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AQUACULTURE ASIA

Soft-shell mud crab production

Integrated mangrove-aquaculture systems

Hilsa seed production

Highland recreational fisheries

AQUACULTURE ASIA

Rethinking approaches to policy in development

"I merely note, if you want to catch something, running after it isn't always the best way." - Andre Norton.

NACA is a technical agency, but of course our work touches on many issues relevant to policy, be it social, environmental, or industrial. NACA often contributes to policy discussions, but mainly from a technical standpoint, drawing on examination of technical issues and discussions with stakeholders on real-world implementation problems. But NACA is not a 'policy' organisation per se.

We work in partnership with many other technical and donor agencies that also perform a similar role, or at least, that have done so historically. But in recent years we have started to see an increasing emphasis on 'policy' in such agencies. Specifically, we are seeing a decreasing emphasis on technical interventions, such as improved technologies and management practices, in favour of 'policy' projects that have, if I may be frank, little to no tangible impact.

Not because they are inherently awful – although they may be – but mainly because there is no real-world follow up. A consultation is held, and the report goes on the shelf, perhaps with some 'policy briefs' and it's done. We've all seen it. The work is often justified with the untested and dubious assertion that it has an outsized impact because it targets policy makers, but officials involved in the work are generally further down the food chain, and no actual outreach is undertaken at the real policy level.

By contrast, some of the most successful development projects I have seen since joining NACA were a series of ACIAR-funded projects assisting poor local communities to plan and manage culture-based fisheries, as a secondary use of communal dams. Dead simple, low-tech solutions that delivered real nutritional and economic benefits to people with few livelihood options. After the projects finished, the communities have continued the activity and it has spread organically to others. Governments, engaged in supporting the activities and coordinating with communities from the start, have incorporated the practices and approaches into their own toolkits and are applying them and offering support to communities elsewhere.

Consider this: A policy change has occurred, although no 'policy work' was ever conducted. There are many other such examples. Farmers in Asia move very quickly to seize on new opportunities. And when governments are involved in successful interventions, high-level policy support is likely to rapidly follow.

This is the key point: Technical agencies can exert a strong influence on policy merely by offering high quality technical guidance and solutions, playing to their own strengths. There is no need for technical agencies to reinvent themselves as 'policy' organisations, in fact, my observation is that it can be counterproductive.

This is not to say that policy consultations and workshops don't have their place in gathering stakeholder input and feedback. But the main reason pure policy work is failing to make an impact is because it isn't being followed up with actual action. The recommendations coming out of consultations should be the basis for the next round of field projects. But sadly, there appears to be a real disconnect between the two.

Simon Wilkinson

Aquaculture Asia

is an autonomous publication that gives people in developing countries a voice. The views and opinions expressed herein are those of the contributors and do not represent the policies or position of NACA.

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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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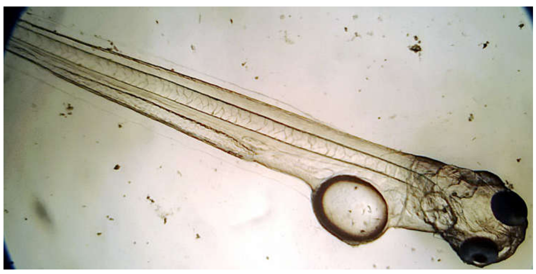

Sustainable livelihood model for coastal families through seabass fingerling production: A success story

D. Deboral Vimala, C.V. Sairam, M. Kailasam, K. Ambasankar, K.K. Vijayan, P. Mahalakshmi, S. Sivananam, R. Subburaj, and G. Thiagarajan

The fisheries sector is often referred to as a sunrise sector, due to its recent resurgence, and assumes significance in the Indian economy in several aspects[1]. This sector contributes to the livelihood of a large section of the economically underprivileged population of the country. Fisheries are an important source of food, nutrition, employment, and income in India. The sector provides livelihoods to about 16 million fishers and fish farmers at the primary level and almost twice that number along the value chain. Fish, being an affordable and rich source of animal protein, is one of the healthiest options to mitigate hunger and malnutrition. The sector has immense potential to more than double fisher and fish farmer incomes, as envisioned by the government (National Fisheries Policy 2020).

At present, the aquaculture sector contributes around 50 per cent of all seafood produced for human consumption, and this will continue to increase in the coming years. Although aquaculture is practised in all kinds of water resources, future aquaculture development is expected to be more prospective in brackishwater. This is because there are fewer competing uses for brackishwater, since it is seldom used for drinking water, crops or animal husbandry. In India, excluding the 1.2 million hectares of coastal land area identified as suitable for pond-based brackishwater farming, about 3.9 million ha of open brackishwater comprising estuaries, creeks, backwaters, and lagoons remain under-utilised for fish production (CIBA: http://www.ciba.res.in/). Successful utilisation of these water bodies for fish production through a participatory approach by coastal fishers can not only provide employment, but also help to meet food demand.

Grading Asian seabass fingerlings.

Need for intervention

Kilarkollai Village in Chengalpattu District of Tamil Nadu is bestowed with open brackishwater sources around the village periphery which are under-utilised. The villagers believed that this resource could not be used for agriculture, washing, cooking, or other purposes. In line with the Union Government's mission of doubling fish production, the ICAR-CIBA team under the Scheduled Caste Sub Plan Scheme/Programme (SCSP) of the Government of India suggested to take up seabass fingerling production to provide livelihoods for the villagers. In this backdrop, the ICAR-CIBA team identified Kilarkollai Village and made a road map to improve the livelihoods of local people through brackishwater aquaculture technologies. To start with, the suitability of the site was assessed for its soil and water quality, and with regard to its potential for Asian seabass (*Lates calcarifer*) fingerling production.

An awareness programme was organised, which aimed at showcasing technology-based aquaculture development, backed by the Institute's technical expertise. Two group discussions were also held with farmers about the aquaculture scenario, their livelihood status, their expectations, and the objectives of CIBA's technological interventions. The ICAR-CIBA team also provided knowledge empowerment to coastal villagers through capacity building programmes on brackishwater aquaculture, so as to adopt the latest technologies for the benefit of the individuals as well as the village as a whole.

Among the total population, around 168 (77%) families belong to scheduled castes and have dwelt in the village for the past 50 years. Out of them, 80.33% are landless poor and are economically and socially marginalised with a standard of living below the poverty line. A total of 61 coastal families attended the awareness programme, and four scheduled caste families enthusiastically came forward to adopt ICAR-CIBA technologies under the SCSP. A team of scientists along with the villagers identified a suitable location for demonstration of seabass nursery rearing in hapas. As mentioned earlier, this study aimed identify and document needs-based and sustainable livelihood interventions for coastal villagers. In this context, natural resource availability, the perceived needs of the respondents, skill development and training, scope of marketing, and sustainability issues were also addressed.

Socio-economic profile of the coastal fish farmers

The results of the study showed that 75 % respondents belonged to the middle age group (46–50) followed by 25% older age. All of them underwent primary level education (II Std-V Std). All were married and living in large families with more than five members. They had access to public services including a ration card, voter ID and a primary health centre. Respondents generated their income by working as labourers in paddy and groundnut fields. All were dependent on agriculture and engaged in other activities such as masonry and coconut harvesting for income. They do not own fishponds nor have experience in fisheries/aquaculture related activities. They have not undergone any training nor were they aware of fish culture activities till ICAR-CIBA came to their village. After the 2004 tsunami, an NGO had provided inputs and assisted them to take up crab fattening as a livelihood. After two cycles, this activity was not continued due to the discontinuance of the support of the NGO. Other than these, none of the activities related to the fisheries sector was taken up. They borrowed from money lenders as well as informal sources. None had access to banks for loans or savings. The lack of savings and the need for the sustenance of livelihoods often led to indebtedness.

Cleaning the hapa.

Livelihood for coastal families through seabass fingerling production

The ICAR-CIBA team found that the open brackishwater bodies were suitable for nursery rearing of seabass. The team, in consultation with the village leaders and beneficiaries, proposed to demonstrate seabass nursery rearing in hapas. Four families were trained on the nursery rearing of Asian Seabass. The training covered all aspects of nursery rearing including seed selection, seed stocking, feeding, grading, regular water quality management and harvesting. The bar mouth at the village was open for most of the year with good continuous water exchange, maintaining water quality suitable for nursery rearing. A nursery rearing unit composed of ten hapas (2x1x1m) was installed in a 120 m^2 backwater area, fenced with fenced HDPE-coated GI mesh. Hatchery-produced seabass fry in the size range of 1.2-1.8 cm were stocked @500/hapa. The fry was fed with formulated feed (Seabass Nursery Plus) developed by CIBA. The seed was graded to maintain uniform size in order to avoid cannibalism and differential growth. The nursery rearing period to grow from fry to fingerling size was 57-73 days. The total number of cultures taken were six, and out of 5,000 fry stocked for each culture, the survival of the fingerlings ranged

from 1,790 (36%) to 2,691 (54%). The size of the fingerlings was 3 cm to 17 cm. Nursery rearing is the first and critical stage in seabass culture since the stocking sized seed is produced during this phase. Four cycles of seabass nursery rearing can be taken up in a year if fry and seed are available on continuous basis.

An interesting thing to note here was that on an average one person spent one hour in the morning and one hour in the evening feeding the fry twice a day and monitoring. At the same time, they could very well attend their regular routine jobs which generated income for them earlier (labour in agricultural fields and coconut picking), and seabass nursery rearing was carried out without any difficulty. Hence nursery rearing can be taken up as an ancillary activity. The net income per cycle among the different families varied between Rs 28,000 and Rs 51,000 and each family made an income of Rs 7,000 to Rs 12,750 for two months effort. The cost of fingerlings is based on the size of the fishes. This model proved to be an ideal one to supplement livelihoods of villagers using natural brackishwater sources. All the input costs, ie., cost of hapas, casuarina poles, seabass fish fry, feed, and labour charges were borne by ICAR-CIBA under the SCSP fund.

Way forward: How to make the livelihood model sustainable?

This successful model included critical points such as awareness meetings, training, delivery of required inputs, monitoring, and marketing. It could be replicated in other places through Government of India schemes such as Pradhan Mantri Matsya Sampadan Yojana. With this experience, the State Department of Fisheries, Government of Tamil Nadu, can initiate specific schemes for these farmers and scale up the aquaculture activities in the village by including educated unemployed youth. This would immensely help this economically weaker section who is facing many challenges arising out of increasing expenditure on account of maintaining their living standards. Coastal villagers are still engulfed in a vicious cycle of poverty due to increased debt and lack of savings, which again affects their quality of life, and the nursery rearing of seabass model demonstrated in Kilarkollai Village is an ideal alternate livelihood option. Further due to the seasonality of fishing operations and higher gestation period in the culture sector, the activity has further diversified the incomes of coastal villagers, which also include fisheries, agriculture, labour, and other activities.

Conclusion

Under the SCSP programme, ICAR-CIBA has played a proactive role in empowering coastal villagers and improving their socio-economic development. This technology encouraged them to engage in partnership farming with the financial and technical support of ICAR-CIBA and helped them to express their individuality, increasing self-confidence among members. Their technical knowledge in seabass nursery rearing has improved and their skill has been sharpened. This was one of the first of its kind activity in Chengalpattu District, which motivated them to participate in seabass nursery rearing in hapas to generate supplementary income. ICAR-CIBA's technology transfer mode has emerged as a successful participatory model for providing alternate/supplemental income, and group activity through work-sharing employment which can be taken up throughout the year as a livelihood. There is ample scope for the state government to undertake policy measures through specific schemes in brackishwater aquaculture.

Acknowledgement

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A pilot of integrated mangrove-aquaculture as a nature-based solution to mitigate climate change in West Bengal, India

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Mangroves are one of the world's most threatened tropical ecosystems and provide a wide range of services including coastal protection, erosion control and storage of carbon. Although natural processes such as coastal erosion and extreme weather events influence forest vulnerability, mangrove degradation is predominantly linked to human activities. Growing population pressure in coastal belts and rising food demand necessitate land use changes driven by commodities, such as aquaculture, which may impact the mangrove environment. For example, shrimp farming developed significantly worldwide in the 1980s and 1990s, primarily in Asia and South America, spurred by rising international demand and a high market price. Since the 1980s, an estimated 1.5 million ha of mangroves have been lost worldwide due to shrimp aquaculture[1]. In India mangroves covered about 4,975 km^2 accounting for 3.6% of worldwide mangrove vegetation. Although mangroves are protected by legal instruments, the Indian coastline witnessed a rapid extension of shrimp farming. In India's states of West Bengal, Andhra Pradesh and Odisha, about 213 km^2 of mangroves and mudflat were destroyed for shrimp farming between 1988 and 2013[2]. Anticipating the impact, the Supreme Court of India ordered the shutdown of all shrimp farms within 500 meters of the high tide line in December 1996.

The coastal region of West Bengal hosts the world's largest contiguous mangrove forest, the Sundarbans. There, reclamation of mangroves mostly for timber and cropland began in 1770 during the British colonial period and continued until the mid-nineteenth century. Since the 1970s, parts of this coast witnessed a transformation from the paddy cum fish/shrimp integrated system to extensive shrimp-fish farming. The situation was more prevalent when both the state and central government have intensified their efforts to develop coastal aquaculture and started promoting export-oriented shrimp farming during the late 1980s to early 1990s. At present, West Bengal has nearly 50,000 ha of brackish water areas. This expansion led to further mangrove destruction and soil salinisation, and a slew of socio-economic issues that worsened after outbreaks of white spot shrimp virus (WSSV) disease around 1994-1996 and 2000-2002. Nevertheless, the export of *Penaeus monodon* from West Bengal has increased by about 80% between 2001 and 2013 and reached almost 50,000 tons. Since then, *P. monodon* production in West Bengal has been dropping whilst *P. vannamei* production has risen by 60% from 2013 to 2020 to about 35,000 tons.

The shrimp industry in India seems to thrive but is confronted with the same threats and sustainability challenges as elsewhere. The most common challenges are poor quality and irregular supply of shrimp seed and low survival rate, and general hazards are disease-related production loss and market uncertainty. Minimal value-added processing and a lack of traceability due to many unregulated and unregistered farms exacerbate the market situation, as growing consumer awareness on sustainable seafood, urges India's shrimp producers to shift to traceable and sustainable systems. Moreover, climate change threatens the viability of the shrimp farming systems both directly and indirectly. Therefore, strategies must be developed both to reconcile mangroves and biodiversity conservation, and to solve issues of food safety, water quality and social welfare.

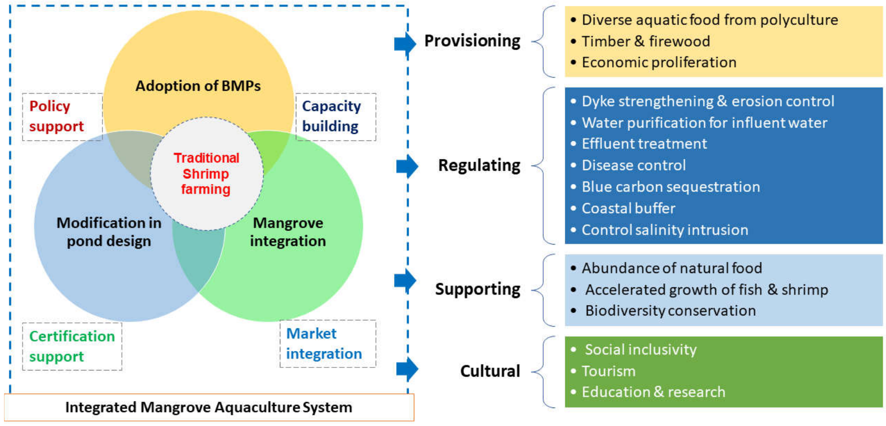
Mangroves are in peril due to shrimp farming across the Sundarban delta. Left and right are northeastern and western parts of Sundarban respectively.

The following sections of this article present and discuss an ecosystem-based shrimp farming system embedded in a local traditional method, bheri, that has the potential to reverse coastal ecosystem degradation.

Integrated mangrove-aquaculture: A potential nature-based solution

Nature-based solutions are interventions that aim to protect, restore and sustainably manage natural and modified ecosystems to benefit human well-being and biodiversity and address societal concerns[3]. Integrated mangrove-shrimp farming or simply aquaculture is the coexistence of mangroves and shrimp aquaculture in a tide-fed environment. In comparison to other shrimp farming systems, integrated mangrove-shrimp farming can additionally produce timber and supports biodiversity.

Potential benefits that can be derived from an integrated mangrove aquaculture system.



In several coastal hamlets of Tamil Nadu, the M.S. Swaminathan Research Foundation (MSSRF) has successfully tested an integrated mangrove fishery farming system to restore mangrove-based livelihoods and rehabilitate ponds, since 2006. Local farmers cultured black tiger shrimp (*P. monodon*) along with mud crab (*Scylla* spp.) and fish (flathead grey mullet *Mugil cephalus*, and Asian seabass *L. calcarifer*). Farmers adopting the integrated mangrove fishery farming system on modified outer and inner embankments planted certain mangrove species (*Rhizophora mucronata*,

Coastal halophytes at the brackishwater canal periphery provide excellent opportunities for nutrient source and sediment trapping for the shrimp farm.

Many of the tidal regions of South and North 24 Parganas offer ideal conditions for mangrove-based silvofisheries.

R. apiculata, *Avicennia marina*) and other saltmarshes (*Sesuvium portulacastrum*). The survival and productivity of *L. calcarifer* was 11% and 12.5% greater in the integrated mangrove fishery farming system relative to the open aquaculture system[4].

The choice of mangrove species for an integrated mangrove-shrimp system needs to account for numerous factors such as inundation frequency, tannin content, carbon : nitrogen ratio, half-life and decomposition rate of mangrove leaves. Leaves of mangroves can have either toxic or beneficial impacts on shrimp and other seafood. Other considerations are the societal uses of mangroves products such as honey, fruit, firewood and timber.

***Bheri*, a traditional shrimp farming system in West Bengal**

The *bheri* is a traditional nature-dependent aquatic food production system of West Bengal which is unique in South Asia. Flanked by embankments, the shallow bheri range from 0.5 to 100 ha and are mostly stocked with *P. monodon* at low density. Bheris also provide ecosystem services such as carbon sequestration, floodwater storage and biodiversity. Depending upon distance from the sea, bheris may be high-salinity (> 20 ppt salinity), medium-salinity (10-20 ppt) and low-salinity (< 10 ppt). Bheri aquaculture practices range from traditional to improved extensive farming. All exchange water at neap (outlet) and spring (inlet) tides by means of a sluice gate made of wooden boards and bamboo poles (locally called *goi*). The water is filtered using bamboo screens (*pata*) to prevent loss of stock; some farmers use nylon nets to prevent natural recruitment, including unwanted organisms. The stocking season usually begins in late January and lasts until mid-October. Harvesting begins three to four days before the full moon and new moon and continues for three to four days after the full moon and new moon using traps made of bamboo locally called *atol* and cast netting. Usually, the last harvesting is done in the second week of December. In the improved system, farmers usually dry and desilt the pond bed, apply moderate quantities of lime and cattle dung, provide farm-made feed, repair embankments and sluice gates more regularly, and have a hut for storage and watchmen (locally called *ala*).

Next to *P. monodon* (6-10 PL/m^2) farmers may stock *L. calcarifer*, *Chelon parsia*, *M. cephalus* and *Mystus gulio*. In low saline areas, farmers may stock Indian major carps, tilapia (*Oreochromis niloticus*) and giant freshwater prawn (*Macrobrachium rosenbergii*). The natural recruitment includes, among others, horina shrimp *Metapenaeus monoceros*, Indian white shrimp *Fenneropenaeus indicus*, sea bass and mullet. The total seafood production ranges between 700-750 kg/ha/year of which 300-400 kg/ha/year is shrimp of which 80-90% is exported. In North 24 Parganas District, after harvesting and dewatering, most farms hire tribal people to handpick a substantial volume of freshwater eel (*Anguilla bengalensis*).

In the North 24 Parganas District the medium and low saline bheries are prevalent and occupy 40% of water bodies. The Bidhyadhari River is the lifeline of shrimp aquaculture and also an outlet for sewage from the Kolkata metropolitan and its factories producing leather, garments, plastic and glass. The Bidyadhari River receives saline water under tidal effect from the sea and discharges into the Bay of Bengal through the Haribhanga estuary.

In recent years, bheri farmers have experienced declining shrimp yields, probably related to poor water quality due to effluent from industrial and urban areas and from semi-intensive P. vannamei farms. Water may have an unusual colour, an unpleasant odour or be foaming. Moreover, due to the clogging of canals and rivers, the sediment burden on farms is growing. Some farmers experienced decreased salinity levels in North 24 Parganas District while it is increasing in the Sundarbans area. Poor knowledge and awareness limit the implementation of simple better management practices (BMPs) such as removing sediment from ponds, applying proper amounts of lime, and biosecurity measures. The large pond areas, complex land ownership and lease system are further hindrances for the adoption of BMPs. Naturally recruited seed are often blamed for the spread of WSSV and other water-borne diseases, but traditional producers choose to stock seeds from natural sources because they find that wild shrimps have superior development, body colouration and survival rates than hatchery-reared shrimp. However, many farmers have switched to *P. vannamei* which has a higher growth rate than *P. monodon*.

Climate change-induced extreme weather events, such as coastal flooding, are becoming common in this part of the Ganges delta. These events result in the breach of pond embankments, escape, stress and mass mortality of stock, the introduction of undesirable species, worsening of water quality, and finally, massive economic loss. Social conflicts due to the salinisation of cropland and labour issues are increasingly common phenomena.

A pilot of integrated mangrove-aquaculture

To understand the possible benefits of mangrove integration in the bheri, our consortium compared three integrated mangrove-aquaculture systems together with three local farmers of Basirhat-II and Haroa blocks in North 24 Parganas (Table 1). The long-term objectives were:

- To improve the shrimp farming environment and establish a mangrove-based organic system.
- To increase shrimp and fish productivity through mangrove-based nutrient recycling in ponds.
- To fortify the carrying capacity of the farm and the adjacent coastal ecosystem.
- Mangrove restoration, carbon sequestration and income generation.

The initial investments in the integrated mangrove-aquaculture system are substantial due to the alteration of pond dykes and other hydrological modifications. All three farms practiced improved extensive shrimp farming and strictly adhere to the internal control system and standard operating protocol of the organic certification standards. For example, all farmers stocked hatchery-reared organic shrimp PL (<10 PL m^2) periodically and only liming was allowed. Usually, no supplementary feed was given, and shrimp grew based on the natural productivity of the farm. The selection of farmers and community willingness are critical steps of this system. Therefore, the farming communities (farm owners, farm-workers, part-time workers) were sensitised and empowered through training and exposure visits that created a consensus about mangrove conservation among local communities.

Before planting mangroves, dykes were redesigned with different slopes to make the plantation easier. Based on the size and topography of the farms, island like platforms were also developed for the planting of mangroves. Mangroves were incorporated into the inner embankments, peripheries, in-pond platform, and outer embankments of the adjacent canal. To provide some immediate benefits, some fruit

About the Consortium

The pilot activities were funded by the German retail chain ALDI SÜD in collaboration with the European shrimp importer Shore and the German Development Bank KfW-DEG in a public-private partnership model. Bluesensus, a German consulting firm, collaborated on the project alongside Indian partners Blue Sea Aquaculture Private Limited (BSA) and Nature Environment & Wildlife Society (NEWS) for implementation in the field. Since 2014, the three farms have been part of the organic shrimp farming clusters of the West Bengal Traditional Black Tiger Project, which was a joint venture between the European retailer Hofer KG and the Austrian Development Agency and supported by Ristic GmbH. As a spin-off from the Hofer KG project, Blue Sea Aquaculture Private Limited was formed in January 2017. In cooperation with hatchery, processing, and exporting partners, BSA has developed three organic shrimp farming clusters of 1532 ha involving 31 farmers with guaranteed traceability and chain of custody. Since 2015, the farms have been certified according to European Union organic regulations and Naturland standards. The BSA project was a pioneer of organic aquaculture standards under the National Program for Organic Production in India.

Table 1. Different integrated mangrove aquaculture systems (IMA) developed in North 24 Parganas, West Bengal.

Parameters	IMA-1	IMA-2	IMA-3
Planting year	2018	2019	2020
Block	Basirhat-II	Haora	Basirhat-II
Village	Andulpota	Bireswar-Gopalpur	Sadiknagar
Geo-coordinates	22°37'25.45"N 88°48'21.51"E	22°36'15.58"N 88°43'49.89"E	22°40'11.13"N 88°44'55.53"E
Area (ha)	5.89	1.45	2.0
Maximum salinity (ppt)	10-12	10-12	10-12
Water pH	7.5-8.5	7.5-8.5	7.5-8.5
Mangrove species introduced / tested	*Avicennia officinalis* *Bruguiera gymnorhiza* *Rhizophora apiculata* *Ceriops decandra* *Heritiera fomes* *Sonneratia apetala* *Nypa fruticans* *Xylocarpus moluccensis*	*Avicennia officinalis* *Bruguiera gymnorhiza,* *Rhizophora apiculata* *Ceriops decandra* *Heritiera fomes* *Sonneratia apetala*	*Avicennia officinalis* *Avicennia marina* *Sonneratia apetala* *Bruguiera gymnorhiza* *Rhizophora apiculata* *Nypa fruticans* *Heritiera fomes* *Xylocarpus moluccensis*
Type of planting	Dyke, platform, peripheral planting	Dyke, platform, peripheral planting, outer canal bank planting	Dyke, platform, peripheral planting
Mangroves (n)	2,510	1,576	3,118
Mangrove coverage	10%	20%	15%

Different modes of integrated mangrove-aquaculture ponds.

trees were also given to farmers who planted these in the periphery of the rest house. The mangroves were collected from a nursery located at Sundarbans. Mangrove species were selected based on salinity and soil profile and varieties of freshwater-loving to salt-tolerant mangrove species were tested in this intervention. Based on the seasonal availability, mangroves were planted at the beginning and end of the monsoon season. The protection against free-roaming livestock was ensured through bamboo fences around the farm. Regular monitoring was conducted to observe the survival and growth of mangrove species. Dead mangroves were continuously replaced.

Observations and lessons

Planting of the mangrove is recent, and a minimum of five years is required to recognise and interpret the effects on ponds, environment and income. The current average shrimp production from these ponds ranges 300-320 kg/ha/year while the average fish production ranged 400-450 kg/ha/year.

In low saline areas across the three sites, the growth of *A. officinalis* (*bain*), *Sonneratia apetala* (*keora*), *Heritiera fomes* (*sundari*) and *Nypa fruticans* (*golpata*) was slightly better than that of *Bruguiera gymnorhiza* (*kankra*) and *R. apiculata* (*garjan*). However, *Ceriops decandra* (*goran*) showed a poor growth rate in farm conditions. It is interesting to note that, flowers were already observed in *A. officinalis* and *S. apetala* within two years of planting. Natural recruitment of mangroves was observed on two farms where the canal is in very close proximity to the farms. In that case, the fastest growth rates were observed for naturally settled *S. caseolaris* (*ora*), *A. officinalis* and *E. agallocha* (*genwa*).

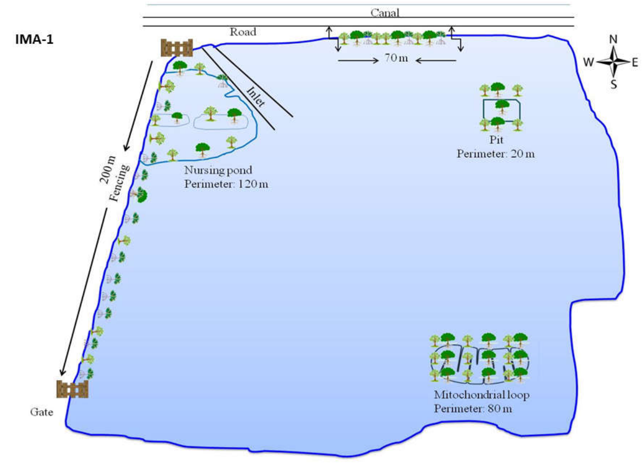
Regular monitoring of plant health is essential in the integrated mangrove-aquaculture system for at least few years after plantation. Small ponds can be maintained better (in case of integrated mangrove-aquaculture system 2), and the impact may be felt sooner. We observed that watering of the plants during December to February as well as in summer seasons reduced mortality. Furthermore, the use of organic amendments enhanced mangrove growth.

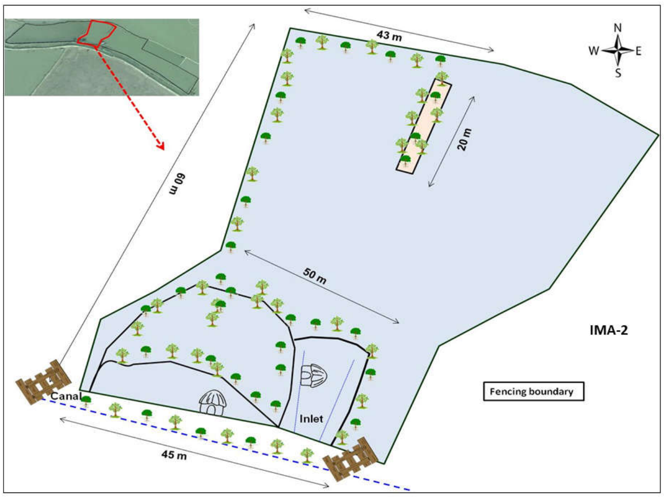
Future outlook and conclusion

Despite the potential benefits of mangrove-shrimp integrated farming in terms of climate change mitigation, its large-scale implementation and adoption may confront social, economic and ecological hurdles. Implementing an integrated mangrove-aquaculture system can be technologically tough for farmers at times, and the platform restricts the pond area available for shrimp farming.

The integrated mangrove-shrimp farming system has the potential for an organic certificate. According to the standard of Naturland[6], farms can acquire organic certification if the former mangrove area in parts of the shrimp farm is reforested to at least 50% within five years. For small individual farmers, the certification cost is too high to gain the premium prices for organically certified products, and farmers need to unite in clusters or cooperatives[7]. The same is valid for farmers wanting to capitalise on the carbon credits of their

Three IMA models implemented in North 24 Parganas District.





mangroves. Some governments provide more accessible rewards for mangrove ecosystem services, eg., land tax reduction or subventions.

To maximise the ecosystems services of the mangroves, experts recommended an associated design in which the mangroves are separated from the pond along the canal to create a natural habitat[8]. If such a design were to be implemented farmers would have to give up part of their pond and might feel that they were losing their land; they should either be compensated, or the design should somehow delimit their propriety. Such a design should guarantee regular mangrove flooding and increased interaction between the farm forest and its surrounding aquatic system.

To achieve sustainable mangrove management, local communities must be involved, and interested shrimp farmers trained, also to educate other farmers about the benefits of mangroves for the environment and shrimp. At present, many brackish water ponds in West Bengal's coastal region, particularly in the Sundarbans, are underutilised and underproductive due to inadequate management and other issues. Improving awareness can help to revert part of these ponds to mangroves; this gives scope for long-term storage of carbon and related payments to farming communities. Integrated mangrove-aquaculture systems can be part of such a strategy. However, institutional, technical, and financial support is required for the reversion to be successful.

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Important factors to consider before deploying integrated mangrove-aquaculture

- Farmer communities' willingness and active participation.
- Land ownership.
- Training.
- Tidal amplitude and suitable biophysical conditions of soil and water.
- Modification of pond dykes and hydrological correction.
- Selection of locally available mangrove species.
- Continuous supply of seedlings from mangrove nurseries.
- Tannin content of mangrove leaves.
- Frequent water exchange and inundation level.
- Protection from livestock grazing and constant monitoring.
- Periodic pruning or thinning of mangroves.
- Initial high investment costs.
- Opportunities for organic certification.

Different views of IMA-2 in 2021.

Recreational fisheries in Uttarakhand

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The hill state of Uttarakhand in the western Indian Himalayan Region encompasses a landmass of 53,483 km^2 area, comprised of around 86% hills and 14% plains. Uttarakhand State is administratively set into two divisions, Kumaun and Garhwal, with a total of 13 districts. The unique landscape and terrain of the state gives rise to enormous natural aquatic resources in the form of 2,686 km of rivers and streams, 132 upland lakes (covering 297 ha) and 14,120 ha of man-made reservoirs[1,2]. Improving utilisation of these water resources for angling and recreational fisheries is an obvious possibility for increasing employment opportunities and generating income for the livelihoods of hill people. The development of sport fisheries or recreational fisheries will equally help in conserving the aquatic flora and fauna by increasing understanding their mode of propagation and sustainability. At present, opportunities for angling and recreational fisheries in the state are limited to certain pockets and a wider preferment of sport fisheries with passable investment and awareness campaigns in potential areas is imperative. Application of geo-informatics for mapping potential natural resources in the state can be of immense help in decision support for policy makers, aiding the suitable utilisation and management of water bodies for sport fisheries.

The availability of popular game fishes adapted to different thermal regimes of this hill state has given the region an enviable reputation in angling and recreation. Anglers come from different corners of the country as well as from abroad. Anglers are provided with a Fishing License for rod and line fishing with a nominal fee of INR 120 for foreign nationals and INR 80 for Indian nationals by the Uttarakhand Department of Fisheries on the day of their arrival. Research institutes

Tor putitora (photo credit: Gagan Bakshi).

Tehri dam is the highest in India.

such as ICAR-DCFR at Bhimtal have been instrumental in undertaking research programmes in species validation for mahseers and other cold water fishes of the Indian Himalayan Region using taxonomic tools such as morphometric identification, mitochondrial DNA markers, environmental DNA (eDNA) and DNA barcoding. Furthermore, concerted effort has been made by the scientists of the institute with the officers of the Uttarakhand Department of Fisheries, anglers, and fishing guides in identifying key angling sites to promote recreational fisheries in the state.

The sport fishes of Uttarakhand

Mahseer

The golden mahseer or Himalayan mahseer (*Tor putitora*) is the most popular game fish amongst anglers in India for its superlative fighting quality, known as the 'tiger in water'. Since angling was a favourite pursuit of the British, the lakes of the Kumaon hills were stocked with fish by Sir H. Ramsay during 1858 for sport fishing[3]. This fish is an endangered species of cyprinid and inhabits rapid streams, riverine pools, lakes and temple tanks in the Himalayan region. Mahseer belong to three genera, namely *Tor*, *Neolissochilus* and *Naziritor*. However, *Tor* constitutes the bulk of mahseer species. Efforts have been made to augment the population of mahseer in natural and manmade waters bodies through captive breeding and seed production. Altogether, three hatcheries for mahseer have been established in Uttarakhand, one operated by ICAR-DCFR Bhimtal, and two more at Satpuli and Tehri / Koteshwar under the aegis of the Uttarakhand Department of Fisheries.

Goonch angling

The group of *goonch* (in Hindi), *baghair* (in Bengali) and baghmas or *gorua* (in Assamese) are basically represented by two species namely *Bagarius yarrelli* and *B. bagarius*. These fishes belong to the order Siluriformes and family Sisoridae. At present they are considered to be 'vulnerable' on the IUCN Red List due to their over exploitation in the natural systems. The muscular build of the fish has given rise to the name 'giant devil catfish' and it is considered an ideal quest for an angler interested in a big catch. The home of the fish is the Western Ramganga River and Kali River in Uttarakhand, which flow through Nainital and Champawat districts. Goonch is less frequently observed on the baits of the anglers which

The goonch (photo credit: Camp the Himalaya).

Trout seed production at Bairangana.

may be attributed to a lack of information on their preferred habitat, food and feeding, migration pattern, and diurnal behaviour in the wild.

Brown trout angling

Enumerating the river resources showed a total combined length of 10,928 km of river network in the state of which 3,151 km has the potential to sustain suitable habitat for brown trout based on the criteria of elevation and the existing thermal conditions[4]. These rivers are within a temperature range below 16°C, are clear and well-oxygenated (6.0-9.5 mg/l), as well as being in sparsely populated areas. Some of the important stretches of river and their upstream areas harbouring the brown trout *Salmo trutta fario* have been reported as Nandakini, Pranmati Gad, Dhauli Ganga, Laisar Gad, Bhilangna River, Har Ki Dun, Pinder[5]; Asiganga, lake Dodi tal, Balkhila Gad, and Madhu Ganga[4]. Applying the tools of GIS in the present communication showed that the Nandakini, Dhauli Ganga West, Laisar Gad, Bhagirathi, Bhilangna, Asiganga, Pranmati Gad, Bal Ganga, Badiyar Gad, Gomati, Balasuti, and Pinder rivers situated in the northern part of Uttarakhand can provide potential ground for brown trout[6]. These river stretches may further be considered for establishing angling beats which can offer potential fishing spots for brown trout using catch and release practice. Although seed production of brown trout in the state is very small, attempts have been made at the trout hatchery of Bairangana to produce seed from 200 brown trout broodstock in recent years.

Other fishes

Altogether, 64 fish species have been reported from the Garhwal region and 31 from the Kumaon region of Uttarakhand by Kumar (2002). This data was updated to a total of 132 species of fishes belonging to 67 genera, 27 families and 8 orders by Uniyal and Uniyal (2021). Apart from the fish groups mentioned above, the other game fishes encountered are cyprinids viz., *Raiamas bola*, *Labeo dyocheilus*, *Bangana dero*, *Barilius* spp., Schizothoracines and a few catfishes. These groups of fish are occasional catches that may be encountered while in search of the major game fishes.

Recreational hotspots in Uttarakhand

One of the best sites in the world for angling of golden mahseer is at Pancheshwar, at the confluence of the Saryu and Mahakali rivers. The Mahakali River demarcates the boundary between Nepal and India. Pancheshwar is located 35 km from Lohaghat town in Champawat District of Uttarakhand. Angling fests and competitions are organised every year in joint collaborations among angling camps, Kumaon Mandal Vikash Nigam (KMVN), and the Department of Tourism. Hatchery produced mahseer seed from ICAR-DCFR Bhimtal are also released at Pancheshwar from time to time to enhance the stock of endangered species. Many angling camps such as The Himalayan Outback, Camp the Himalaya, Pancheshwar Fishing Retreat and The Golden Cast are active in the region to provide logistical support and accommodation during the angling season. The best time to go for fishing at Pancheshwar is before the arrival of monsoon and before onset of winter. Fish guides namely Mr Sanjeev Paroriya, Mr Shyam Gurung, Mr Roshan and Mr Hoshiyar Singh are true adventurers in the region who support visitors in their quest for mahseer and goonch. Other important angling sites for golden mahseer in Uttarakhand are Vanghat / Marchula along the Western Ramganga River; Vyasghat at the confluence of Ganga and Nayar rivers; and Ramnagar and Almora along Kosi River.

Vanghat is an excellent mahseer beat, located in Nainital district of Uttarakhand. This promising angling spot lies along the cascading Western Ramganga River that meanders through the verdant forest of Jim Corbett National Park. The mighty golden mahseer and giant devil catfish goonch have drawn avid anglers around the globe to Vanghat as witnessed by angler Mr Gagan Bakshi. Many eco-camps and resorts have been established in the vicinity to provide accommodation and fishing trips for visitors. September to May is the best time for fishing in the Western Ramganga River. Vanghat has a rich biodiversity in the form of exotic birds, butterflies, mammals, reptiles and other animals as the area is located within the national park. Angling can be done with the permission of Divisional Forest Officer in those locations where human threat is minimal.

Vyasghat can be another excellent option for angling golden mahseer. The search for mahseer starts from Devprayag, the confluence point of the Bhagirathi and Alaknanda rivers

Indian trout barb Raiamas bola.

situated 14 km upstream of Vyasghat. The route follows downstream for a stretch of 36 km over the Ganges. Similarly, 4-5 km of river is covered over the Nayar River from the confluence point.

Bhimtal based ICAR-DCFR collaborated with the Department of Fisheries, Department of Tourism and District Administration of Pauri Garhwal, Government of Uttarakhand in organising a three day interactive meet and angling competition among the anglers, fishing guides, farmers, officers, and scientists during 20-22 November 2020 with an objective to highlight Vyasghat as an important site for promoting mahseer angling on the global map, as well as to raise awareness on generating revenue and rural employment

Snow trout are an anglers' delight.

among the local people through eco-tourism. The programme also stressed undertaking other ancillary tourism activities such as rafting down the Ganges, trekking, bird watching, camping and sight-seeing in the hills, which have positive direct and indirect consequences towards the conservation of mahseer[9]. Banyan by the Ganges, a resort along the riverside with a picturesque background invites global tourists to spend a relaxing vacation where one can enjoy the thrill of taming the 'tiger of water'. September to November is the ideal time for fishing at Vyasghat as stated by the proprietor, Mr Manishankar Ghosh.

Ramnagar and Almora are two important mahseer angling locations along the Kosi River. Ramnagar is situated south of Jim Corbett National Park. The Kosi River forms the eastern boundary of the park down from Mohan Township (near Marchula) to Ramnagar. These two sites on the Kosi River are important habitats for the golden mahseer and other hill stream fishes such as *Naziritor chelynoides*, Labeo dyocheilus, and *Bangana dero*. One can also witness the catch of mahseer and other hill stream fishes at the Ramnagar market. Almora is a populated hill station of Uttarakhand and is known for its wildlife, culture, and cuisines. Anglers of Almora in association with ICAR-DCFR have made attempts to replenish the declining fish stock in the Kosi River with hatchery produced golden mahseer fingerlings. Both the areas are yet not fully organised for inviting avid anglers worldwide and the fishing is done on traditional lines. Many resorts and home stays are in the vicinity to provide accommodation and healthy food to the visitors here. People fish almost round the year except the peak monsoon season, as spoken by angler Mr Mohan Rayal.

The lakes of Uttarakhand namely Nainital, Bhimtal, Sattal, Naukuchiatal and Naldamayanti Tal are stocked with mahseer, and the fish is a major attraction for tourists. People offer the fish puffed rice, baked bread and biscuits, generating additional income for local vendors. The Lake Development Authority here takes care of the recreational amenities in the lakes for the benefit of tourists. Uttarakhand State is also known as Dev Bhoomi, as people believe the existence of God and Goddesses in every particle and henceforth make the holy land here a deity. This gives rise to many temple fish sanctuaries in the region. One of the exemplary examples is the Baijanath temple on the banks of the Gomti River in Bageshwar District where golden mahseer is conserved. Many such secluded mahseer sanctuaries can be witnessed on the Kosi River in the Kherna region and Ramganga River near Jim Corbett National Park. ICAR-DCFR has made a concerted effort in stocking these waters with young mahseer as a conservation measure and to support natural propagation of the fish. In addition, the confluence of rivers has also religious meaning in the Hindu tradition and is locally called *prayag*. Devotees across the country visit prayags with believe that a dip at the confluence cleanses the heart, mind and soul of a person and advances them closer to liberation or mukti (salvation). The panch (five) prayags are Vishnuprayag at the confluence of the Vishnu Ganga and Dhauliganga rivers; Nandaprayag at the confluence of the Alaknanda and Nandakini rivers; Karnaprayag at the confluence of the Alaknanda and Mandakini rivers; and Devprayag at the confluence of the Alaknanda and Bhagirathi rivers. All these prayags have a temple at the peak of the adjoining hills. The fish are not caught or disturbed in these confluences adjacent to the temples, which serve as natural reserves of fish and other aquatic biodiversity. These temple reserves are

Ranching of young mahseer at Pancheshwar.


A catch of golden mahseer at Vyasghat.


Participants of the interactive meet at Vyasghat.

not declared fish sanctuaries and are managed by the temple priest and devotees together through community participation. Such community-based conservation measures deserve recognition and concerted efforts need to be made to ensure the protection of fish species. These sanctuaries along the river stretches harbour healthy riverine fish populations and are an excellent way to prevent extinction of highly threatened fish species such as mahseer.

A winner receiving an award during the angling competition at Vyasghat.

Distribution of ICAR-DCFR hatchery produced mahseer young for ranching in the Kosi River at Almora in association with anglers.


A haul of hill stream fishes at Ramnagar market.

Conclusion

Recreational fishing is fishing for pleasure or competition is a popular leisure activity in the country. Today, recreational fishing is considered as an ecotourism activity, which is defined as “responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education”. Ecotourism can be a viable option in Uttarakhand as the state has numerous pristine destinations where fauna and cultural heritage are the primary attractions, and henceforth can provide viable income-generating options for economic development for local communities. Angling for mahseer, goonch, hill trout

A school of golden mahseer conserved in tanks of Baijnath temple.

Above: Origin of Ganga River at Devprayag. Below: Temples at river confluence point at Rudraprayag.

and other fish along with associated recreational avenues depends on healthy aquatic ecosystems. The ever-increasing population in the country imposes a significant pressure upon these inland water ecosystems including through destructive and illegal methods of fishing. However, the fish guides, resort and home stay owners are vigilant these days towards the poaching of fish on their respective beats as they are aware of the endangered status of the game fishes. Furthermore, active, and concerted efforts by the various public sector organisations have generated mass awareness at the rural front in conserving game fishes in their natural habitat for economic benefit. Commercial catch of these important game fishes by fishermen for consumption have been stopped and fishing is practiced solely on a catch and release basis by anglers. Fishing for recreation in these parts of Uttarakhand will enable future generations to experience destinations relatively untouched by human intervention, thus making them more passionate towards nature.

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Soft-shell mud crab production for export in Purba Medinipur, West Bengal, India

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In India, the cultivable mud crabs *Scylla serrata*, *S. tranquebarica* and *S. olivacea* are high-value export items commanding a good market price, mainly in hotels and restaurants of countries in southeast Asia, including Singapore, Malaysia, Vietnam, and Indonesia, and more broadly in the United Arab Emirates, Europe and USA. Among the eleven diversified export items, the main forms include frozen cut crab (with and without claw), frozen mud crab, frozen whole crab, frozen soft-shell crab, frozen crab meat, chilled soft-shell crab, live mud crab, pasteurised crab meat, chilled crab[1] (Source: https://mpeda.gov.in). Both frozen soft-shell crab, that originated in Indonesia, and frozen crab meat can be considered as value-added edible seafood products. This promising and established trend of export of mud crabs to international markets encourages local production of adult market sized crabs, fattened crabs and soft-shell crabs in brackishwater aquaculture ponds on a commercial scale and their promotion in coastal districts of India. These are now emerging as feasible business ventures in India[2]. Higher production of *S. serrata* and *S. olivacea* and subsequently proper processing will sustain the sector and exporters of these products.

The naturally occurring coastal and estuarine waters in North 24 Parganas, South 24 Parganas and Purba Medinipur districts of West Bengal generate a large quantity of juvenile, sub-adult and adult mud crabs, which can be exported after their grow-out, fattening and production of soft-shelled

A panoramic view of the production unit for soft-shell orange-clawed mud crab, Scylla olivacea.

A recently-moulted crab and its shed exoskeleton within a box.

stock, as needed. When wild-caught mud crabs of 50-100 g are reared individually for a short period and harvested on moulting, the process is termed 'soft-shell crab rearing'. Since March 2020, this activity has been undertaken commercially and seriously on a medium- to large-scale at National Aqua Farm, which is producing good quality, soft-shelled, orange-clawed mud crab *S. olivacea*. The farm is located in a brackishwater region at Village and P.O. Narandia, Balisai Gram Panchayat under Ramnagar-II Community Development Block, PS Ramnagar, Purba Medinipur District, West Bengal. The first author, a non-local Kolkata-based business person is the sole proprietor of this farm. The details of current management practice on the farm are presented in this communication. The proprietor obtained hands-on training in green mud crab farming at the Rajiv Gandhi Centre for Aquaculture (RGCA), Nagapattinam, in 2017 and started *S. olivacea* grow-out farming in brackishwater ponds in 2018 on trial and error basis. He finally decided to get involved in soft-shell mud crab production in boxes, and further packing and freezing (similar to 'frozen whole round' form) for export, an idea he considered less risky than *Penaeus monodon* and *P. vannamei* farming.

Moulting in mud crabs

As we know, moulting is a physiological growth process in mud crabs and other crab species, whereby the existing hard exoskeleton (outer shell) is shed and replaced by a soft, newly formed one, which hardens over the next 48-72 hours. Crabs moult when, due to growth, they are unable to contain their additional meat within the existing shell. Just before moulting, a new exoskeleton forms on the mud crab body below the old, hard and dead shell. During moulting, crabs expand, emerge, and shed their older shell in about 15 minutes and become larger in size. Soft-shelled mud crabs are those which are within the transitional phase, possessing a soft exoskeleton, within the first hour of moulting. Under natural conditions, the new exoskeleton begins hardening after 1.5-2.5 hours post-moulting and gets progressively tougher after steadily taking in water.

Male and female soft-shell *S. olivacea* are harvested on this farm before their new shell starts hardening, within 30-120 mins after moulting. Once such newly moulted crabs are harvested and taken out of water, hardening of exoskeleton is stopped and it remains soft. The entire body of soft-shell mud crab (including exoskeleton and chelate legs) can be eaten after cooking; its shell is not at all crunchy but soft, unlike normal adult mud crab. Thus, soft-shell mud crabs have a more meat in comparison to normal adult/sub-adult crabs. In general, for 70-100 g *S. serrata* and *S. olivacea*, in controlled and confined farm pond conditions and grow-out farming, moulting occurs at one-month intervals and 1.4-2.0 times more weight is gained after moulting if the crabs are given good quality feed in sufficient amount. The stocked 40-60 g mud crabs moult at about fifteen-day intervals. The rate of moulting is slower in winter months.

Soft-shell mud crab production unit

After recent completion of a moult, mud crabs remain defenceless until their new exoskeleton hardens, and may become prey to other animals, particularly other mud crabs or meat crabs of similar or larger size[3]. To prevent cannibalism amongst stocked *S. olivacea* and increase yield of the soft-shell form, submerged-type black-coloured durable plastic boxes with hinge lids and small openings on all sides are used to rear the crabs individually. The boxes have perforations of around 3 x 3 cm^2 on top, 1.5 x 1.5 cm^2 on the sides, and smaller holes on the bottom. The boxes are around 20 cm wide and 25 cm long, cost INR 80-100, and are purchased from south India. They can be used for both crab fattening and soft-shell crab production. Nine crab boxes can be accommodated within a 1 m^2 area in floating frame.

Likewise, the fourth author observed 600 fighting fish *Betta splendens* being maintained individually until adult and marketable size in used hospital saline bottles at a progressive aquarium fish grower's home at the 'freshwater ornamental fish hub' Udayrampur village, South 24 Parganas District. As *B. splendens* are aggressive towards one another, they must be reared separately. He previously learnt the state-of-the-art of fattening of mud crabs *S. olivacea* in larger boxes at the mud crab farm of Sri Dibakar Majumdar, located at East Ganeshnagar Village, Namkhana Development Block, South 24 Parganas[4].

The soft-shell *S. olivacea* production unit is set up in a well-maintained brackishwater pond of 0.4 ha (one acre) in area and 0.9-1.0 m deep, taken on lease contract. In all, 15,000 crab boxes have been positioned within floating rafts or frame-like structures. All boxes float on the surface of the pond one after another in linear series along its length (108 m). Each raft or floating frame is comprised of five parallel long and white PVC pipes 5 cm diameter, which are further divided into four lanes filled by four rows of boxes, extending from one end of the pond. One raft holds 1,000 boxes (250 in one row), and a total of fifteen rafts are positioned in the pond. The length of a raft is about 52 m. This pond can hold a maximum of 20,000 crab boxes. The farm keeps an additional stock of 500 new boxes on standby. Each box is 75% submerged, allowing the resident crab to remain below the water surface. The location of the farm is just beside the 84 km long Tamluk-Contai-Digha State Highway in Purba Medinipur at Banksalghat point/bus stop in Ramnagar-II Block and 15 km on the way to Digha, a famous sea beach and coastal resort town in West Bengal. On new moon and full moon days, the bottom water in the pond is exchanged and fresh tidal water is let in through a sluice gate with a close-meshed screen from a nearby brackishwater canal, which extends for 5 km from this farm towards Bay of Bengal. The canal meets the sea at a point in between Mandarmoni and Tajpur, two other well-known sea beaches-cum-seaside resorts in the same district.

Close view of a LDPE plastic crab box.

Close view of a recently-moulted S. olivacea.

Close view of a shed S. olivacea exoskeleton.

The farm obtains its stock as normal hard-shell male and female *S. olivacea* of 50-75 g, caught by crab collectors from tidal and estuarine areas occupied by mangrove vegetation in the coastal belt of Purba Medinipur and South 24 Parganas. The crabs are bought @ INR 120-200/kg at 3–6-day intervals and stocked in boxes individually. Within each batch, some *S. olivacea* may have moulted in nature 14 days before the day of stocking, some 10 days before and some 4 days before. The quantity of purchase depends on availability of mud crabs

An employee examining the boxes on one of the rafts.

of preferred size in depots, the stock available with collectors and the number of empty boxes the farm has after harvest of soft-shell crabs in the right condition.

The quantity needed for restocking is estimated. A straight walking platform or wooden footbridge with roof 1.5 m wide made of closely-placed planks of wood 20-30 cm wide is indigenously constructed across at the middle of pond along its width. Farm workers handle crab boxes individually, monitor the condition of each and every crab and feed them. Boxes in all fifteen rafts are kept under observation, checked individually at a three-hour interval (4-5 hours during night time) from the third day of stocking, and the moulting status of the crabs is monitored. If the crabs are not inspected to identify individuals in the soft-shell state, their exoskeleton will harden, and they will become unsuitable for harvest and sale. Rechargeable head torch lights are used by farm workers in late evening and night hours to inspect the boxes.

Using connecting ropes, an entire raft can be slowly moved over the pond surface forwards or backwards below the platform (0.5 m distance) by sitting on it. If shedding of exoskeleton is found to have taken place in any of the boxes with a soft-shell crab lying beside it, these particular ones are lifted from respective raft onto the platform, the recently moulted *S. olivacea* brought out, handled carefully and kept in a bucketful of water in live condition in the shade.

Moulting for lesser numbers of *S. olivacea* has been found to take place in this farm on the full moon and new moon days and also 3-5 days prior to (approaching to) these days. Normally no moulting is observed on the first 4-5 days of stocking; it increases from the sixth day until the 18th day, with harvesting of soft-shell crabs completed within 22-25 days of stocking from all boxes. Moulting of some mud crabs may take place on the fifth day (supposedly), and some may moult on the seventh and eighteenth day of stocking, depending on their growth. The first and second authors harvest 50 soft-shell *S. olivacea* from every 1,000 crab boxes every day.

Low-cost small- to medium-sized marine and brackishwater finfishes, viz., *Coilia dussumieri*, *Polynemus* sp, *Setipinna phasa*, *Lepturacanthus savala*, *Harpodon nehereus*, *Chirocentrus dorab*, reddish *Johnius* sp., both in wet (fresh) and dried forms, are cut into smaller pieces and fed to stocked *S. olivacea* in individual boxes @ 5-6% of body weight on daily basis. Fresh fishes are brought from the nearby Digha Mohona (12-14 km from this farm) and Shankarpur marine fish landing centres. During the marine fishing ban period (March to June) and times when fishing trawlers do not operate, sun-dried fishes are brought from dry fish processing areas and fish drying yards (camps) of coastal villages namely Shankarpur, Mandarmoni, Khejuri, Jalda, Soula, Digha Mohona and Junput in Purba Medinipur. Wet and dried fishes are bought @ INR 70-80 and INR 15-20/kg respectively. Dried fishes are mostly supplied by persons with whom a contract has been made beforehand.

Post-harvest management of soft-shell *S. olivacea*

At the mud crab processing hall of this farm, live soft-shell *S. olivacea* are collected in buckets are placed in big aluminium vessels (round mouth, 50 cm open diameter) @ 9-10 crabs/vessel, containing freshwater under continuous aeration for 20-45 minutes to clean the outer body surface and bring out residual faecal material from inside. Thereafter the live crabs are placed (closely spaced and one above another) in chilled water contained in 20-25 litre plastic buckets and kept inside a single-door chest freezer at 0-4°C temperature for 5-6 hours. The whole-bodied soft-shell *S. olivacea* are individually wrapped in 20 x 20 cm^2 thin and clear food-grade plastic polyethylene sheets, taking the shape of intact rolls of crab flesh, each 12-14 cm in length and 3-4 cm in diameter. One roll of polythene sheet costs INR 200-250.

Individually packed soft-shell *S. olivacea* rolls are kept inside another deep freezer with double doors, maintained and preserved at -20°C. These are supplied in frozen 'ready to cook' form to licensed seafood (crab) exporters at the price INR 600-800/kg. *S. olivacea* of 60-75 g at stocking are typically 80-110 g at the time of harvest at this farm, with females gaining comparatively less weight. The first author supplies 70-90 kg material to exporters every time.

End note

In the open area of this brackishwater pond, the first author has stocked riverine seeds of *Liza parsia*, *L. macrolepis*, *L. tade*, *Rhinomugil corsula* and *Mystus gulio*, purchased from fish seed traders of Purba Medinipur and South 24 Parganas and practices modified-extensive polyculture of mullet. Another pond just beside this present one has been taken on lease for the same. To maintain an abundance of plankton as a natural food throughout the culture period, Sri Roychowdhury applies an organic juice, comprising a mixture of rice polish 750 g, wheat flour 350 g, sugarcane molasses 500 g, limestone powder 100 g, edible soda 200 ml/g, soya sauce 15 ml, commercial probiotic 100 g, and a small amount of vinegar for every 0.1 ha water area. For a 4,000 m^2 pond, a mixture of groundnut oilcake 100 kg, sugarcane molasses 10 kg and yeast 500 g may be applied at fortnightly intervals. Lime is applied @ 40-45 kg/ha twice a month to maintain good water quality and avoid growth of pathogenic micro-organisms. Both finfishes and *S. olivacea* in boxes benefit and remain healthy in good water conditions.

After harvesting soft-shell *S. olivacea* from boxes, the shed-off old, hard shells are collected and discarded. Plenty of such dried and semi-dried cast off shells (resembling dead whole-bodied mud crabs) remain heaped at one point on the pond embankment. These can be placed inside excavated holes on the earthen embankment and a useful organic fertiliser is produced after it decomposes, enhancing vegetable production in farms and that grown on pond embankments, if applied. For soft-shell mud crab production, 8-10 g of

Chilling down soft-shell S. olivacea.

Frozen and packed soft-shell S. olivacea for export.

Heap of discarded exoskeletons from moulting S. olivacea.

Series of rafts as seen from one corner of the pond.

chopped fresh finfish *Amphipnous cuchia* or small-sized *Tilapia nilotica* may be given to every 50-100 g *S. serrata* or *S. olivacea* stocked, once every three days.

The first author feels that such entrepreneurial activity should be promoted. He is willing to train interested agriculturists, small-scale marginal fishermen, brackishwater fish farmers and unemployed youth in nearby coastal villages on remunerative soft-shell mud crab production, its grow-out farming and fattening. Many are unaware of the techniques and its prospect as a livelihood option. These people can be united through groups. Many farmers are now less interested to invest in brackishwater shrimp farming due to the incidence of viral diseases and white faeces syndrome leading to crop failure. Nine local persons have been employed as permanent labourers on this mud crab farm.

For soft-shell mud crab production and also crab fattening using the ‘box farming’ technology, farmers have to depend heavily on wild-caught crabs and exploitation of natural resources. Recently fish farmers Sri Sambhu Maity, Sri Prasenjit Jana, Sri Amit Bera, Sri Sukumar Ari have started production of fattened mud crab *S. olivacea*, both males and females, for export, in boxes positioned within floating frames. They are doing it on small- to medium-scale in brackishwater fish ponds in the Nandigram, Haldia and Nayachar regions of Purba Medinipur on the bank of the Haldi River. Some farmers in Khejuri-I and Ramnagar-I Blocks in this district are practicing grow-out farming of mud crabs in open pond area (small and owned) with input support from the state government. It is hoped that in the near future, mud crab farm owners in the private sector in West Bengal will be able to avail of adequate numbers of crablets and stockable-sized stages of *S. serrata* and/or *S. olivacea* reared and produced from mud crab hatcheries and nursery rearing facilities of the Rajiv Gandhi Centre for Aquaculture and other government institutions and corporate enterprises.

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Conducting artificial fertilisation, hatching and spawn development of Indian shad, *Tenualosa ilisha*: Pathfinding hilsa domestication

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Hilsa, *Tenualosa ilisha* is a fascinating food fish. Its charming lustre, culinary flavour and medicinal importance make it a favourite of the people of West Bengal, India and Bangladesh in particular. However, it has complex habitat requirements, migrating between marine, estuarine and riverine waters. Usually, adults mature in the sea, and then venture a long journey towards rivers via estuarine environments for breeding.

The domestication of such a fish growing in diverse ecosystems at different life stages has provided quite a challenge to researchers.

Breeding hilsa

Ideally, in breeding hilsa, fertilisation in captivity needs to be performed under controlled conditions. However, male and female broodstock are collected from fishers who catch hilsa with monofilament gill nets while sailing country boats, and artificial fertilisation is performed onboard. Some of the specific constraints which are encountered in hilsa breeding include the following:

- It is difficult to collect enough healthy males and females in breeding condition, with oozing milt and eggs. In particular, it is difficult to obtain them both at the same time.

Family operated boat - earning a living catching hilsa in the tidal flow of the Hooghly River.

- Captured broodstock are highly stressed from the monofilament net and handling, and typically only survive a few minutes after capture.

- Sometimes, gravid females and males are available, but one or both of sexes are not viable enough for breeding.

- Hilsa migrates twice a year during February-March and September-October, around the full and new moon periods, which places a time constraint on the breeding operation.

Breeding prerequisites and necessities

When viable broodstock of both males and females are collected after catch from fishermen, artificial breeding operations are undertaken immediately. First, the maturity status of both females and males is checked, females should have freely oozing yellow eggs and males should ooze white coloured milt on abdominal pressure. If the broodstock are in suitable condition to proceed, then the fish are temporarily placed in a large circular container filled with river water until enough have been collected. However, care must be taken not to cause females to release their eggs into the container or absorption of water leads to closure of the micropyle. Battery operated aeration is provided and a mild water flow is maintained by hand to keep the fish vibrant to some extent.

Once enough broodstock have been collected the stripping operation needs to be started. Breeding of hilsa is by and large performed with stripping method comprising two different techniques such as the dry method and the wet method; the former is better than the latter.

Dry stripping

Removal of water from the buccal cavity, gills and body surface of hilsa is necessary to prevent water mixing with the stripped eggs. To do so, individual fish are kept upside down by hand for a few minutes so that excess water from mouth and gills is removed. Mixing water with eggs causes them to lose fertility. Then the surface of both male and female broodstock is sponged with a clean towel or tissue paper to make the body surface dry. A gentle finger or thumb pressure is applied on both sides of the upper region of the female abdomen so that the eggs are moved and eventually come out through the vent. Stripped eggs are collected and spread in a clean steel or enamel tray. Then the male is stripped to remove milt. Having obtained eggs and milt:

- The eggs and milt are mixed thoroughly with a soft feather to bring sperm in contact with the eggs.

- The small amount of previously conditioned river water (filtered through a bolting silk hapa) is sprinkled gently over the milt-egg mixture to activate the process of fertilisation.

- Immediately after addition of water, the tray needs to be swayed for a moment to mix the water uniformly over the egg-milt mixture.

- The addition of sprinkled water stimulates sperm to start moving very fast and to adhere with the egg membrane.

- Sperm remain active and viable for only 40-50 seconds, during which they must enter via the micropyle and eventually fertilise the egg.

- After 4-5 minutes, a large amount of water is gently added and the mixture must be kept undisturbed.

Post-fertilisation the eggs should be cleaned through repeated washing with conditioned water. The washings involve removal of decanted water, followed by addition of fresh conditioned water 4-5 times. This practice removes clogged milt, mucous, scales, faeces, blood, oil droplets and other waste which might facilitate bacterial or fungal infection. After washing, the fertilised eggs are transferred into circular plastic tub of 20 litres capacity partly filled with conditioned water. Continuous mild aeration with battery operated aerators is required to increase the dissolved oxygen level and make the eggs buoyant.

Water hardening of eggs

Fertilised eggs start swelling and separate from each other just after fertilisation. Swelling of eggs, known as 'water hardening', seems to be an indication of successful fertilisation. Usually, eggs require 45 minutes to fully swell. Swollen fertilised eggs measure around 2.0 mm in diameter, are spherical, transparent and contain yellowish yolk with numerous oil globules. The egg membrane is single layered. Comparatively, unfertilised eggs measure around 1.8 mm in diameter and have a whitish yolk.

Female hilsa in breeding condition.

Male hilsa in breeding condition.

Stripping eggs from a female hilsa.

Stripping milt from a male hilsa onto stripped eggs.

Fertilised eggs are further transferred into another container equipped with aeration to increase dissolved oxygen and begin embryonic development. At this stage the fertilised eggs may be transferred into a hatchery or aquaria for further incubation and hatching. Fertilisation rate varies between 95-98%. The fertilised eggs are packed into polythene bags with oxygen and transported to the laboratory of Kalyani Field Station, RRC of Rahara, ICAR-CIFA.

Mixing milt and eggs with a soft feather.

Egg incubation

The transported eggs have both fertilised and unfertilised mass which needs to be segregated prior to incubation. The unfertilised eggs decompose quickly and pollute the water and must be removed to avoid damage to fertilised eggs. If the quality of water deteriorates, the whole batch of eggs will be spoilt, including viable eggs. To remove the unfertilised eggs, spread a small amount of egg mass in a steel tray so that fertilised and unfertilised eggs are clearly visible. The unfertilised eggs can then be removed from the mass with a dropper, without touching the fertilised eggs.

The fertilised eggs are then incubated in a steel tray, or aquarium or hatching pool depending on the number of eggs collected. The most important aspect includes handling of eggs, water management and aeration. Water exchange at regular intervals seems to be the most important operational factor, and aeration must also be provided for proper development of the eggs.

Fertilised eggs being spread in a steel tray.

Rearing of hatchlings

After hatching, the young are collected by dropper to eliminate egg shells and are put into aquaria with the same water and continuous mild aeration. Hatchlings are reared without any natural or supplementary feed for the first four days. On the fourth day, the larvae have reached spawn size of 5 mm/0.5mg. The dead larvae, if any, need to be removed to avoid water quality deterioration. In such a practice, bolting silk may be used while water is being siphoned and later replenished with fresh water.

Packets of fertilised eggs kept in hatching pool for acclimatisation.

Spawn development and management

Usually, by the fourth day larvae are able to swim at the water surface and they can be easily be harvested with a small container. During harvest a small number may be collected to avoid any injury or damage due to stress or handling. Harvest is usually undertaken either morning or evening when the ambience becomes fresh and water temperature becomes comparatively cooler but collecting hatchlings in evening is better. Using a florescent light during hatchling collection improves the contrast between the water and transparent body of hatchlings and makes their movement easier to see and easier to collect them. The spawn are then transferred into another rearing system for fry development.

Conclusion

Domestication of hilsa requires extra effort while nurturing the natal stage which is very sensitive and susceptible to mortality. In particular, the early stage of larvae including hatchlings and spawn development up to the fourth day requires the utmost care and attention. Kalyani Field Station of the Regional Research Centre, Rahara, ICAR-CIFA has developed standardised protocols for incubation and hatching of fertilised eggs, maturation of hatchlings and early spawn development of hilsa, which are the first of their kind for hilsa domestication and culture. This has been made possible through a decade of continuous research, dedication and devotion to both benefit farmers

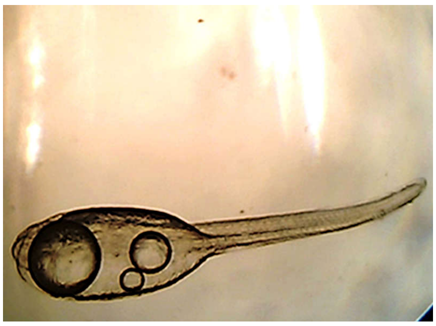
Fertilised eggs incubated in aquaria.

Hatchlings harvested with dropper for transfer to other rearing tanks.

Hatchlings harvested to transfer to another rearing tank.

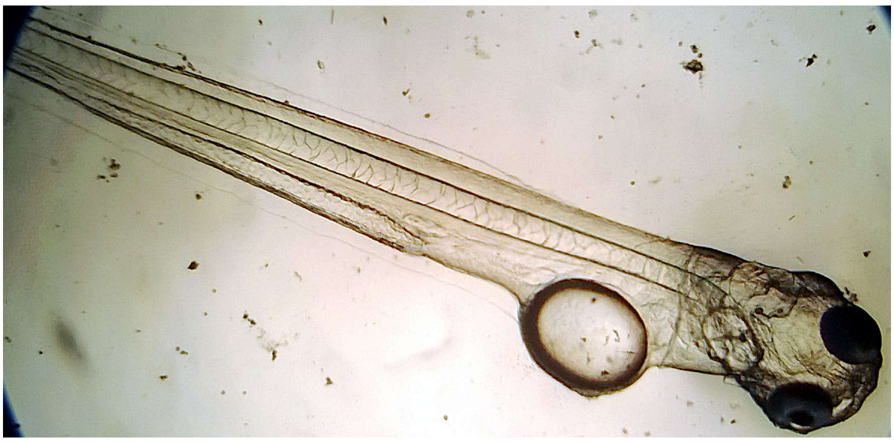
New hatchlings.

Scientists observing the growth of hatchlings.



A close view of 2 day old hatchling.

4 day old hatchlings.



A close view of a 4 day old hatchling.

and contribute to the conservation of wild hilsa populations through development of captive breeding techniques and domestication, to alleviate pressure on wild sourced stocks.

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Training Course on Mariculture Technologies in Asia-Pacific

The Yellow Seas Fisheries Research Institute (YSFRI) convened a free online Training Course on Mariculture Technologies in the Asia-Pacific Region from 19 to 23 September. The course was organised by YSFRI, NACA, the Qindao Marine International Cooperation Center and the Asia-Pacific Fishery Commission. The course was guided by the Chinese Department of International Cooperation and Bureau of Fishery and Fishery Law Enforcement, Ministry of Agriculture and Rural Affairs, and the Asia-Pacific Fishery Commission.

The objectives of the training were to strengthen human resources, upgrade the management and technology level of marine aquaculture and to contribute to sustainable development of Belt and Road developing countries and, more broadly, the world.

The training was principally aimed at government officers, researchers, enterprise managers and technicians from developing countries. Over 150 people from 21 countries participated in the course. Participants will receive a certificate in due course.

The programme included:

- Aquaculture in China.
- Introduction to the Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences.
- Progeny production and culture technology of marine fish.
- Aquaculture of sea breams.
- Global aquaculture development status and technology innovation.
- Tropical coral reef fish breeding and culture technology.
- Selective breeding for Pacific white shrimp, *Penaeus vannamei*: a case analysis.
- Studies on the artificial culture techniques of marine crab in China.
- History, current status of marine shellfish culture and the major cultured species in China.
- Theory and technology of *Porphyra* culture.
- Breeding and culture of sea cucumber (*Apostichopus japonicus*) in China.
- Best management practices for feeds and feeding.
- Epidemiology of farmed shrimp and biosecurity.
- Operational training of rapid detection for aquaculture pathogens.
- Viral nervous necrosis of teleost fish.
- Diagnostic methods for the detection of acute hepatopancreatic necrosis disease.
- Development of coastal integrated multi-trophic aquaculture in China.
- Seawater pond integrated multi-trophic aquaculture.
- Seafood products processing.
- Marine biotoxins and food safety.
- The International Consortium on Artemia Aquaculture: Relevance to larviculture.
- The status of aquaculture development in the Asia-Pacific region.

NACA would like to thank the YSFRI, MARA and their staff for sharing their expertise with the network through this training course.

FAO/NACA Virtual Workshop on Aquaculture Transformation in Asia and the Pacific Region

At the current rate of growth, the planet will have to feed an additional 2 billion people by 2050, requiring an increase in food production of 60–70 percent from current levels. Fish and other aquatic animals and plants are a key part of our future food and nutrition supply and yet many challenges will need to be overcome to grow and sustain aquatic food systems.

'Blue Transformation' is a vision for FAO's work on aquatic food systems for the future of fish and other aquatic foods to achieve the objectives of the 2030 Agenda for Sustainable Development and the FAO aspiration of leaving no one behind through sustainable, inclusive, and resilient food systems for better production, better nutrition, better environment, and a better life.

Blue Transformation requires actions in three major areas:

- Promoting the sustainable intensification and expansion of aquaculture to respond to the growing global demand for aquatic foods.
- Ensuring the sustainable management of all fisheries to deliver healthy stocks, restore ecosystems and secure equitable livelihoods for all.
- Supporting the upgrading of aquatic value chains to improve the social, economic, and environmental outcomes of aquatic food systems.

Blue Transformation cannot be achieved without innovative partnerships. It requires a commitment from international partners, national and local governments, local communities, consumers, farmers and other private sector actors, to work together towards sustainable and healthy aquatic food systems. With the right approach and united action there can be a sustainable intensification and expansion of aquaculture to respond to the demand for aquatic food at the scale needed.

There is a need now to translate the vision for Blue Transformation into clear and workable strategies for transforming the aquaculture sector, recognising the target of 35 percent growth in global sustainable aquaculture production by 2030. The Shanghai Declaration provides some more specific guidance on maximising aquaculture's contribution to the 2030 Agenda and its SDGs .

FAO and NACA jointly organised the workshop from 13-14 September, via Zoom. The workshop served as a pre-consultation in preparation for a high-level meeting on Aquaculture transformation: innovations and investment for sustainable intensification and expansion of aquaculture in Asia and the Pacific region, which is scheduled for November 2022.

There were around 50 participants, including nominated technical experts and officials, representatives of NACA Lead Centres (CIFA, FARDC, FFRC, IFRO, SEAFDEC-AQD), the private sector, academic and research institutions, and other regional organisations.

Specific objectives of the workshop were to:

- Share key findings of the background papers prepared for the high-level meeting and get feedback from participants particularly on priorities for aquaculture transformation in the region.
- Validate a draft white paper on "Aquaculture transformation: innovations and investment for sustainable intensification and expansion of aquaculture in Asia and the Pacific region", which will be tabled for consideration at the high-level meeting.
- Identify follow up and collaborative actions to put aquaculture transformation into policy and practice for the region.

During the workshop, the purpose and needs for aquaculture transformation were presented together with country reports and regional synthesis, development strategies, and priority actions for transformation. Each presentation session was followed by a panel discussion to generate a more in-depth understanding on some important topics presented.

The outcomes of the workshop will be incorporated into the draft white paper to be presented for further discussion and decisions at the high-level meeting in November.

The workshop opened with a presentation on "Aquatic food systems in Asia and the Pacific Region: Transformation, opportunities and challenges", by FAO RAP; and country and regional highlights on "Strategies for aquaculture transformation", by Jiakun Xu of the Yellow Sea Fisheries Research Institute. Authors of country papers presented highlights on transformation opportunities in their own nations, which were followed by a panel discussion looking for common ground.

On the final day, a regional synthesis "Aquaculture transformation was in Asia-Pacific: Key challenges, innovation and priority areas of action" was presented by Yuan Derun, NACA. This was followed by two panel discussions.

The first was on investing in aquaculture transformation in Asia and the Pacific region, featuring Sophie Ryan, Acting Lead of the Global Aquaculture CEO Roundtable and CEO of the Global Salmon Initiative, Dave Robb from SeaBos and Tom Prins from Aqua-Spark.

The final panel discussion was on vision, strategic goals, priority areas and implementation of blue transformation, featuring Wenbo Zhang, J.K. Jena (DDG ICAR, India), Yingjie Liu, Vice President of the Chinese Academy of Fisheries Sciences, and Tim Pickering from the Secretariat of the Pacific Community.

Further details on the outcomes of the high level meeting will be published on the NACA website in due course.

Belt & Road Forum for International Freshwater Fishery Industry Innovation

An online forum was held on 16 August to enable technical exchange between policymakers, fishery extension officers, researchers and entrepreneurs in development of the freshwater fisheries industry through technology innovation. The forum was held under the guidance of the Chinese Department of International Cooperation and Fishery Administration, MARA, and the Chinese Academy of Fishery Sciences (CAFS). It was jointly organised by the Freshwater Fisheries Research Center of CAFS, and NACA.

Aquaculture technology innovation plays a catalytic role in transforming aqua-food systems and accelerating progress towards achieving the Sustainable Development Goals (SDGs). Innovative technologies and systems provide a range of solutions that can increase aquaculture productivity and efficiency, enhance farmers' access to rural services, and improve decision and policy making processes. For example, as seen from the response to the COVID-19 pandemic, digitisation technologies can open new markets through digital marketplaces and e-commerce to reach the last mile.

Belt and Road countries are experiencing fast population growth. Employment and food security should be top concerns for the people in the region. According to the Global Food Security and Nutrition Status issued by UN (2022), there are 800 million people suffering starvation in 2021, an increase of 150 million since the beginning of COVID-19. Obviously, the pandemic made the situation much worse.

Nevertheless, the pandemic pushed the aquaculture industry to innovate even faster. In responding to the challenges posed by the pandemic, many young entrepreneurs in Africa have explored innovative ways of adapting their businesses to the changing market conditions (FAO, 2020). But progress is uneven in geographic and socio-economic terms and in many areas people have a lower access to technological innovations and concepts. There remain several barriers to adoption of new concepts in most rural areas of the Belt and Road countries, such as infrastructure, affordability, and literacy and skills. Removal of these barriers is crucial to leverage new technologies' potential for achieving the SDGs. It is important to address persistant barriers such as the lack of new skills and customised technical solutions that can be easily up taken by relevant stakeholders.

Technology innovation is essential to the future workforce in aquaculture. It is a strong enabling factor for better productivity, better nutrition, better environment and better life. Governments and the private sectors can work together to create more opportunities to demonstrate and extend innovative technologies through policy support, education programs, capacity building and financial assistance.

The forum focussed on innovations and developments in freshwater fishery biotech, breeding, culture models, digitisation, and industrialisation, featuring presentations and discussions from experts of international organisations, the Chinese Academy of Sciences, Chinese Academy of Engineering, universities and entrepreneurs in virtual exchanges and discussions. The forum sought to find solutions for industry development to inform policy making in Belt and Road countries, as well as planning and implementation of relevant programmes and projects at global, regional, and national levels.

The programme included:

- The contribution of Chinese aquaculture innovation to south-south cooperation.
- Digital technology innovation and digital fishery development.
- Integrated fishery-solar low-carbon production system.
- Technological innovation promotes global food security and stability.
- Status quo and development trend of global fishery science and technology innovation.
- Prospects for sustainable development of aquaculture in southeast Asia.
- Current situation and future development direction of aquaculture science and technology in central and eastern Europe.
- Aquaculture technology innovation in Indonesia.
- Development and technological progress of aquaculture models in Kenya.
- Sustainable and efficient automated tilapia farming technology development in Egypt.

8th Global Conference on Gender in Aquaculture and Fisheries 21-23 November

GAF-8, the 8th Global Symposium on Gender in Aquaculture and Fisheries – will be held from 21-23 November, 2022, hosted by the Society of Fisheries Technologists (India) (SOFTI), Kochi and the ICAR-Central Institute of Fisheries Technology, Kochi.

GAF-8 is a stand-alone event, that will be packed with a variety of different activities and sessions covering all aspects. The GAF8 session and event themes, call for abstracts and other information will be available shortly.

Please see the GAF website for registration and other details:

https://www.gafconference.org/register.htm

Reported Aquatic Animal Diseases in the Asia-Pacific Region during the First Quarter of 2022

With the implementation of the new aquatic animal disease reporting in the Asia Pacific region from January 2021, and in lieu of the published QAAD Reports (last issue published was 4th quarter of 2020), NACA is publishing reported aquatic animal diseases submitted by countries in the Asia-Pacific region. This report covers the first quarter of 2022. The following diseases were reported:

Finfish diseases

- Infection with haematopoietic necrosis virus (IHN): Australia in wild juvenile redfin perch (*Perca fluviatilis*).

- Infection with *Aphanomyces invadans* (EUS): Australia in wild yellow bream (*Acanthopagrus australis*); Bangladesh in catla (*Catla catla*) and rui (*Labeo rohita*); India in *Channa* spp. and mrigal carp (*Cirrhinus mrigala*).

- Infection with red seabream iridovirus (RSIV): India in Asian seabass (*Lates calcarifer*)

- Viral encephalopathy and retinopathy (VER): Australia in farmed giant grouper (*Epinephelus lanceolatus*) and farmed pot bellied seahorse (*Hippocampus abdominalis*); Chinese Taipei in hybrid grouper (*Epinephelus fuscoguttatus* x *E. lanceolatus*).

- Grouper iridoviral disease (GIV): Chinese Taipei in hybrid grouper and blackhead seabream (*Acanthopagrus schlegelii*).

- Carp edema virus (CEV): India in koi carp (*Cyprinus carpio*).

- Infection with Tilapia lake virus (TILV): India in tilapia (*Oreochromis niloticus* and *O. mossambicus*); Philippines in tilapia (*Oreochromis* spp.).

Molluscan diseases

- Infection with abalone herpesvirus: Australia in wild green lipped abalone (*Haliotis laevigata*) and black lipped abalone (*H. rubra*).

Crustacean diseases

- Infection with white spot syndrome virus (WSSV): Chinese Taipei in whiteleg shrimp (*Penaeus vannamei*); India in *P. vannamei*; Philippines in PLs, juveniles, grow-out and broodstock of P. vannamei, eggs, PL and broodstock of *P. monodon*, grow-out of *Macrobrachium rosenbergii* and broodstock of mudcrab (*Scylla serrata*).

- Infection with infectious hypodermal and haematopoietic necrosis virus (IHHNV): India in black tiger shrimp (*P. monodon*); Philippines in grow-out of *P. vannamei* and eggs, PL, grow-out and broodstock of *P. monodon*.

- Acute hepatopancreatic necrosis disease (AHPND): Philippines in PL and grow-out of *P. vannamei* and nauplii and broodstock of *P. monodon*.

- Hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP): India in *P. vannamei*; Philippines in PLs of *P. vannamei* and *P. monodon*.

Amphibian diseases

- Infection with *Batrachochytrium dendrobatidis*: Australia in *Adelotus brevis*, *Limnodynastes peronii*, *Limnodynastes dumerilii*, *Litoria caerulea*, *Litoria ewingii*, *Litoria peronii*, *Litoria phyllochroa*, *Litoria quiritatus*, *Litoria verreauxii*, *Platyplectrum ornatum*, *Pseudophryne bibronii* and *Rhinella marina*.

Other diseases

- Bangladesh reported infection with *Streptococcus agalactiae* in tilapia (*Oreochromis niloticus*) and climbing perch (*Anabas testudineus*), and infection with *Aeromonas* sp. in climbing perch and shing catfish (*Heteropnuestes fossilis*).

- India reported infectious spleen and kidney necrosis virus (ISKNV) in angel fish (*Pterophylum scalare*).

E.M. Leaño
Senior Programme Officer
Aquatic Animal Health Programme

The online version of this report, and the QAAD series, is available from:

https://enaca.org/?id=1220

International Training Course on Biology and Pathology of the Penaeid Shrimp 2022

The course will be held at Centex Shrimp, Faculty of Science, Mahidol University in Bangkok, Thailand, from 14-25 November. Highlights of the course include:

- Updates on major shrimp diseases including EHP, white faeces, and AHPND.

- Shrimp farming systems and management.

- Shrimp molecular immunity.

- Molecular approaches for disease detection including PCR and CRISPR.

- Hands-on laboratory sessions, including pathogenic viral detection using PCR, histological preparations, EHP assays and bioinformatic analysis.

- An optional field trip to local shrimp farms in Surat Thani.

Reservations close **31 October**. For more information, please contact centexcourse2022@gmail.com or download the flyer from: https://enaca.org/enclosure/?id=1231

Mahidol University
Faculty of Science

BIOTEC
a member of NSTDA

International Training Course

Biology and Pathology of The Penaeid Shrimp 2022

14 – 25 November, 2022

@ Centex Shrimp, Faculty of Science, Mahidol University, Bangkok, Thailand

FROM RESEARCH TO PRACTICAL BIOTECHNOLOGICAL SOLUTIONS FOR THE SHRIMP INDUSTRY

Highlights

- Updates on major shrimp diseases (EHP, white feces, AHPND, etc.)
- Shrimp farming systems and managements
- Shrimp molecular immunity
- Molecular approaches for disease detection (PCR, CRISPR,etc.)
- Hands-on laboratory sessions, including pathogenic viral detection using PCR, histological preparation, EHP assays, bioinformatic analysis, etc.

"Includes a field trip to local shrimp farms!"

Registration fee

For non-Thai participants
Early bird rate (now-September 16, 2022): 1,700 USD
Regular rate: 1,850 USD
(Prices exclude transfer fee)

สำหรับคนไทย
Early bird rate: ๒๒,๐๐๐ บาท
Regular rate: ๒๔,๐๐๐ บาท
นักศึกษาที่ศึกษาในประเทศไทย: ๙,๐๐๐ บาท
เข้าฟังเฉพาะบรรยาย ๑๒,๐๐๐ บาท

Optional field trip to Surat Thani (November 26-27, 2022)

900 USD/๑๕,๐๐๐ บาท
*round-trip flight and 1-night accommodation included

Activities
- Shrimp farm visit (3 farms)
- On-site discussion on shrimp farm management

Reservation period: now - October 31, 2022

Reservation: centexcourse2022@gmail.com
Tel: 02-201-5871; Fax: 02-354-7344
100% of fee must be transferred within 14 days after reservation

Disclaimer: In the event that the minimum attendance is not reached, we reserve the right to cancel the workshop. You will be refunded for the amount you have paid.

Angkasa Putra inaugurated as first President of the South-East Asian Fisheries and Aquaculture Student Association

The South-East Asian Fisheries and Aquaculture Student Association (SEAFAS) is the first youth association that includes active students and youth in the scope of fisheries and aquaculture in South-East Asia. SEAFAS was inaugurated by the President Elect of the World Aquaculture Society – Asian Pacific Chapter, Associate Professor Dr Krishna Salin.

The SEAFAS Declaration was carried out as one of a series of events in the Blue Economy Conference and Trade Exhibition 2022 which was held at the Madidihang Auditorium of the AUP Polytechnic (Politeknik Ahli Usaha Perikanan) – the Ocean Institute of Indonesia, Monday 22 August 2022.

Angkasa Putra from AUP Polytechnic was elected as the first President of SEAFAS. He has published more than 30 articles with on marine and fisheries issues in national and international journals, proceedings, magazines, and online media as a positive contribution to the development and improvement of science through youth perspectives. He was inaugurated following a statement by the President Elect of World Aquaculture Society – Asian Pacific Chapter through the Charter of Appreciation and presentation of the SEAFAS flag.

Angkasa Putra, first President of the South-East Asian Fisheries and Aquaculture Student Association, receiving flag from Salin Krishna, President Elect of WAS Asian-Pacific.

"Hopefully SEAFAS will become a new energy in gathering creative, innovative, inclusive, visionary, and implementable thoughts in improving the quality of human resources and developing ASEAN fisheries and aquaculture. Global scientific forums provide a golden opportunity to bridge these thoughts. In addition, the critical spirit of enthusiasm, strong literacy, and optimism are internal weapons to support the dream of the implementation", said Angkasa Putra.

The Minister of Marine Affairs and Fisheries of the Republic of Indonesia opens the Blue Economy Conference and Trade Exhibition.

The declaration and inauguration were witnessed by the Minister of Marine Affairs and Fisheries of the Republic of Indonesia (Ir. Sakti Wahyu Trenggono, MM, IPU), the Envoy of the President Seychelles for ASEAN (Mr Nico Barito), Deputy Head of Mission Norway Embassy for Indonesia (Mr Kristian Netland), Head of Research and Human Resources for Marine and Fisheries (Dr I. Nyoman Radiarta), the representative of Michigan State University USA (Dr Lauren Jescovitch), Director General of Capture Fisheries (Dr Muhammad Zaini), Director General of Power Strengthening Competitiveness of Marine and Fishery Products (Ir. Artati Widiarti, MA), Director General of Marine Spatial Management (Irjen Pol. Drs Victor G. Manoppo, MH), Director General of Supervision of Marine and Fishery Resources (Laksamada Muda TNI Adin Nurawaluddin, M. Han), Head of the Fish Quarantine, Quality Control, and Safety of Fishery Products (Dr Pamuji Lestari), Director General of Aquaculture (Dr Tb. Haeru Rahayu), Director of AUP Polytechnic (Dr Muhammad Hery Riyadi Alauddin), the representative of Tanin Sevnica Slovenia (Dr Rahul Gadipathi), the representative of MOTIV Cargill Vietnam (Dr Nguyen Duy Hoa), Echelon II Scope Officer of the Ministry of Marine Affairs and Fisheries, expert staff to the Minister of Marine Affairs and Fisheries, the representative of Telkom Indonesia - Indonesia Telecommunication and Digital Research Institute, the representative of the Philippines, the representative of Biocycle, CPP, business partners and industry, Ministry of Marine Affairs and Fisheries, and officials, lecturers, staff, AUP students, and participants in the 2022 Blue Economy Conference and Trade Exhibition.

Artemia webinars: Video recordings of technical presentations available

The International Artemia Aquaculture Consortium, hosted by NACA, recently convened two technical webinars on *Artemia*. As foreshadowed in the last issue, the technical presentations of both are now available for viewing.

Webinar on management of Artemia resources of the Great Salt Lake, Utah USA

The International Artemia Aquaculture Consortium (IAAC) hosted a webinar on Management of the Artemia Resources of the Great Salt Lake, 5 May 2022, at 14:00 UTC. The purpose of the webinar was to familiarise participants with recent international developments in *Artemia* research cooperation, and to examine the Great Salt Lake as a case study in successful management of *Artemia* resources in a multi-stakeholder environment. The programme / available recordings are as follows:

Link: https://artemia.info/news/?id=33

- Welcome and aims of the webinar
  Patrick Sorgeloos, Artemia Reference Center, Belgium
- History of sustainable harvest management on Great Salt Lake
  Thomas Bosteels, Great Salt Lake Brine Shrimp Cooperative Inc., Utah USA
- Initial policy efforts to protect Great Salt Lake
  Timothy Hawkes, Utah State Representative
- Managing salinity and nutrients on Great Salt Lake: A cooperative approach involving multiple stakeholders
  Thomas Bosteels, Great Salt Lake Brine Shrimp Cooperative Inc., Utah USA
- More mature law and policy efforts to protect water supply: Enhanced stakeholder engagement, what does the future hold?
  Timothy Hawkes, Utah State Representative
- Q&A
  Moderated by Simon Wilkinson, Network of Aquaculture Centres in Asia-Pacific
- Closing remarks
  Mike Rust, National Oceanic and Atmospheric Administration, USA

Webinar on the history of Artemia activities in Africa

The Kenya Marine and Fisheries Research Institute in partnership with the International Artemia Aquaculture Consortium hosted a webinar on the History of Artemia in Africa on 4 May 2022.

A diverse range of *Artemia* activities in different African countries were presented, to take stock of where the continent is, explore opportunities and address the various challenges impeding the production and utilisation of *Artemia* for improved livelihoods and overall aquaculture development in Africa. The programme / available recordings are as follows:

Link: https://artemia.info/news/?id=32

The programme, for which recordings are available, was as follows:

- Welcome remarks
  Eric Okuku, KMFRI Mombasa Centre Director
- Aim of the workshop
  Patrick Sorgeloos, Artemia Reference Center, Belgium
- Introduction of *Artemia* in Keyna
  Prof. Rasowo, Technical University of Mombasa, Kenya & Eddy Naessens, INVE Aquaculture, Belgium
- History of *Artemia* activities in Kenya
  Morine Mukami, Kenya Marine and Fisheries Research Institute
- History of *Artemia* activities in Tunisia
  Mohamed Salah Romdhane, National Institute of Agricultural Sciences of Tunisia
- History of *Artemia* activities in Libya
  Gilbert Van Stappen, Artemia Reference Center, Ghent University, Belgium
- History of *Artemia* activities in Uganda
  Martin Serrwanda, Mountains of the Moon University, Uganda
- History of *Artemia* activities in Tanzania
  Imani Kapinga, Tanzania Fisheries Research Institute, Tanzania
- History of *Artemia* activities in Mozambique
  Rafael Rafael, Aquaculture Research Center, Mozambique
- History of *Artemia* activities in South Africa
  Horst Kaiser, Rhodes University, Grahamstown, South Africa
- History of *Artemia* activities Algeria, Eritrea, Namibia, Madagascar and Botswana
  Patrick Sorgeloos, Artemia Reference Center, Ghent University, Belgium
- Q&A, discussion, conclusions and recommendations
- Closing remarks
  Simon Wilkinson, Network of Aquaculture Centres in Asia-Pacific

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NACA is a network composed of 19 member governments in the Asia-Pacific Region.