculture

Shrimp farming is not the same as poultry or dairy.

In most terrestrial livestock systems, vaccines are available. Periodic medication is possible. Individual animals can be treated directly.

Shrimp do not have adaptive immunity in the same way. Vaccination is not currently a practical tool. Once disease enters a pond, there is no reliable curative intervention.

Management is therefore preventive and ecosystem-

based. Clean seed is essential. Biosecurity helps. Nutrition and water management are important. But in open earthen systems, pathogens cannot be completely excluded.

Because of this, genetics becomes more important in shrimp farming.

Tolerance to pathogens and resilience under environmental stress are central to crop stability.

Investing in the Future of the Indian Shrimp Sector

SPF and domestication remain important foundations. They must continue. But they are not sufficient on their



Figure 3: Indian shrimp farm - small ponds with good biosecurity fencing



Figure 4: Healthy & high-quality shrimps harvested from successful crops

genetic improvement programs for indigenous species such as *Penaeus indicus*, alongside continued improvement in vannamei and monodon. These programs should be built through collaboration between public research institutions, private breeding companies, government agencies, private sector partners and farmers.

Farmers should not be passive recipients. They must be part of the design and evaluation process.

Such efforts require sustained funding, structured challenge testing and realistic field validation under Indian conditions.

If we bring growth, tolerance and real field performance back into balance, crop stability will improve. If we don't, we will continue to see uncertainty in expansion.

The choices we make now will shape how stable Indian shrimp farming becomes in the years ahead.

Ecuador did not copy anyone. They adapted their breeding philosophy to their farming reality. India too must periodically reassess whether its genetics and production model are aligned with present-day field conditions. The lesson is not to abandon SPF or biosecurity, but to ensure that genetic direction, farming systems and environmental realities remain in balance.

own in today's environment.

The Indian 50,000 crore shrimp sector must invest in its genetic future.

Beyond sentinel trials, there is a need for long-term



Figure 5: Pond bottom liming to disinfect EHP spores and improve soil condition

Organic Acids Plus (with Binder)

Technical Data Sheet

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

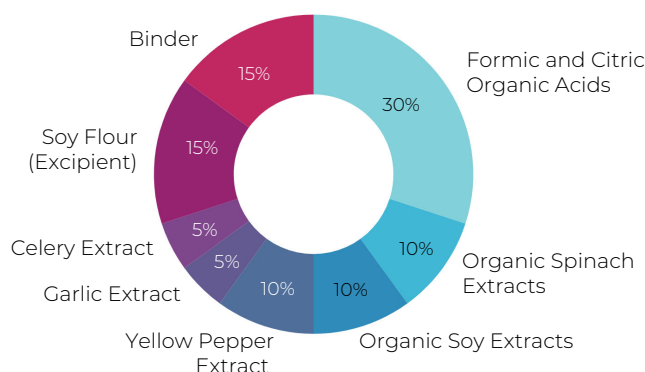
Trusted Inputs.
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Organic Acids Plus (with Binder)

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.

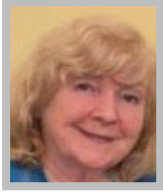
The recommended dose is 3-5 grams per kg of feed. To calculate the necessary amount, first determine the daily feed ration to be supplied, and then the dose of Organic Acids Plus. No additional binder (agglomerant) is needed, as the product already comes with its own.

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.



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South Australia's algal bloom crisis: A climate change challenge for global oyster farming

A harmful algal bloom came to South Australian (SA) waters in early 2025, first observed at Waitpinga Beach on the Fleurieu Peninsula, where surfers developed respiratory symptoms. By early June, thick foam and dead sea life accumulated on shorelines at metropolitan beaches, spreading to regional areas of Kangaroo Island, Spencer Gulf, Gulf St Vincent, the Fleurieu, Yorke, and Eyre Peninsulas. Results are drastically disturbed aquatic ecosystems, with estimated losses of 106,000 marine animals across 550 species.

Stealthily, this unwelcome guest, identified as *Karenia mikimotoi*, along with *Karenia kristina*, which causes brevetoxin-related risks to human health, marine life, seafood, and oysters, infiltrated SA waters. Impacts have been diverse, including on the \$59 million farm-gate value oyster farms (PIRSA, 2025), communities, tourism, and reduced consumer confidence in buying seafood (Brine, 2025). Fish and oyster sales experienced 30 percent reduction in sales, even if no algal bloom had been present (Thompson, 2025).

At the time of writing, government officials are still removing dead fish daily from beaches (Figure 1), with

affected locations shifting unpredictably as currents, tides, and temperatures enable the migration of these highly mobile drifting blooms.

Impact on SA oyster farms

Since the late 1980s, South Australia has been an ideal area for Pacific Oyster farming due to pristine, sheltered bays, abundant phytoplankton, suitable temperatures, stable salinity levels, and nutrient-rich waters from the Great Australian Bight.

In 2025, algal bloom-related income losses were up to \$500,000 per oyster farm, due to forced government shutdowns. Further losses were to aquaculture suppliers and oyster tourism operators.

Nine oyster-growing areas in SA were closed across Yorke Peninsula, Kangaroo Island, and Franklin Harbour (Cowell), when brevetoxin levels were deemed to be at the enforceable shutdown level of 0.8 mg/kg set by Food Standards Australia New Zealand. Quarantine enforcement measures involved millions of oysters, with some farms being closed for seven months. (Simmons & Wilson, 2025).

The main algal bloom impact period was from May to July 2025, but it has lingered, with Franklin Harbour still being shut down.

Twenty other SA oyster harvesting areas remained open, selling safe-for-consumption oysters (Simmons & Wilson, 2025). Some oyster farms, such as Coffin Bay, suffered lowered consumer confidence, even though oyster farms were not shut down (Figure 2)

How has the South Australian government assisted?

In this high-magnitude, broad-reaching arrival of *Karenia* bloom species into SA waters, the SA Government has been seriously challenged and underprepared, both in terms of scale, the high and unpredictable mobility of these blooms moving on ocean currents, and their ongoing persistence. Strategies of a reactive and proactive nature included:

- Development of an Algal Bloom Summer Plan aimed to protect SA coast and local communities. Funding of \$102.5 million to businesses (including oyster businesses), communities, and environmental restoration; \$20.6 million for reef and seagrass restoration; \$17.3 million for water monitoring and bloom forecasting.
- Community support and incentives for seafood and coastal dining for businesses and communities.
- Public awareness with a Beachside app on algal bloom locations, and beach signs (Figure 3), clean-ups, regular communication through media, mailouts, and informative websites (Algal Bloom Update, 2025).
- Daily water samples and shellfish samples (oysters, pipi, mussels) have been collected across multiple coastal sites, in both urban and regional areas. These samples are analysed by microalgal taxonomists to identify algal types and their concentrations. Results determine whether farms are open or closed.
- Daily satellite maps of daily surface chlorophyll as indicators of the spread of the algal bloom, and in which

regions, are also used for forecasting and modelling of potential future impact.

- Monitoring of nutrient levels, temperature, and salinity levels, aiming at identifying factors that foster algal bloom.
- Australia's standard procedures for managing biotoxin identification have been followed.
- There have been public updates twice a week made public on the government website.
- Reactive closures by PIRSA of oyster farms if toxins are detected or at risk, including Franklin Harbour, Kangaroo Island, and Yorke Peninsula.
- Daily government removal of dead fish from beaches.
- Support to oyster farmers for testing, business support packages, and implementation of reef restoration and hatchery expansion.

Community responses

Communities in Australia assist in times of crisis, as seen during the algal blooms.

- Citizen scientists assist in fast response monitoring for algal bloom: taking water samples, reporting water colour changes, fish deaths, or smells. Logging of bloom sightings through apps or local council sites.
- Supporting oyster farms that are open for sales, social media support, and ensuring media accuracy.
- Initiatives such as water sensitive urban design, reduced fertiliser use, catchment clean ups, and planting seagrasses and mangroves.
- Oyster reef restoration as also occurs in Queensland with community groups (Pierce & Scobie, 2024), cleaning of catchments, planting of seagrasses and mangroves, volunteering, and emotionally supporting farmers.

Oyster farmer initiatives

Challenges for oyster farmers are dual: need to focus on short-term survival and assisting to reestablish ecosystem restoration. Often, when oyster harvesting areas are shut down, the focus is just on maintenance of oysters, with a reduction of feeding and handling to reduce stress on oysters.

- SAOGA (South Australian Oyster Growers Association) chairperson stated:

"The industry has been working with the Department of Primary Industries and Regions after the closure of some oyster farms" (Thompson, 2025).

- Moving oysters from biotoxin-affected areas to more open cleaner areas



Figure 1: Dead fish at O'Sullivan's Beach October 2025 (Morrison).



Figure 2. Coffin Bay oyster beds. By Bahnfreund - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=60650267>

fitting with government rulings. There is dissent from other oyster farmers re this initiative due to fear from transfer of algal bloom.

- Donation of oyster shells for reef restoration
- Working with scientists in research and monitoring
- Adaptation of stocking levels and selective breeding for heat and disease resistant oysters
- Farm infrastructure adjustments including deeper longlines and better water-flow

Climate change warnings for oyster farms globally

Human efforts

The realisation is that human intervention has little impact on dispersing the algal bloom at the scale observed

in South Australia in 2025; however, a broader range of reactive restoration approaches such as reef creation, are underway. (McAfee & Connell, 2025).

Warming oceans

More severe and more frequent algal bloom is one impact of a warming ocean. Rising sea temperatures also cause salinity level fluctuations, changing rainfalls with high nutrient-rich runoff disturbing ecological water systems, and increased CO₂ levels (EPA n.d.).

Impact on oysters

Reduced oyster growth, higher oyster mortality in summer, and reduced resistance to pathogens (Okon et al., 2025).

Storm damage

Climate change can cause storm damage to longlines, loss of baskets and oyster stocks, infrastructure damage, as occurred in Manning River in NSW (Fig. 4).

Mitigation strategies for climate related algal bloom risks

- SA is reactive and proactive in already having a Draft sector-based aquaculture strategy for Oysters (2025). There is also the SAOGA Strategic Plan.
- Support water monitoring with early warning satellite systems (Joshi et al., 2024): faster than water sampling.
- Prevent oyster stock relocation, movement, or sale during algal bloom breakouts.
- Designing deeper oyster baskets to grow oysters below warmer water surface layers.
- Mitigate risk by having oyster farm sites in deeper and cooler ocean waters and across different bays (if possible) to reduce overall warmer ocean impact.
- As in northern Australia and Queensland,



Figure 3: Algal bloom beach guidelines (sa.gov.au).



Figure 4: Thousands of oyster baskets wash away. (ABC Mid North Coast: Floss Adams).
<https://www.abc.net.au/news/2025-06-17/manning-river-oyster-farmers-benefit-flood>

breeding more resilient heat, disease-resistant, and toxin-tolerant oyster strains, suited to warming geographic conditions.

- Faster, more responsive, and coordinated communication from government, oyster industry, and community, to reach all stakeholders.

Hope, not despair

The future of oyster farming looks challenging, but technology support for early warning systems, developing more heat and toxin-resistant oyster strains, choosing suitable cooler locations, ecosystem restoration, effective government regulations, and support to protect the oyster industry, all offer hope for the future of oyster farming in the face of climate change. Oyster farmers are overall a sharing community operating with support from the wider community. Strength for survival lies in communities, not just in clean oyster-farming waters.

“An oyster farmer is resilient ... they’re as resilient as what they farm,” (Peita Carroll, Manning River oyster farmer 2025).

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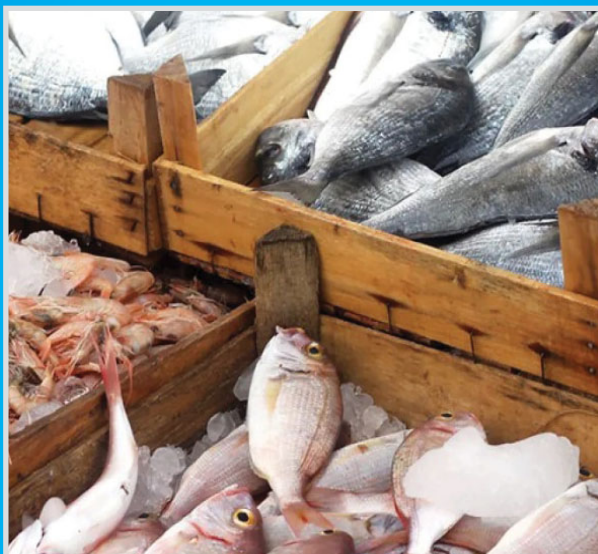
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Global seafood industry under pressure from tariffs and fuel costs



One of the biggest stories in May was the growing concern over U.S. tariffs, rising fuel prices, and geopolitical instability affecting global seafood trade. At the 2026 Seafood Expo Global in Barcelona, companies across the aquaculture and fisheries sector warned about shrinking margins, disrupted supply chains, and market uncertainty. Shrimp exporters in India and Asia are among the most exposed sectors.

India accelerating shrimp farming expansion



India continued its aggressive expansion in aquaculture, especially shrimp farming. The government announced development of new shrimp farming clusters, with Haryana's Sirsa region emerging as a major inland shrimp production hub. This is strategically important because India is trying to maintain export dominance despite tariff pressure and international competition from Ecuador and Southeast Asia.

Seaweed aquaculture becoming a strategic global industry

Seaweed moved from a niche topic to a major blue-economy priority. International discussions in Asia focused on "Seaweeds-2047," emphasizing climate mitigation, sustainable aquaculture, bioplastics, functional foods, and carbon reduction. Governments and investors are increasingly treating seaweed as both an environmental and commercial opportunity.



Upcoming Aquaculture and Fisheries Conferences and Exhibitions:

International Conference on Fisheries and Aquaculture 2026

Date: 29–30 September 2026

A research-focused international conference with strong academic participation in aquaculture technology, fisheries science, sustainability, aquatic health, and innovation. Good opportunity for publishing and networking with Asian institutions.

<https://aquaconference.tiikm.com>

THE 13th INTERNATIONAL CONFERENCE ON

**FISHERIES &
AQUACULTURE
2026**

IceFish 2026



Date: 22–24 September 2026

A major North Atlantic fisheries and processing exhibition focused on fishing technology, seafood processing, cold-chain systems, and marine equipment. Particularly important for industrial fisheries and processing sectors.

<https://icefish.is/newfront>

World Congress on Aquaculture, Fisheries & Marine Biology 2026

Date: 8–10 October 2026

The World Congress on Aquaculture, Fisheries & Marine Biology 2026 will bring together international researchers, aquaculture companies, seafood industry professionals, policymakers, investors, and technology providers to discuss the future of sustainable aquatic food production and marine resource management.

<https://www.worldaquacultureconference.com/information/welcome-message>



Report of World Seafood Congress 2026

Chennai, India | 9–11 February 2026



The World Seafood Congress 2026 successfully concluded in Chennai, India, bringing together global seafood industry leaders, policymakers, researchers, regulators, exporters, aquaculture companies, sustainability experts, and technology providers from across the world. The congress was organized by the International Association of Fish Inspectors (IAFI) in cooperation with the Government of India and several international partners including FAO, WorldFish, and UNIDO.

Held at the Chennai Trade Centre, the event focused on the future of sustainable seafood trade, seafood safety, traceability, innovation in aquaculture and fisheries, carbon reduction strategies, blue economy development, and strengthening resilient aquatic food systems. The congress highlighted how global seafood markets are rapidly evolving under pressure from climate change, stricter sustainability regulations, rising consumer expectations, and supply chain transparency requirements.

One of the strongest themes throughout the congress was sustainability and responsible seafood production.

Speakers from international organizations emphasized that seafood industries can no longer rely only on production growth; instead, future competitiveness will increasingly depend on traceability, environmental responsibility, ethical sourcing, and climate-conscious operations. Discussions on carbon-neutral seafood production, sustainable marine ingredients, seaweed development, and circular economy solutions attracted significant attention from both policymakers and private companies.

Aquaculture innovation was another major focus area. Experts discussed offshore aquaculture systems, smart aquaculture technologies, AI-driven monitoring systems, digital traceability, disease management, feed innovation, and seafood processing technologies. Several sessions explored how developing countries can use aquaculture as a strategic tool for food security, employment generation, and export growth while reducing environmental pressure on wild fisheries.

The congress also highlighted the increasing global importance of aquatic foods in nutrition security and resilient food systems. Representatives from FAO and

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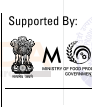
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WorldFish stressed that fisheries and aquaculture are no longer viewed merely as commodity sectors, but as strategic pillars of future global food systems. Special attention was given to supporting small-scale producers, improving inspection systems, strengthening seafood safety standards, and creating fairer access to international seafood markets.

In addition to technical sessions and policy discussions, the exhibition area showcased advanced seafood processing equipment, aquaculture technologies, cold-chain systems, quality control solutions, and digital seafood traceability platforms. The event also provided extensive networking opportunities among seafood exporters, processors, investors, startups, regulators, and media representatives from different regions of the world. The participation of international organizations,

industry associations, government agencies, and private-sector stakeholders demonstrated the growing strategic importance of fisheries and aquaculture in the global economy. India's role as host country also reflected its rapidly expanding influence in global seafood production and shrimp aquaculture exports.

Future Aquaculture magazine proudly participated in the congress as one of the media supporters of the event, contributing to international knowledge exchange and global communication within the fisheries and aquaculture sectors. The magazine's presence at World Seafood Congress 2026 further strengthened its role as an emerging international media platform connecting industry, science, sustainability, and innovation across the global aquaculture community.

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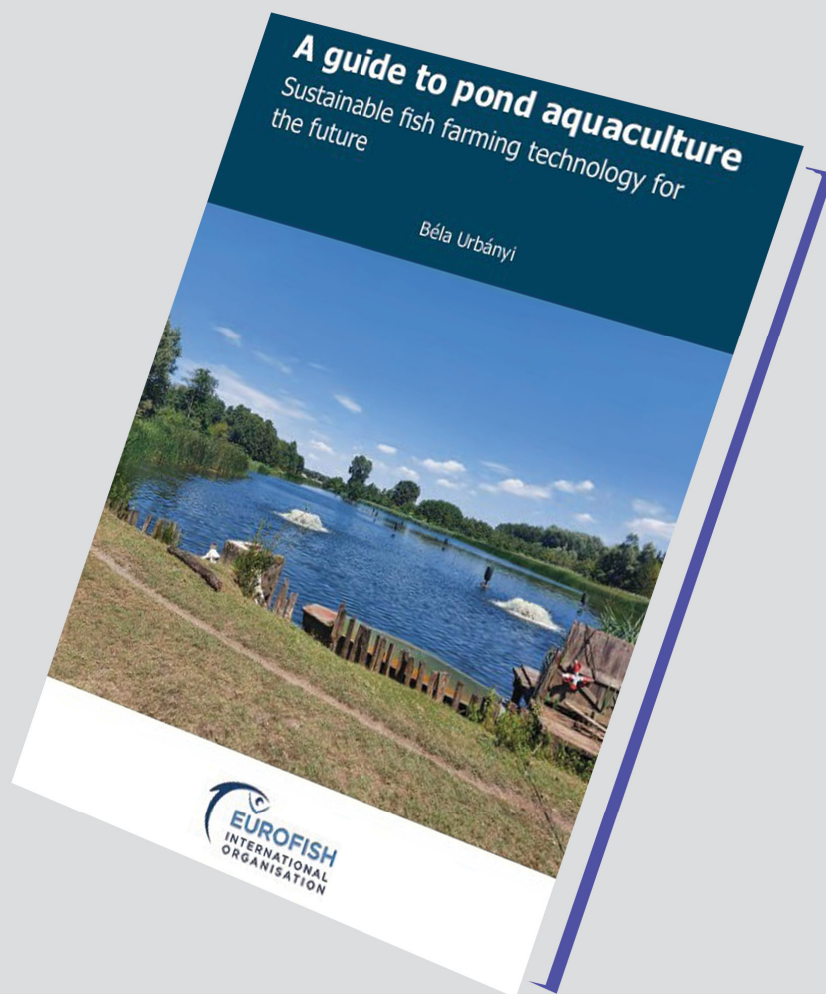
| No.3, May 2026

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Printed as on: 07-11-2025



Book introduction



A Guide to Pond Aquaculture: Sustainable Fish Farming Technology for the Future

Editor:

- Bela Urbanyi

Publisher / Year:

- Publisher: EUROFISH international organization
- Year of Publication: 2026

Summary

A Guide to Pond Aquaculture: Sustainable Fish Farming Technology for the Future is authored by and published by (EUROFISH international organization). This publication reflects the organization's long-standing mission to promote sustainable fisheries and aquaculture development across Europe and neighboring regions.

The book provides a structured and forward-looking overview of pond aquaculture as a resilient and environmentally compatible production system. Drawing on scientific research and practical European experience—particularly from Central and Eastern Europe—it explains the technological foundations of pond construction, water management, species selection, feeding strategies, ecological balance, and integrated multi-trophic approaches. Special attention is given to sustainability principles, biodiversity protection, efficient resource utilization, and the role of pond farming in climate adaptation and rural development.

Unlike purely technical manuals focused only on production efficiency, Urbányi positions pond aquaculture within a broader socio-economic and environmental framework. The text discusses ecosystem services provided by fishponds, including water retention, nutrient recycling, habitat conservation, and landscape management. By combining traditional carp-based systems with modern technological improvements, the book highlights how pond aquaculture can remain competitive while meeting contemporary environmental standards and market expectations.

Overall, A Guide to Pond Aquaculture serves as a strategic and technical reference for policymakers, researchers, extension specialists, and aquaculture entrepreneurs seeking to modernize pond farming systems in line with sustainable development goals and future food security demands.

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