ISSN 0859-600X
Volume 29 No. 3 July-September 2025

# AQUACULTURE ASIA

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AQUACULTURE ASIA

## Aquaculture innovation in focus

NACA has recently become involved in aquaculture innovation as part of a wider FAO initiative to transform the sector. The goal is to build more efficient, inclusive, resilient and sustainable food systems through innovation, investment and partnerships.

One strand is the FAO/NACA White Paper on Aquaculture Transformation. Developed through extensive consultations, it sets out a vision to transform Asia-Pacific aquaculture by 2030.

A second strand is a high-level meeting series, now in its third session, which provides a platform for governments, industry leaders and development partners to work towards a shared vision and sector transformation.

The third and most recent strand is work to establish an Aquaculture Innovation and Investment Hub (AquaHub). The hub will bring together innovators, start-ups and investors to accelerate transformation. Initial development is supported by Canada's International Development Research Centre (IDRC) via a sub-project of the regional AQUADAPT initiative.

AquaInnovate, the first AquaHub event, was held from 12-16 May. It provided a platform for start-ups and innovators to pitch their businesses, receive coaching from industry veterans and entrepreneurs, and meet leading aquaculture investors. Startup pitches and expert presentations are available on the NACA website and YouTube:

https://enaca.org/?id=1403

A new AquaHub website is under construction and slated for launch in February. An interim site with participant and partner profiles is available at:

https://aquahub.asia

We are just getting started in this area and will share further updates, including the AquaHub website launch announcement.

Please also consider subscribing to NACA's YouTube channel. We are recording technical presentations from NACA workshops, conferences and other events to make information accessible to as many people as possible.

https://www.youtube.com/@aquacultureasia/

Lastly, consider subscribing to our new Email Newsletter service, by submitting your email address in the blue form on the NACA home page (scroll halfway down the home page):

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Simon Wilkinson

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**NACA**

An intergovernmental organisation that promotes rural development through sustainable aquaculture. NACA seeks to improve rural income, increase food production and foreign exchange earnings and to diversify farm production. The ultimate beneficiaries of NACA activities are farmers and rural communities.

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# AQUACULTURE ASIA



# From office to field: The role of women in Saudi Arabia's small-scale aquaculture and fisheries sector

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*Saudi women actively involved in production tasks.*

Since 2019, the Ministry of Environment, Water and Agriculture (MEWA), in collaboration with the Food and Agriculture Organization of the United Nations (FAO), has promoted aquaculture and fisheries development through the REEF initiative - the Sustainable Agricultural Rural Development Programme. The programme aims to strengthen food security while supporting long-term environmental and agricultural sustainability in line with Saudi Arabia's Vision 2030.

With its extensive coastline, Saudi Arabia offers favourable conditions for small-scale aquaculture and seafood processing. Seafood consumption has risen steadily in recent years due to national dietary shifts and economic diversification. However, artisanal seafood processing remains underdeveloped, particularly in rural regions. At the same time, large volumes of fish waste are generated in fish markets and aquaculture facilities, yet value-recovery systems are limited. A growing number of young Saudis are entering aquaculture and processing, but women's participation still lags, especially in field-based and technical roles.

For many Saudi women, opportunities in aquaculture and fisheries have traditionally been shaped by education, social norms, limited mobility and a lack of field-oriented roles. The development gap between urban and rural areas, combined with transport access, job characteristics and varying education levels, has meant that most women have worked indoors, in marketing, administration or processing. Participation in field roles, including fish handling, hatchery work and post-harvest operations, has remained relatively limited.

FAO and MEWA are promoting small-scale aquaculture and seafood processing in rural areas for the following reasons:

- **Economic development:** Aquaculture and seafood processing can create new jobs, stimulate local economies and open markets for small households, providing diverse applications and revenue streams. In particular, they can increase employment and income for women working in coastal rural communities (above).

- **Promoting fair employment:** These activities provide opportunities for women with diverse educational backgrounds, reducing the need to commute to urban areas and lowering entry barriers linked to formal qualifications. With short training and sufficient motivation, women can take on productive roles within their communities.

- **Food security and nutrition:** Seafood is nutritious, producible and cost-effective in Saudi Arabia, and can enhance food security. Many traditional processing practices are simple and do not require expensive equipment.

- **Environmental sustainability:** Operational activities do not require large volumes of freshwater or arable land. This is particularly relevant in coastal and rural areas where freshwater resources are scarce.

- **Opportunities for a sustainable value chain:** Targeted interventions can align traditional knowledge with modern practices, strengthening rural livelihoods, empowering women and supporting a bioeconomy within the fisheries sector - key goals of Vision 2030.

Based on these objectives, FAO and MEWA have implemented field projects on small-scale seaweed aquaculture and seafood processing in coastal areas since 2023.


*Above, below: Saudi women actively involved in production tasks.*

## Empowering women through seaweed farming

Traditionally, Saudi women were involved in office-based roles within the aquaculture value chain. Recent field initiatives have enabled women to enter operational segments such as seaweed farming and hatchery management, reflecting shifts in social and cultural norms. Seaweed farming and processing have also become less intensive, requiring fewer management staff and lower training costs in Saudi Arabia. Compared with fish and shrimp farming, which began in the 1980s, Saudi Arabia has made notable progress in seaweed farming in recent years, although it has not yet reached commercial scale.

In 2024, FAO initiated production of the red seaweed *Gracilaria multipartita* among small-scale producers in the Jeddah area (western coastline) and the Farasan Islands (southern coastline). In both projects, women have been actively engaged in seaweed-farming trials using raft systems. Tasks include tying seedlings onto cultivation ropes, maintaining line spacing, and managing post-harvest drying. Seaweed farming has proven accessible for women because it demands less physical effort, relies minimally on machinery and suits community-based operations. Ongoing plans under the REEF programme aim to replicate these activities nationwide, enabling more women to take significant roles in small-scale seaweed production.

## From traditional practice to value-added products: women in seafood processing

In parallel with seaweed farming, an FAO-supported initiative focused on improving women's participation in small-scale seafood processing. The project aims to empower women processors and reduce seafood waste in support of sustainability goals in the Farasan Islands in 2025. These areas face a larger urban - rural gap, and women's education and employment resources are relatively scarce.

The project supports women already engaged in traditional processing, such as salting and drying. It offers tailored training and essential equipment, and introduces branding and marketing skills to develop value-added products. The goal is to help these women form structured processing groups and enhance their livelihoods. Training sessions on hygiene, technical skills, teamwork and branding have so far empowered 23 women processors. Initial results show better hygiene practices and strong interest in forming formal cooperatives and using branded packaging. A tuna-canning activity was particularly motivating, demonstrating a potential threefold increase in product value.

## Conclusion and way forward

The development of aquaculture and seafood processing in rural areas holds significant promise for economic diversification, environmental sustainability and food security. The successful implementation of small-scale production along the coastline shows both feasibility and potential. However, several limitations still need to be addressed:

- **Expansion of small-scale production:** Scale up farming projects to other small producers in different regions. Western coastal areas may be especially suitable because they are better placed for subsequent processing for food or feed.
- **Market development:** Establish supply chains and market linkages for seaweed and fish products, domestically and internationally. Form alliances through industry - government - academia collaboration, particularly in food and biomedical fields. Local academic institutions and private enterprises can help deliver these projects, creating employment and supporting industrial development.
- **Capacity building and training:** Provide training for local communities and stakeholders to build expertise in seaweed farming and processing, with a focus on women in coastal rural communities.
- **Product quality control:** Maintain quality during processing. Facilities must meet strict hygiene standards, and producers may require training in best practices. Any quality issues can affect selling price or marketability, so risks should be mitigated through quality assurance.


The seaweed farming project delivers clear benefits: it supports women's groups through food processing activities, creates skilled jobs in mariculture and aligns with environmental sustainability by cultivating a renewable marine resource. Seaweed farming is a modern, sustainable aquaculture opportunity that can thrive within sustainable agricultural rural development, diversifying the economy and making use of the country's extensive coastline for food and biotechnology production.

In Saudi Arabia, seafood processing includes both a growing industrial sector and a traditional artisanal sector. In rural areas, women often use informal, seasonal methods such as salting and sun-drying, sometimes without adequate hygiene or protective infrastructure. Their work, though culturally important, is largely unrecognised in formal markets and is hampered by the lack of dedicated workspaces, training and cooperative models. Communities would benefit from improved equipment and shared facilities, which could enhance both income and product quality. Recommended actions include formalising women's processing groups, providing continuous training, establishing dedicated workspaces, distributing essential processing equipment and forming partnerships with seafood companies. In areas near tilapia farms, these measures can also support wider aquaculture development.

Looking ahead with optimism, the focus will move from feasibility to implementation. Priorities include supporting more rural women's groups, building small-scale aquaculture processing capacity and linking products to domestic markets. Saudi women have strong potential to become a significant part of the aquaculture workforce. With sustained support and inclusive policies, they can move from supporting roles to becoming key contributors in the evolving aquaculture sector.

### Acknowledgements

The authors express their gratitude to the Ministry of Environment, Water and Agriculture, and the Food and Agriculture Organization of the United Nations for providing photos and materials with special thanks to all Saudi women who have actively participated in operational activities.

# Farming of orange mud crab in the Indian Sundarbans: Opportunities and challenges

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*Orange mud crab inside a fattening box.*

Mud crab is an important candidate species for brackish-water aquaculture in India. The two commercially important species are *Scylla serrata* and *S. olivacea*. Of these, *S. serrata* (green mud crab) is preferred for aquaculture because it grows larger and commands a higher price. However, fattening of *S. olivacea* is becoming popular, as this species is abundant in West Bengal and Odisha. Recent developments, such as farming in HDPE boxes, have encouraged fattening of *S. olivacea* (orange mud crab) for the production of mature crabs that fetch a premium price.

Live mud crabs have a niche market in countries such as Singapore, China, Thailand and Japan. Small consignments are exported on demand from hubs including Chennai and Kolkata. Unlike other seafood commodities, crabs are exported live and priced by individual size. A live mud crab of more than 900 g can fetch ₹1,100 - 2,000 in export markets, depending on demand and season. In 2023 - 24, 4,746.58 tonnes of crabs (live, fresh or frozen) were exported to various countries, earning US$ 42.60 million (Department of Commerce, Government of India). The high unit value makes mud crab a sought-after species for brackish-water aquaculture. Nevertheless, several bottlenecks on the farming side: Uncertain seed availability, cannibalism during grow-out, nursery-rearing issues and difficulties in harvesting limit large-scale expansion. Even so, small-scale grow-out and mud crab fattening are being adopted by coastal fish-farming communities.

Mud crabs are crustaceans with a hard exoskeleton and mainly inhabit mangrove and estuarine brackish-water areas. As noted, the two major species are *S. serrata* and *S. olivacea*. Previously, *S. serrata* in Indian waters was misidentified as *S. tranquebarica*. Molecular taxonomy now supports the existence of two species in these fisheries: *S. serrata* and

*Mud crab fattening boxes.*

*S. olivacea*[1]. Both occur along much of the coast, but in the Sundarbans the main species supporting fishery and culture is *S. olivacea*.

Like other crustaceans, mud crabs undergo periodic shedding of the exoskeleton (moulting), a key process affecting growth and reproduction. In mud crabs, weight gain across a moult is substantial, often approaching 100% of pre-moult weight. For example, a 100 g crab may reach 180 - 230 g after moulting, depending on nutrition. This seems attractive for aquaculture, but a single moult may take a couple of months because the intermoult period is long. Moulting is more frequent early in life; as crabs grow larger, the time required for each moult increases sharply.

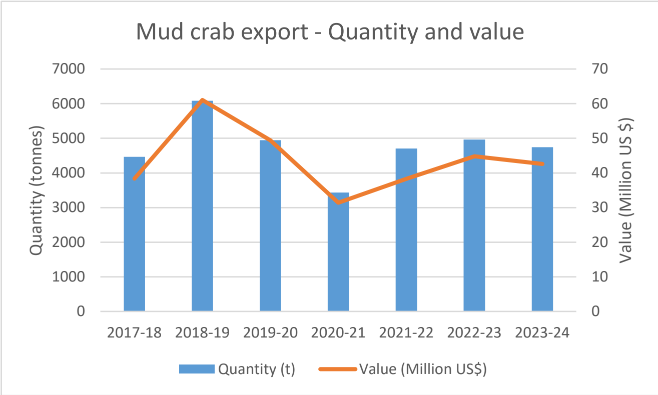
## Status of mud crab culture in India

### Grow-out culture

Except in the Sundarbans, mud crab aquaculture in India is mainly focused on *Scylla serrata*, which can grow to a larger size. In the wild, *S. serrata* can reach about 2.5 kg body weight, whereas *S. olivacea* typically attains around 600 - 700 g; in both species, males grow larger. Initially, *S. olivacea* was not considered aquaculture-friendly because of its smaller size, burrowing habit and more aggressive behaviour compared with *S. serrata*. However, innovative culture practices and demand for different product categories have given momentum to farming *S. olivacea*, which could be scaled up in future as a major culture activity. Even so, despite several ongoing culture practices, most production still comes from wild capture.

Farming mud crab in earthen ponds remains the major aquaculture activity in the country. Recommended stocking density is below 0.5/m². Because recovery at harvest is difficult, pond-based farming is still practised extensively. Although the two species share biology and habitat, their culture practices differ in important ways. At present, pond-based farming of *S. serrata* is carried out in Tamil Nadu, Andhra Pradesh, Kerala and Karnataka using wild-caught crablets and hatchery-produced crablets, driven by high market demand and larger size. Pond-based farming of *S. olivacea* is less popular; small-scale activities are undertaken along the coasts of West Bengal and Odisha, mainly in polyculture with other brackish-water fishes.

Unlike *S. serrata*, *S. olivacea* shows strong burrowing behaviour and often creates large holes in dykes, damaging structures. Where pond bottoms are muddy with silty clay, crab recovery is difficult, which reduces farmers' interest. Wild-caught crablets and rejected crabs procured from local traders are commonly used as seed for stocking. Trash fish from fish-landing centres is the main feed in these systems. Harvested crabs are usually sold in local markets, with larger individuals sent for export.



*Ponds dried and prepared for fattening of orange mud crab*

**Mud crab fattening**

Fattening of mud crabs is a major aquaculture activity and is popular with farmers because of the higher returns. It is a capture-based practice in which recently moulted, larger crabs are reared for a short period (about 30 - 35 days) to harden the shell. Newly moulted crabs have soft shells and lower meat content and are rejected during export grading. These crabs are therefore purchased at lower prices (₹300 - 400) and reared further to obtain a premium price once they harden. Rearing is done in individual HDPE boxes, as well as in pens and ponds. This approach is mainly used for *Scylla serrata* and is already practised across the coastal regions.

Fattening of *S. olivacea* differs from that of *S. serrata*. Recently moulted crabs are not used; instead, female crabs of 100 - 200 g are reared in HDPE boxes for 30 - 40 days to promote gonadal development. Shell-hardening is also practised in *S. olivacea* but only for larger crabs. Females with a gravid ovary showing a bright orange colour fetch a premium price in export markets and are in high demand in Taiwan, Thailand and China. Prices for fattened orange mud crabs can reach about ₹1,200 - 2,000 during peak export seasons, depending on grade. Unlike *S. serrata*, maturation in *S. olivacea* is faster; they mature at 90 - 100 mm carapace width and 90 - 150 g body weight. This is a key reason for the development of fattening in *S. olivacea*.

At present, fattening of orange mud crabs in individual boxes and ponds is a major culture activity in the Sundarbans because of the better returns. Production of gravid *S. olivacea* has grown with the introduction of HDPE boxes for individual stocking and monitoring. The boxes used are slightly smaller than those for *S. serrata*. HDPE boxes commonly range from 20 × 18 × 16 cm (L × W × H) to 30 × 21 × 22 cm. They are fixed to floating rafts made of PVC pipes and deployed in open waterbodies, brackish-water canals or ponds. For ease

*Male orange mud crab.*

of feeding, 20-40 boxes are loaded per raft. Approximately 20,000-30,000 boxes can be stocked per hectare, allowing for raft movement during feeding.

Stocking material comes from wild collections and is usually purchased from local traders at ₹300-400/kg. Immature crabs of 100-200 g body weight are mainly selected for fattening. During the fattening period, crabs are fed trash fish procured from the market at about 10% of body weight per day.

## Fattening mud crab with the claws tied

Alongside box fattening of orange mud crabs, farmers in the Sundarbans also practise a distinctive method of fattening crabs in open ponds with the claws tied, which is gaining popularity. Crabs of 80 - 150 g are stocked into small earthen ponds of about 400 - 500 m². Approximately 80 - 100 kg of crabs are stocked per pond, with the chelipeds (claws) tied as for transport. Tying the claws reduces fighting and cannibalism. Feeding is not hindered because trash fish is chopped before feeding. Daily feed is about 5 - 6 kg of trash fish, and water is exchanged using source water from nearby creeks.

Farmers report that crabs fatten within 12 - 18 days with this method. The activity is seasonal, mainly from August to January when prices are higher. Crabs for stocking are purchased at ₹200-350/kg and sold during peak export seasons at ₹1,000 - 1,200/kg. The method is favoured because it requires less labour and investment, though reported survival fluctuates between 50% and 90%.

## Marketing of mud crab

The marketing chain typically starts with the fisher or farmer who collects or cultures the crabs, and local traders or aggregators act as intermediaries. Crabs taken from the wild or from fattening units are usually delivered to a nearby trader for aggregation, because export hubs are distant and daily volumes are small. Initial grading is carried out by the trader according to size and export categories. Grading codes for orange mud crab differ from those for *Scylla serrata*. For *S. olivacea*, males and females are graded separately because mature females form an important category, which is not usually the case for green mud crab.

The ovary of mud crabs is H-shaped; when fully mature it occupies most of the space inside the carapace. Maturity can be assessed by shining a strong light through the underside of the carapace to observe shadows on the dorsal side. Gravid crabs are graded using this technique; empty crabs are returned for further fattening or sold locally. Although traders may use different codes, basic categories and sizes are similar. Female crabs with full ovaries are commonly classified as F1 (≥ 180 g), F2 (≥ 150 g) and F3 (≥ 100 g), fetching about ₹1,200 - 1,300, ₹800 - 900 and ₹700 - 800, respectively (Table 1). During grading, traders also check for physical damage, loss of appendages and reproductive status. Grading is done carefully because crabs are exported live and must arrive intact. Fishers are paid according to export rates, less a trader's margin, and aggregated crabs are shipped to the nearest export hub for onward transport.

*S. olivacea female after rearing in the box based fattening system.*

*Grading the mud crab for gonadal development. Above: Immature crab. Below: Fattened fully gravid crab.*

## Scope and challenges in mud crab aquaculture

Mud crab aquaculture has strong potential for scale-up within the brackish-water sector, especially for fattening crabs in HDPE boxes. Housing crabs individually helps address cannibalism, and ponds used for other fish can be utilised

*Earthen ponds of Namkhana, West Bengal for pond-based fattening of S. olivacea practiced with tied claws.*

for rearing. Demand for crabs is likely to grow, and strategic steps can help capture this potential. New techniques - such as soft-shell crab production and vertical farming - are also emerging.

Despite industry interest in box-based farming, many farmers report technical constraints to scaling. Box-based fattening of orange mud crab is currently declining, with some farmers reducing operations for several reasons. Mortality and low survival during fattening, often linked to disease, are major concerns. A key factor is reliance on wild-collected stock, for which health status cannot be properly assessed. In addition, the quality of juvenile crabs sourced from local traders can be poor due to handling during grading and prolonged holding in sheds before transport to farms.

Prices are not fixed and fluctuate with international markets. Because crabs are kept individually, feeding is labour-intensive, pushing production costs higher and squeezing margins in the off-season. Farmers also struggle to obtain fair prices from local traders due to the number of intermediaries in the marketing chain. Nevertheless, advances in crablet production and the development of formulated feeds could address many of these issues.

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# Seed production of giant freshwater prawn in brackish-water ponds in Purba Medinipur, West Bengal

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*A healthy adult harvested from a grow-out pond.*

## *Macrobrachium rosenbergii* farming in West Bengal (with respect to Purba Medinipur)

Freshwater prawn farming is an important and valuable aquaculture sector in Asian countries including China, Bangladesh, Thailand, India, Vietnam and Myanmar[1]. The giant freshwater prawn *Macrobrachium rosenbergii* is becoming one of the most important cultured species in inland aquaculture in India due to its fast growth, strong demand in domestic and export markets, good price and compatibility with major carps[2]. Recently, its culture has expanded rapidly in India with improved seed availability from the wild and hatcheries, and wider adoption of semi-intensive practices. It began with traditional methods with low stocking densities and minimal management, but has developed into a major economic activity[3 4].

In West Bengal, *M. rosenbergii* is cultured in waterlogged paddy plots under rice-prawn integration; in pen enclosures installed in freshwater floodplain wetlands (“beels”); in freshwater farm ponds as monoculture; in tide-fed canals of the Indian Sundarbans; in brackish-water ponds as mono- or polyculture; in modified-extensive brackish-water polyculture with mullets and *Penaeus monodon* in large brackish-water bodies (“bheri/gheri”); in composite fish culture with major carps (avoiding *Cyprinus carpio*, *Cirrhinus mrigala* and *Labeo bata*); and in rectangular cement cisterns (6.1 m × 5.5 m × 1.06 m, or similar) constructed at home premises. *M. rosenbergii* can also be incorporated as a component of carp polyculture in ponds.

Of the twenty-three districts in West Bengal, Purba Medinipur stands out as a leader in commercial grow-out culture and production of Indian major carps, brackish-water shrimps *P. vannamei* and *P. monodon*, and *M. rosenbergii*. This district is resource-rich and a pioneer, dominating freshwater and brackish-water aquaculture and marine capture fisheries (and their annual production). In Purba Medinipur, *M. rosenbergii* monoculture is undertaken in grow-out freshwater ponds by small- and medium-scale farmers; main producing areas include villages under Bhagabanpur-1, Bhagabanpur-2, Moyna, Sabang, Pingla, Contai-1 and Contai-3 CD Blocks[5]. Notably, another established and successful sector in Purba Medinipur is the production of stockable-sized seed (post-larvae; PL) of *M. rosenbergii* in rural brackish-water ponds, sold to grow-out prawn farmers.

*Kalinagar river in Purba Medinipur.*

## Healthy seeds for successful grow-out culture

Demand for *M. rosenbergii* seed has risen sharply in recent years with increased emphasis on farming this high-value species[6]. Success in grow-out farming and wider adoption, extension and higher production depends on the availability of good-quality post-larvae (PL) and juveniles in sufficient numbers. In West Bengal, about 0.20-0.25 million hectares of freshwater ponds may be suitable for *M. rosenbergii* grow-out. To produce a single crop in one-tenth of this area under monoculture, a total of about 500-600 million juveniles would be required (at ~25,000 juveniles/ha), which in turn would need roughly 1,500 million healthy PL[7].

*Bleaching powder applied over a sundried post-larvae production pond.*

In Purba Medinipur, *M. rosenbergii* seed (7-10 mm; "paddy grain" size) is collected from the Rupnarayan River from early April to late August each year, mainly by women in Gujarkharui village, Sahid Matangini CD Block, about 5 km from Kolaghat on the Kolaghat-Tamluk Road[8]. In the district, PL (10-20 mm) are available in the Shilabati River in the Ghatal area, peaking from March to May; juveniles (40-70 mm) occur in the Keleghai River in Narayangarh, Potashpur and Egra areas (July-October); and collections are also made from the Subarnarekha River near Dantan, the Rasulpur River in Khejuri, and from Kalinagar Canal and Pousi Khal in Bhagabanpur (July-September)[9]. Collections are typically made just after the onset of high tide and supplied to grow-out farmers.

*Close view of M. rosenbergii post larva 10-15mm.*

During periodic segregation of *M. rosenbergii* seed from the total catch, collectors discard non-target organisms such as early fry of some riverine brackish-water finfishes and PL of other, less valuable prawn and shrimp species which do not survive. In this context, cost-efficient production of *M. rosenbergii* PL in confined, controlled systems in Purba Medinipur is preferred and increasingly relied upon as a source of stockable-sized seed, rather than river capture.

## Giant prawn seed production in ponds: The beginning

In 1993, consultancy and financial support led to construction of a small-scale demonstration shrimp/giant prawn hatchery at Digha, Purba Medinipur, based on a plan presented by an officer of the Department of Fisheries, West Bengal. It had

*A brooder male of M. rosenbergii.*

*A healthy berried female of M. rosenbergii.*

*A healthy juvenile stage of M. rosenbergii.*

six 4,500 L rearing tanks, algae-culture tanks, a 25,000 L brine-storage tank and a pump house[10]. The Meenakshi Giant Prawn Hatchery at Digha was intended to produce and supply good-quality *M. rosenbergii* PL and higher stages to farmers from March to October each year. However, grow-out farmers in Purba Medinipur showed greater interest in wild-collected PL and PL produced in brackish-water earthen ponds by inland fishers in coastal villages near Contai town. The then Fisheries Minister of West Bengal, Sri Kiranmoy Nanda, prioritised the popular indigenous practice of producing *M. rosenbergii* PL in brackish-water ponds in Contai-1 and Contai-2 CD Blocks, on a large scale, with guidance and technical support from the Digha Experimental Giant Prawn Hatchery. *M. rosenbergii* PL began to be produced in increasing numbers, meeting seed demand for grow-out farmers. A giant prawn seed market with improved facilities was set up at Radhamoni on the Mecheda-Nandakumar High Road (Courtesy: Dr S. N. Biswas, Retd. Joint Director of Fisheries, West Bengal).

The technology flourished. Professional seed producer Sri Tuhin Rana (aged 40), of Vill. and P.O. Basudebberia, Aurai Gram Panchayat (GP), Deshapran (Contai-2) CD Block, Purba Medinipur, told the first author on 1 May 2025 that this activity has been in vogue for 25-28 years in the coastal Blocks of Purba Medinipur. He noted that PL produced in government and non-government hatcheries is not sufficient to meet farmers' needs, and exploitation from rivers is discouraged because it reduces riverine finfish and shellfish biodiversity. Production in well-maintained brackish-water ponds is an innovative, profitable, low-investment option.

Since 2009, Sri Rana has produced *M. rosenbergii* PL (with fewer juveniles) during March-May in three brackish-water ponds, each with 2,080 m² effective water area (EWA). He purchases healthy, ripe berried females carrying fertilised eggs at various stages (orange, yellow and slate-grey) in the brood chamber on the ventral abdomen, typically 50-150 g from their natural habitat in the Kalinagar River at Suniaghat (4-5 km from Basudebberia). These are bought at INR 700-3,200/kg for stocking in early March. Female brooders collected from other waterbodies 22-25 km away are also transported with care in open containers, such as 20-25 kg plastic "Fevicol" buckets and 15-16 L vanaspati jars half-filled with water, and stocked at about 200-350 brooders per 2,080 m² pond.

## Sri Rana's management practices

As pre-stocking practice, Sri Rana dewaters and empties his ponds in mid-March, allowing the bottom soil to dry and crack under strong sunlight. Any thick layer of soft, black, foul-smelling topsoil is removed or sun-dried. He applies agricultural lime (limestone powder) at 10 kg per pond. On the next day, high-tide water from a nearby canal connected to the Rasulpur River is let in through a fine-mesh microfilament screen and maintained at 1.06-1.20 m depth with 10-12 ppt salinity. After 36-48 hours, bleaching powder is applied at 35-50 kg per pond. On day four, paddle-wheel aerators positioned at opposite corners of each pond are run vigorously to increase dissolved oxygen and drive off residual chlorine. The water is circulated strongly and deliberately kept turbid with suspended soil particles. Short, cut branches of date-palm are placed in bunches in the pond.

*First author, Sri Tuhin Rana and fishery technician Sri Gokul Rana.*

The next day, commercially available powdered zeolite (3-4 kg per pond) and an aqua-product (e.g. yucca powder) that adsorbs toxic gases in water and soil (300 g per pond) are mixed with sand and applied. After 2-3 days, in the mornings, the water is again made turbid manually for two consecutive days. He then applies a dolomite-based aqua-product (3 kg per pond) and a mineral mix (2 kg per pond) in the morning during aeration. Female *M. rosenbergii* brooders are stocked 12-18 hours after this application.

The following evening, he adds a fermented mixture to each pond containing bakery yeast (250-300 g), rice dust (2-3 kg), groundnut oil-cake (1-3 kg) and sugarcane jaggery (2-3 kg) mixed into 20 L of lukewarm water and pre-fermented for 36-60 hours. This promotes high zooplankton production. On subsequent days after brooder stocking, the water is made turbid daily by manual churning for one hour. Adult *M. rosenbergii* prefer turbid to clear water[12]. On the fourth day after applying the indigenous organic formulation

*A close view of circular hand net used for collecting post larvae.*

*Sri Gokul Rana observing growth of M. rosenbergii post larvae.*

*A pond of Sri Tuhin Rana dewatered after one crop of post-larvae.*

(zooplankton enhancer), he reapplies the mineral mix at 2-3 kg per pond. Four days later, in the morning, he "activates" the ponds ("probiotics charging") with a commercially available soil-plus-water probiotic at 400 g per pond to improve bottom health and overall water quality.

### Feeding to growing larvae, production and sale

In *M. rosenbergii*, gonadal maturation, mating and fertilisation occur in freshwater. Egg ripeness is indicated by colour: newly spawned eggs are bright orange; the colour shifts to yellow and then slate grey just before hatching. As embryonic development proceeds in the brood pouch, eggs change from orange to yellow and finally to deep grey[11 12]. According to Sri Rana, larvae (which hatch at night) appear in the pond 9-12 days after stocking brooders carrying orange or yellow eggs. First larval stage (FLS) is observed within 2-3 days when brooders carry blackish to grey eggs. The larvae jump and cling to nearby substrates, such as the short, cut branches of date palm. Post-larvae (PL; 7-10 mm) are produced 11-12 days after the FLS appears in his well-maintained brackish-water ponds.

Ponds are aerated daily in the early morning, forenoon and evening, two hours each period, until metamorphosis from larvae to PL. Locally termed "Pin" stage in Bengali, these PL are the marketable *M. rosenbergii* seed. Sri Rana produces and harvests PL within 15-16 days of stocking females carrying grey to deep-grey eggs; more time is needed if eggs are orange or yellow. PL are held in buckets with well-oxygenated water. Healthy PL (7-10 mm) are transported and sold in oxygenated bags to progressive farmers at Fakirhat Upazila (Bangladesh); in Jharkhand and Mumbai; at Basirhat and Malancha in North 24 Parganas (West Bengal); and in Nagaland and Tripura, at INR 700-1,000 per 1,000 PL. Buyers acclimatise PL gradually to lower salinity and then to freshwater: freshwater is slowly added to the untied oxygenated packets, and PL are released into ponds after waiting 20-30 minutes.

After FLS formation, Sri Rana uses biscuit powder or good-quality gram flour (finely powdered roasted, water-swollen chickpea) in liquefied form as feed at one-day intervals. In addition, he applies the indigenous organic formulation the day after FLS formation, using one-third of the original ingredient amounts. Pond salinity and pH are maintained at 10-14 ppt and 7.5-7.8, respectively. Salinity is adjusted to the target level on the day before bleaching-powder application. He keeps nitrite and ammoniacal nitrogen below 0.1 ppm. A portion of the PL grow to 24-25 mm in a further 12-18 days, which he sells at about INR 1.50 per piece. Sri Rana noted that PL survival is poor during sudden, moderate to heavy rainfall.

At present, the main areas in Purba Medinipur where this activity is extensive include Dhobaberia, Bankipur, Sarda, Amtolia, Aurai and Basantia GPs in Deshapran CD Block. According to Sri Naba Kumar Acharya, Fishery Technician and subject expert at Vill. Pachuria, Khejuri-2 CD Block, some local fishers there also produce *M. rosenbergii* PL in earthen brackish-water impoundments using water from the Khejuri River.

## Sri Amol Das's giant prawn seed production ponds

Another progressive *M. rosenbergii* seed producer, Sri Amol Das (48) and his father, Sri Sukumar Das, of Vill. and P.O. Namaldiha, Aurai GP, Deshapran CD Block, told the authors on 27/04/2025 that he began this activity in 2001. He owns ten *M. rosenbergii* seed-production ponds, each with 1,500 m² effective water area (EWA), sourced with brackish water from the Kalinagar Canal. Unlike Sri Rana, Sri Das relies on pond-reared brooders rather than wild-caught females. He purchases *M. rosenbergii* at INR 800-2,000/kg from two grow-out farms at Gorbhera village, Bhagabanpur-1 CD Block, Purba Medinipur, located 40-42 km from his site.

### Production of berried females at Gorbhera village

At Gorbhera, marketable *M. rosenbergii* are harvested from freshwater grow-out ponds during November-December after about seven months from PL, at 45-50 g body weight. About 70% of adults are removed; the remainder are maintained in the same pond for a further 3-4 months to reach brooder stage, mate and spawn. The farmer ensures the pond bottom remains free of toxic gases such as ammonia, sulphur dioxide, hydrogen sulphide and methane. A published article[13] notes that, after six months, adults should be maintained at a sex ratio of 1M:4F. The *M. rosenbergii* adults turning to brooders are fed commercial pellets (formulated for L. vannamei) and a home-made feed containing fishmeal, boiled lentil pulses, groundnut oil-cake, soybean meal and other ingredients.

In the grow-out ponds, a ripe female *M. rosenbergii* moults and then copulates with a hard-shelled male. Egg release follows within 2-3 weeks. Fertilisation is external; the eggs

*Sri Amol Das collecting post larvae samples from a date palm tree branch in pond.*

*A branch of date palm tree used in post-larvae production pond.*

are bright orange and are carried back to the brood chamber. Berried females of 50-60 g (some 60-80 g), aged 9-11 months, are collected during March-April and transported to Sri Das's brackish-water ponds for stocking at about 140 females per 1,500 m² pond (≈ 7.0-8.5 kg per pond) to produce one crop of PL. (Note: As in grow-out ponds, the peak breeding period of *M. rosenbergii* in the Hooghly estuary and in canals and creeks of coastal Purba Medinipur is March-May.) To produce three crops from each pond during March-May (with proper pre-stocking preparation and harvesting between cycles), Sri Das uses roughly 25 kg of female brooders per pond per season.

According to him, this is highly profitable because PL can be harvested and sold within a short period, typically from day 15-16 after stocking berried females carrying deep-grey to blackish eggs, or within 15-22 days. He also emphasised that the work is sensitive: pond-water salinity, transparency/turbidity, dissolved oxygen, hardness, ammonia and pH must be kept within specific target ranges throughout the production period.

### Pond management practices of Sri Das

After dewatering, Sri Das first turns over the pond-bottom soil using a tractor plough. He then proceeds as follows: applies quicklime at 50 kg per pond; after one week, admits tidal water from the Kalinagar Canal to a depth of 1.36-1.52 m; applies a commercial product to kill early stages and sub-adults of unwanted fishes, insects, small molluscs and micro-organisms; applies bleaching powder the next day at 25 kg per pond; from day 3-4 after bleaching, aerates vigorously

*A post-larvae production pond of Sri Amol Das.*

about 4 hours per pond by day and by night for the next 4-5 days; deliberately makes the water turbid by manually churning the bottom so clay and silt remain suspended; applies a mineral mix at 25 kg per pond three days after starting aeration; applies the organic formulation “Juice” after 36 hours’ fermentation to promote zooplankton; applies a commercial dust-type probiotic in the early morning at 250 g per pond; and applies a good-quality “soil + water” probiotic at 5 kg per pond. He notes that benzalkonium chloride may be applied three days after bleaching at 1.5 kg per 1,500 m². Applying the mineral mix at 7-8 day intervals gives good results. Additional liming (calcium carbonate) is not required when bleaching powder has already been used.

The ponds are ready for stocking 10-11 days after filling. From the day chlorine is removed until the first larval stage (FLS) appears, the water is purposefully kept turbid by hand-churning the bottom and by operating a machine for two hours each in the early morning, daytime and night. According to Sri Das, 7-8 ppt salinity is favourable for PL production. Each pond has a 5 HP paddle-wheel aerator installed.

*Healthy adult M. rosenbergii produced using post larvae of Sri Amol Das.*

*Sri Amol Das, his associate and both authors beside one of Sri Das's pond.*

Bunches of short, cut date-palm branches are hung upside down and fully submerged in the water column, supported by long vertical wooden poles, at 15 points per pond. After lifting, the bunches are gently shaken to collect attached PL in a circular hand net held beneath. Larger branches are placed singly, upright, with the base inserted into the bottom and the tip emerging above the water surface.

Sri Das checks daily for larvae and PL from day 6 after stocking berried females, using a 0.75 m-diameter circular hand net of 10-micron mesh and a white enamel tray. Adequate zooplankton presence supports proper larval growth. From brooder stocking onwards, he runs the paddle-wheel aerator in each pond for two hours in the early morning, daytime and evening, continuing until PL harvest is complete.

### Organic “juice” preparation and sale of post-larvae

To prepare the organic formulation “Juice” (an indigenous prebiotic), Sri Das mixes bakery yeast (450 g), three packets of Britannia biscuits (1,200 g), date-palm molasses (5 kg), wheat flour (4 kg), finely pulverised “Starter” grade shrimp pellets (2 kg), sun-dried and boiled paddy grains (1 kg) and “rice of the previous night soaked in water” (2-5 kg). The mixture is fermented for 36 hours, diluted and applied to each 1,500 m² pond during the daytime.

When berried females with grey egg masses are stocked, saleable PL are produced by day 15, measuring about 7-8 mm (a little longer than a cumin seed). Harvest continues from this day until day 25. PL are sold at INR 300-350 per 1,000 in oxygenated plastic bags at the pond site. A larger 22-25 mm stage is sold at INR 400-500 per 1,000. Buyers include progressive prawn farmers in Purba Medinipur; farmers at Ghatakpukur, Basirhat and Malancha in North 24 Parganas; and some villages in Bangladesh. In West Bengal, most giant freshwater prawn culture is concentrated in North 24 Parganas[14], in both freshwater and brackish-water polyculture systems.

## End note

Inland aquaculture plays an important role in poverty reduction: it provides reliable income, creates jobs and empowers low-income communities, small-scale and rural farmers[15]. In Purba Medinipur, both *M. rosenbergii* grow-out culture and PL production in ponds are carried out mostly by smallholder farmers, many of whom are resource-poor and marginal. Although smaller in scale than brackish-water shrimp farming,

*Good quality M. rosenbergii being sold at a fish market.*

these are established practices and clear avenues for income generation. Pond-based PL production creates employment while meeting the seed needs of grow-out farmers. In West Bengal, notable success has not yet been achieved in hatchery breeding and PL production of *M. rosenbergii*[16]. Rural pond PL production requires modest investment and is currently practised from March to June each year in Deshapran and Khejuri-2 CD Blocks of Purba Medinipur.

Among other systems, *M. rosenbergii* is a promising species for the cage-culture technology developed by ICAR-CIFRI for inland open waters of India (e.g., reservoirs), provided quality seed is available in adequate quantity[17]. The farmer-led seed-production method in brackish-water ponds in Contai-3 CD Block has been studied by researchers at the West Bengal University of Animal & Fishery Sciences and adds significant value to grow-out farming[18]. Pond oxygenation for 5-8 hours in every 24 hours (08:00-10:00, 15:00-17:00, 22:00-00:00 and 03:00-05:00) is essential; without sufficient aeration, egg incubation and hatching are impaired and larvae will not survive. Pond water should be iron-free and salinity should not exceed 15 ppt. After stocking *M. rosenbergii* mothers, bottom chaining/churning and aeration help maintain turbidity, which is important. Organic "juice" may be applied 2-3 days before stocking. Before stocking, apply a reputable Soil probiotics (mixed with sand), followed by a Water probiotics mixed with date-palm molasses in freshwater.

*M. rosenbergii* eggs hatch in freshwater ponds, but larvae do not survive; hence brackish-water ponds are used. Short, cut portions of date-palm branches and larger pieces should be treated with $KMnO_4$ before use. Both Sri Rana and Sri Das routinely check ammonia ($NH_3$) and maintain it below 0.1 ppm, with hardness at the lower end of the acceptable range. Suitability of pond water is the key to successful PL production. Although copper sulphate applied before stocking can kill unwanted molluscs, its use in aquaculture is no longer recommended. During transport of berried females from freshwater ponds and riverbanks to brackish-water ponds, stress should be kept to a minimum. For PL transport, 2,000-3,000 *M. rosenbergii* PL (7-10 mm) can be packed per polythene bag with roughly 1 part water to 2 parts oxygen for journeys of 5-6 hours. Buyers report that growth of these PL is comparable to riverine PL.

According to Sri Subhajit Mondal, a PL producer at Vill. Phulbari, Deshapran CD Block since 2019, PL (7-10 mm and 22-25 mm) in oxygenated packets are fit for journeys of 10-12 hours (or less) to destinations in Bangladesh and elsewhere. The larger PL can reach 35-40 g body weight in 100-120 days of grow-out when fed commercial pellets. He estimates that 2.0-2.5 million PL may be obtained from a 1,000 m² pond with effective water area. For one crop, he stocks 5-6 kg of berried females per 1,000 m² pond. The authors note that, because seed production in brackish-water earthen ponds occurs in summer, it is advisable to provide full or partial

*Transportation of berried M. rosenbergii in containers on two-wheeler.*

overhead shade to prevent excessive water-temperature rise. Higher temperatures may be unfavourable for the FLS and subsequent larval stages, and for PL. Direct, intense sunlight also raises salinity, which can exceed 15 ppt, is undesirable for PL production.

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# AI and IoT (AIoT): The New Wave in Fish Farming

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Aquaculture, once reliant on manual labour and traditional techniques, is undergoing a digital revolution. The emergence of artificial intelligence and the Internet of Things (AIoT) is reshaping fish farming into a smart, automated and sustainable sector. While conventional practices have long supported aquaculture's expansion, AIoT represents a shift towards inteligent, data-driven farm management.

Artificial intelligence now plays multiple roles across the production cycle, from hatchery management and feeding optimisation to disease diagnosis and harvest planning. By processing large data sets from sensors and imaging tools, AI enables real-time analysis of fish behaviour, stress indicators and biometric traits such as length and weight (Barreto et al., 2022; Tonachella et al., 2022). Predictive models extend this capability by identifying patterns that signal disease onset or sub-optimal conditions, helping reduce economic losses and mortality (Gladju et al., 2022).

Complementing AI, IoT infrastructure - sensors, cameras, cloud platforms and connectivity modules - forms the backbone of real-time data collection from diverse aquatic environments. These tools continuously monitor water parameters such as temperature, salinity, pH and dissolved oxygen, enabling timely intervention and informed decision-making (Bodaragama et al., 2024; Nagothu et al., 2024).

As aquaculture faces growing challenges such as disease outbreaks, nutrient waste and climate variability, AIoT-enabled precision aquaculture offers improved biological monitoring, environmental control and traceability (Antonucci & Costa, 2020). Innovations including digital twins and automated water-quality systems allow farmers to simulate conditions, predict outcomes and optimise operations while minimising ecological impact (Ubina et al., 2023; Singh et al., 2022). In short, integrating AIoT into fish farming is not just an upgrade; it is a reinvention of aquaculture. This new wave supports a future of resilient, efficient and environmentally conscious aquatic food production capable of meeting global demand without compromising sustainability.

## Challenges in traditional fish farming

Fish farming (aquaculture) plays a vital role in meeting rising global demand for seafood and now accounts for more than half of the fish consumed worldwide. Despite this importance, traditional methods face several challenges:

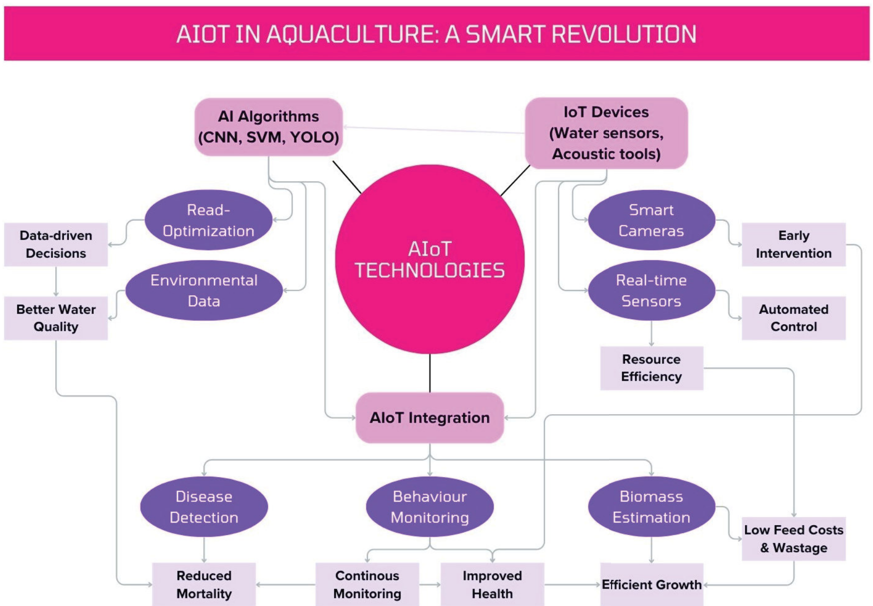
- Water quality monitoring is time-consuming and often relies on infrequent, manual testing.
- Feeding practices are frequently based on judgement rather than data, leading to over- or under-feeding.
- Disease outbreaks can spread rapidly in densely stocked ponds and are often detected too late.
- Labour shortages and rising costs are making operations less economically sustainable.

## What are AI and IoT?

Artificial intelligence (AI) refers to machines and software that perform tasks requiring human intelligence, such as learning from data, recognising patterns and making decisions. The internet of things (IoT) is a network of physical devices such as sensors and cameras connected via the internet to collect and share real-time data.

## Overview of studies exploring AI in aquaculture

Numerous studies highlight the transformative impact of artificial intelligence (AI) in aquaculture, with applications across the production cycle. Rastergari et al. (2023) examined internet-of-things (IoT) systems for maintaining water quality and monitoring environmental



parameters, emphasising the role of smart technologies in farm management. In disease detection, Darapaneni et al. (2022) demonstrated periodic optical monitoring to identify early signs of disease, enabling timely intervention. For intelligent feeding, Chen et al. (2022) used real-time sensor data to estimate shrimp biomass and determine precise feed requirements, while Wu et al. (2022) reported that intelligent feeding equipment can reduce labour, lower risk and improve overall efficiency. In deep-learning applications, Chen et al. (2022) applied an InceptionV3 pre-trained model that achieved 98.94% accuracy in classifying abnormal appearances in groupers, showing clear potential for health monitoring. Mustapha et al. (2021) further underscored AI's utility in traceability, feeding, disease management, growth forecasting, environmental observation and market analytics, affirming its role in improving productivity and sustainability.

## AIoT applications in aquaculture

Combining the internet of things (IoT) with AI is reshaping aquaculture by introducing more intelligent, efficient and sustainable practices.

### Enumeration of aquatic organisms

Accurate counting is essential for stock management, health monitoring and feed optimisation. Traditional methods are manual, invasive and error-prone, especially in high-density systems. Advances in AI, computer vision and sensors now support automated, accurate counting across species including fish, shrimp and sea cucumbers. For example, Hu et al. (2023) introduced ShrimpCountNet, a deep-learning density-estimation model that reached 98.72% accuracy when counting shrimp larvae. Pai et al. (2022) combined the YOLOv5 algorithm with optical-flow analysis to detect and count fish while tracking movement patterns as stress indicators. Sthapit et al. (2019) applied acoustic signal-processing to estimate fish populations within nets, achieving <10% error.

### Estimation of fish biomass

Accurate estimation of fish biomass is vital for optimising aquaculture operations, enabling precise assessment of health, growth rates and population density. Reliable biomass data supports efficient feeding strategies, minimises waste accumulation and enhances sustainability. Recent advances in machine learning, computer vision, sonar and smart sensing have enabled non-invasive, real-time biomass estimation, addressing the limitations of manual methods and stress-related inaccuracies. For instance, Zhang et al. (2024) implemented a customised deep-learning model (DL-YOLO) integrated with stereo vision for real-time fish detection, achieving a mean relative error of 2.87% and an $R^2$ of 0.98 when estimating fish length, height and weight. Similarly, Rossi et al. (2021) introduced a Bluetooth-enabled dynamic scale capable of measuring juvenile seabream biomass with a mean relative error below 1.4%. In addition, sonar combined with machine-learning models such as VGG networks has been used to estimate biomass in high-density tanks under variable water conditions, demonstrating the potential of AIoT systems for precision aquaculture.

### Intelligent feeding technologies

Smart feeding systems are a major advance in aquaculture, offering automated solutions that monitor feeding behaviour and environmental conditions to deliver precise amounts of feed at optimal times (Huang et al., 2025). The aim is to improve feed efficiency, reduce waste and support sustainable growth. Current research provides a strong foundation for systems that use several approaches to optimise feeding strategies. For example, Huang et al. (2024) and Li et al. (2022) employed gradient-boosting machines (GBM) and bioenergetic models to refine feeding frequency and nutrient allocation, improving growth performance. Advanced computer-vision techniques, such as R(2+1)D models and enhanced ResNet34 architectures, have been applied for automated detection of feeding behaviour and real-time feed identification (Cao et al., 2024; Atoum et al., 2015). Acoustic monitoring has also been used to correlate sound intensity with hunger levels, with models like the Audio Spectrum Swin Transformer (ASST) enabling accurate classification of feeding intensity (Wei et al., 2020; Zeng et al., 2020).

### AI-driven water-quality management

Maintaining optimal water quality is essential for sustainable, productive aquaculture, as the health, growth and welfare of aquatic species are closely tied to environmental conditions. Fluctuations in key parameters, dissolved oxygen (DO), pH, temperature and ammonia, can harm fish physiology, reduce growth and increase vulnerability to disease. Integrating IoT sensors with AI-based predictive analytics is increasingly important, enabling continuous, real-time monitoring and timely interventions to mitigate adverse conditions (Sun et al., 2020; Collos et al., 2014). For example, Sun et al. (2020) reported that deep-learning techniques, including convolutional neural networks (CNNs) and recurrent neural networks (RNNs), can forecast critical events such as oxygen depletion and water-quality deterioration. Similarly, Singh et al. (2022) presented a sustainable IoT solution for freshwater aquaculture that uses AI-driven monitoring to predict algal blooms and maintain environmental stability.

### Tracking fish movement

Accurate monitoring of fish behaviour, health, feeding patterns, breeding activity and population dynamics is essential in both controlled and natural environments. Schraml et al. (2021) showed that iris-pattern recognition can serve as a biometric tool for short-term identification of Atlantic salmon, achieving over 95% accuracy. Liu et al. (2019) developed a 3D video-tracking system to monitor fish behaviour in tanks, reporting precision above 95%. Williamson et al. (2017) used a modified nearest-neighbour algorithm to track fish and seabird activity around tidal turbines, even under turbulent conditions. To address issues with moving cameras, Chuang et al. (2017) proposed the deformable multiple-kernel (DMK) tracking algorithm, which maintained high accuracy despite variable camera motion.

### Monitoring fish behaviour

Monitoring behaviour is crucial for ensuring health, welfare and growth in aquaculture systems. Behavioural changes often signal stress, disease, feeding status or unfavourable environmental conditions, allowing earlier, better-informed decisions. Hu et al. (2024) introduced a deep-learning system using a ResNeXt 3 × 1D convolutional network, achieving 95.3% accuracy in detecting abnormal behaviours. Hassan et al. (2020) developed a Doppler-based acoustic telemetry method to estimate swimming speed in marine cages, reporting a root-mean-square error of 7.85 cm/s across a range of biologically relevant velocities.

### Use of AI technologies for the diagnosis of aquatic animal diseases

A key application of artificial intelligence (AI) in aquaculture is early identification and control of disease, which is essential for maintaining health and welfare (Rather et al., 2024). AI offers rapid, accurate and non-invasive diagnostic capabilities that can greatly improve detection and management. Using machine-learning and deep-learning techniques, AI can analyse images to identify physical symptoms, such as lesions, discolouration or abnormal growths, in fish and shrimp. AI-powered systems can also monitor behavioural changes, including erratic swimming or reduced feeding, by analysing video or sensor data. Predictive models built from historical disease records, environmental conditions and water-quality parameters can forecast potential outbreaks. These tools support early diagnosis and timely intervention, help reduce antibiotic use and improve farm productivity through decision-support systems tailored to local conditions.

Multiple AI techniques have been applied effectively in disease detection. Li et al. (2023) used a deep-learning algorithm (YOLOv4, implemented in Python) to detect fish parasites, *Ichthyophthirius multifiliis*, *Gyrodactylus kobayashii* and *Argulus japonicus*, achieving 95.41% detection accuracy. Ahmed et al. (2022) applied a support vector machine (SVM) to distinguish infected from healthy fish, reporting 91.42% accuracy without augmentation and 94.12% with augmentation. Hassan et al. (2022) used a convolutional neural network (CNN) to detect red-spot and white-spot diseases, recording 94.44% accuracy for red spot and 91.67% for white spot. Together, these studies illustrate AI's growing role in improving the accuracy and efficiency of disease detection in aquaculture.

AI algorithms can also support better decisions by analysing complex data sets. By leveraging data from sensors, satellite observations and historical records, AI can optimise decision-making to support fish health and growth (Gladju et al., 2022). Furthermore, AI can flag early signs of disease by integrating behavioural patterns, physiological indicators and environmental factors. These technologies also enable precision-aquaculture practices, optimising production processes through real-time data analysis (Fini et al., 2025).

### Benefits of smart aquaculture

Integrating AI and IoT offers several benefits:

- Higher productivity: Real-time data supports more precise management.
- Cost savings: Less feed waste and lower labour costs.
- Environmental sustainability: Improved water management and reduced pollution.
- Better fish health: Earlier problem detection lowers mortality.
- Data-driven decisions: Farmers act on evidence rather than guesswork.

## The future of AI and IoT in aquaculture

As technology advances, opportunities for smart aquaculture are expanding:

- Aerial monitoring: Drones with thermal cameras could survey large farms.
- Traceability: Blockchain may track fish from farm to fork, improving transparency and food safety.
- Selective breeding: Genetic algorithms could help choose optimal breeding pairs.
- Automation: AI-powered robots may handle harvesting and pond cleaning.

With more sophisticated machine-learning models, predictive analytics will play a larger role in planning production cycles, managing resources and responding to climate change.

## Conclusion

The integration of artificial intelligence and the internet of things (AIoT) is ushering in a new era of innovation and efficiency in aquaculture. AIoT is addressing long-standing challenges such as water-quality management, disease detection and feed optimisation by enabling real-time monitoring, predictive decision-making and automation across production stages. Smart technologies show strong potential to improve fish health, reduce environmental impact and lift overall productivity.

As digital tools become more accessible and capable, the sector is moving from traditional, labour-intensive operations to intelligent, data-driven systems. Barriers to widespread adoption remain cost, infrastructure and training, but the future of aquaculture clearly lies in precision, sustainability and technological integration. Continued research, collaboration and innovation will be essential to unlock the full potential of AIoT and build a more resilient, responsible aquaculture industry.

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NACA Newsletter

Published by the Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand

ISSN 0115-8503

Volume XXXX, No. 3
July-September 2025

# AquaInnovate showcases regional aquaculture innovation and nature-based solutions


*AquaInnovate participants.*

The first AquaInnovate event, held in Bangkok from 12-16 May, brought together aquaculture startups, entrepreneurs, researchers, and investors from across the Asia-Pacific region for an intensive week of learning, pitching, and collaboration. Convened by NACA and FutureFish, with funding support from Canada's International Development Research Centre (IDRC), the programme focused on accelerating nature-based aquaculture innovation and building a stronger regional startup ecosystem.

## A platform for innovation

AquaInnovate was designed to provide entrepreneurs with the knowledge, networks, and tools to transform promising ideas into viable businesses. Over 25 participants from across Asia-Pacific joined the event, representing a diverse mix of early-stage companies, researchers, and innovators. Across five days, they engaged in interactive sessions, personalised coaching, field visits, and practical workshops, all aimed at sharpening business models and fostering partnerships.

## Startup pitches and feedback

A key feature of the event was the startup pitch sessions, where 14 aquapreneurs presented solutions ranging from sustainable aquafeeds and probiotics to shrimp health innovations, aquaculture automation, and circular economy approaches. Each pitch was followed by questions and feedback from peers, industry experts, and investors.

Entrepreneurs received practical advice on investment readiness, market positioning, and scaling strategies, helping to refine their value propositions

Industry representatives from HydroNeo and UniFAHS shared lessons on scaling aqua-tech and biotech innovations, stressing the importance of affordability, trust-building, and local validation. Their insights reinforced the challenges and opportunities for startups navigating fragmented markets in Asia.

## Expert sessions and coaching circles

The programme featured a series of expert-led sessions on core themes, including:

- Business fundamentals - practical steps to strengthen operations, build scalable ventures, and prepare for investment.
- Investing for impact - strategies to attract mission-aligned capital and engage with investors in developing Asia.
- Nature-based aquaculture solutions - aligning innovation with ecosystems, community resilience, and sustainability.
- Gender equality and social inclusion (GESI) ensuring aquaculture innovation is accessible, equitable, and empowering.

Small-group coaching circles gave participants the opportunity to workshop challenges directly with experts, covering issues such as IP ownership, commercialisation strategies, financing, and inclusive business design. These sessions provided targeted feedback and encouraged peer learning.

## Field visits: Learning from Thai innovators

Participants travelled to two pioneering farms in Thailand for hands-on learning. At LST Farm, Somprasong Natetip demonstrated Thailand's only biosecure hatchery producing SPF all-male freshwater prawns, showcasing genetic RAS systems and low-energy water treatment innovations. At Boonsawang Farm, Gunn and Suthi Mahalao shared their approach to premium seabass farming, covering disease management, certification, and diversification into new species. These visits offered practical insights into the realities of farm operations, innovation adoption, and the commercial drivers shaping aquaculture businesses.

## Watch the presentations

Videos of startup pitches and expert sessions from AquaInnovate 2025 are now available from the NACA website and YouTube channel, which you may access directly from the linked descriptions below:

https://enaca.org/?id=1403

An interim website for the AquaHub has also been established, and with the full website slated for launch in February 2026. For background on the participants and full programme details, please see the Aqua Hub website at:

https://aquahub.asia

Reimagine Fish Farming with RAS-P.I.N.A.S

Elisa Claire Sy of E-Primate presents RAS-P.I.N.A.S, a closed-loop, water-efficient system for land-based fish farming. The technology integrates biofiltration, aeration, and mechanical treatment to support high-density production while conserving water and land and reducing disease risk. RAS-P.I.N.A.S also offers flexibility in farm siting, with trade-offs in energy use and infrastructure costs. Recirculating aquaculture systems are gaining traction as a key innovation in Asia's sustainable aquaculture future.

Green Controller: Smart Farming for a Sustainable Future

Green Controller by ICM Electronics is a smart water quality monitoring system for aquaculture, powered by high-precision titanium sensors. It tracks dissolved oxygen, salinity, and pH in real time, with full control through a mobile app and instant anomaly alerts. The system enables automated aeration based on live data, reducing energy use, lowering aerator run time, and improving feed conversion efficiency for more sustainable aquaculture operations. This pitch was presented Sukmit Teekhasenee of ICM Electronics.

Cweed Aquasolutions: Empowering Communities Through Nature-based Solutions

Cweed Aquasolutions, a spin-off from Universiti Malaya, works with coastal communities to develop seaweed cultivation through integrated multi-trophic aquaculture. The initiative repurposes abandoned shrimp ponds in Peninsular Malaysia, providing training and technical support for farmers to start seaweed farming. Cweed Aquasolutions also buys back harvested product, creating a sustainable livelihood model that links community development with nature-based aquaculture solutions. This pitch was presented Adibi M. Nor, CTO of Cweed Aquaculture Solutions.

ShrimpGuard: Nature's shield for healthy shrimp

ShrimpGuard, developed by BIOTEC, NSTDA, and Kasetsart University in Thailand, is a phage-based innovation for managing shrimp health. It targets Vibrio infections using bacteriophages combined with immune-boosting agents, reducing antimicrobial use while improving farm productivity and sustainability across ASEAN. The project also engages farmers directly through training, outreach, and field trials to ensure practical application and lasting benefits for coastal communities and the wider aquaculture sector. This pitch was presented by Wanilada Rungrassamee of BIOTEC.

Circular Nutrition: Transforming Fish Byproducts into Sustainable Aquafeed

Circular nutrition in aquaculture focuses on reducing waste and closing nutrient loops by transforming fish byproducts into sustainable aquafeed. Simon Das from the Tropical Aquafeed Innovations Lab at James Cook University presents how this model can cut reliance on wild-caught forage fish while supporting cost-effective, nutritionally balanced diets. The lab's work includes developing weaning protocols for pellet-ready fingerlings, training farmers in advanced feeding practices and economics, and promoting gender and youth inclusion. Circular nutrition highlights how rethinking resource use can make aquaculture both more efficient and more sustainable.

TOMGOXY: Super Intensive Vannamei Shrimp Farming Towards Sustainability and Carbon Neutrality

TOMGOXY is an AI- and IoT-powered shrimp farming system developed by RYNAN Aquaculture in Vietnam. It transforms traditional ponds into super-intensive, high-efficiency systems that deliver higher yields with reduced water and energy use. The platform integrates smart sensors, cloud analytics, and advanced aeration to maintain optimal water quality, cut antibiotic reliance, and advance sustainable shrimp aquaculture. By combining digital technology with practical training and on-farm deployment, TOMGOXY helps farmers increase productivity, lower costs, and build long-term resilience in the shrimp industry. This pitch was presented by Dang Pham of RYNAN Aquaculture.

QS Aqua Technology: Nature-based Innovation for Sustainable Aquaculture

QS Aqua Technology, a startup from the InnoHub Program of Universiti Putra Malaysia, develops nature-based probiotic solutions for sustainable aquaculture. Their approach combines beneficial bacteria that support gut health and maintain balanced pond ecosystems with quorum sensing inhibition compounds from microalgae. These compounds block harmful bacteria from communicating, preventing disease outbreaks and reducing dependence on antibiotics. By improving pond health and resilience through microbial and algal innovations, QS Aqua Technology offers farmers safer, more sustainable tools to manage aquaculture production. This pitch was presented by Maya Liyana Hamzah.

### PowBio: A nature-based microbial solution turning fish pond waste into protein

PowBio is a microbial inoculant developed by NileBioFish (NINEBIO GROUP Co., Ltd.) in Thailand to support sustainable biofloc aquaculture systems. Co-developed with Maejo University's Faculty of Fisheries and Aquatic Resources and supported by the Thailand National Innovation Agency, PowBio uses high-efficiency microorganisms to turn fish pond waste into natural protein. By reducing ammonia and nitrite levels, improving water quality, and recycling nutrients within ponds, PowBio helps farmers cut feed costs, lower water exchange needs, and reduce chemical inputs. The result is healthier harvests without muddy off-flavors—delivered through a practical, low-cost, and easy-to-use solution for more productive and resilient aquaculture. This pitch was presented by Nissara Kitcharoen of NileBiofish.

### DeepBlue Aquaculture: Phytogenics Approach to Improve Mud Crab Growth Performance

DeepBlue Aquaculture, the world's largest soft-shell crab operation, is pioneering the use of phytogenics to improve mud crab growth performance. Soft-shell crab farming is traditionally labor-intensive and low-yield, making it difficult to scale. Their proprietary plant-based additive, PhytoEcR, boosts mud crab growth and moulting rate—delivering up to 20% higher weight gain after 45–60 days, with a 40% increase in moulting rate and 35% faster moulting compared to control groups. PhytoEcR is now moving into commercial-scale testing, aligning with global trends in phytogenic feed solutions to enhance productivity and sustainability. This pitch was presented by Andrew Ng of Deep Blue aquaculture.

### Life Cycle Assessment for Eco-friendly and Sustainable Aquaculture by Nature-based Practice

This presentation introduces a life cycle assessment tool designed to evaluate the sustainability of nature-based aquaculture practices. The tool measures environmental impacts such as carbon footprint and supports farmers, researchers, and policymakers in identifying mitigation strategies for more eco-friendly production systems. This pitch was presented by Kobboon Kaewpila of the Life Cycle Sustainability Assessment Laboratory, King Mongkut's University of Technology.

### LEAPS: Leveraging Climate-Smart Shrimp Aquaculture Solutions in Indonesia

LEAPS is a climate-smart aquaculture initiative in Java that combines shrimp farming with mangrove restoration to strengthen coastal community resilience. Implemented under the AQUADAPT program with funding from Global Affairs Canada and IDRC, the project promotes inclusive, nature-based approaches for small-scale shrimp aquaculture. By integrating real-time IoT water quality monitoring, wastewater treatment and gender-responsive practices, LEAPS reduces greenhouse gas emissions while restoring mangroves and supporting communities. The project also informs evidence-based policy, helping scale sustainable aquaculture solutions across the region. Aligning shrimp farming with ecosystem restoration, LEAPS supports livelihoods and adaptation. Pitch presented by Rocky Pairunan and Burhanuddin Zein.

### Digital Solutions for Farmers in Myanmar

Farm Suite by Greenovator is a digital farm management tool tailored for aquaculture in Myanmar. The platform helps farms and agribusinesses streamline planning and daily operations by tracking activities, inputs, and yields through a real-time, business-grade dashboard. Recognised as a top-3 innovation in the Grow Asia Challenge, Farm Suite provides an affordable, professional alternative to manual record-keeping. With its mobile app interface, it delivers actionable insights that empower aquaculture managers to boost productivity and sustainability. This pitch was presented by Yin Yin Phyu.

### UniFAHS: The Startup Journey of a Thai Phage Biotech Pioneer

Kitiya Vongkamjan, co-founder of UniFAHS, shares the journey of building a pioneering phage biotechnology company in Thailand. UniFAHS develops bacteriophage-based solutions to tackle antimicrobial resistance and improve food safety in agriculture, aquaculture, livestock, and food processing. From its origins in research at Chulalongkorn University to recognition as a Global Finalist in the Extreme Tech Challenge 2022, UniFAHS has grown into a venture-backed startup, raising USD 1.4 million in seed funding from A2D Ventures, ADB Ventures, and InnoSpace (Thailand). The story highlights how cutting-edge science can be transformed into scalable commercial solutions with real-world impact.

### HydroNeo: Startup Journey of a Smart Aquaculture Innovator

In this presentation, Fabian Reusch, founder of HydroNeo, shares the story of how HydroNeo began and the lessons learned along the way of building a tech startup in Thailand. Aimed at fellow aquaculture entrepreneurs and startup founders, his talk is an open and honest reflection on the realities of the journey — not a polished, glamorous pitch that only highlights the wins, but a candid look at both successes and setbacks, the difficult decisions, and the ongoing challenges that shape the real path of building a company.

### Nature-based Aquaculture for Entrepreneurs and Innovators

Mariska Bottema (WorldFish) and Rebecca McMillan (IDRC) discuss the concept of nature-based aquaculture, why it matters for innovation and entrepreneurship, and how it can support ecosystems, communities, and profitability. Topics include: Defining nature-based aquaculture and its connection to nature-based solutions; criteria such as climate resilience, ecosystem health, reduced antimicrobial use, and inclusivity; global examples: mangrove–shrimp integration, women-led seaweed farming, integrated multi-trophic systems, and rice–fish farming; supportive technologies including IoT, renewable energy, and life cycle assessment; and opportunities for entrepreneurs: resilient farms, reduced risks, lower costs, premium markets, funding, and partnerships.

### Nature-based Seafood Markets & Creative Partnerships

A discussion panel on how creative partnerships build markets for nature-based seafood from farm to fork with Special Guest Chef Black (Blackitch Artisan Kitchen)

# Knowledge brokering for nature-based solutions in aquaculture

NACA's AQUADAPT knowledge-brokering project has released three new publications from Fiji, Thailand, and the Philippines, prepared to inform development of the Aquaculture Innovation and Investment Hub (AquaHub) and country innovation and investment plans. The work aligns with the FAO-NACA transformation agenda by documenting practical nature-based solutions (NbS) already in use, the conditions that enable them, and where further evidence is needed to scale. AQUADAPT is funded by Canada's International Development Research Institute (IDRC).

### Climate change and social resilience

Across all three countries the focus is the same: Mitigate and adapt to climate change risks, improve efficiency and resilience, and capture social inclusion benefits where possible. The publications assemble farm-level cases and early metrics (productivity, energy use, costs, and-where available-emissions), providing a baseline for policy, technical assistance, and investment decisions.

### Fiji

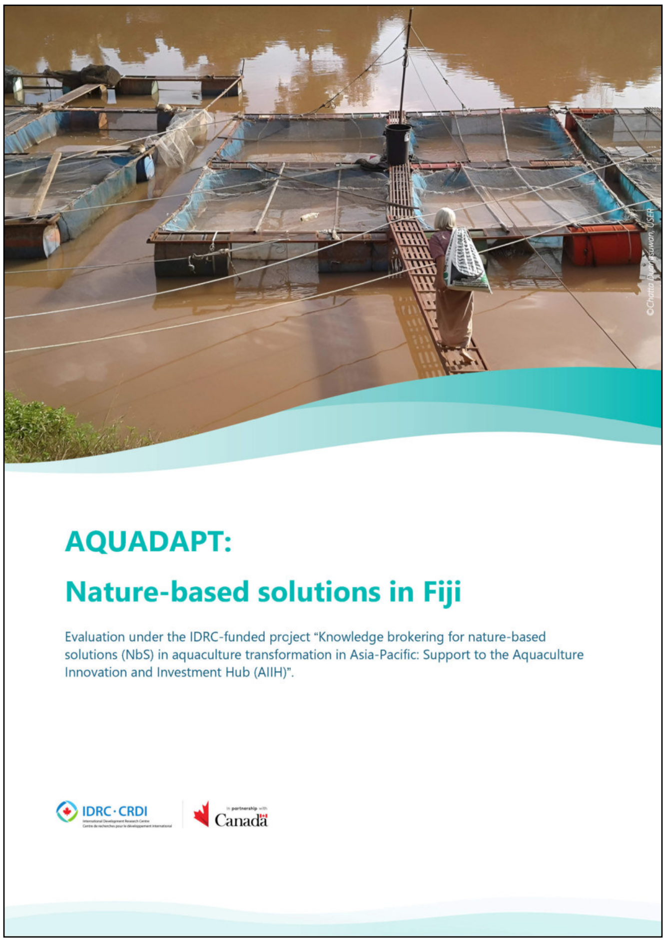
The Fiji report profiles four enterprises-Kerry Farms, SEAPAC PTE Ltd., Growa Fish Fiji Ltd., and the Muana-Ira community mangrove oyster project-covering tilapia, giant freshwater prawn, whiteleg shrimp and bivalves. Reported NbS include solar power (e.g., a planned 50-kW system at SEAPAC and solar pumping/aeration at Kerry Farms), hydropower and trompe aeration at Growa Fish, HDPE linings and biofloc, and an unfed, nature-positive oyster operation led by a women's group. The study also notes supply-chain realities for equipment (average landed-cost split ~71% purchase price, 14% shipping, 15% taxes/duties/inland freight), absence of major notifiable aquatic diseases at the time of reporting, and significant women's participation.

### Thailand

Thailand's showcases present quantified outcomes from three energy-focused innovations. On a striped snakehead farm, adding on-grid solar for pumping and a daytime solar aerator increased productivity by ~21-25%, cut electricity per kilogram by ~42%, reduced energy costs per kilogram by ~42%, and lowered combined $CO_2$ emissions by ~28% (to ~0.79 kg $CO_2$-eq per kg of fish). At an intensive shrimp farm, a smart aerator control system reduced electricity per kilogram by 20% and lifted farm output by ~33%. A second shrimp site combining 50.4 kWp solar with smart aeration improved energy intensity by ~22% per kilogram and raised annual output by ~29%, while trimming costs and emissions.

### Philippines

AQUADAPT: Nature-based solutions in the Philippines reports a preliminary scan of NbS in use-off-grid power, renewable materials and design improvements-plus an initial pipeline of 50 aquaculture innovations based on BFAR regional submissions, to be extended and screened with BFAR National Research Centers. Early field observations from CALABARZON and Region III document farms implementing NbS; forthcoming work will add GESI and transformation dimensions as detailed assessments proceed.




### What this means for the AquaHub

Taken together, these findings begin to show where NbS are already delivering practical gains-lower energy intensity, steadier water quality, and, in some cases, measurable productivity improvements-while also exposing data gaps that matter to investors (e.g., consistent cost/benefit records, durability of performance across seasons). For the AquaHub, the near-term value lies in converting these documented practices into a structured pipeline: pairing innovators and farms with appropriate finance, technical partners and verification methods, and supporting governments with evidence for targeted incentives. As the datasets mature, the AquaHub can help standardise metrics (energy per kg, $CO_2$ per kg, survivals, payback) and convene partnerships that de-risk adoption at scale.

### Publications & downloads

- AQUADAPT: Nature-based solutions in Fiji: https://enaca.org/enclosure/?id=1397
- AQUADAPT: Nature-based solutions in Thailand: https://enaca.org/enclosure/?id=1399
- AQUADAPT: Nature-based solutions in the Philippines: https://enaca.org/enclosure/?id=1398


INFOFISH has organised editions of the International Trade and Technical Conference and Exposition on Tilapia since 2001. The most recent was TILAPIA 2015, held in Kuala Lumpur in 2015 with the participation of more than 250 delegates from 25 countries. The Conference brought together more than thirty speakers comprising industry leaders, government representatives, researchers and experts who deliberated on the latest updates regarding production, markets and trade; innovations along the value and supply chains; industry initiatives on certification; and tilapia health management.

TILAPIA 2025, the 5th edition of the series, will be held in collaboration with the 13th International Symposium on Tilapia in Aquaculture (ISTA13); the University of Arizona; US Soybean Export Council (USSEC); and with the technical support from the Food and Agriculture Organization of the United Nations (FAO) and NACA. Themed "Innovation, Integration and Profitability in Tilapia Aquaculture: Modernisation for a New Era", TILAPIA 2025 will present updates on the production status of global, regional and major tilapia producing countries. It will also deliver consolidated information on emerging markets; innovative technological developments along the value and supply chains such as integration of farming practices, genetics and reproduction, nutrition and feed technology, biosecurity and health management; standards and certifications; wellbeing of small-scale holders and tilapia itself; policies related to investing in climate-smart, gender-focused and nutrition-sensitive aquaculture projects; valueadded products; diversification of markets; and consumer awareness as per local and international market demand; which might be useful for key industry stakeholders and relevant decision-makers from the competent authorities to move forward.

Alongside the Conference, there will be an international trade exhibition which is expected to be held with the presence of about 20 exhibitors represented by leading tilapia hatcheries, farms, feed millers, buyers, processors, traders and cage manufacturers etc.

For more information, the programme and registration please visit the Tilapia 2025 website.

https://tilapia.infofish.org/

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## 12th Symposium on Diseases in Asian Aquaculture
## 23-27 September 2025, Chennai, India

The Fish Health Section of the Asian Fisheries Society (FHS-AFS) invites everyone to the 12th Symposium on Diseases in Asian Aquaculture (DAA12), to be held from 23-27 September 2025 in Chennai, India. DAA12 continues the legacy of the DAA series by providing an exceptional platform for researchers, industry professionals, and students to come together and share their expertise in the vital field of aquatic animal health.

Hosted by FHS-AFS in collaboration with the ICAR-Central Institute of Brackishwater Aquaculture in Chennai, India, DAA12 promises to be an enlightening experience. With the theme "Transformative Innovations Shaping the Future of Aquatic Animal Health Management", it reflects our commitment to addressing the pressing challenges faced by our industry today. Over the five-day event, participants can look forward to a dynamic program featuring seven technical sessions that showcase the latest advancements and research in aquatic animal health.

Key topics will include: Finfish and Shellfish Health, One Health and Aquatic Animal Biosecurity, Aquatic Animal Epidemiology, Disease Surveillance & Reporting and New Emerging Technologies in Aquatic Animal Health Management. Each session will feature esteemed experts delivering insights that will foster rich discussions and promote the sharing of cutting-edge research.

We warmly invite researchers, industry professionals, academia, and students to join this exciting symposium and collaborate on sustainable solutions for aquaculture's future. Mark your calendars for an unforgettable experience in DAA12 at Chennai, India!

For more information, please visit the Diseases in Asian Aquaculture 12 website.

https://daa12.in/

# Reported Aquatic Animal Diseases in the Asia-Pacific Region during the Fourth Quarter of 2024

Listed below are the reported aquatic animal diseases submitted by countries in the Asia-Pacific region, which covers the fourth quarter of 2024. The original and updated reports can be accessed at the QAAD page:

https://enaca.org/?id=8

### Finfish Diseases

- **Infection with Infectious haemat-opoietic necrosis virus:** Australia in wild juvenile redfin perch (*Perca fluviatilis*).
- **Infection with red seabream iridovirus (RSIV):** Chinese Taipei in seabass (*Lates calcarifer*) and hybrid grouper (*Epinephelus fuscoguttatus* x *E. lanceolatus*); India, reported as Infectious spleen and kidney necrosis virus (ISKNV) in oscar (*Astronotus oscellatus*), blue acara (*Adinoacara pulcher*) and midas cichlid (*Amphilophus*) hybrid; and, Indonesia in barramundi (*L. calcarifer*).
- **Infection with Koi herpesvirus (KHV):** Indonesia in common carp (*Cyprinus carpio*).
- **Infection with Tilapia lake virus (TiLV):** Indonesia in Nile tilapia (*Oreochromis niloticus*) and saline tilapia.
- **Viral encephalopathy and retin-opathy (VER):** Australia in farmed Queensland grouper (*E. lanceolatus*); Chinese Taipei in hybrid grouper (*E. fuscoguttatus* x *E. lanceolatus*) and orange spotted grouper (*E. coioides*), India in mangrove red snapper (*Lutjanus argentimaculatus*); and, Indonesia in barramundi (*L. calcarifer*), hybrid grouper and pompano (*Trachinotus* spp.)
- **Enteric septicaemia of catfish:** India in pangas catfish (*Pangasius hypophthalmus*); and Indonesia in pangas catfish.

### Molluscan Diseases

**Infection with abalone herpesvirus:** Australia in blacklip abalone (*Haliotis rubra*).

- **Infection with Perkinsus olseni:** India in wild green mussel (*Perna viridis*).

### Crustacean Diseases

- **Infection with white spot syndrome virus (WSSV):** Chinese Taipei in whiteleg shrimp (*Penaeus vannamei*); India in *P. vannamei*; Indonesia in *P. vannamei* and black tiger shrimp (*P. monodon*); and, the Philippines in *P. monodon* and *P. vannamei* (PLs and grow-out) and wild crabs and shrimps.
- **Infection with Infectious myone-crosis virus (IMNV):** Indonesia in *P. vannmei* and *P. monodon*.
- **Infection with taura syndrome virus (TSV):** Indonesia in *P. vannamei*.
- **Acute hepatopancreatic necrosis disease (AHPND):** The Philippines in *P. vannamei*.
- **Hepatopancreatic Microsporidi-osis caused by *Enterocytozoon hepatopenaei* (HPM-EHP):** India in *P. vannamei*; Indonesia in *P. vannamei* and *P. monodon*; and the Philippines in *P. vannamei*.

### Amphibian Diseases

- **Infection with *Batrachochytrium dendrobatidis*:** Australia in an unknown species of amphibian.

### Other Diseases

- India reported **Infection with Tilapia parvovirus** in Nile tilapia (*Oreochromis niloticus*).

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NACA is a network composed of 20 member governments in the Asia-Pacific Region.