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Small-scale aquaculture in Myanmar

Best practices for small-scale shrimp farmers in Thailand

Mahseer in India

Endangered catfish

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We need an aquaculture internet of things

Aquaculture tends to lag far behind terrestrial agriculture in technological development and uptake. Why is anyone's guess, perhaps it is the legacy of a relatively new sector that is still coming to grips with the husbandry of a diverse range of animals and plants, in terms of understanding their needs, developing improved varieties and optimal practices for production. A lot of progress has been made over the last few decades, but much of aquaculture remains an art rather than science.

In particular, aquaculture has been rather slow to adopt automation and information technology, especially in developing countries where labour costs are low, IT personnel are hard to find in rural areas, and perhaps people haven't seen a need for it, or appreciated the potential benefits. Certainly, a farm needs to reach a certain scale of production before it starts making sense. But when you start scaling up there are potential advantages to be had.

The digital revolution of the 1970s first saw the widespread adoption of personal computers, which were connected by the internet revolution of the 1990s, and miniaturised and made portable by the mobile phone revolution of the 2000s. Today the most widespread computers are the mobile phones in our pockets and they represent more than half of global internet access. In Asia, it's almost two thirds.

We are at the beginning of a new revolution, the Internet of Things (IOT): Smart networked devices and sensors that collect information about their surroundings, communicate with people or machines, make decisions based on programming models and interact with the physical world through control of electronic switches, motors and actuators. Many of these devices are low-cost, literally a few dollars and they are getting cheaper all the time. Many require very little power, running for days or weeks on a small battery or indefinitely with the addition of a small solar panel. New wireless protocols allow devices to communicate with nearby mesh networks, or with distant receiving stations literally kilometres away.

There are many potential applications for IOT technology in aquaculture, but the obvious candidates lie in water quality monitoring and early warning. A tiny computer (microcontroller) equipped with relevant sensors could track and log water quality on a continuous basis, providing reports, warnings or advice to farm management when parameters deviate from optimal ranges.

Consider also how much energy is spent on aeration. Rather than running aerators according to experience and rule of thumb, a microcontroller could actually measure dissolved oxygen levels in real time and turn aerators on and off as needed to maintain optimal levels. Significant energy savings should be possible, and again automated warnings could alert the management in a timely fashion and save a pond if something goes wrong. These devices can easily pay for themselves.

Getting into the realm of speculation now, but with real time logging of water quality data it may well be that some interesting correlations will show up with the incidence of particular diseases, which may guide future improvements to farm management practices and productivity. It's worth looking into, and we will.

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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NACA

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

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Mahseer in recreational fisheries and ecotourism in India

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A catch of 11.5 kg golden mahseer by Mr. Dorjee Sona from Yamne River in East Siang District during March 2016.

Mahseer, a large bodied potamodromous freshwater fish endemic to Asian rivers is a flagship species of considerable economic and recreational interest. Mahseer is the most popular game fish amongst anglers in India as this fish is the toughest fighter amongst freshwater sports fish and is therefore known as the undisputed king of Indian freshwaters. The existence of such a mighty game fish in Indian water is depicted in Vedic times[1] in the writings of King Someswara (1127 AD) in his Matsya Vinoda on account of angling of mahseer with rod and line[2]. Angling of mahseer in the country was further pursued by the British, attracting the attention of anglers Beevan (1877), Thomas (1873, 1897), Dhu (1906, 1918, 1923) and Nevil (1915). The lakes of Kumaon hills were reportedly stocked with mahseer by Sir H. Ramsay during 1858 for sport fishing[3]. Codrington (1946) and McDonald (1948) wrote about its natural history and on special traits of fish from an angler's point of view. The adventures of the English in search of mahseer across the country was described by Ghorpade (1978). Kulkarni and Ogale (1979) who considered mahseer the noblest sport fish of India, a great favourite of anglers, both from India and overseas. Belonging to the carps, family Cyprinidae, India is home to 15 species out of 47 species of mahseer that exist in the world[4]. Mahseer belong to three genus namely *Tor* (Gray), *Neolissochilus* (McClelland) and *Naziritor* (McClelland). However, genus *Tor* constitutes the bulk of mahseer and there are different opinions of the species of mahseer available under different genus[5].

Recreational fishing or sport fishing is one of the most sought after adventure tourism activities and has a booming international business opportunity. The most common form of recreational fishing is done with a rod, reel, line, hooks and any one of a wide range of baits. The three common methods for capturing mahseer are fly fishing, spoon fishing and bait fishing, although recent innovations are reported. Fly fishing or fly casting method employs artificial fly to hook the fish with the help of rod and line. In spoon fishing, spoon like artificial metallic shining lures are used basically to fish 'heavier' waters where mahseer occurs. Bait fishing or bait casting is performed using both natural and artificial lures. The natural baits are earthworms, minnows and insects.

Today, recreational fishing is an intrinsic part of ecotourism which involves travel to destinations where pristine fauna and cultural heritage are the primary attractions and can provide viable income-generating options for economic development for local communities and opportunity of education and activism among travelers, making them more passionate towards nature and its resources.

In this article, we have made an attempt to compile information on recreational mahseer fisheries in India. The Indian aquatic resources in the form of rivers, streams and lakes and the importance of the mighty mahseer as a game fish through the perspectives of active anglers and vision of stakeholders and researchers is highlighted herewith. In this context, the river systems of the Indian Himalayan Region are worth mentioning which offer some of the most remote, pristine, wild and untapped resources harbouring mahseer and providing opportunity for fishing and recreation in the country. The river conditions are varied with different terrains of the Himalayas influencing fishing techniques[6]. Undoubtedly, one of the most successful ways to hook mahseer in these torrential rivers is also by floating on rafts downstream over a period of time enabling to access the remotest angling spots.

Arunachal Pradesh

Subansiri River: This river of Arunachal Pradesh originates in the Himalayas and enters into India via Taksing of Upper Subansiri District, flowing down along the towns of Daporijo and Ziro, to enter into the vast wilderness of the lower valleys and finally terminating to meet the mighty Brahmaputra. Anglers among the sparse human habitation travel along the river Subansiri as adventure enthusiasts in these picturesque mountains of Arunachal Pradesh, with crystal clear post monsoon waters coursing through them and home to the big fighting fishes *Tor putitora* (golden mahseer), *Neolissochilus* spp. (chocolate mahseer) and the *Bagarius bagarius* (goonch) as shown.

The Siang River belt: This river flows for 294 km through the hills before joining the Brahmaputra River in the plains. The Siang River belt is mostly inhabited by the Adi tribe and sub-tribes *Minyongs, Padams, Shimongs, Milangs, Pasis, Karkos, Ashings, Pangis, Tangmas* and *Boris*. Their life is closely mingled with nature where hunting and angling (*gekar* in Adi language) are some of their oldest traditional practices. Mahseer (locally *Ngocho*) is a favorite species for the anglers of the belt. A few of the preferred sites along the banks of river Siang are Bodak, Sigar, Raling, Kyiet, Berung, Sikabamin for angling due to the abundance of mahseer along with an accessible topography and water movement. Attention has been paid recently towards developing ecotourism in the Siang belt by arranging rafts, fish rods, tents and other basic amenities and in turn inviting innumerable tourists from different parts of the country.

The Menchukha region is another angler's paradise, situated in West Siang District of Arunachal Pradesh, 180 kilometres northwest of headquarters Aalo and is only 29 kilometres away from Indo-China border. The Siyom River (locally known as Yargyap Chu) flowing through Menchukha township is home for the exotic and Indian trouts. Mr Dorjee Sona, an active angler from Menchukha, encountered golden and chocolate mahseer abundantly in the Yamne River, which flows from Upper Siang District and meets the mighty Siang River

A golden mahseer of 12.6 kg weight from the Subansiri River in November 2014.

A chocolate mahseer (Neolissochilus stracheyi) caught by diving in the Basar area of the Siang drainage.

near Ponging village. Anglers of the region have developed a community based anglers association "Arunachal Anglers" with an objective to strengthen the protection measures for the endangered group of fish – mahseer.

Lohit River: Angling and fishing camps in the Lohit are famous for mahseer (*Tor putitora, Tor tor, Neolissochilus* spp.) and catfish *(Bagarius bagarius)* fishing and adventure sports. One of the major angling and fishing camps along the Lohit is Tezu situated at 27°55′N latitude and 96°10′E longitude. The angling and fishing season over the Lohit starts from October to April whereof the maximum temperature remains 20° C during the day.

Pare River: This river flows through Papum Pare District along the small township of Sagalee situated at an altitude of 162 m asl between 27°14′N latitude and 93°61′E longitude, and located 29 km east of the state capital Itanagar. The Pare River harbours the golden mahseer and chocolate mahseer, says a young avid angler Mr Ngurang Neega from Sagalee town. The angler arranges angling expeditions for the visitors from neighbouring states Nagaland, Meghalaya, Sikkim, Assam and tourist from countries like Nepal and Bhutan. The competitions are done on the principle of catch and release and the fish are not harmed. The angling competitions have remained successful to associate the local community in promoting eco-tourism in an unrevealed place of Arunachal Pradesh.

Kameng River: The river Kameng in Arunachal Pradesh originates in Tawang District from a glacial lake below snow-capped Gori Chen mountain at an elevation of 6,300 metres asl. The river is known to harbour the mahseer in the upper and lower reaches as witnessed in the hooks of the anglers of the area. Catch and release angling competitions are organised on regular basis at places like Seppa, Nameri, Bhalukpong with an objective to promote conservative angling with rod and reel and to spread awareness for protection of the river system along with its natural habitat specially the local species, which due to illegal poaching, chemical poisoning, electrocution and dynamiting process has caused much damage in the recent era as reported by an angler Mr Biplab Chakraborty.

Assam

Jia Bhoreli River: This river is one of the major south flowing tributaries of the Brahmaputra. The river harbours the legendry mahseers *Tor tor* (locally lao pithia), *Tor putitora* (locally sonali pithia), *Tor mosal* (locally lobura), *Tor progenius* (locally jungha pithia) and *Neolissochilus hexagonolepis* (locally boka pithia) which create a magnificent fishery in the foot hills of Assam and Arunachal Pradesh[3].

The Assam Bhoreli Angling and Conservation Association (ABACA), situated at the banks of the Jia Bhoreli River at Nameri, Sonitpur District is one of those eco-camps set up for popularising adventure sports among the rural youth, angling on catch and release and create awareness on conservation of fish[7]. The camp presently sustains on organising angling, camping, rafting, trekking, bird watching, heritage and culture. The camp is also bestowed with breeding and seed production facilities for propagation of golden mahseer. Mr Gautam Tamuli, a life member of ABACA and once an active angler in the region for the search of mahseer during 1987-1995 was much appreciated in those days for his record catch of golden mahseer *(Tor putitora)* weighing 12 kg and 20 kg at Nameri Mukh, 17.4 kg at 17 Mile near Bhalukpong and a 12 kg golden mahseer at Old Nameri Mukh. His record catches can be witnessed today from the preserved teeth of some of those mahseer restored in his residence.

Karbi Anglong and West Karbi Anglong: These are the hills districts of Assam. The district with dense tropical forest and numerous tributaries of the mighty Brahmaputra has sultry temperature of 23° to 32° Celsius in summer and 6° to 12° Celsius in winter. The rivers are reported by Mr Chatra Pator

(I/c SDFDO) to harbour many species of mahseer viz., *Tor tor, Tor putitora* and *Neolissochilus* spp. creating an immense potential for angling in these hilly districts of Assam. Some of those potential angling sites are (a) Koka at the banks of river Kopili with beautiful waterfalls (b) Amreng at the banks of river Amreng, provided with a tourist lodge and a heritage old British made bridge across the river (c) The Amtereng Dam site of Karbi Langpi Hydro project over river Karbi Langpi with the attraction of the reservoir (d) Siloni, a river island over the river Longnit attracting the anglers for day out.

Mr Rupsing Hanse, a prominent angler of village Harlongjove, Hamren sharing his experiences recalled his prize winning catch of a chocolate mahseer weighing 4.2 kg during 1996-97. The angler further added that with these bountiful of resources, both the hill districts of Assam has an immense potential for recreational fisheries and eco-tourism, provided certain policies are framed and implemented based on the present issues with the concerted effort of the state departments, research organizations and local community.

Manas River: This river is a transboundary river in the Himalayan foothills between southern Bhutan and India situated 26°10′ to 26°50′N Latitudes and 90°00′ to 91°00′E Longitude. It is one of the biggest river systems meeting the river Brahmaputra. It is reported that upper stretches of river Manas and its tributaries are predominantly inhabited by mahseer species viz., *Tor putitora, Tor tor* and *N. hexagonolepis*. Mr Pranab Bora, once an active angler, mentioned to have a record catch of a golden mahseer weighing 12.5 kg in 1981 with a landing time of 35 minutes. Mahseer of size 2.0-2.5 kg was a usual catch during those days in 1970-71 at river Manas. He further spoke about Late Sanjay Deb Roy, the then a senior forest official to hook a 20 kg mahseer at Manas River.

Nagaland

Nagaland is endowed with abundant lakes, rivers, reservoirs, ponds and offers numerous sport fishes like golden and chocolate mahseer and other indigenous species to catch. The kaleidoscope diverse topography, culture and rich biodiversity of the state attracts tourist from all over the world. Some of the important mahseer endowed rivers in the districts of Nagaland are Dhansiri and Intangki (Dimapur), Milak and Dikhu (Mokokchung), Doyang (Wokha), Arachu, Lanyi, Seidzu, Tesuru and Tizu (Phek), Zungki and Likhimro (Kiphire). To promote tourism through sport fishing and to create awareness to conserve the indigenous and endemic fish species of the State, an Anglers Association Nagaland (AAN) organises angling festival, angling competitions and special days like World Fish Migration Day in lakes, large ponds and reservoirs belonging to local communities and individuals of the area.

Sikkim

Sikkim with its vast river systems is an anglers' delight where the mighty Teesta River and Rangeet provide ample scope for mahseer. Some of the important confluences of major rivers within Sikkim which forms the hotspot to hook the mighty mahseer as reported by an angler Mr Ian Christopher are (i) Singtam Town - river Teesta and Rani River (ii) Rorathang Town - Rorathang River and Rani River (iii) Rangpo Town - Rorathang River and Teesta River (iv) Jorthang Town - Rangeet River and Rambang River (v) Teesta Town - Teesta River and Rangeet River. Angling is mostly done during the

Table 1: Specification of fishing equipment used by few representative mahseer anglers in India.

State	River	Angler (s)	Major species of mahseer	Biggest catch sizes (kg)
Arunachal Pradesh	Subansiri	Mr. Naushad Ali	*Tor putitora*, and *Neolissochilus* spp.	5.7-18.0
	Siang and tributaries	Mr. Dorjee Sona	*Tor putitora*, and *Neolissochilus* spp.	8.3-11.5
	Pare	Mr. Ngurang Neega	*Tor putitora*, and *Neolissochilus* spp.	10.0-12.0
	Kameng	Mr. Biplab Chakraborty	*Tor putitora*, and *Neolissochilus* spp.	1.6-13.0
Assam	Jia Bhorelli	Mr. Gautam Tamuli; Mr. Naushad Ali	*Tor tor, Tor putitora, Tor mosal, Tor progenius* and *Neolissochilus hexagonolepis*	20.0
	Manas	Mr. Pranab Bora	*Tor putitora*, *Tor tor* and *N. hexagonolepis*	2.0-20.0
Nagaland	Dhansiri, Intangki, Milak, Dikhu, Doyang, Arachu, Lanyi, Seidzu, Tesuru, Tizu, Zungki, Likhimro	Anglers Association Nagaland	*Tor putitora*, and *Neolissochilus* spp.	Not determined
Sikkim	Teesta and Rangeet	Mr. Ian Christopher	*Tor putitora*, and *Neolissochilus* spp.	3.0-24.0
Meghalaya	Pools and sanctuaries	Mr. Bhutto Marak	*Neolissochilus* spp.	1.0-5.0
Mizoram	Rivers of Kolodyne drainage	Local residents	*Neolissochilus* spp.	Not determined
Uttarakhand	Mahakali, Saryu	Mr. Mohan Rayal	*Tor putitora*	15.42 kg
Peninsular India	Narmada, Cauvery	Mr. Derek Dsouza	*Tor khudree*	Data not available
			Neolissochilus spp.	

Mr Ian Christopher angling mahseer in the Rangeet River, Sikkim.

pre and post monsoon seasons and the major mahseer encountered in these rivers are the golden mahseer and chocolate mahseer.

Meghalaya

Fee fishing: Meghalaya is literally known as the 'Abode of clouds' with the fame of having the highest rainfall on earth and this makes the state full of aquatic resources. The state is predominantly inhabited by the Khasis, Jaintias and Garos who are fascinated for angling as their common traditional fishing practice for recreation. Rich in chocolate mahseers namely *Neolissochilus hexagonolepis* and *N. hexastichus,* local entrepreneurs from areas Mylliem, Smit, Mairang, Umsning and Laitlyngkot of Khasi hills have ventured into fee fishing for anglers allowing fishing in their own ponds and tanks on payment basis. Fishing competitions are also being organized once or twice in a year in these areas.

Mizoram

Angling, as a whole is an age old practice for the people of Mizoram and is performed on traditional means by simple hook and line for catching the locally available carps, catfishes, murrels etc till date. Md Mintul Ali, Scientist of KVK Mamit identifies some of the potential larger water bodies for recreational fisheries as Palak, Tamdil, Rungdil and Rengdil lakes and Serlui reservoir. Recent study has shown that the rivers of the state viz., Chhimtuipui, Mat, Serlui and Tuirial harbour a variety of mahseer species viz. *Tor tor* and *Neolissocheilus hexagonolepis* as stated by the Department of Fisheries, Govt. of Mizoram.

Uttarakhand

Fishing in Uttarakhand has been an awesome experience for those who try for mahseer fishing. Some of the important locations known for sport fishing and eco-tourism are given below.

River Mahakali: The confluence of river Mahakali and Saryu at Pancheshwar along the Indo-Nepal border is one of the least fished but the best known mahseer (*Tor* spp.) rivers in Kumaon region of Uttarakhand. Rafters can indulge in adventurous white water river rafting with fishing in this water.

River Kosi: River Kosi in Corbett National Park is witnessed with bountiful of golden and chocolate mahseers. Betalghat and Chhara are the best angling sites in Kosi River.

River Ramganga: The best places to locate golden mahseer for angling along the Ramganga River are Machula bridge and Van Ghat pools.

Himachal Pradesh

Himachal Pradesh is endowed with numbers of fast flowing rivers and streams in the name of Beas, Sutlej, Ravi, Tirthan, Sainj, Uhl, Baspa, Pabar, Lambadug, Giri, Rana, Nugal Gai, Baner, Bata etc., originating from glaciers, rumbling and swirling along the rugged mountain passing through awesome gorges, canyons, alternating with pools and fiery rapids. Mahseer is one of the major fish available in these streams along with exotic and indigenous trout and an array of catfishes. Each year a large number of anglers both from home and abroad visit the state in the pursuit of age-old art of angling. Fishing in these streams is regularized under the State Fisheries Act, where the anglers are provided with a fishing license and are charged with nominal fees for angling. A few of the lucrative mahseer grounds in Himachal Pradesh are at Kangra valley, Sari Marog (confluence of the Binwas tributary with the river Beas), Mandh-Khad confluence, Lambagaon pool, Neogal confluence, Chamba pattan, Kuru pool, Dehra and Pong dam reservoir and Gaura.

Jammu and Kashmir

In Kashmir valley, mahseer has been the major fish having socio-economic and recreational significance. Efforts are being made for the development of mahseer sport fisheries by the Department of Fisheries, Govt. of J&K in areas of Tawi River (Jammu), Ujh stream, Ravi River (Kathua), Tawi River (Udhampur), Poonch River (Poonch), Rajouri Wali Tawi (Rajouri), Salal reservoir, Nallah Rud, Ans, Chenab, Pouni Nallah (Reasi).

Peninsular India

Anglers on the lookout for the mahseer can also try their luck in the rivers of the Indian peninsula – Godavari, Cauvery, Krishna and Mahanadi – almost throughout the year (except

Lures for mahseer.

during the monsoons). In Karnataka, the lure of the Cauvery proves difficult to resist for anglers – it is probably the best river for sport-fishing in peninsular India.

Cauvery River: In Karnataka, Galibore, Bheemeshwari and Doddamakali are amongst the important fishing camps along the Cauvery. Anglers from all over the world pay their annual visit to these exclusively reserved stretches to pit their wits against the mahseer while non-anglers revel in nature's bounty. The major species of mahseer that can be spotted at the angling sites of the Cauvery is *Tor khudree*. Much effort has been made by Wildlife Association of South India (WASI) and Coorg Wildlife Society (CWS) for the protection of the habitat of mahseer and the adjoining pristine stretches of the river. Licenses are issued to anglers for fishing strictly on 'catch-and-release' as told by angler Mr Derek Dsouza.

Chalakudy River: This river, the 5th longest river in Kerala, harbours *Tor tor* as one of its important fish species[8]. The river with its importance for its reservoirs and adjoining townships provides ample scope for development of mahseer angling[9]. The Wayanad mahseer, *Neolissochilus wynaadensis* is another species in the larger streams of the region[10,11].

Fish sanctuaries

Fish sanctuaries are under implementation in Meghalaya under Meghalaya State Aquaculture Mission (MSAM) with an objective to conserve and enhance the aquatic bio-diversity and to promote untapped and underprivileged places as tourist spots to benefit the local rural people. A few of these functional fish sanctuaries of the state are (i) Amlayee mahseer fish sanctuary at Nongbareh (West Jaintia Hills) over the Amlayee River where 1.5 km of its stretch is protected for chocolate mahseer *(Neolissochilus hexagonolepis)* and at the same time inviting visitors for active participation in sport fishing on the concept of 'catch and release' angling, (ii) Asim Bibra fish sanctuary over Chibok River (East Garo Hills) where community fishing event is celebrated every year with an objective to conserve the God gifted aquatic hotspots for development of livelihood ways, (iii) Deku Dobagre fish sanctuary established over Bugai River (South Garo Hills) based on the richness of chocolate mahseer, (iv) Wachi Wari fish sanctuary (West Garo Hills) over Simsang River providing an ethnic beauty for an ideal fish watching platform for chocolate mahseer by feeding them, (v) Songkal Wari fish sanctuary (West Garo Hills) on Simsang River between two main towns Tura and Williamnagar, where any visitor can view thousands of mahseers swimming in shoal based on the concept of in-situ aquatic life conservation. Seeing the encouraging results, 'wari' at Rombagre, Selbalgre were established and within a span of five years, this concept has

An angler with a chocolate mahseer caught in the Pare River.

An angler with a 7 kg golden mahseer caught from the Kameng River in October 2015.

reached to more than hundred in the area. This has led to the population of mahseer on the rise in Meghalaya following the practice of catch and release by the anglers. Females are not too far behind in the state and undoubtedly have the most number of female anglers anywhere in India.

Mahseer watching

Fish watching platforms have gained much momentum in the recent times as this practice is considered to have multiple positive benefits to human health. Keeping fish in tanks and ponds also facilitates in-situ conservation of these endangered fish - mahseer. Many of the upland lakes, religious and protected tanks, stretches of rivers and streams, pools are examples of fish watching spots. Mahseer can be best watched in the upland Kumaon lakes viz., Nainital, Bhimtal, Naukuchiatal and Sattal and tanks such as Nal Damayanti. Similarly, the districts of Tawang, Lower Dibang valley, Papumpare and Upper Siang in Arunachal Pradesh are best known for bestowing numerous numbers of lakes having multidimensional importance for angling, scenic beauty, bird watching and hill trekking etc. Ward's lake, Jarain pitcher plant lake and Thadlaskein Lake at Meghalaya, Dighalipukhuri at Guwahati, Machchiyal in Himachal Pradesh are others which offer excellent sites for development of fish watching spots together with other recreational amenities like boating, children's park, food courts etc.

Jasingfaa Aqua Tourism Centre: This centre, situated in Assam, is a leading example to set up a fish based adventure tourism activities in the country bliss with the amenities to satisfy the passionate anglers, bird and fish watching. Of late, the highly priced sport fish golden mahseer was introduced with the aegis of ICAR-DCFR, Bhimtal and reared specially for brood banking and fish watching with a motto *"Help golden mahseer to save biodiversity for humanity"* and with an objective to protect the fish under controlled conditions so that generation to come will have the opportunity to know and enjoy encountering this majestic river fish. Angling festival and special workshops on angling tips are being arranged regularly in the centre.

Conclusion

India has tremendous potentiality for mahseer recreational fisheries in many states, provided the tourism sector is developed to the expected level starting from identifying the potential areas followed with formulation of effective policies and guidelines for entrepreneurship development and supported with ancillary services. The type of ecotourism developed in the country on fish angling and fish watch has both as outlined has positive indirect and direct consequences towards the conservation of mahseer. In this context, mahseer has been recognised as the 'state fish' in 7 states of India and has all the qualities to become a 'national freshwater fish' because of its fame for its magnificent colour, fighting skills and sizes[12].

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A prized catch of golden mahseer from the Mahakali River at Pancheswar in 2016.

Current know how and possibility for growout culture of an endangered catfish, *Horabagrus brachysoma*

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A haul of Horabagrus brachysoma fingerlings ready for pond stocking.

The contribution of freshwater aquaculture produce in India is noteworthy. Indian major carps are still at the head of production and fish production is projected to reach about 12 million tonnes by 2020. Hence there is an urgent need to utilise modern techniques for production over the traditional methods, increase productivity and to diversify species and systems. Minor carps, medium carps, catfishes and air-breathing fishes present opportunities for the diversification of aquaculture. Some varieties of carps and catfishes have low growth potential, but still retain marketing scope as there is a trend of eating whole fish fried or in curries. *Horabagrus brachysoma* is one such catfish, which has immense demand among the consumers. Even though its production is limited, success has been registered after overcoming various technical problems involved during its production. The article communicates the culture practices of this catfish in captivity.

Why *H. brachysoma* considered as a potential species for aquaculture diversification?

- Very few fish species other than this catfish have dual importance as both ornamental and food fish.
- It adapts well to freshwater and matures in captive conditions.

- Size variation among the population during captive rearing is a usual phenomenon in many catfishes, but *H. brachysoma* tends to exhibit homogenous growth at different life stages.

- Catfish feeds usually contain fish meal as an important ingredient, which escalates the cost of production. However, *H. brachysoma* is omnivorous in nature and can be fed well with the feed prepared from plant ingredients also.

- Many catfishes have low fecundity *(Clarias batrachus, Mystus* sp. and *Ompok* sp.*)*. This is considered as one of the major constraint in fish during their seed production in a hatchery. But *H. brachysoma* is a highly fecund species.

Seed production: A prerequisite for culture

It is not easy to get stocking material from nature to start aquaculture of any species. Hence, it is essential to depend on hatcheries to produce the desired size and number of seed for growout. The process involved in hatchery production of *H. brachysoma* seed is briefed here.

The broodstock can be raised in earthen ponds or cement cisterns with compound feed containing 30-32% protein to get a suitable size of 80-100 g fish for induced breeding. Morphological identification of male and female is only possible during its spawning season (July-August), when the bulging abdomen of females and free flowing of milt of males is observed respectively. Female fish need a single injection at the rate of 1-1.5 ml Ovaprim per kg body weight, which renders them suitable for stripping after 12-13 hours post-injection. The incubated eggs hatched after 21-22 hours. Mixed zooplankton is one of the best foods for the larvae during their rearing from the fourth day onwards until fry stage. The fry are further reared for 3-4 months to reach fingerling size, ready for stocking.

Pre-stocking management

Pond size and environment

Either earthen ponds or cement cisterns are suitable for growout of this catfish. Pond sizes usually vary depending on the seed availability. As this fish does not perform well at high density it is better to opt for a medium size pond of not less than 0.04 ha. Cement cisterns can also be used to raise marketable fish, but the fish grow less efficiently compared to pond conditions. Hence the fish take more time to reach harvestable size. Water quality parameters such as pH, alkalinity, dissolved oxygen, ammonia of the pond should be within 6-8, > 120ppm, > 5ppm and < 0.05 ppm respectively for optimum growth and survival.

Harvested fish ready for marketing.

Fingerlings released in pond for grow-out culture.

Pond preparation

Pond preparation is essential to provide optimal conditions for higher growth, survival and yield. Hence the perennial ponds must be weed free and dewatered to ensure a predator free environment. Seasonal or dewatered ponds should be manured to generate natural food in the pond system. Usually ponds should be fertilised with raw cow dung (10-15 tonnes/ha), single super phosphate (200 kg/ha) and urea (200 kg/ha) for plankton bloom. Even though the culture is feed based, the fishes efficiently utilise the natural feed for their growth and survival in many occasions. Hence, initial pond fertilisation is enough rather than a repeated fertilisation as in carp ponds.

Size of seed

The size of seed plays an important role in growth and yield during the culture period. The possibility of lower growth and survival as well as enhanced culture period cannot be ignored if the lower size of the seed is stocked. Hence it is always advisable to stock seed of around 10 g seed in culture ponds, which also avoids early mortality during post-stocking.

Stocking of seed

Fingerlings are usually brought from outside sources or produced on the farm, while stocking the culture pond. It is essential to ensure that the seed are healthy and free from stress. It is often found that the seed accumulates stress during transportation. As this catfish accumulates stress easily, the seed should be acclimatised in the pond environment for quite a long period to get rid of stress before their release in the pond. It is advised to undertake water exchange as well as aeration during transportation. A lot of mortality is usually encountered if they are released immediately after transportation. It is always beneficial to undertake transportation or stocking of seed during the early hours of the day to curtail mortality. The production of a pond depends on the growth, survival rate and on the number of fish stocked. Simultaneously the growing period is also another important factor. As this catfish grows slowly, it is always recommended to stock at a lower density such as 30,000-40,000/ha or even less to achieve a marketable size in short period. We have observed that this catfish readily accepts feed supplied from the upper, middle and lower layers of the water column. Hence monoculture of this fish is preferable rather than co-culture with other varieties such as carps due to its active feeding habit, which would affect the growth of other co-cultured fish species.

Post stocking management

Feeding

Even though the fish utilises the limited natural food from the pond, it is essential to supply compound feed for growth during the culture period. Less expensive feed made from plant ingredients is usually fed due to its omnivorous feeding habit, to reduce the cost of feed. This fish readily accepts sinking, slow sinking and floating feed types. 1-2 mm floating pellets containing 30-32% protein at the rate of 2-3 % body weight is sufficient enough for the growing fish. Floating feed has the beneficial effect of assisting farmers to gauge the consumption pattern, utilisation, acceptability of feed and activeness of fish during feeding. This is also helpful to curtail the ration size during winter months and facilitates health management if at all required during the operational period.

Environment management

The culture environment deteriorated due to accumulation of metabolites and unutilised feed material. Mostly, water quality parameters such as dissolved oxygen are seriously affected, apart from ammonia accumulation during the culture activity. This is usually seen in cement cisterns while undertaking grow out activity compared to pond condition. Mortality of fish due to asphyxia is usually observed during the early morning. Hence it is essential to exchange water intermittently to give the optimum environment for their growth and to avoid the fish loss.

Health management

Incidence of disease is often found during the winter season or during the shifting of winter to summer. Diseases such as fin rot, ulcers/red patches near the tail or on the body are found. These can be controlled by frequent water exchange at the beginning of incidence. It is better to segregate the affected fishes, to restrict further spread of disease. Usually before the incidence, fish show slow swimming and feed poorly. Hence it is essential to take care of environmental management to restrict the incidence of disease.

Harvest

It is better to go for monoculture of this species as it shows vigorous feeding behaviour and may apply pressure on other species. Culture at low stocking densities yields better fish size compared to high stocking density even though the hectare production is low. Fish of 50-60 g are highly preferred by consumers as there is a habit of eating single fish in the dish.

There is ample opportunity to culture this catfish in cement tanks or ponds. The growth of fish always remains low during cement tank rearing compared to pond culture, about 15-20 g in average weight. The higher growth in ponds might be due to the availability of natural feed and their utilisation by the fish. The growth and yield patterns of this fish have been evaluated at different densities, which indicated that up to 40,000/ha are good enough to produce marketable fish within a years' time with a production range of 1.5-2.0 t/ha. The yield can be enhanced at higher densities such as 50,000/ha, but this may result in small fish. In this situation, the culture period can be increased to harvest larger fish. But farmers generally prefer to reduce the culture period to lower risk.

The time of stocking may be another management aspect to get better growth or yield in this fish. The required size of fingerlings is only available just prior to the winter season. So the growth of fish is hampered accelerates only when the water temperature reaches around 27-28°C. Hence the stocking of fish should be so adjusted that the fish gets more growing period for higher growth.

Better management practices

- The fish should not be cultured with multi-species as it shows active feeding behaviour, which may restrict growth of other species.
- As the fish grows slow, it is better to culture it at a low density to achieve marketable size in a shorter growing period.
- The culture of this fish emphasises the stocking of larger, stress-free fingerlings to benefit growth, survival and yield.
- Good oxygen levels in the culture environment must be ensured during morning hours to avoid asphyxia, which may lead to mass mortality.
- Floating feeds containing 30-32% protein must be provided for optimal growth and to facilitate monitoring of feeding and ration size during the culture period.

Accelerated poverty alleviation of tribal households - cage fish farming by displaced fishers in reservoirs of Jharkhand

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Jharkhand, a new Indian state created in 2001 presents a unique culture, demography and geographical characteristics. Around 28% of the states 33 million people (2011 census) are tribal, forming a group in the state. Agriculture is the predominant livelihood for rural communities and subsistence level farming dominates the food production system, with limited opportunities for on-farm employment to landless people for the greater part of the year. There is limited scope for labour movement in search of employment, particularly in tribal and hill areas where road and communication networks are limited. However, fisheries and aquaculture are regarded as an integral part of food production system and livelihood for over 135,000 people who are dependent on fishing and related activities, with major participation of tribal fishers.

With the team effort of Department of Fisheries (DoF) the state has the distinction of achieving high growth in fisheries and aquaculture during the last decade of around 49% per annum over the base year (2001) and 9.4% over previous year. Fish production has increased to 116,000 tonnes worth around Rs. 1 billion (US$150 million) from the initial 14,000 tonnes. The concerted efforts of DoF have resulted in continually improved production and sector growth in spite of several predicaments, transforming fisheries and aquaculture activities in the state from subsistence level to extensive, semi intensive and near commercial scale in some segments.

In the initial phase of development DoF had couple of major challenges to address. One was to mainstream the tribal communities who lost their land and other assets due to reservoir construction by the government, and the other was to bridge the fish demand – supply gap.

Our efforts to mainstream the paths of tribal people to improved livelihoods and prosperity was addressed by way of roping them in, initially to reservoir fisheries activities, by extending support in the form of fish seed for reservoir stocking, nets and watercraft. As a first step, this could only marginally remediate lost incomes and employment opportunities. The uncertainty in fish catch, slowing resource productivity and catch rates, employment and income loss, continued to negatively affect livelihoods even after the intervention. However, the main benefit of this support was in building community confidence and improving community relations with DoF staff.

Due to the increased economic needs and necessities of life, the community regarded the gains as inadequate to raise their financial status and continued to feel aggrieved. Hence, offering them better alternative economic activities to sustain them became the next challenge to the government.

Jharkhand has a very large fish eating population (over 70% of its population) with a very moderate per capita fish consumption of around 7-10 kg/year due to limited fish availability (per capita availability of fish 20.5 g/day against the national average of 24 g). The state has experienced critical imbalance in demand and supply of fish and hence closing the demand gap against the backdrop of a growing population, economic progress and rise in per capita fish consumption was another major challenge, through augmentation of the supply side. At this stage, the state was looking out for multi-pronged approaches to facilitate a several-fold increase in fish production and profitability in a short span of time, while addressing community socio-economic concerns in the development process.

At that point in time the few available alternatives to the government were to i) harness available water bodies to their best and optimum productivity levels, ii) enhance resource productivity through better management practices, and/or iii) shifting production practices to input based approaches.

The predominance of rain-dependent seasonal tanks, small water bodies, uncertainty of water availability for fish farming activities, and poor investment capacity of fishers and private resource owners heavily constrained implementation of these options. The latter alternative of input (feed) based intensive farming practices required a good quality and perennial water supply throughout the year and active private participation and investment. Unfortunately circumstances were not congenial at the time due to heavy demand on the state for community welfare, and as proven technologies for intensive farming were not at all in practice.

Having partly succeeded in taming the volatile situation across the affected regions, DoF started looking at options with the potential to remedy the situation, while addressing fish demand and supply. During 2011-12, the department was associated with central institute involved in experimenting with cage fish farming in one of the reservoirs close to Ranchi, and the fish production result was quiet encouraging.

This has provoked a new thinking of taking the activity further forward through community development objectives in selected reservoirs as they are the only reliable perennial water bodies of the state. They were also the only option to integrate cage farming activity with ongoing reservoir development programs facilitating higher production and income and a year round supply of fish to markets, thus meeting both the ends of increasing fish production and providing dependable income to fisher communities and displaced tribal people.

Why cage fish culture?

The economic dictum is that available resources (natural and human and material) should be put to optimum use to generate the most efficient outputs. Farming of pangasius *(P. hypophthalmus)* fish in cages is an intensive farming activity that potentially provides a high return per unit of material and labour invested. In comparison with open reservoir fishing, cage culture offers many times more production from a given water area. A water volume of 96 m^3 has the potential to produce anywhere between 3.5-4.5 tonnes of fish in 10-12 months while the catch in reservoirs is around 80-140 kg/ha. At the same, time, it has potential to generate around 200-250 person-days of employment to fishers compared to a mere 4-5 days fishing (assuming a daily catch of 5 kg/person). The prevailing advantage of labour share by tribal fishers helps to minimise operational cost. These driving forces encouraged the DoF to embark upon this ambitious programme for the first time in the state.

Initial predicaments for implementation

The major constraints for adoption of cage fish farming by displaced fishers was the high cost of infrastructure and operations in terms of feed, labour and seed. A total non-availability of skilled labour with experience in cage farming and absence of support services added to the complexity.

Right opportunity at the right time

At about the same time, the Government of India had established a National Mission Programme on Protein Supplementation (NMPS) and prioritised cage fish farming as a means to produce high volumes of fish for this goal. The Jharkhand DoF did not lose any time and jumped onto this new program convincing the state government to provide financial support for implementing the project. Thus 2011 saw the start of a new journey in fisheries horizons in Jharkhand with many challenges ahead.

Coping with predicaments

Having committed to this innovative scheme, the DOF was confronted with a challenge of how to manage this new production system and to support displaced fishers, who lacked skills and experience in fish farming and had limited financial status, when the technical team of the DoF also had no previous exposure to cage fish farming. Cage construction, siting and farming of pangasius were new challenges to all! However, the DoF staff took up this challenge in earnest. Teams of technical personnel were positioned in each selected reservoir and were tasked to go all out to not only learn the new technology by themselves, but also train and convince fishers to participate as well.

Uncertainty of takers

Cage culture is a high investment - high return proposition and entails huge costs, both fixed and recurrent. Even though a subsidy of up to 90% was available on infrastructure and inputs, individual displaced fishers were not in a position to take up the activity independently and hence the Department decided to rope in the Fishers Cooperative Societies of the displaced fishers to the venture and launched a mass campaign to convince the societies to join hands with Department. Although initially the response was not encouraging due to about a 10% share without assured returns, only a few societies came forward to trial the venture with support and involvement of Department.

Implementation

The activity was moved forward in the Chandil reservoir of Saraikela district with twelve batteries comprising 46 cages and two cage house (GI pipe model) for farming and six batteries (24 cages) for seed rearing. Similarly at Tenughat reservoir, Bokaro district (twelve plus six batteries) with two cage houses were established during 2011-12 under the direct supervision and management of the DOF staff. It was a kind of pre-testing of the technology, with regards to the technical feasibility of the venture and its suitability as a development intervention to the societies.

Development phase

Based on initial success and the confidence built both in DOF staff and the participating fisher societies, cage farming was expanded to reservoirs of several other districts over a five year period. A 'push and boost' strategy was adopted by DOF to implement, refine and stabilise the activity and make it popular among the members of fisher societies. The steps included:

- Mobilising fisher cooperatives and their members, educating them on the advantages and benefits of cage culture.
- Confidence building in operating both fishing and cage based farming in the same reservoir.
- Providing technical support and training to fishers.
- Efforts made for fabrication of cages.
- Selection of suitable sites in reservoirs.
- Support for mooring and fixing of cages.
- Empanelment of suppliers.
- Seed procurement.

- Arrangements and intermediation for the feed supply and delivery.
- Establishment of a feed mill on site and production by roping in members of fisher societies.
- On-site technical support and oversight by DOF personnel in production of the first crop and advisory support for the subsequent crops.
- Improvements to existing marketing channels and arrangements.

During different phases of implementation, several issues were encountered including uncertainty of seed supply, frequent hikes in feed cost, heavy mortality of young stock, lukewarm market response and natural vagaries of heavy winds that damaged the cages, some to the point where they could not be used. The DoF staff handled the situations and moment of crisis without becoming disheartened and were ably supported by the resilient outlook of fishers against all odds. These incidences proved to be blessings in disguise to the “Mission Cage Culture” as they created opportunities for research and development. As the time passed with instances of success in activity, more and more fisher societies asked for support and later, with gained confidence and earnings from the activity, demand from individual fishers also surged and DoF was to make way for the new development.

Trial and error / learning by experience strategies

It would be unrealistic to claim that the first experiment was a great success at the first go. Like any new technology, cage culture also had some teething trouble initially but the DoF personnel motivated progressive fishers at all levels and stages of farming and would not let go of the opportunity. Several grey areas were identified in the process and remedies were developed for each on a continued basis. The second and subsequent trials made use of new applications and changed approaches which started paying rich dividends in the form of better yields and profitability. The response, though lukewarm in the initial period, built up over a period of time due to relentless and sustained efforts of the DoF personnel.

Impacts

“Mission Cage Culture” proved to be a great boon to resource poor displaced fishers in terms of incremental income (a net profit of Rs. 100,000-120,000/cage) and average fish production of 3.5-4.5 tonnes/cage/year under the best management practices. The additional employment generated was around 250 person-days/cage. Considering the production in 2,452 cages spread across 17 districts of the state in 25 reservoirs, and also in abandoned coal pits, by 2015-16 the annual contribution to fish production was estimated at 9,800 to 10,000 tonnes. This was equivalent to around 6-7% of total state fish production with a value of around Rs.750 – 800 million. The annual employment generation from entire activity was estimated at over 435,000 person-days.

Cage farming has contributed to both social capital formation and financial empowerment. As a result, the previously poor displaced tribal people are now able to generate higher income from the activity, which has significantly improved their livelihoods, generate various other assets. It has become

an added source of income and most of them have been able to cross the poverty line and are leading a more comfortable life. They have also accumulated some durable assets due to improvement in household income. The activity has also supported others involved in intermediation, sales and marketing. Consumers have benefitted in terms of improved access to fresh fish and live fish to their door steps at an affordable price. All of this progress, observed at different levels of the production and supply chain, has proven the success of the activity and are a testament to the efforts of DoF personnel.

Conclusion

The DoF now feels that this segment of farming could be a feasible platform for inclusion of displaced tribal people and for enhancing state fish production. In years to come with refinement of technologies, better positioning of support services, innovative processing and value addition, developing semi processed and processed, ready to cook and ready to eat products, the activity could serve as one of the major engines for economic growth for the reservoir fishers of rural Jharkhand.

The success of the initiative and the process adopted in implementation by the Department of Fisheries has added new dimension to reservoir fisheries activities in the entire country and has opened up new opportunity for private investment by entrepreneurs, communities and public-private partnerships.

Small-scale aquaculture of wild fish in Myanmar: A preliminary report from the Bago Region

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Introduction

Myanmar aquaculture has previously been considered to be medium to large scale with little or no small scale aquaculture (Edwards 2005). The FAO/NACA (2003) report on aquaculture in Myanmar says:

"There is no record of small pond holdings because this information is not collected and ponds less than 8 m x 8 m do not require licensing. Based on the observations of the Mission, there appear to be very few small (less than 400 m^2) fish pond operations. This is unusual relative to other countries of Southeast Asia, where small ponds are quite popular."

A recent comprehensive study of aquaculture in Myanmar documented a large increase in medium and large scale operations and also indicted that based on satellite imagery there are 200,000 small backyard ponds in the southern Delta some used for growing fish mainly for home consumption (Belton et al 2015). There has, however, been no previous detailed description of small scale aquaculture in Myanmar.

During a village visit by staff of the Community Lead Coastal Management Gulf of Mottama (CLCMGoM) project to Tadar Oo village, Kawa Township in Bago Region, we were invited to visit an aquaculture pond. There we discovered a small scale aquaculture system using monsoon flooding of the rice fields to stock the pond with wild fish, which were subsequently fed. At harvest about 20% of the fish were selected as broodstock to carry over to the dry period and spawn at the start of the next monsoon. This system is similar to rice field fisheries practices throughout floodplain areas in Asia (Gregory & Guttman, 2002; Guttman 1998; Halwart & Gupta 2004) What makes this system different is that the fish are not just trapped and then harvested but they are fed and broodstock is selected for the next year's production. We consider this a type of aquaculture as opposed to culture based fisheries and are calling it a form of indigenous aquaculture. CLCMGoM is a project of the Swiss Agency for Development and Cooperation (SDC) implemented by Network Activities Group (NAG), HELVETAS and IUCN.

Methods

As a result of the information from Tadar Oo further information was collected from villages in Bago Region from August 2016 to January 2017 A survey questionnaire was developed by staff of the Network Activities Group (NAG) based on knowledge of aquaculture in the Myanmar delta region and the background information determined from the initial visit to the pond in Tadar Oo. The questionnaire was completed based on semi structured interviews with key informants in eight villages in Thantpin, Kawa, and Waw Townships in Bago Region during August-September 2016. A summary was prepared and this lead to a follow up visit by NAG staff in October 2016 to three of the previous visited villages and an additional commercial operation to check the data and follow up on details. A final detailed survey was carried out in

Google Earth Image showing numerous farm fish ponds surrounded by trees in the Bago region.

January 2017 during the harvest of two ponds in Kan Myint Village, Kawa Township, Bago Region. At this time information was collected on harvesting, marketing, identification of fish species, lengths and weights of fish and additional details on the operations. In general the details from the Kan Myint ponds confirmed and validated the information collected during the village interviews. The villages visited are listed in Table 1. The results reported here are the first reports of small scale aquaculture in Myanmar.

Results

Number of ponds: The survey indicated that wild aquaculture practice was very wide spread (Table 1) with 693 farmers from the eight villages managing over 775 ponds. The number of ponds varied from 50 to over 150 per village. The number of farmers with ponds ranged from 40 to 150 per village with the percentage of farmers who had ponds varied from 16% in Ma Mauk to 95% in Ko Teko. Google satellite images show numerous small green areas that represent a small pond surround by trees that further supports the widespread nature of this system.

Size of ponds: Ponds are small varying from less than 0.04 to over 0.40 ha (Table 2) but most ponds (80%) were less than 0.11 ha and 90% were less than 0.20 ha. The two ponds surveyed in Kan Myint were 0. 08 and 0.11 ha.

Table 3 gives an example of pond size versus paddy area for one village. The total pond area for the nine farmers interviewed was about 4.8 ha and the average pond area was 0.18 ha. There was no clear trend in number of ponds with paddy area but in general interviews in other villages suggested that farmers with large paddy areas had more ponds.

Pond depth varied with location and was shallower in areas closer to the Gulf of Mottama due to saltwater intrusion if the ponds were dug too deep. The depth varied from 1.8 m^2 to over 6.1m^2. In general they all held water during the dry

Table 1: Villages surveyed for indigenous aquaculture and number of ponds.

Date surveyed	Village	Township	Number participants male (female)	Number farmers in village	Number farmers with ponds	Total number of ponds/village & size of ponds (ha)
23-8-16	Koke Ko Tan	Thanat Pin	9 (2)		50	60
25-8-16	Ko Tone Tan		5		40	50
31-8-16	Ko Teko		10 (4)	94	89 (95%)	34 x 0.16 ha 65 x 0.04 ha
31-8-16 21-10-16	Thana Tan		4 (3)	250	110 (44%)	8 x small 137 large
19-10-16	Htat Ka Maing		One larger scale farmer		1	5 total 4.8 ha
25-8-16	Ta Dar Oo	Kawa	7 (9)	128	48 (38%)	8 x 0.04-0.20 ha 48 >0.04 ha
26-8-16 20-10-16	Ma Mauk		6 (6)	340	55 (16%)	64
2-9-16	Htain Tapin	Waw			150*	150*
2-9-16	Ka Daut				150*	150*
Total					693	774
Harvest Survey						
18-01-17	Kan Myint 1	Kawa	One farmer & harvesters		1	1-810 m^2
19-01-17	Kan Myint 1	Kawa	One farmer, harvesters, & fish buyer		1	1-1,112 m^2

** This is a conservative estimate as number of ponds was not recorded.*

season with the dry season minimum depth varying from 0.5-2m^2. Only one village used plastic pond liners to hold water in the ponds.

Table 2: Size of farm ponds and estimated number of farmers with each pond size in all villages.

Size of ponds (ha)	No. of farmers	Percentage of farmers
<0.04	91	24.0
0.04-0.11	205	53.9
0.11- 0.20	48	12.6
0.20-0.40	22	5.8
>0.40	14	3.7

Table 3: Example of paddy field area, number of ponds, and area of ponds from nine farmers in Thanatan Village, Thant Pin Township, Bago Region, Myanmar.

Paddy field area	No. ponds	Pond area hectares	Total pond area hectares
6	1	0.001	0.001
10	2	0.20	0.40
30	3	0.13	0.40
40	3	0.16	0.49
40	2	0.001 & 0.24	0.25
50	1	0.40	0.40
70	1	0.20	0.20
100	3	0.13	0.40
300	10	0.22	2.23
Total	**26**		**4.78**
Average			**0.18**

The two ponds harvested in Kan Myint were quite deep with pond depths of 5.9-8.2 m^2. Additionally both ponds were either adjacent to a second pond or one pond was divided into two. This arrangement allowed water to be pumped from one pond to the other during harvest, thus conserving water for the dry season holding of the broodstock. We did not include this question in the earlier surveys so do not know how wide spread this practice is.

Aquaculture practices: This system relies on the seasonal nature of the monsoon system and the associated fish. As the rice fields flood with the monsoon rains during June and July, the fish move from the ponds, rivers, creeks and canals to the flooded rice paddies where they reproduce and feed. All the ponds relied on recruitment and replenishment of indigenous species and were essentially a trap system as the water level drops in the flooded paddy fields at the end of the monsoons, September-October, the fish retreat to deeper areas including the farm ponds.

Various approaches were used to entice the fish to the ponds. Many farmers had dug canals that channeled the fish to the ponds. A few claimed to use attractants such as horse oil (a traditional medicine); cans of tinned fish with holes punched in them; and some used what was called a schooling pond which was deeper and where the fish collected before they were channeled to the fish pond. A few claimed that feeding in the pond during July-August also attracted fish to the ponds.

Some farmers with rice areas above 20 hectares diked the whole paddy land. Some had actually developed a closed system as they used bamboo fencing or netting on the inflow/outflow drainages, resulting in little migration of fish into or out of the system. Others had a more open system only seasonally fencing or netting the outflow drainages to retain fish.

Fish pond at the end of the monsoon season (October).

Farmers with smaller rice area did not have dikes and had an open system that relied on recruitment from fish migrating into the paddy fields and recruitment from the brood fish saved in the farm ponds.

Most farmers renovated their ponds every two to three years and dug out the accumulated silt from the bottom and placed it around the pond banks. The two ponds in Kan Myint both had been renovated before the monsoons in 2016 by digging out the bottom, one by manual digging and the other by machine.

Feeding: Most of the farmers feed the fish at least when they had retreated into the ponds, this was usually October. Feeding might be for only a few weeks or up to harvest in December or January. The most common feeding method was to broadcast rice bran and occasional broken rice. Feeding was normally done once or twice a day. Additionally, many farmers made a paste with fish paste, peanut cake, or coconut cake mixed with rice bran which was then placed in either a pot, basket or net bag hung in the pond. This was replaced when consumed, anytime between daily to weekly. One village indicated that the paste was mixed with cow dung while another village added cow dung to the pond. A few farmers fed a few pellets probably duck feed, while a few indicated that they occasionally added cow or horse hides. This appeared to be opportunistic as they did not buy the skins but when an animal died (or was slaughtered) they would add the skin. They claimed this was an attractant for snakeheads. Shrimp shells and horse bones were also

Table 4: Preliminary list of fish species in the wild fish aquaculture in Bago Region.

Scientific name	English name	Myanmar language	
Clarius batrachus	Walking catfish	Nga khu	ငါးခူ
Heteropneustes fossilis	Scorpion catfish	Nga gyee	ငါးကြင်းသား
Channa striata	Striped snakehead	Nga yant	ငါးရံ့
Channa sp. (*Lucius*?)	Snakehead	Nga pa naw	ငါးပါးနော့
Mystus cavasius	Gangetic catfish	Nga zin yaing	ငါးဇင်းရိုင်း
Anabas testudineus	Climbing perch	Nga ppay ma	ငါးပြေမ
Trichopodus pectoralis	Snakeskin gourami	Bee lar (often called tilapia)	ဘီးလား။ ဂ်ပန်ငါး။ တီလားပီးယား.။။
Ompok bimaculatus	Butter catfish (sheath fish)	Nga nu than	ငါးနူးသန်း
Lates calcarifer (*L. uwisara)*	Sea bass	Ka ka tit	ကကတစ်
Notopterus notopterus	Bronze Featherback	Nga phae	ငါးဖယ့.
Cirrhinus mrigala	Mrigil	Nga gyin	ငါးဂျင်း
Mixed *Barbonymus* spp., *Puntius* spp.	Barbs	Nga khone ma	ငါးခုံးမလေး
Osteobrama sp.	Carplet - barb	Nga pha ma	ငါးဖါးမ
Parambassis ranga	Indian glass fish	Nga zin zat	ငါးဇင်စပ်
Wallago attu	Wallago	Nga batt	ငါးဘတ်.

Table 5: Harvest data from two fish ponds in Kawa Township Bago Region, Myanmar.

Fish names			Weight kg (Viss)[1]					
			Pond 1			Pond 2		
Scientific	English	Myanmar	Harvest	Brood stock	Total	Harvest	Brood stock	Total
Channa striata	Striped snakehead	Nga yant	104.5 (64)	40.8 (25)	231 (141.5)	89.8 (55)	11.7 (7.2) 10 fish	101.5 (62.2)
Clarius batrachus	Walking catfish	Nga khu	12.2 (7.5)			73.5 (45)	3.0 (1.8) 10 fish	76.5 (46.8)
Anabas testudineus	Climbing perch	Nga pyay ma	73.5 (45)			1.6 (1)	-	1.6 (1)
Trichopodus pectoralis	Snakeskin gourami	Bee lar	24.5 (15)	-	24.5 (15)	8.2 (5)	-	8.2 (5)
Lates calcarifer	Giant seabass	Ka ka tit	5.0 (3.1)	-	5.0 (3.1)	-	-	-
Notopterus notopterus	Feather back	Nga phae	0.6 (0.38)	-	0.6 (0.38)	-	-	-
Wallago attu	Freshwater shark	Nga batt	21.2 (13)	-	21.2 (13)	-	-	-
Puntioplites proctozrysom?	Smith barb	Nga phar ma	8.2 (5)	-	8.2 (5)	1.6 (1)	-	1.6 (1)
Puntius sp.	Barb	Nga khone ma	3.3 (2)	-	3.3 (2)	2.5 (1.5)	-	2.5 (1.5)
Total			**253.1 (155)**	**40.8 (25) 13.9%**	**293.9 (180.0)**	**177 (108.5)**	**14.7 (9) 7.7%**	**191.9 (117.5)**

[1] Viss is a unit of weight used exclusively in Myanmar, 1 Viss = 1.6329 kg

Table 6: Standard length (cm) and weight (g) of harvested fish from two ponds in Kan Myint Village.

Species	Nga yant striped snakehead		Nga khu walking catfish		Nga pyay ma climbing perch		Bee lar snakeskin gourami	Ka ka tit seabass	Nga phae feather back
	Pond 1	Pond 2	Pond 1	Pond 2	Pond 1	Pond 2	Pond 2	Pond 1	Pond 1
					Length				
Average	51.36	43.84	22.28	29.48	16.85	17.50	17.33	40.40	32.00
SD	±2.06	±9.08	±3.35	±4.62	±2.41	±2.01	±2.52	±1.52	±2.83
n	25	25	25	25	13	10	3	5	2
Range	48-68	28-58	15-27	22-38	13-20	13-20	15-20	38-42	30-34
					Weight				
Average	1,244	858.40	81.60	248	77.69	122	53.33	1,020	300
SD	±238.19	±595.68	±31.84	±80	±22.79	±43.67	±11.55	±83.67	±141.42
n	25	25	25	25	13	10	3	5	2
Range	1,000-1,800	200-2,600	20-130	100-360	40-100	60-200	40-60	900-1,100	200-400

Table 7: Estimate yields for various sized ponds of wild fish aquaculture in Bago Region including two ponds in Kan Myint that were sampled when harvested.

Pond size (hectares)	No. of ponds	Total yield range (kg)	Average kg / hectare
0.04-0.12	4	122-245	1,946
0.08-0.1 (Kan Myint)	2	192-294	2,764
0.16-0.20	4	490-1,715	3,012
0.40	3	1,633-2,041	2,677
4.9 (commercial)		24,494	5,044

indicated as being used in two villages. In the two ponds in Kan Myint one farmer did not feed but added rice straw. The other farmer fed from August to December. He placed rice bran into a bag and tied it to a bamboo pole in the pond and added new feed every week.

Natural feeding was enhanced by adding brush to the ponds to create a brush park and other ponds were well covered by water hyacinth. These acted to increase surface area for algae and microbial growth that enhanced feeding, attracted small fish, shaded the pond and also prevent theft. The trees surrounding the ponds supplied cover and shade.

Figure 4.: Fish pond in Thana Tan Village, Thant Pin Township, Bago Region, Myanmar, covered with water hyacinth.

Harvesting: Prior to harvest the brush parks and water hyacinth were removed and the water level lowered with a pump. Collection of the fish was normally done by a small fish scoop, although small ponds were often harvested by hand. The smaller ponds were harvested by the farmer and family, larger ponds used labourers, while Thana Tan village used a village cooperative system so the harvesters received a share of the catch. In Kan Myint both farmers used a 7hp diesel motor to power a 10cm (4") pump to pump out the ponds. The fish were then harvested using dip nets, bamboo buckets and hand capture. The 10 to 15 harvesters were family members or family members supplemented by neighbours. In both cases they did not receive a cash payment but received lower value fish for either direct consumption or used for fish paste (Table 6).

Harvesting was normally done in December or January after about four to five months of growth. Harvest dates were determined by fish prices (most villagers were well aware of market prices), water level and the fact that fish tended to lose weight later in the season. Harvesting was done either by the farmer directly or by a fish trader.

Small-scale fish pond in the dry season.

Species: At least 15 species were reported as being harvested (Table 4). The most abundant species were the blackfish: *Channa* (snakeheads); *Clarias* (catfish); and *Anabas* (climbing perch). Various barbs are reported earlier in the season but all respondents indicated the carnivorous species feed on them and very few are harvested.

The detailed harvest from two ponds in Kan Myint village is given in Table 5. Pond 1 contained a greater diversified species mix with nine species, while pond 2 had six species. Two to three species make up most of the catch ranging from 78 to 94%. Snakeheads are the most numerous in both ponds, with climbing perch the second in one pond, and catfish in the other. Snakeskin gourami are the next most numerous in both ponds.

Size of fish: The sampling of the harvested fish at Kan Myint allowed data to be collected on length and weights of the harvested fish (Table 6). The weights are approximate due to the limited accuracy of the scale, the need to work around the harvesting constraints and that many fish were weight alive thus difficult to weigh. There is considerable variability between the two ponds. The average weights varied from over 1.2 kg for snakeheads to 53 grams for snakeskin gourami. The snakeheads were the largest in pond 1 at 51 cm and 1.2 kilos, while the catfish were larger in pond 2 at 29.5 cm length and 248 grams. The climbing perch were close to the same lengths in the two ponds but were considerably heavier in pond 2.

Yield: Estimated yields for the various pond sizes are given in Table 7. The small scale farmers' yields ranged from 122 kg to over 2,000 kg per pond and from about 1,900 kg/hectare to 3,000 kg/hectare. Additional data was obtained from a farmer with larger scale ponds of 4.8 ha who estimated yields of over 5,000 kg/ha. This was higher than the estimates from the

Table 8: Disposition of harvest from Kan Myint ponds.

Market Condition	Species	Total weight Viss, (kg), %		Price US$ / kg (MMK / Viss)	Income US$ (MMK)	
		Pond 1	Pond 2		Pond 1	Pond 2
Live	Walking catfish	12.2 (7.50) 4.2%		$3.26 (4,364)	$24.43 (32,730)	
Sold at pond & shipped live to market	Striped snake-head & Walking catfish		163.3 (100) 85.1%	$3.25 (4,350)		$324.63 (435,000)
Weight sold dead	Striped snake-head	104.5 (64) 35.6%		$3.00 (4,021)	$191.75 (256,950)	
Sold at village	Sea bass & wallago	26.2 (16) (8.9%		$3.24 (4,348)	$52.24 (70,000)	
Total sale		143.1 (87.5) 48.7%	163.3 (100) 85.1%		$268.42 (359,680)	$324.63 (435,000)
Gift to neighbours and harvesters	All other species	110.0 (67.4) 37.4%	13.9 (8.5) 7.2%			
Total harvest		253.1 (155)	177.2 (108.5)			
Brood stock		40.8 (25) 13.9%	14.7 (9) 7.7%			
Total yield		293.9 (180)	191.9 (117.5)			

small scale farmers but is probably related to more extensive feeding and greater control as the ponds are supplied with fish from 40 hectares of rice fields that are all diked.

Broodstock selection: The unique aspect of this wild fish aquaculture is the selection and saving of broodstock from one year to the next. Every farmer interviewed saved broodstock particularly of snakehead, catfish and climbing perch. In general we were told that 10-20% of the catch was saved. A number of farmers indicate that in the first year of a pond they would not harvest fish but save all for next year's brood. The detailed harvest data from Kan Myint (Table 5) indicates that these farmers saved snakehead and catfish while one also saved climbing perch. The broodstock saved ranged from 8 to 14% of the total harvest.

Various selection criteria for broodstock selection was suggested, including size (not always the biggest), and sex (some villages indicating they could determine sex of snakeheads by the shape of the head). In Kan Myint the only selection criteria for broodstock was large size. This is confirmed by the sampled fish from pond 2 (Table 6), the ten selected snakehead broodstock averaged 1.2 kgs versus an average of 0.86 kg for the sampled fish and the ten catfish broodstock averaging 0.30 kg versus 0.25 kg for the sampled fish.

The brood fish were retained in the pond over the dry season and only in a very few cases was there feeding but some farmers did occasionally add water to the ponds when the water level dropped too low.

Economics

Market: The fish were sold to the village fish collector who sold on the fish to nearby township markets, or direct to a township broker either at pond side or in the township. In many cases the fish buyers had advanced money to the farmer (interest rate 4-5%/month). The fish were transported to market via motorcycle/tricycle or local bus. Three villages, and the commercial farmer sold the fish live, transporting them in wooden buckets by car or tricycle to nearby township markets. Fish dying during harvest were iced and then sent to market. The live fish received twice the price of dead fish. One village, close to a township market shipped their fish (dead) directly to the market but did not use ice. Some fish were used for household consumption with small fish being used for fish paste and one village dried snakeheads but only for home consumption.

In Kan Myint the fish went to Thantpin Township market. One famer sent the fish (both live & dead) via motorcycle to a Thantpin Township collection center while the other sold directly to a broker who collected the fish at the pond and then sent them live via local bus to the market. Table 8 gives details on the disposition of the catch. Both farmers sold the snakehead and walking catfish to the market, making up 40% of the harvest in pond 1 and 85% from pond 2. Pond 1 sold the sea bass and wallago in the village, while both ponds distributed the other species to the harvesters and neighbours, with pond 1 distributing 37% and pond 2 distributed 7% to the harvesters.

Economic returns: Detailed production costs were obtained from a few farmers. Table 9 gives an example from two different pond sizes and the two ponds in Khan Myint. While these are only estimates and all operating costs may not be included (e.g. interest cost are not included) nevertheless the return on investment of 132 to 440% is impressive. Data from the two Kan Myint ponds allowed calculation of the averaged profit per hectare of $US 2,281/ha, this compares to the net margin for monsoon rice production in Bago of $146/ha (LIFT 2016). Thus the yield from the indigenous aquaculture system was 15.6 higher than rice production. This confirms Kan Myint farmer's comments that this aquaculture system was much more profitable than rice farming.

The commercial farmer with 40 ha of flood plain has 4.8 ha of wild fish indicated a total income of over US$1,500 per hectare. This farmer has recently added 30 areas of commercial aquaculture ponds using stocked fish and intensive feeding but indicated that the wild fish aquaculture was much more profitable than the commercial aquaculture.

Table 9: Example of economic returns of wild fish aquaculture from ponds in two villages in Thant Pin Township, Bago Region, Myanmar.

Location	Kote Ko Big pond	Kote Ko Small pond	Kan Myint Pond 1	Kan Myint Pond 2
Expenses				
Renovation	250,000	80,000	100,000	100,000
Feed	240,000	60,000		7,500
Harvest	14,000	29,000	15,000	15,000
Ice	25,000	5,000	-	-
Transport	6,000	15,000	20,000	-
Interest	?	?	-	-
Total operating Costs	735,000 MMK $565	194,000 MMK $149	135,000 MMK $85.82	122,500 MMK $91.42
Income	4,000,000 MMK $3,077	450,000 MMK $346	359,680 MMK $268.42	435,000 MMK $324.63
Profit	3,265,000 MMK $2512	256,000 MMK $197	244,680 MMK $182.60	312,500 MMK $233.21
Profit/hectare	-	-	$2,256	$2,305
Return	440%	132%	213%	255%

History

All ponds (with the exception of the large scale farmer) appear to have been initially dug for household water supply but the farmers subsequently discovered that fish moved into the ponds and they started raising the fish. The ponds have multiple uses in addition to fish culture: they are used for household water (the water is normally carried to the house for washing, cooking, etc.); livestock watering. In addition all ponds were surrounded by a variety of trees, fruit trees and bamboo and many grew vegetables on the banks that were occasionally irrigated with pond water during the dry season.

All most all farmers said they had started 25-40 years ago, although two villages said they had learned from their grandparents. No one indicated that there had been any extension or training but they stated they had learned themselves. There is, however, very similar practice across villages suggesting considerable village to village information exchange.

Discussion

This survey of eight villages and one commercial farmer has indicated a widely practised aquaculture system present in the Bago Region and has been in existence for at least 40 years. The system relies on the natural monsoon cycle in which the rice fields flood and indigenous fish species move into the flood areas from seasonal ponds, rivers creeks and canals, reproduce, feed, and grow. As the waters recede the fish are trapped in the small farm ponds. The ponds are small, most less than 0.1 ha, where they are fed and then harvested after about five months. The fish harvested are primarily black fish: *Channa* (snakehead); *Clarias* (catfish); and *Anabas* (climbing perch) but at least 15 fish species have been identified. During harvest about 10-20% of the fish are selected and saved for broodstock to reproduce for the next year. In some cases the ponds are connected to the rice fields by canals and other approaches are used to attract fish. The ponds have multiple uses being used for house hold water, watering animals, and a variety of trees, fruit trees and vegetables are grown on the pond banks.

Table 10: Annual License Fees in Bagon Region based on pond size (source DoF, Bago Region).

Pond size (m^2)		Fee MMK (US$)
From	To	
0	0.028 (113)[1]	No Requirement for licensing
0.03 (121)	1.00 (4,047)	1500 ($1.12)
1.01 (4087)	2.00 (8,094)	3000 (2.24)
2.01 (8134)	3.00 (12,141)	4500 ($3.36)
3.01 (12,181)	4.00 (16,187)	6000 ($4,48)
		Late payment after 30 September ($1.49)

[1] This is larger than reported elsewhere.

This system is similar to rice field fisheries in other nearby countries (Bangladesh, Cambodia and Thailand) where fish spawn and feed in the flooded rice fields during the monsoons then as flooding declines the fish move to trap ponds in the rice fields and other permanent water bodies to be subsequently harvested (Gregory & Guttman, 2002; Guttman,1998). What is unique, in this Myanmar system, is that the farmers feed the trapped fish and select and maintain broodstock to spawn the next year. We are calling this system indigenous aquaculture as there is partial control of the fish. This system differs from conventional aquaculture in that there is no need to raise fish in hatcheries and stock because this system relies on natural spawning and indigenous species. In addition this system, by conserving brood fish, may also be playing an important role in restocking the wider flood plain area. In Cambodia there is now considerable effort to create community fish ponds as fish refuge to enhance the rice field fishery (Brooks et al 2015).

It is difficult to compare this wild fish aquaculture to commercial aquaculture yields or wild fish catches as this is a trap system and relies on collection of fish from a much larger area of rice fields. Thus the production is partially dependent on the area of rice field foraging and not just the pond size, nevertheless the yields to this low input system of 2,000-5,000 kg/ha are impressive. Yields from flood plain wild capture fisheries in Bangladesh are estimated at 119 kg/ha (Scullion 1996), rice fish farming in China averages 180 kg/ha (MacKay, 1995), and yields from intensive commercial aquaculture in Myanmar average 4,800 kg/ha.(Belton et al 2017). Additionally the yield from the small ponds (0.08-0.1

hectare) in Kan Myint of 200-300 kg per pond is close to the average household catch in the total rice field fishery in Cambodia of 321 kg (Gregory & Guttman, 2002).

Estimated economic returns are also impressive with low input costs and return on operating cost of 50-440%. The system is much more profitable (15.6 times) than monsoon rice production, and will be even more important in marginal rice areas or years when rice yields are reduced due to flooding. In addition there are other benefits of the multiuse ponds that supply household water, fruit, vegetables and timber. The system also contributes to food security with fish being marketed in local township markets, sold direct to villagers, and lower value fish distributed to village families who participate in the harvest.

The issue of licencing of the ponds is interesting. Ponds smaller than 113 m^2 do not need a license, but most of the ponds in this survey while small are above the size that would require a license. The theoretical license fee for ponds is given in Table 10. In most villages the ponds were not licenced by Department of Fisheries (DoF) nor did they pay a fee, nor was one demanded. The two villages in Waw Township did pay a fee to the Township Administrator of 2,000-4,000MMK depending on pond size. In addition villages where the ponds are located within leased areas ('inns') the farmers pay a fee to the lease owner for the fish in their pond. As the ponds were originally constructed for water storage it is assume that the farmers have not obtained the La Na 39 document (the land use title document that permits conversion to non-agricultural uses). The question is as the ponds primary purpose is for household water supply and they were constructed many years ago, do they require licensing. It does appear that as a result of this survey Bago Department of Fisheries has expressed increased interest in collecting a fee from farmers.

In addition new ponds above 113m^2, in theory would require a complicated procedure (La Na 39) to request an application to convert paddy land to ponds (Khin Maung Soe et al 2015, Belton et al 2015). Bago DoF have indicated that new ponds will require permission to convert paddy land to an alternative use such as fish ponds, unless the farm land is already classified as wasteland. This conversion process has been identified as a major constraint to small scale aquaculture expansion in Myanmar (Belton et al 2015).

This system that relies on indigenous fish, natural hatching, and low input feeding, and marketing to nearby markets would appear to be an excellent system to expand to other areas as an additional supplementary income source and food security strategy for small scale farmers .What is surprising is that the practice is widespread in Bago Region and has been carried on for a long time yet appears to be virtually unknown. Given similar conditions in other areas of Myanmar like the Ayeyarwady Delta and Mon State it is anticipated that similar systems may be in existence in these areas. It is suggested that this system should be further documented and then extended to suitable areas of Myanmar where it is not yet being practised.

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Adaptive learning in sustainable aquaculture: Best practices for small-scale shrimp farmers in Thailand

NACA

Shrimp pond with central pit to accumulate waste. A buried drainage line allows periodic cleaning, reducing the amount of organic matter in the pond during growout, reducing disease risk.

Background

"Early Mortality Syndrome" (EMS), of the type more accurately known as Acute Hepatopancreatic Necrosis Disease (AHPND) is causing major losses in marine shrimp aquaculture in Thailand and in number of Asian countries including China, Malaysia, Vietnam, India, Malaysia and the Philippines. The disease, associated with infection by a strain of the bacteria *Vibrio parahaemolyticus* has been found to occur 20-30 days after stocking of shrimp seed. In order to prevent the disease and reduce risk due to the AHPND, it is necessary to use specific pathogen free (SPF) seed as well as good pond preparation and management techniques to stabilise the pond ecosystem and to reduce organic waste in shrimp ponds.

The Petchaburi Model for sustainable white shrimp culture is an applied shrimp culture innovation that was initiated by Thailand's Department of Fisheries (DOF) in 2014. It is done by growing shrimp in water treated with seaweed culture prior to stocking of shrimp seed in ponds. This method is conducted with other pond management techniques such as the use of quicklime (calcium oxide), cleaning the pond bottom to remove organic matter in between culture cycles, use of microbes, and use live feeds or *Artemia* during the early period of growing cycle to reduce the buildup of organic matter from uneaten feed. The model is seen as a practical and effective model for reducing risk of AHPND in Thailand.

The principle of the model is now being applied under the project entitled "Adaptive Learning in Sustainable Aquaculture Best Practices for Small-Scale Shrimp Farmers in Thailand (SSSF)" funded by the Walmart Foundation and IDH through the Sustainable Fisheries Partnership Foundation (SFP) and implemented by the Network of Aquaculture Centres in Asia-Pacific (NACA) and The Food School (TFS) in collaboration with DOF, Thailand. The project is aiming at promoting collaboration among small-scale marine shrimp farmers and groups of marine shrimp farmers in Thailand to improve their farm management and to promote environmental friendly practices, prevent disease, stimulate their economies and markets. It is implemented through a participatory approach with regards to stakeholders and role of women in shrimp production and decision making processes. The project targets to improve sustainable marine shrimp culture for about 2,000 small-scale shrimp farmers in Thailand.

Issues addressed

Marine shrimp farmers in Thailand normally grow shrimps in a 1 - 4 rai pond (1 rai = 0.16 ha) and expect a total production of 2 tonnes/rai. With FCR of 1:1.5, feed requirement will be 3-12 tonnes. With feed of 20 kg/pack (1,000 Thai Baht), the total costs of feed will be about 150,000-600,000 Baht/crop of 4 months. Therefore, shrimp farmers have certain risks in producing each crop. Due to the AHPNS, marine shrimp farmers are facing high risks on their investment. They cannot borrow money unless they have information that will convince the banks for future success in their investment.

The project aims to develop local zonal management groups that will be involved in co-management of the local aquaculture industry. The anticipated wider benefits will be reduced environmental impacts of aquaculture through better farm management minimising waste release and water use; improved industry management and coordination of activities between local farms; and better representation of small-scale producers in local aquaculture management dialogues. More specifically for small-scale farmers, better livelihood returns are expected through reduced stock losses and increased diversity of income though improved use of secondary crops from shrimp ponds. The project specifically addresses the needs of women involved in Asian aquaculture, particularly those managing farming activities, marketing, and income.

In the concept and preparation phase for the project, the “Petchaburi Model” was held up as the benchmark for best practices for disease prevention. The term came from a Royal Sea Farming and Aquaculture Demonstration Project in Petchaburi province The Petchburi Royal Demonstration Project uses an “integrated, environmentally friendly and balanced farming system” that in the case of aquaculture, introduces milkfish, *Chanos chanos*, and/or tilapia or a grape-like seaweed, *Caulerpa lentillifera*, also called “green caviar”, for sediment treatment and water quality improvement. Some secondary products have been tested for commercial potential.

Partners

The following were among the partners in the management and development of the SSSF-Thailand Project:

- Sustainable Fisheries Partnership Foundation
- Network of Aquaculture Centres in Asia-Pacific (NACA)
- The Food School (TFS)
- DOF, Thailand
- Samroiyod Small-Scale Farmers’ Cooperatives
- Sustainable Shrimp Cooperative of Trad
- Trang Aquaculture Cooperative
- Ranong Shrimp Club
- Thai Union Feedmill Co. Ltd.
- Thai Royal Feedmill Co. Ltd.
- Charoen Pokaphand Feedmill Co. Ltd.

Objectives

The project sought to provide technical and capacity development support (adaptive management and adaptive learning) to selected small-scale farmers in Thailand to develop local strategies for shrimp farming development and to disseminate and adopt better management and best practices that increase productivity and reduce environmental and disease risk. More specific goals were to:

- Restore the confidence of small-scale farmers to grow white shrimp again using science-based best practices, local adaptations and practical innovations to prevent disease.

- Identify and model field-level better management practices that could increase productivity, enhance livelihoods and at the same time reduce environmental and disease risks.

- Engage more women farmers or women in farming communities to raise their visibility, recognition of their roles and contribution in farming and processing.

- Create a multiplier effect of farmer-to-farmer transfer of knowledge, experience-sharing and communication within local communities via existing networks (e.g. shrimp clubs, cooperatives or creation of new groups) that could eventually lead to zonal management.

Activities

The project met with local shrimp clubs and cooperatives, the Shrimp Farmer Association of Thailand, national and provincial government agencies. A survey on existing shrimp farming practices and stakeholder workshops were held involving a total of around 500 farms, to document the existing situation.

Shrimp cooperatives meeting certain critiera (small- to medium scale farmers, women leaders and innovative farmers) were subsequently engaged in establishing demonstrations of better management practices in farms in five provinces of Trad, Prajuabkirikhan, Ranong and Trang, and collecting performance data for comparison with existing practices.

The performance data was presented to assessment workshops attended by 30-40 farmers in each target province, followed by provincial-level seminars to extend the results to farmers more widely, attended in total by around 500 producers.

Outcomes

The project reached out to a total of around 500 small to medium scale farmers directly through the various phases and planned activities. Special attention was given to inclusion of women during the selection of model farms and workshop participants. Based on best available information at that time and reliable local networks, the project team selected four key locations - Prachuabkirikhan, Trad, Trang, Ranong - together with neighbouring provinces of Petchburi, Samut Songkhram, Samut Sakhon, Chanthaburi, Chumphon and Krabi as support. The project was able to extend its reach additional provinces and organisations linked with the farm-raised shrimp supply chain such as hatcheries, processors, feedmills, chemical and equipment distributors via attending shrimp festivals and seminars organised by the project.

In total the project's outreach was extended to around 2,000 farmers and members of farming communities. Both individuals and communities reported benefits in terms of improved knowledge, income and relationships with other farmers' groups and the Thai DOF.

Women made up 39% of the total participants in project activities but 35% of the farm owners directly involved with shrimp farming. The workshops also caught the interest of women's groups involved with post-harvest and processing, who attended or indicated an interest in participating. Two out of the six model farms were owned and managed by women, who demonstrated levels of productivity and management expertise that were ranked highly both by their peers and the project team. The majority of monitoring personnel from partner organisations consisted of women (12 out of 20). All of the above accomplishments highlight the value and contribution of women as well as build up their visibility and confidence.

The project created a multiplier effect that resonated with shrimp clubs, associations and cooperatives. New groups are being formed, to supplement or enhance existing ones in starting discussions related to zonal management. There are government and private sector-led initiatives for selected provinces that are being finalised and/or in the process of being implemented. Production statistics for 2016 as compared to 2015 show increases in two of the main shrimp producing provinces and four of the supporting provinces. In both years, the share of the provinces where the project was implemented is around 45% of total annual Thai production. We believe that the project has contributed to this growth and stability while at the same time affirmed the importance of best practices and disease prevention amongst shrimp farmers.

The project developed a unique program using core concepts of adaptive learning, an approach that emphasises learning by doing in the field, supplemented by multi-stakeholder workshops and interactive group learning. A key element of the strategy was the use of six model farms in four coastal provinces on the Gulf of Thailand and Andaman Sea.

With support and direction from the project team and the local Thai DOF Centers, the model farms demonstrated in one selected pond within their farm best management practices for one crop cycle. The team documented the whole process from pond preparation, stocking, grow out, harvest and in some cases, post-harvest. Afterwards, the model farms shared their experiences – successes as well as challenges – with other farmers in the province. Through this adaptive learning strategy, the team expected small but significant improvements that could be shared within the community to determine, collectively, potential solutions that could prevent common risks of disease, uphold the principles of sustainable shrimp farming better practices, reduce environmental damage as well as restore confidence and increase productivity.

Evaluation

Assessment workshops were held in mid-July for the farms in Prachuabkirikhan; followed by Trang during early September. Trad and Ranong originally planned for October were advanced to the second half of September; those for sixth farm and a second crop in Prachuabkirikhan, in mid-December. The schedule was advanced for Trad, in particular, due to pending restructuring of the Thai DOF's Coastal Fisheries Research and Development Centres (CFRDCs).

The assessment workshops followed a pattern of internal individual discussions with the model farmers on the crop results, specific challenges, observations and insights they have on what transpired. During these internal assessments, the project team attempted to capture and highlight lessons learned and areas for improvement.

The results of the farmer's evaluation of project impacts by province were carried out by a team from the Network and Information Technology Security Management Group, DOF under supervision of Mr Pongpat Boonchuwong, NACA Mentor/DOF Advisor in Fisheries Economics and Marketing.

The project developed a unique program using core concepts of adaptive learning, an approach that emphasises learning by doing in the field, supplemented by multi-stakeholder workshops and interactive group learning. A key element of the strategy was the use of six model farms in four coastal provinces on two different bodies of water - Prachuabkirikhan, Trad on the Gulf of Thailand; Ranong, Trang on the Andaman Sea.

To achieve the project goal and objectives, SFP facilitated the selection of a strong local team of implementers. It tapped into The Food School's field-level technical expertise, good relationships with local farmers, processing plants and overseas buyers, in addition to its experience and credibility in training, auditing and implementing supply chain projects for sustainable seafood systems. NACA, the other implementing partner, is an intergovernmental organisation that coordinated with DOF, Thailand to provide policy support and collaboration as well as to propose a strategic plan for management and implementing the project at the local level. In particular, NACA brought technical expertise and government relationships that complement TFS capabilities. From the government sector, the project received support from the Thai DOF, at the national and provincial levels. The NACA/DOF advisors and mentors; the Director and chiefs of the Marine Shrimp Research and Development Institute; the directors, technical staff and resource persons from the provincial Coastal Fisheries Research and Development Centers (CFRDCs) were all instrumental in the project's successful implementation. From the private sector, the SSSF Project benefitted from the interest and participation of seafood manufacturers, hatcheries, feedmills, chemical suppliers but most of all from the support of farm cooperatives, shrimp clubs and various local associations.

Impacts and key success factors

Many lessons have been learned – some the hard way, through failure of a crop – but all have made a positive impact on the farmers' livelihood and income; confidence; technical knowledge and skills; capacity to change, analyse, improve; ability to communicate and work in a group as while interacting effectively with other stakeholders, from the private and government sectors.

Oral and written feedback from the farmers showed that they valued highly the discussions, the experience-sharing and the knowledge dissemination. Topics on better shrimp farming practices, disease and preventive measures, access to market and supplies, finance management and record keeping are the ones they learned most about. In particular, the farmers now have a better understanding of what options they have for affordable best practices (specifically for small-scale farms) and how they could adapt and implement these, e.g. for pond preparation, water and sediment handling, animal health, feed management, in their farms to reduce disease risks. Following the experiences of the model farmers, the farmers also realised that better practices are not requirements imposed on them as "trade barriers" but practical guidelines that could improve productivity, hence generate better income from their farms. Such revenue increase was dramatically proven in the case of the two most successful farmers from Prachuabkirikhan and Ranong. All other model farmers, except one, also profited from the pilot crops. The one who did not succeed turned his crop failure into a valuable learning experience and is in the process of analysing his operations and implementing improvements.

Discussions on market access made an impression on the farmers and affirmed their value within the global supply chain. At the same time, they raised questions on how the farmers could have better control over where their products go and how to optimise the opportunities they could have for premium prices for quality, sustainably-produced shrimps. The farmers expressed appreciation for the SSSF Project's efforts to make available information – technical as well as economic – and considered it as a good model for sharing and compiling information, especially because of its support from the Thai DOF, on both national and provincial levels, as well as from private organisations knowledgeable of global markets and standards. The farmers found this credible access to information central to their business and would like to see an ongoing, more centralised channel for directing concerns or seeking guidance.

With regards to standards and certification, many farmers expressed an interest in knowing more as well as eventually working towards some certification, on top of the Thai DOF requirements, to give them global visibility. Their biggest concern, however, is cost. There are some groups eg. processors, NGOs,and overseas groups, willing to support them. However, the farmers feel that, unlike with the SSSF

Project, the gaps (geographical, technical, cultural) between these groups and the farmers are too big. Moreover, there are unwritten pressures that the farmers feel may take away their control and restrict their opportunities.

Some farmers have, during some of the discussions, made known their discomfort with middlemen. They tend to be secretive or do not know which processor and markets the shrimps are sold to. If the farmers had better information, knowing the increasing demand for sustainable quality shrimps, due to various demographic factors and media exposure, the farmers will be better positioned to optimise their opportunities for production and a premium price.

The impact of the project on women has been satisfying and interesting to both the project implementers and the farmers. The successes, commitment and attitudes of the two women model farmers stood out. At the same time, although these are good examples to motivate women to get more directly involved as farm owners, we still see gaps in ways to build up women farmers' confidence so that they could assume leadership roles and their efforts in their own farms can be visibly measured and rewarded. The assessment questionnaire results, for example, brought home a puzzling trend on the tendency of women farmers to get lower price premiums than men.

With regards to sectors that service the farms, eg. hatcheries, feed mills, chemical and equipment suppliers, the farmers appreciated the guidance provided by the SSSF Project regarding appropriate stocking density, use of sustainable non-IUU feed, avoidance of chemicals or care in using them, in cases where they are needed. However, a remaining concern for the farmers is the pressure that they get to overstock, overfeed and overuse these materials under various arrangements that lock them in with certain suppliers.

Better interaction between DOF centers and farmers; motivation for locally adapted best aquaculture practices and management techniques; encouragement of local innovation on natural feed, probiotics as well as secondary products; better recognition of localisation and innovation efforts by farmers; better use of sediment as fertilisers in orchards and other agricultural products – these are all positive impacts that evolved from the examples set by the model farms.

Similarly, the following benefits were observed within the communities where the SSSF Project was implemented: Better communication and experience-sharing among farmers; greater awareness of collective management through best practices, especially co-management of water resources; greater pride in the value of their product to international markets and being part of a global supply chain; more interest in post-harvest activities especially new products that could provide supplementary income; increased awareness of the need for collective preparedness in case of emergency situations especially for those situations that are hard to control e.g. weather patterns, and better understanding of the impact their farms could have on the environment.

Most farmers reported an increased understanding of how to manage effluents to minimise environmental impacts on the land or bodies of water adjacent to or linked to their farms. They also now have better awareness of how to utilise natural water sources carefully to avoid contaminating them or spreading disease. To this end, for SSSF, the project's technical team and experts worked with the local CFRDCs to establish a monitoring regime and requirements for disease and quality testing of soil, water, sediment, effluents, and antibiotics.

The workshops and the interactions with farmers and government officials at field level all served the purpose of raising greater awareness about on feed with responsible-sourced sustainable ingredients. The IUU issue as it relates to fishmeal, which in turn becomes the raw material for commercial feed, was explained in the broader context of other factors related to responsible wild capture fisheries e.g. fishing seasons, areas, gear type, migrant labor, fishmeal/fish oil alternatives.

Measures to alleviate or prevent environmental impacts in each province were discussed. The farmers received an overview of why programs to restore mangroves, mitigate coral reef damage, and prevent coastal erosion are community activities that need their participation. In addition, efforts by some local centers to promote crab banks or shellfish farming or seaweed culture projects are valuable to the community as they, likewise, restore natural ecosystems.

We received questions about the issue of post-harvest processing. This is an area dominated by women in the farming communities who are involved with family-scale processing, packaging or selling dried shrimp, shrimp paste or shrimp crackers made from undersized shrimps; or secondary products from plants and animals used in water and sediment treatment systems such as dried, salted, smoked, stewed products or fish burgers from milkfish; pickled, salted or dried shellfish, and fresh seaweed. Potentially, such products and activities could generate income and livelihoods for the farmers. Unfortunately, the project did not extend to post-harvest processing. However, there might be a potential future project for this sector.

The SSSF Project emphasised to the farmers the fact that they are intricately linked with local supply chains which in turn are linked to global supply chains. Hence, farmers who wish to be global players, will have to understand and implement the requirements of global markets and consumers. Within the vulnerable groups of women and small-scale farmers, who have limited resources, group membership was proposed as one way of gaining access and opportunity. This idea was well-received and started lively discussions about options for farmers' groups.

Thailand has always had strong local, regional and national farmer groups in the form of cooperatives, shrimp clubs, farmers and processors' associations, and federations and they are slowly but surely incorporating sustainability and zonal management concepts into their discussions. All provinces in the SSSF Project have active farmers' networks – formal as well as informal. The SSSF Project model farmer, Mr Decha Bunloedate, in Prachuabkirikhan, is the head of the Samroiyod Small-Scale Farmers' Cooperatives, which has 254 members (only 20% of whom are currently active). In Trad, another model farmer, Mr Boonlerd Chang-Ngam, founded the Sustainable Shrimp Cooperative of Trad that currently has 70 active members. The Trang model farmer, Mr Charoen Yongstar, is a committee member of the Trang Aquaculture Cooperative which has 143 members. The Trang Coop is divided into five zones (made up of provincial

districts). Mr Charoen Yongstar heads one group with 40 members, who meet monthly, visit each other and other farmers in neighboring provinces of Krabi, Satun, Surat Thani and Songkhla. The Ranong model farmers, Mr Tanon Yodpinich and Mr Chokchai Sukjit are partners of the Andaman Banghin Farm. Ranong does not have a coop but it has the Ranong Shrimp Club Led by Mr Amnat Worakit, its nearly 80 members keep informed and actively involved with technical and economic developments within the industry. Women comprise less than 10% of its members but It keeps close contact with farmers' groups and Thai DOF testing laboratories in the provinces of Phang-nga and Chumphon. In Prachuabkirikhan Province, one of the SSSF Project's model farmers, Ms. Siyarut Israwongchai, functions as the secretariat for a newly-formed group called the Aquamimicry Aquaculture Alliance. This is a loose grouping with members from fifteen countries in Asia, Europe and South America. The main goal is to raise sustainable, chemical-free, nearly organic shrimp, both white and black tiger.

On a national level, a newly-formed National Farmers' Council has as Chair of the Advisory Board (Fisheries), a well-respected shrimp farmer who has devoted many years of work to bettering the lives of small-scale farmers. He used to head a federation of cooperatives that negotiated for many years for better access to finance and insurance for small-scale farmers. However, up until now, have been no banks that would lend to or finance projects by small-scale farms. However, this could change if and when credit unions affiliated with farmers' groups are formed under planned reforms to be implemented by the National Farmers' Council, which in addition to a Fisheries chapter, has a separate Agriculture division.

The success of the SSSF Project owes a lot to the strong support from the Thai DOF. This was recognised and praised by the project team and farmers in all the provinces under the scope of the project. It led to a better understanding of the importance of the work of the Thai DOF Marine Shrimp Research and Development Institute and the provincial Coastal Fisheries Research and Development Centers. It became clear that the CFRDCs are indispensable in supporting farmers in each province and would require additional assistance in upgrading facilities and resources in order to provide diagnostics, monitoring and testing for disease, soil and water quality as well as antibiotic residues.

Regarding environmental impacts from shrimp farming and aquaculture, the amendment of the Fisheries Act B.E. 2490 (1947) into the Royal Ordinance on Fisheries B.E. 2558 (2015), now clearly includes aquaculture activities and responsibilities for enforcement. At the moment, detailed, specific Ministerial decrees and notifications are being developed or formalised so the work of government agencies related to aquaculture will require a period of time to stabilise. In spite of the state of flux, there are obviously many positive developments on the institutional side that will benefit the shrimp industry of Thailand and filter down to the individual farmers and farming communities.

Replicability

The SSSF Project was initially envisioned as a training program for 4,000 farmers. However, with challenges posed by a dramatic decrease in the number of farms all over Thailand, the scope was narrowed down to key provinces and a smaller group led by selected model farms. This turned

out to be the right approach as we succeeded in reaching out strategically to the farming areas and farmers' groups significant to the Thai shrimp industry.

The adaptive learning approach we developed by for this project was a departure from the original plan of workshops and classroom training on topics related to disease and best practices. By selecting and supporting model farms in key provinces, the SSSF Project successfully highlighted and demonstrated local knowledge related to those topics. Both successes and failures functioned as field-level practical lessons that farmers encounter in real-life situations, not only theoretical knowledge. The focus on local input gave added confidence and pride to the communities that the SSSF Project operated in. With relatively limited resources, the SSSF Project covered geographically diverse areas in the country; completed many complex activities – in the field and off the field; forged relationships with farmers and farmers' groups in remote areas; communicated and/ or demonstrated important knowledge and skills, within a relatively short period of time.

Challenges

The main difficulties faced during the project period and the lessons learned are as follows:

- There were five successful crops and two unsuccessful ones. The farmers who "failed", though, were not deterred by the setback. Some spoke honestly to their peers to impart valuable lessons in line with the strategy of adaptive learning. There were financial, personal, technical and institutional benefits that met or exceeded our expectations.

- Five of the six model farms successfully overcame or prevented disease risks and benefitted financially from their crops. Those financial benefits from one crop, in terms of gross income, in the most cases, were equal to or exceeded what they had reported as their previous annual income. All successful crops and even one emergency harvest showed profit.

- The older farmers, who had experienced crop failures or risks due to disease, differed in their techniques for mitigating the situations they encountered. Whatever the case, the experience reinforced or changed their views on their management practices and caused them to review disease factors and options for preventive measures.

- The younger farmers tended to be more receptive and compliant to the recommendations and guidance of the SSSF Project. In particular, one young woman farmer, who did best, showed enthusiasm and motivation to learn and succeed as well as the willingness to take risks. She stood out in her thirst for knowledge, adeptness in seeking information and ability to draw out other farmers' experiences that she can apply to her farm.

- All of the model farmers reported gaining confidence in being able to overcome disease risks. Even the ones who encountered disease incidents and failed crops, took the experience positively and communicated the merits of the project to their peers.

- There are many local innovations in terms of pond preparation, pond structure, probiotics, natural feed, postlarvae breeding programs that are worth documenting in a training manual or videos for dissemination to a wider audience.

- There are still many challenges that farmers, the industry and the government sector face eg. how to cope with changes in weather/impacts of climate change; unpredictable or limited supply of healthy/SPF PLs; insufficient support for good breeding programs; pressures to overstock and overfeed; better guidance for feed management; better diagnostic tools for disease; more information on disease causes and spread together with the current situation in their province and neighboring provinces; better understanding of environmental impacts, sustainability, traceability and zonal management.

- Relationship building and diplomacy in dealing with farmers got a lot of focus for this phase of the project. The SSSF Project Team successfully dealt with sensitive crop failure situations, analysed them together with the farmers, and turned them into learning opportunities and (for some) financial gain.

- Separate project team assessments and peer assessments were less confrontational. The internal assessment scoring tool is a good guide as it captures not only the end result but the process of implementation, attitudes, motivation and willingness to improve. Honest information on both failed or successful crops are valuable learning opportunities. It is important to disseminate lessons learned to a wider audience and in a larger context.

Observations and lessons learned

We learned a lot during the development and implementation of this project. Some of our observations and lessons are listed below, in the hope that they may prove useful to others working on similar issues. Implications for policy makers and development professionals

- Participate in community-based projects that focus, mitigate or prevent environmental degradation e.g. mangrove restoration, coastline erosion prevention.

- Develop clear interpretation guidelines for the amendments to the *Fisheries Ac*t directly relevant to aquaculture and farms.

- Maintain or enhance breeding programs in order to make available to farmers healthy, affordable PLs, not necessarily limited to *L. vannamei* alone.

- Continue programs researching and testing the effectiveness of probiotics that could mitigate disease risks and improve shrimp health. Make these products affordable to small-scale farmers.

- Consider a centralised service center that could capture farming community concerns, supply information needs, as well as facilitate licensing and monitoring.

- Coordinate with other government agencies as needed to monitor potential environmental impacts to and from shrimp farms. Define what constitutes negative impact to the environment from shrimp farms. Consider potential impacts/risks from climate change.
- Review zonal management policies and develop as needed a program targeted at disease containment in specified zones.
- Continue research on types of disease, causes and preventive measures.
- Interface with divisions in charge of wild fisheries regarding sustainable feed concerns.
- Issue guidelines on best practices for shrimp aquaculture using closed systems.
- Develop farm-level programs to motivate more women to take up shrimp farming.
- Project implementation periods are often short. It would be better to monitor at least two crop cycles.
- Suggest using adaptive learning concepts more than classroom learning and to include demonstration farms for more effective learning.
- Request that baseline questionnaires and reporting formats be sent ahead of time so that they could be reviewed and translated prior to scheduled activities.
- A similar project with greater focus on hatcheries and breeding programs may be useful, as there appears to be a lot of problems and variations in seed quality.
- It would be useful to extend such projects to address issues further up the supply chain and to encompass issues such as zonal management for disease containment and mitigation.
- Review interest in post-harvest related projects as these could supplement farm-related projects and tap into the involvement and contribution of women.

Technical suggestions

- Bear in mind that there are cost-effective options for developing a closed system that recycles water after treatment. Expensive technology is not always the answer.
- When considering pond siting and infrastructure, make sure that there will be no potential risks or damage to the environment.
- Prepare a layout of the farm and identify the points, through risk analysis, where there could be disease risks or risks to the environment.
- Pond preparation is crucial to the success of a crop; therefore it must be done thoroughly; monitor and test the soil and water for disease prior to stocking.
- Know the quality of source water as well as that of water in all other ponds. Keep all reservoirs and ponds clean and implement biosecurity measures for the farm.
- Insist on lower stocking densities; know the SPF status and source of your PLs; obtain documentary evidence to support the hatchery's claims.
- Obtain information on all inputs – PLs, probiotics, chemicals, feed to ensure traceability and safe sustainable materials.
- Note all feed lot numbers received and used. Keep good accurate records of shrimp feeding amounts, growth and health condition.
- Develop internal monitoring systems for optimum parameters for growth e.g. pH, DO, calcium, magnesium, alkalinity, ammonia, nitrite. At the same time, verify these with periodic external monitoring by the local CFRDC or other agencies.
- Maintain good networks among farmers in your area to discuss common problems, co- management ideas or information sharing on technical or commercial matters.
- Join or form farmers' groups that could provide opportunities for training and extension.

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Marine finfish seed production and growout training course, July 2018, Thailand

The 9th Regional Training Course on Marine Finfish Seed production and Grow-out will be held from 2 - 20 July 2018 in Krabi, Thailand. The course will be taught by staff of the Krabi Coastal Fisheries Research and Development Centre. The training course will be conducted in English.

Marine finfish aquaculture has been significantly contributing to fish production and the economies of coastal communities in Asia. During the past few decades, substantial advances have been made in science and technology on marine finfish aquaculture and the region has accumulated a wealth of knowledge and technical expertise.

Drawing on expertise throughout the region and supported by experienced field experts in collaborating centres, this three-week hands-on training course will provide participants with skills in marine finfish seed production and grow-out operations, with an emphasis on tropical groupers and Asian seabass (*Lates calcarifer*).

Who should apply?

Professionals who are interested in:

- Upgrading knowledge in marine finfish production.
- Enhancing skills in marine finfish hatchery and grow-out operations.
- Looking for innovative ideas.
- Improving efficiency and profitability of business operations.
- Building academic and business connections.

Who are the trainers?

- Academicians and fish biologists from leading universities and research institutes specialised in marine aquaculture.
- Experts in phytoplankton and zooplankton labs and live feed production.
- Experienced hatchery technicians.
- Professionals from commercial companies and hatcheries.

What will I learn?

You will practice broodstock selection and maintenance, induce fish to spawn, incubate eggs, prepare live feed and develop feeding regimes for newly hatched larvae, practice

early and advanced nursing, seed harvesting, packaging and transportation and observe grow-out operations. You will also be presented with a theoretical background on biology, reproductive physiology, nutrition and health management. Field visits will showcase production technology and operation of small and medium-scale grouper hatcheries, nurseries, grow-out farms, live feed production and supply, and live seafood exports in Thailand. Some government research and extension institutes will also be visited. Topics covered in the training course include:

- Biology of major cultured marine finfish (groupers, seabass, snapper, and pompano).
- Site selection, hatchery design, equipment and setup.
- Broodstock selection and management.
- Egg handling and incubation.
- Water quality management.
- Nutrition, feed and feeding for marine finfish larvae.
- Live food production.
- Larviculture and nursery of fry.
- Biosecurity.
- Diseases and fish health management.
- Harvest, packaging and transportation of fish seed.
- Grow-out operations.

- Aquaculture business management and investment appraisal.

Seminars on special interests

- Production techniques of mud crabs.
- Marine ornamental fish: Major species, production and market perspectives.

Training activities

- Lectures, discussion and classroom exercises: (30% of training time).
- Hands-on practices (50% of training time).
- Field trips and others (20% of training time).

How to apply?

Download the application form below, fill in and send it to NACA through post, fax or email or apply online at https://enaca.org/enclosure.php?id=972

Global fish passage forum to include first symposium on hydropower and fish

Peter Starr

The American Fisheries Society and the Environmental and Water Resources Institute of the American Society of Civil Engineers are holding this year's annual fish passage conference in Australia in December in collaboration with hosts Charles Sturt University and the New South Wales Government. The International Conference on River Connectivity in Albury from December 10 to 14 includes the First International Symposium on Hydropower and Fish Management.

https://fishpassage.umass.edu

The latter is scheduled to be chaired by Luiz Silva, a Brazilian freshwater fish scientist now based at the university's Institute for Land, Water and Society in Albury, located at the headwaters of the Murray River which forms part of the largest river basin in Australia. Dr Silva has contributed significantly to the understanding of fish passage in tropical regions and is credited with developing strong links to the hydropower industry in Brazil.

The overall conference is scheduled to be jointly chaired by Lee Baumgartner, associate professor at the Institute, and Matthew Gordos, fish passage manager at the New South Wales Department of Primary Industries.

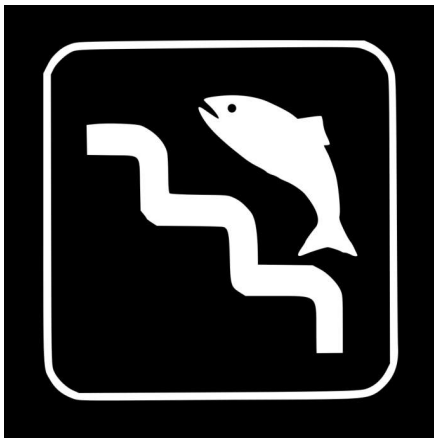
Global significance

The separate symposium is part of an initiative of the Technology Collaboration Programme on Hydropower of the Paris-based International Energy Agency (specifically its working group on hydropower and fish, known as Annex XIII). According to the conference website launched by the University of Massachusetts during the second week of January "there is an increasing goal worldwide to seek multidisciplinary tools and solutions for the hydropower development and fish management nexus.

Hydroelectricity is a major economic activity, especially in developing countries, but also a major threat for the aquatic biota, especially fish. In many cases, the lack of knowledge on the ecology of fish species affected by dams is the main factor constraining the ability to provide more informed decisions and management plans for hydropower."

The symposium is expected to focus on global issues related to hydropower and impacts on fish biology and ecology, bringing perspectives from different countries, especially those where such development is a major economic activity. The five main topics are:

- Hydropower dams and impacts on habitat availability for fish.
- Hydropower structures/operation and direct impacts on fish.
- Hydropower monitoring and management for fish.
- Design, development and monitoring of mitigation measures.
- Hydropower policies and decision-making.



Relevance to Mekong Basin

Dr Baumgartner, one of the two co-chairs of the conference, said organisers were aiming for strong attendance from the Mekong region.

"River development will greatly impact aquatic resources and water use in the Lower Mekong Basin," he told Terra Daily.

"Current hydropower output of about 3,325 MW is expected to rise seven percent per year over the next two decades with the construction of 134 new dams. Irrigation networks are expected to expand by more than 250 percent over the same period. This growing number of large-scale water resource development projects in the basin is challenging the long-term sustainability of the world's most productive inland fishery."

The Australian freshwater fish ecologist currently leads a five-year project on quantifying the biophysical and

community impacts of improved fish passage in Laos. The project - financed by the Australian Centre for International Agricultural Research (ACIAR) - was launched in 2016. “The Lower Mekong capture fishery is extremely important,” Dr Baumgartner said.

“It contributes more than 50 percent of the animal protein and supports the livelihoods of close to 70 million people living in the basin. But river development threatens this productivity. “

“In South America, similar development in the Amazon River depleted fisheries production by 70 percent. In North America, the Columbia River salmon fishery also collapsed following dam construction. To partly restore the associated fisheries, $7 billion was invested from hydropower earnings into applied research over 50 years.” Dr Baumgartner said these cases highlighted how robust science was needed to identify, evaluate and mitigate the effects of river development.

“It is far cheaper to do so before investing in water resource development rather than responding to subsequent fish declines after construction has taken place,” he said.

“Without effective mitigation strategies, capture fisheries production will fall substantially, impacting a major source of animal protein and income.”

The conference in Albury in December follows a regional gathering organised by ACIAR and the United States Department of the Interior in Vientiane in 2016 in which a wide range of experts working in the Lower Mekong discussed fish passage issues for the first time. The conference provides a forum to raise these issues on the international stage.

According to Dr Baumgartner, the December conference will bring together international experts in riverine development, fish passage and aquatic ecosystem management to show how research can be applied to enhance global policy and decision-making.

“It’s open to government agencies, developers, researchers, local provincial and district leaders and natural resource managers as well as recreational fishers to help share knowledge of successes and opportunities for sustainable fisheries,” he said.

“The broad aim is to ensure economic development is furthered while maintaining, and where necessary, restoring healthy fisheries.”

Initially known as the National Conference on Engineering and Ecohydrology for Fish Passage, the annual gathering of experts was hosted by the University of Massachusetts, Oregon State University and the University of Wisconsin between 2011 and 2014 as well as in 2016 and 2017. The first conference outside of the United States was in the Dutch city of Groningen in cooperation with various European organisations in 2015.

The conference call for abstracts opens on February 1 and closes on April 30. Readers interested in being placed on the mailing list for the conference should contact Dr Baumgartner directly (lbaumgartner@csu.edu.au).

The author is editor of Catch and Culture - Environment, the fisheries and environment research and development newsletter of the Mekong River Commission.

International Workshop on Rehabilitation, Propagation and Conservation of Mahseer, April, India

An international workshop on mahseer conservation, propagation and rehabilitation will be held in Bhimtal, India from 23-24 April 2018. The workshop is organised by the ICAR-Directorate of Coldwater Fisheries Research in collaboration with the Coldwater Fisheries Society of India.

Despite their abundance at one time in India and other Asian nations, wild mahseer populations have been declining because of degradation of aquatic ecosystems, urbanisation and indiscriminate fishing. Mahseer are presently struggling for their mere existence in different lakes and rivers of the Indian sub-continent. Depletion of broodstock has severely affected the availability of healthy seed for its sustainable management. Therefore, captive rearing, breeding and propagation of mahseer are necessary challenges for the fishery scientists and other stakeholders to address.

In view of the aforesaid facts, an international workshop on Charting the Innovative and Strategic Paths for Rehabilitation, Propagation and Conservation of Mahseer will be convened with an aim to discuss researchable issues and to build a strategic action plan for sustainable management of mahseer in fisheries and aquaculture.

Eminent scientists from India, England, Thailand, Malaysia, Sri Lanka, Bangladesh, Nepal and Bhutan will deliver lead talks on key issues during the workshop.

For more information including contact details, please download the brochure below:

https://enaca.org/enclosure.php?id=973

World Brackishwater Aquaculture Conference, 23-25 January 2019, Chennai, India

BRAQCON 2019 will provide a unique platform for people involved in brackishwater aquaculture and fisheries, nationally and internationally. Sharing of experience and research advancements in the frontier areas would facilitate maximum utilisation, cultivation, conservation and development of aquatic resources. The conference would elicit interest among young researchers and scientists to undetake studies and research to further open up new blue growth avenues for a better world. BRAQCON 2019 is also an attempt to foster cooperation between concerned governmental, non-governmental institutions, private sector and farmers for advancement of sustainable aquaculture and fisheries in brackishwater ecosystems.

The conference would cover latest research and development in the broader themes of the conference in the form of special sessions, contributed papers, expert group discussions and brainstorming on issues facing aquaculturists and ecosystem managers in India and around the world. The following are the themes of the conference:

- Brackishwater ecosystems.
- Brackishwater and estuarine biodiversity and conservation.
- Aquaculture production systems.
- Reproduction and larviculture.
- Fish and shellfish nutrition.
- Aquatic environment and climate change.
- Aquatic animal health.
- Socio-economic and livelihood issues of fisheries and aquaculture.
- Aquaculture genetics and biotechnology.

Side events will include the Farmers Conclave 2019 where industry participants can share their views with policy makers and researchers and an 'Aquaculture start-up meeting', aimed at entrepreneurs planning to enter the industry and allied sectors wishing to present ideas, innovations and technologies.

For more information please visit the BRAQCON 2019 website:

http://www.ciba.res.in/braqcon/

Offshore Mariculture Asia 2018, 15-17 May, Singapore

The 8th Offshore Mariculture Conference will be held in association with the U.S. Soybean Export Council, USSEC, in Singapore, from May 15 - 17, 2018.

In the last European edition of the conference in Barcelona, it was highlighted by the FAO chairman that Asia is the hub in terms of quantity and potential, and it needs to intensify with more fish per cubic metre of water. The market in Southeast Asia is now well-primed for large scale/large volume production and the focus for this first Asian edition of the conference will be marine fin fish.

The conference has previously enjoyed six successful conferences in Europe, held in Malta, Alicante, Dubrovnik, Izmir, Naples and Barcelona. This March launched the 7th edition in the Americas in Ensenada, Baja California, Mexico in response to the need to grow this important sector worldwide to meet the growing demand for seafood. This highly successful launch, supported by both regional and federal Mexican governments, saw 200 attendees from 20 countries and included high profile investors.

The 2018 Offshore Mariculture Asia Conference will be an invaluable platform for networking as it will provide ample opportunities to meet and network with fellow delegates, sponsors, and speakers to knowledge share and move the sector forward.

The conference will consist of 2 days of technical presentations and panel discussions from high level experienced operators in the sector. The event concludes with a technical visit to an operating farm, providing delegates with an insight into their inner workings.

Organised by Mercator Media Limited, publishers of World Fishing and Aquaculture, the conference will include the latest legislation, investment and financing opportunities together with the day to day practicalities of running an offshore business.

To register or obtain more information please visit the Offshore Mariculture Asia 2018 website: http://www.offshore-mariculture.com/asia

Video lectures: Regional Training Course on Culture-based Fisheries in Inland Waters

Participants in the Regional Training Course on Culture-based Fisheries in Inland Waters.

As foreshadowed in the last issue, video recordings of lectures from the Regional Training Course on Culture-based Fisheries in Inland Waters are now available for download, or you can view online at:

https://enaca.org/?id=939

The course was held at Nha Trang University, Vietnam, from 30 October to 8 November 2017. The objective of the course was to provide participants with the skills to assist local communities to plan and manage culture-based fisheries.

The lectures include presentations on:

- Hydrobiological characterisation of water bodies for culture-based fisheries development.
- Assessment of production potential.
- Bioenergetic modelling.
- Stocking calendar, size, density and seed transport.
- Species selection.
- Multiple-use of water resources in culture-based fisheries.
- Community consultation.
- Legal and policy framework for culture-based fisheries development.
- Gender mainstreaming in culture-based fisheries.
- Constraints to culture-based fisheries development.
- Fish stock dynamics.
- Harvesting and marketing strategies.
- Case studies from China and Vietnam.

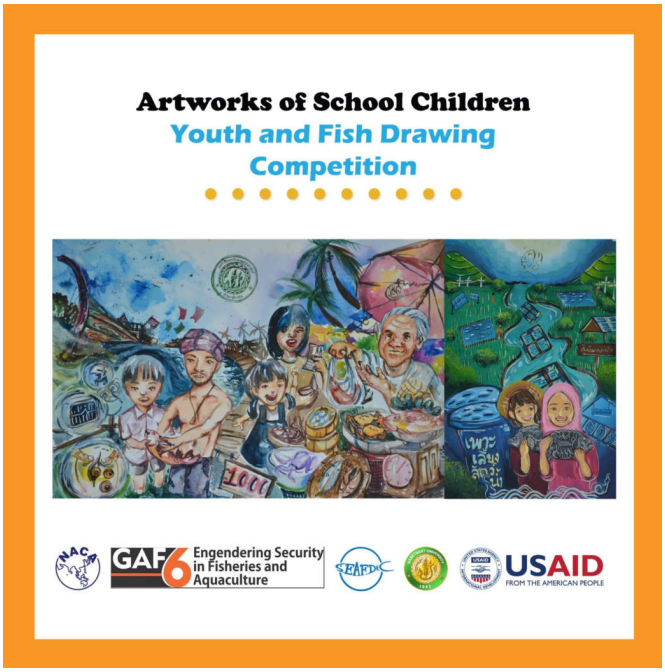
The course was sponsored by the **United Nations University Fisheries Training Programme** (UNU-FTP).

Youth and Fish Drawing Competition Art Book

This Souvenir Book reproduces the winning entries from the Youth and Fish Drawing Competition for Thai junior and senior high school students that was held during the 6th Global Symposium on Gender in Aquaculture and Fisheries (GAF6) in Bangkok, 4-7 August 2016. The competition was organised by the Faculty of Fisheries - Kasetsart University, the Network of Aquaculture Centres in Asia-Pacific and the USAID Oceans and Fisheries Partnership. This was the first activity involving youth in raising awareness of the gender dimension to be conducted at a GAF event.

The Youth and Fish Session was born out of the need to help raise awareness, through art in schools, of gender in aquaculture and fisheries. In her introductory speech to the event, Dr Arlene Nietes Satapornvanit, Gender Specialist at the USAID Oceans and Fisheries Partnership, said “we believe that we should start our advocacy about gender awareness and sensitivity at a young age, so that these concepts will be ingrained in the mind-set of the youth, and they will keep and carry it on until adulthood. That being gender sensitive is not only a one-time activity but a lifestyle. The youth are the future leaders and if we have leaders who are gender sensitive, we can be assured that there is inclusivity in their actions, and that no one will be left behind.” The Youth and Fish Session was considered a pilot activity and it is hoped that this could be expanded to other countries in the region in the future.

Ten senior and seven junior high schools participated, with two students (male and female) from each school. They were accompanied to the venue by their parents and teachers. The competition ended after nearly three hours of drawing and painting.



The organisers would like to acknowledge the panel of judges for their time in looking at all the entries. The students produced beautiful and meaningful art and the judges faced a challenge in choosing the winners. Congratulations to all the students, schools, teachers and parents for their participation and support. The event was supported financially by the Network of Aquaculture Centres in Asia-Pacific.

An electronic version of the book is available for download from: https://enaca.org/?id=937

Report of the Sixteenth Meeting of the Asia Regional Advisory Group on Aquatic Animal Health

This report summarises the proceedings of the 16th meeting of the Advisory Group, held 26-27 August 2017 in Bali, Indonesia. The group discussed:

- Progress in NACA’s Regional Aquatic Animal Health Programme.
- OIE standards and global issues.
- Listing of diseases in the Quarterly Aquatic Animal Disease Report.
- Regional disease status, including of shrimp, finfish, amphibian and molluscan diseases, and listing of Tilapia Lake Virus (TiLV) in the quarterly disease report system.
- Reports on the aquatic animal health programmes of partner agencies.
- Disease reporting and revision of the Quarterly Aquatic Animal Disease List.
- Developments in antimicrobial resistance.

The Advisory Group meets annually to provide advice to NACA member governments on aquatic animal health management. The group’s role includes reviewing disease trends and emerging threats in the region, identifying developments in global aquatic disease issues and standards, evaluating the Quarterly Aquatic Animal Disease Reporting Programme and providing guidance on regional strategies to improve aquatic animal health management.

The report is available for download from the NACA website at: https://enaca.org/?id=975

FAO-NACA expert workshop on newly emerging aquaculture practices

Aquaculture production is an indispensable source of protein food for human consumption in the world as a whole. It is particularly important in the developing countries for national socioeconomic development apart from food production role it plays. Despite a slowdown in its annual growth rates in recent years, aquaculture remains one of the fastest growing food production sectors and is expected to continue to expand into the foreseeable future. The general trend in aquaculture development is going towards a higher level of intensity in terms of material and management inputs, coupled with advances in sophistications in aquaculture technologies and production operation system development.

Over the years there have been new development and innovations in aquaculture farming systems and culture facilities, resulting in the improved efficiency in natural resources uses and the rearing conditions and quality of farmed aquatic species. In recent years, relatively new farming systems, technologies and business integration models have been increasingly adopted in commercial aquaculture production, such as the recirculating aquaculture system, in-pond raceway aquaculture system, high efficiency aeration systems and the integration with other farming or non-farming operations.

The new development in the direction of further diversified aquaculture farming systems and rearing facilities point to the need to review of the currently practiced aquaculture farming systems for comparison with the farming system classification in current use by FAO and other international organisations for aquaculture statistical purposes. The comparison would reveal the gaps in illustrating the aquaculture development status and trend between the statistical data structured by the existing classification and the farming systems in real use.

To address these issues, FAO and NACA will convene a technical workshop of selected aquaculture experts to:

- Review and develop a summary of the currently practiced conventional aquaculture farming systems, newly emerging farming systems as well as potential novel farming systems with promising future.
- Compare the aforesaid farming systems summary with the farming system classification in current use by FAO and other international organizations for aquaculture statistical purpose.
- Identify the major gaps in illustrating the aquaculture development status and trend between the statistical data structured by the existing classification and the farming systems in real use, with a focus on the usefulness of aquaculture data structured by farming system for the purpose of debunking the interactions of aquaculture development with these factors, including the use of natural resources (mainly land and freshwater), dependency on artificial feeds, energy use, the extent of financial requirement for investment and operation, environmental concerns and potential risks.
- Develop a category with structured hierarchy of aquaculture farming systems classification to suit the need of flexible categorization of aquaculture statistical data in the collection, storage and reporting at national and international levels.

The workshop will be held in June; the venue will be announced in due course.

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