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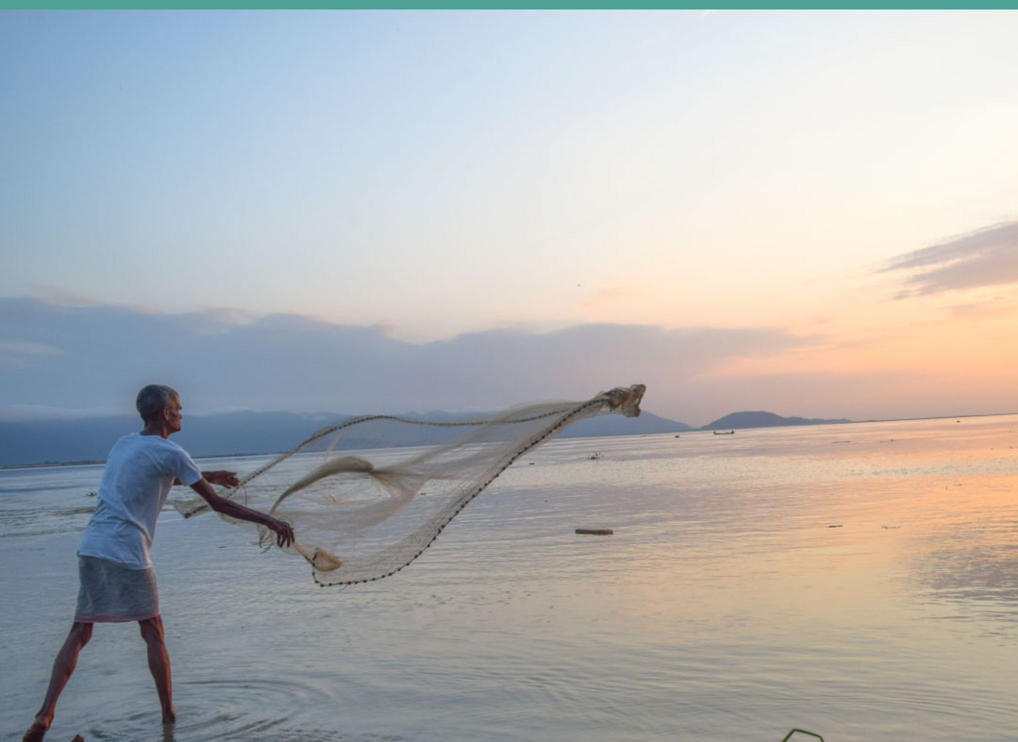
AQUACULTURE ASIA

Empowerment of women fishers

Seed production of *Heteropneustes fossilis*

Fishing gear of Assam

Integrated multi-trophic aquaculture



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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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More on antimicrobial usage and resistance in aquaculture

Scrutiny of antimicrobial usage (AMU) and the development of antimicrobial resistance (AMR) continues to gain traction, with two regional consultations on the subject being held in Bangkok in September (please refer to the newsletter article in this issue for details).

The usage of antimicrobial substances in aquaculture and agriculture generally has been a contentious issue for many years. However, the focus has shifted. In the past the main concern was food safety, in that that the residues of some (banned) antimicrobial substances posed a direct threat to human health. This has and remains a significant trade issue, with governments routinely screening imported foods for compliance with maximum residue limits.

More recently, it is the risk of antimicrobial resistance that is driving concerns. Put simply, any time you use an antimicrobial substance you are selecting for resistant strains of both target and non-target organisms. When the usage is routine, wholesale and indiscriminate, it is inevitable that resistance will increase. Switch to another antimicrobial substance and you're heading towards a multi-drug resistant future, where nothing works and common infections cannot be treated.

There are a raft of aquaculture-specific problems such as the non-availability of veterinary services (diagnosis) in rural areas, the difficulty of getting the right dose into the animals, and the difficulty in containing water-borne microbes, but I've covered those in a previous column and will not revisit them here.

So what to do? The first step undertaken by the projects mentioned above, undertaken by FAO, NACA and USAID working together, has been to undertake a regional assessment of antimicrobial usage and associated risks in aquaculture. The study has examined the current status of AMU in aquaculture and related regulation of the sector by different governments. Similar work is also being conducted in the agriculture and terrestrial livestock sectors.

The projects are working towards establishment of a regional framework for AMR surveillance in aquaculture, and the consultations provided an opportunity to gather input and feedback on what guidelines for AMR surveillance should look like. The consultation covered policy issues, existing international frameworks for aquatic animal health and food safety, the principles and objectives for AMR surveillance guidelines extending down to details on data management, storage and sharing.

It was apparent from the discussions that we are at a very early stage in developing AMR surveillance for aquaculture let alone management. What data there is paints a very alarming picture, nobody should think that this is a hypothetical issue that may become a problem in the distant future. Multi-drug resistant microorganisms in aquaculture are already here. It was also evident from the consultations that this problem is not confined to aquaculture nor can it be solved by aquaculture. It is an issue that needs to be addressed by human health authorities and across agriculture together, as part of the "one health" approach.

Simon Wilkinson

AQUACULTURE ASIA

CONTENTS

Concept of seed production of *Heteropneustes fossilis* in farmers' fields in West Bengal, India

Md. Shied Mondal[1] and Subrato Ghosh[2]

1 Prop. Mondal Hatchery and Fish Seed Suppliers, Vill. and P.O. Sarapul, PS Swarupnagar, Dist. North 24 Parganas, West Bengal; 2. 122/1V, Monohar Pukur Road, P.O. Kalighat, Kolkata – 700026, West Bengal, India.

Heteropneustes fossilis male brood fish.

Distinguishing features of *H. fossilis*

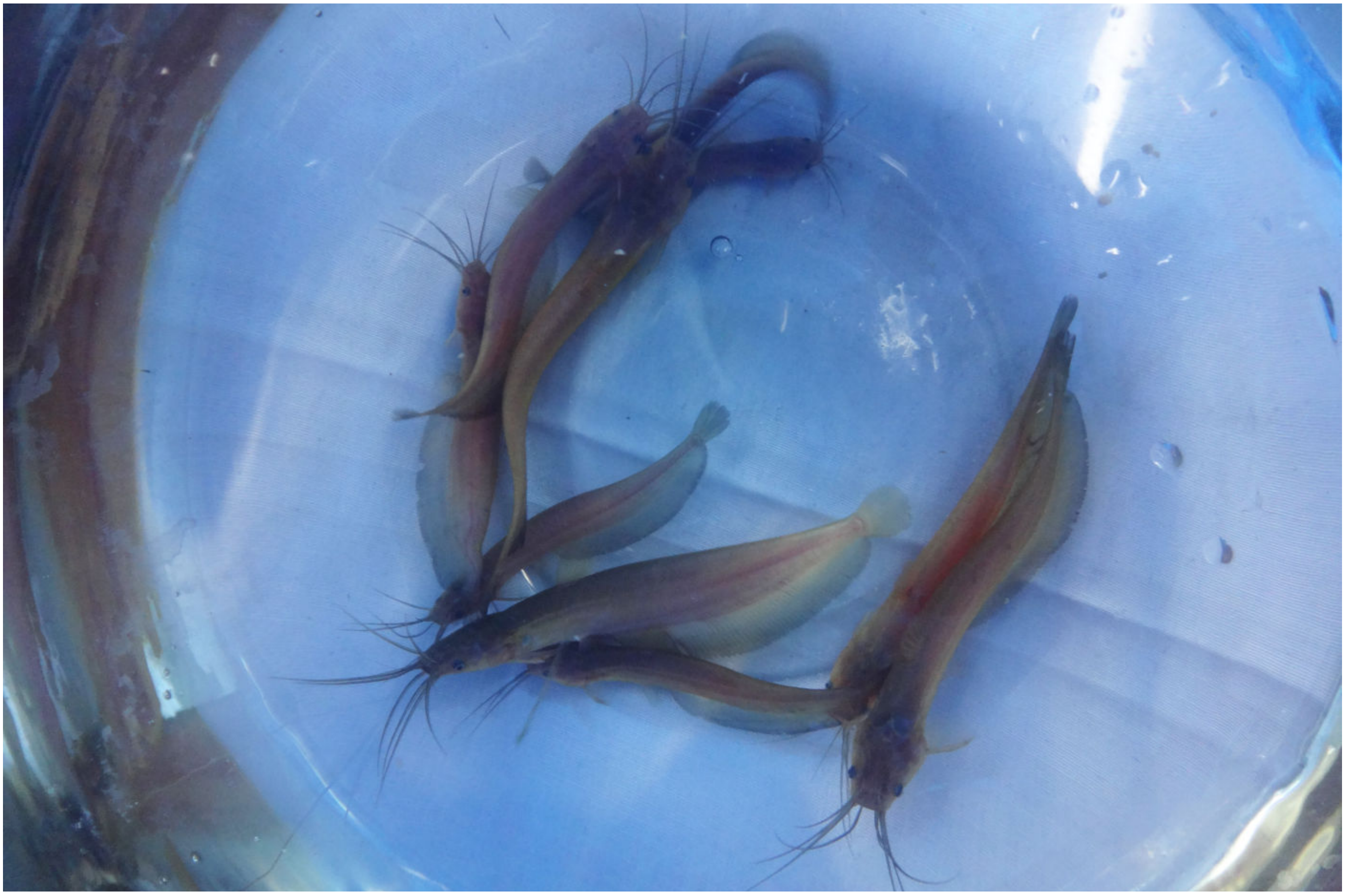
The freshwater catfish *Heteropneustes fossilis* can inflict a painful sting and wound with its pectoral fin spine on hands of fish farmers, if handled carelessly or when provoked. Poison can emanate from a gland in the pectoral spine of male fish. When the spine penetrates the body of handlers, its presses its base against the venom-containing cells, squashes them and squeezes the venomous contents into the wound in victim's skin and underlying tissues. Quite intense pain develops at site of injury, progressively extending to surrounding areas. Secondly, it possesses two tubular pulmonary air sacs, which run backwards on either side of the vertebral column almost up to the caudal peduncle from gill chamber through the myotome muscles in the back. This accessory respiratory organ of the fish never comes in direct contact with the aquatic environment and can allow the fish to survive for about 16 hours out of water. Thirdly, *H. fossilis* is a high-priced fish, well regarded for its high nutritive and medicinal values and invigorating qualities from time immemorial.

Brief history

2016 marked the 60 years since the first successful induced breeding of *H. fossilis* in India. It was performed by Dr L. S. Ramaswamy and his research student B.I. Sundararaj in June 1956 at Bangalore Central College, under the then Mysore University, using pituitary gland from the same species. In the 1984 breeding season at Hessaraghata Fish Farm, Bangalore, success was achieved in induced breeding of *H. fossilis* in the All India Coordinated Research Project on air-breathing fish culture; pituitary gland extract was used @ 30 and 90-120mg/kg body weight as 1st and 2nd injections respectively to females (100 g) and 30-50mg/kg as a single injection to males (60-80 g)[1]. In 1998, Dr M. A. Haniffa and co-researchers at St. Xaviers' College, Palayamkottai, India had developed a low-cost simple breeding and egg incubation/hatching technique for *H. fossilis*, which could easily be adopted by rural fish farmers[2]. In 2017, the same researchers reviewed the seed production of *H. fossilis* by induced breeding, and emphasised 'Seed production as an urgent need for *H. fossilis* farming in ponds'[3]. In 2000, scientists at ICAR-CIFA, Bhubaneswar standardised the technique of seed production of *H. fossilis*.

Brood stock maintenance and breeding

As practiced at Mondal Hatchery and other leading *H. fossilis* seed production units in West Bengal, females 18 months of age (weighing 200-250 g) are preferred as broodstock for induced breeding. Females become mature with ripe oocytes at 9-10 months of age but the males are not yet mature at this age. Males weighing 120-160 g are selected. Broodstock of both sexes are prepared from 8 months old by rearing for 8-9 months in small ponds (water depth: 105cm), stocked @ 18,000-20,000 fish in 1,335 m^2 ponds (water depth 1 m). In such ponds, *Anabas testudineus* 50-200g size are also stocked @ 1,500-2,000, which enhances dissolved oxygen content and helps in auto-oxygenation in the pond with the help of their accessory respiratory organ. Commercially available floating pelleted feed (beginning with 3mm and ending



Advanced fry of H. fossilis.

with 6mm diameter) are fed twice daily 5:00 and 18.00 hours @ 9% of total biomass. For *H. fossilis* and *Ompak pabda*, feeding the fishes at sunrise and during sunset gives a good result. The vent of the females turns pinkish with a blunt navel-like state. For *H. fossilis*, each breeding set comprises 6-8 males and 4 females. Commercially available fish pituitary gland stored in processed and dried form, supported with zinc powder and cotton in small vials with rubber cork, is used as inducing agent. Females are given two injections of pituitary gland extract at an interval of three-and-a-half hours and single injection is applied to males.

Dry stripping method and nursing of larvae

In the dry stripping method, in conditions when non-release of eggs occurs seldom in case of *H. fossilis* females due to 'plugging' of genital pore, fresh tubewell water is boiled and those fishes are kept in mildly hot water for 25 mins; which facilitates loosening of 'plugged point' and 75% release of ova. Brood fishes are ready to be stripped four hours after injection of the females. A pair of testis from male fish is dissected out and homogenised or squeezed through a cotton cloth using 2% saline solution. The milt is further diluted with 1 part water added to every 2 parts of saline-associated milt, and spread over the stripped eggs. Sperm and eggs are mixed well with a feather for 3-4 mins and fertilised eggs are washed with freshwater. They are greenish-blue/ greenish-brown in colour and demersal in nature. The eggs are incubated in individual mini rectangular trays of dimension 25cm x 20cm x 5cm. Water hardness 250-400 ppm favours incubation of *H. fossilis* eggs, whereas for *Clarias batrachus* the ideal concentration is 100ppm.

As observed, after an incubation period of 9.5-10 hours at 29-30°C water temperature, *H. fossilis* larvae begin to hatch, measuring 7-8 mm on the third day. This stage is stocked in rectangular chambers of 3 m x 1.8 m dimension with a water depth of 30 cm. About 30,000 larvae are obtained from every four females. Early fry/advanced larvae are stocked @ 45,000-60,000 / chamber. In each chamber, four bubble diffuser-type oxygenation machines are introduced. Growing larvae are fed two times a day with a mixture of 2-3 boiled chicken eggs and 100 g milk powder mixed with 3 litres of water in each such chamber. On summer days with strong sunshine, 30-40 g of glucose powder is mixed with 2 litres of water and sprinkled over each rearing chamber. In addition to this, oxygen powder (marketed by Gabbro Company) is applied at one-third of a teaspoon per chamber. *H. fossilis* larvae measure 15-18 mm six days after stocking; these are harvested from chambers and stocked in pre-prepared productive nursery ponds @ 200,000 / 1,335 m^2. The fish attain 3.8-4.8cm in length after 20-22 days of rearing. Dust-type supplementary fish feed from CP is used two times a day @ 12% of body weight in each nursery pond.

These fish fry and advanced fry of *H. fossilis* (pure variety; 1,500-1,600 pieces weighing 1kg) are sold @ Rs 2.60/- / piece. They are considered as 'Grade-A'. In fish seed whole-sale markets, 'Grade-B' type of advanced fry of *H. fossilis* may also be available for sale (Rs 1.80/- / piece), which is basically a cross-bred variety of male *Clarias gariepinus* and female *H. fossilis* produced in hatcheries.

Induced breeding using Ovaprim and live larval feed

If a single dosage of Ovaprim or Gonadoprim is applied to mature females and males @ 2 ml and 1 ml / kg body weight respectively, they release gametes spontaneously and fertili-sation occurs, stripping is not required. Female *H. fossilis* can be induced to breed twice at an interval of 45 days. Brooder management may be done from January until early May and in its initial phase, a low dose of pituitary gland extract @ 0.2ml / kg is applied only to females, which were not used for breeding in previous season. Some catfish breeders in North 24 Parganas and South 24 Parganas districts maintain *H.*

fossilis broodstock at low densities, ie. 100 fish in every 33 m² pond. ICAR-CIFA broodstock pellet feed is used (Rs 73/- / kg) @ 5% of body weight daily and 500 g boiled rice is used in addition to it for every 100 fishes.

To the four-day old growing *H. fossilis* larvae and onwards, some fish breeders prefer to provide cultured microworms as food. Plastic tiffin boxes are used as culture container and sliced bread (four sides/edges removed) used as culture medium base. A small amount of old microworm culture stock is used as inoculum over bread surface. A mixture of distilled water and yeast is spread over medium base until it gets fully wet. A box with drilled pores on the lid is kept closed and after four days, yellowish microworms 1mm in length are produced. Bread with inoculums may be soaked in beer. *Artemia* nauplii may also be provided to them in larval rearing chambers. In 20 litre drinking water containers, 200-220 g of salt is added to make up a 10-12ppt concentration and a small teaspoon full of *Artemia* cysts are added. Under sufficient aeration, freshly produced nauplii are washed thoroughly with freshwater for 2 minutes and subsequently fed to *H. fossilis* larvae. In the absence of diffuser-type oxygenation machines, artificial showers/water sprinklers must be installed over larval rearing chambers to aerate the water. Fry stage and above are not cannibalistic in nature. The first author may be contacted for dosage of induced breeding using commercially-prepared dry pituitary gland and for other details.

End note

The pond farming of *Heteropneustes fossilis, Puntius sarana, Labeo gonius, Cirrhinus reba, Anabas testudineus, Mystus vittatus, M. cavasius,* and *Ompak pabda* is not a usual practice in India, and these fishes are considered as new candidate species in freshwater pond aquaculture. Fry and advanced fry of major carps are sold at a price per kilogram, but those of non-conventional cultivable fishes, like medium carps, climbing perch, non air-breathing and air-breathing catfishes are sold at a price per piece. Progressive fish breeders are much more interested in production of the latter which is undoubtedly more profitable. Through application of induced breeding technique, better quality fish seed of selected species and varieties are produced in modern fish seed farms in West Bengal under controlled conditions in specific supply periods in commercial scale; these are made easily accessible to fish farmers in nearby and distant regions, even in Bihar and Jharkhand for grow-out culture. In rural aquaculture, following modified-extensive method of farming, 350-360kg of marketable-sized *H. fossilis* may be produced from every 1335 m^2 pond at the end of six months.

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Haul of pond reared H. fossilis in market.

Fishing gear and practices in flood waters of Assam

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Flooding is a common phenomenon for the people of Assam, a northeastern state of India. Annual flooding is mostly due to breaches of the embankments of the two major drainage systems of the state, the Brahmaputra and Barak rivers, along with their numerous tributaries. The situation is intensified by heavy rains during the south west monsoon, accounting for 1,100-11,000 mm rainfall per annum[1] in the hilly states surrounding Assam, resulting in a huge discharge of water into the Brahmaputra and Barak drainages. Altogether, the flood prone area in Assam is around 31,500 km^2 or nearly 40% of the total land area of the state and 9.4% of the total flood prone area of India[2]. The Brahmaputra and Barak river valleys in Assam also have the distinction of nurturing some of the finest floodplain wetlands of the country comprising 212,713 ha. The distribution of floodplain lakes (beels) in different parts of Assam is given in Table 1.

The floodplains are nutrient rich due to annual inundation and play a significant role in for four to five months where fish larvae, juveniles and adults are nourished in this activated habitat. Fish migrate back to the rivers or depressions at the end of the monsoon with the receding water[3,4,5]. Altogether, the river systems of the northeastern region and their adjacent floodplains are reported to harbour some 422 fish species belonging to 133 genera and 38 families[6], and make a substantial contribution to the fishery of the state and the livelihoods of fishers who have access to it.

Fishing remains a traditional activity with tremendous socio-economic impact in the rural sector and the flood waters impact the livelihoods of many people. In spite of the negative effects of flooding, local populations have become more resilient to flooding with time and adapted their livelihoods to take advantage of the available opportunities. The fisherfolk in particular share an intrinsic relationship with flood waters, employing a variety of traditional, non-traditional and professional fishing gears and methods to harness nature to its maximum. Non-professional, seasonal or casual fisherfolk near to the inundated catchments also put out their gear in anticipation of the arrival of the fish. Fishing therefore becomes an important economic activity for the people living adjacent to the rivers and floodplains[7,8] and this has led to the development of a diverse range of fishing gear and methods[9]. An attempt has been herewith to document some of the major

Operation of a cast net in flood waters.

A fish aggregating device (hukuma)

fishing gears and their method of operation during the flood season in Assam in with reference to their technique, efficiency, the targeted fish species and their probable impacts on human lives[10-12].

Pulling of water hyacinth: A primeval method of fishing without using an actual fishing device, locally known as meteka tana. The water hyacinth or meteka grows profusely in floodplain wetlands, swamps and other derelict water bodies of Brahmaputra valley. During the floods, air breathing fishes such as *Channa* spp., *Anabas testudineus, Clarias batrachus, Heteropneustes fossilis, Nandus nandus, Colisa* spp., *Monopterus cuchia*, and *Mastacembelus* spp., take shelter within the roots of water hyacinth. The plants are very carefully lifted by hand, brought ashore and fishes are separated from the roots. Women are mainly engaged in this method of harvesting fish during the day hours for a period of 3-4 hours.

Operating a khorahee.

Spearing: Spears are known by many names throughout the river stretches of Assam. Most of the spears in use have a single-pronged or multiple-pronged ends with pointed, barbed or barb less blades and are thrown by hand to wound the fish.

Kuchiahana is a sort of primitive hunting spear made of a smooth iron rod (1 m length) with one barb to ensure that fish will be held fast once the barbed point pierces the body. The tribal people of Assam use this gear to catch in particular *Monopterus cuchia* (freshwater eel), which thrives in soft muddy inundated areas of aquatic bodies. The spike is continuously pierced through the soft mud and once the fisher gets the catch, he can immediately feel the jerk exerted by the restless fish. The fishers generally gather a single

Lght fishing.

Table 1: Distribution of floodplain lakes (*beels*) in different parts of Assam

Region	No. of beels	Area (ha)	River valley/lakes
Central Assam	342	31,080	Brahmaputra valley
Lower Assam	352	29,000	Brahmaputra valley
Upper Assam	376	23,000	Brahmaputra valley
South Assam (bordering Bangladesh)	322	800	Barak valley

Source: Handbook of Fisheries and Aquaculture

Operation of scoop gear (jakoi) in inundated water bodies.

A bigger sized tubular trap (paori) in operation.

A drift long line (ponga boroxi).

eel or 2-3 catches in a day. These fishermen are mostly non-professional and were seen to operate this gear in flood waters to catch eels.

Kosh or *Jakhra*: This implement possesses 18-24 split bamboo splits prongs, each measuring around 37 cm in length. Some designs are provided with sharp iron barbs capping the prongs at the other end. The splits are firmly tied towards the butt end in one bunch and the prongs are arranged in a way so as to cause them to diverge from one another. This is a heavy weapon and requires considerable strength to hurl. It is generally thrown by a man standing at the prow of a boat, sometimes from the bank of a stream. The spear is operated in inundated waters to catch larger sized fishes such as *Sperata aor, Wallago attu, Labeo rohita,* or *Cirrhinus mrigala* etc.

Light fishing: A lit torch, prepared using dried jute stems or other cheap combustible material such as discarded cloth pieces tied to a stick at one end. In many places a kerosene lantern is also used. The torch is placed at the forehead of a boat and the peddler at the stern propels the boat slowly and quietly while his companion remains statuesque and immobile at the prow. The fisher either holds a long spear, a harpoon or a sickle in the right hand to launch at fish that are attracted to the light. Larger sized insectivorous fishes such a *Channa marulius, C. straitus, Sperata aor, Wallago attu* and *Clarias magur* are mostly caught. This fishing method is locally known as jorakata in Assam.

Angling by hook and line: These are the devices consisting of baited hooks attached to a line or lines, the principle of capture based on the feeding and hunting behaviour of the fish species. This gear is being operated by any age group of people and is taken more as a sport.

Hand lines: A line made of nylon of certain length with or without sinkers and with an iron hook. Hand lines may be as short as 0.5 m with baits such as flour balls, earthworms, insect larvae, and cooked rice. The baited hook is slowly played in marginal water. Small sized fishes such as *Puntius, Anabas, Channa* spp are caught.

Pole lines: Pole lines become a common sight during the floods. This gear consists of cotton or nylon made hand lines attached to a bamboo pole or poles and are operated in water with baited hooks. This is a simple fishing method with a rod of suitable length (2-10 m) and girth (2-3 cm) and a line of desired length as per the water depth. Floats attached to the line are made of a piece of lightwood, sandal or rubber and the sinkers are made of a piece of lead or iron. Live baits are usually given in the form of tadpoles, small frogs, earthworms and small sized *Channa punctatus*. Predatory fishes such as *Wallago attu, Mystus seenghala, Sperata aor, Channa marulius, C. straitus* are caught via this method.

Drift long lines: Long lines without a fixed attachment that are free to drift with the current or shallow bank tides. These are locally known as *nol boroxi* or *ponga boroxi*. This is a

Box shaped traps

single vertical line suspended from a short bamboo piece of 30-35 cm length or the stem of a water hyacinth as float. The line (s) carry a barbed hook and are operated by simply dropping it into the water waiting for the fish to bite. The length of the vertical line is dependent on the water depth. This device is most suitable for catching murrel (snakehead) in weed choked stagnant water bodies. Acceptable baits are earthworms, small fish, and eggs of bees and ants, and wheat balls.

Trapping: Traps are either temporarily or permanently fixed to the bottom and the principle of capture is based on leading the fish to enter, but making it difficult to exit through openings that are often defended with non-return valves or labyrinths. Traps vary widely in shape from conical, cylindrical to rectangular or box shaped. The framework is formed of fine screen-work made of slender slips or splints of bamboo, separated by narrow interspaces and bound together by strands of coir fibers, fine strips of cane and bamboo or plastic ropes.

Fish aggregating devices: These are artificial implements stuffed with bunches of twigs, bushes, and weeds etc which afford refuge for fish. Some of the fish aggregating devices regularly seen in the flood waters of Assam are the bamboo made *dolonga, derjakori* or *tak* or *hukum*. These devices vary in their shape viz., bowl shaped, pyramid shape or cone shaped. The devices are submerged in water keeping a bamboo pole or a banana trunk attached to the trap to mark its position over water. The device is typically around 1.0-1.5 m in height. The mouth is rigid with bamboo strips stitched along the perimeter. The device is lifted periodically to harvest the trapped fish.

Tubular shaped traps: These traps vary in shapes from spindle, cylindrical to bottle shape and are made of bamboo. The most commonly used traps are the spindle shaped Seppa. The trap has a girth maximum near to middle and tapering at both anterior and posterior ends. The trap is 20-86 cm in length and is provided with 1-4 trap doors located along the mid alignment of the base. Internal and external bamboo hoops maintain the rigidity of the receptacle. The trapped fish are removed from an opening at the posterior extremity. These traps are operated in inundated paddy fields and shallow water bodies during the monsoon season. Catch includes small size fishes such as *Mystus* spp., P*untius* spp., *Botia* spp., small prawns, *Colisa* spp., *Channa punctatus, Chanda* spp*.,* etc.

Paori is another category of trap operated during the flood season in Assam. It is one of the largest traps having a typical length of 1.2-2.5 m and a diameter of 47-94 cm. It is broader and circular towards the anterior end while tapering towards the opposite end. The splits are of 0.3-0.75 cm in thickness (0.6-1.5 cm circumference) and are tied firmly with one another with plastic ropes or cane cords, keeping a interstitial

A spear (jakhra).

space varying from 1.5-3.0 cm in between. Thick bamboo strips are stitched from both inner and outer sides of the body at certain intervals along its circumference to provide rigidity to the trap. The anterior end is concave and possesses a trap door for the entrance of fish. The trap is kept in water for a day or a week. The trap is operated either against the water current or along the current and grounded with a bamboo pole at its apex to avoid its drifting. The cost of the gear ranges from Rs. 100-1500 and the life span is 1-3 years. Large sized fishes weighing 1.5–15.0 kg comprise the major catch, which includes *Aorichthys aor, Chitala chitala, Channa marulius*. Tortoises can also become a catch in this trap. The trap is generally known as paori in Jorhat district, doo in Cachar district, *juti* in Karimganj district and sasha in Nagaon district of Assam.

Box shaped traps: These are box-shaped traps made of bamboo splits finely knitted with cane and bamboo strings. These traps are provided with a bamboo screen at the mouth to guide the fish into the trap door. Darki or bosna are some of these box shaped traps, typically with 1-2 trap doors placed just above the base along the periphery of the longer axis. The length of the trap varies from 63-150 cm, width 14.0-41.5 cm and height 28-74 cm. The trap door measures 4.5-25.0 cm in height, 3-18 cm in width and 8.5-17.0 cm in depth. The trap has an opening at the rear end of the apex or top for removing the trapped fishes. This trap is operated in either singlly or in series, provided with bamboo screens. Thicker bamboo strips are used both at the top and the bottom of the trap at an interval of 13-35 cm depending on the size of the box in order to provide rigidity.

Scooping: This category of gear is made of bamboo in which the capture of fish is affected by a bailing or dipping action, manually disturbing the bottom dwelling fishes and capturing them through a scooping motion. Scoop gears are versatile gears and are operated mostly by the womenfolk in all districts of Assam.

Jakoi: This is a bamboo made device with triangular outline. The body of the gear is made of bamboo matting which is supported with a rigid mouth made of a single piece of thick bamboo split. The thick bamboo split further extends beyond the apex to form a short handle. A string or rope is attached to two arms of the mouth near to its base. The operator places the gear with its mouth facing her and disturbs the bottom with their feet, so that in a quest to escape, the fish enter the trap. The gear is scooped continuously under water to make the catch. *Mystus* spp., *Macrognathus* spp., *Mastacembelus* spp. etc are the major fish catch with this gear.

Chalonee: This is a saucer shaped circular bamboo made sieve with a diameter of 0.8-1.2 m. The device is inserted below a patch of floating water hyacinth in weed infested water bodies such as *beels* and ponds. Fish taking shelter underneath and within the roots of the water hyacinths are shaken off the root tufts to fall onto the sieve. Murrels (snakeheads), perches and small sized eels are the major catch. The gear is operated in shallow inundated areas.

Khorahee or *paachi:* This device is similar to the above gear in the mode of operation, fishing season and the catch composition. However, these are bowl shaped (concave) baskets and thereby reduce the chances of fish escaping. A *paachi* is a bigger basket than khorahee and can lift heavier load of floating weeds and have higher longevity.

Push nets: Push nets are triangularly-framed gears and are operated by one person and capture is affected by a forward, horizontal pushing motion along the bottom of shallow waters by hand while wading or from boats by handle. Push nets are locally known as *ghoka* and *pah jal* in Kamrup district, *thela jal* and *faloin jal* in Dhubri. The triangular frame consists

A seine net (ber jal).


A hand lift net operated by women.


A double stick seine net (tana jal).


Large sized traps operated in flood waters of Assam.


A tribesman with kuchia hana.


A hand operated lift net.

of three bamboo poles. Two poles intersect each other and the third forms the base. Either of the arms in the frame is of equal length or one longer than the other. The net is operated along the riverbanks and water logged areas during the receding flood water to catch mostly small sized fishes, prawns and fingerlings. *Ghoka jal* or *pah jal* or *thela jal* is made of polyamide 210/1/3 with a mesh size of 7-35 mm. The net usually consists of nine selvedge (210/4/3) at its lower periphery. The width of the mouth is 2.65 m. The hanging height of the net from the intersecting point of the poles is 1.5 m. The cost of the gear is around Rs. 600 and has a life span of 4-5 years. Unlike *ghoka jal*, the webbing of this gear is made of fine mesh polyethylene mosquito net. The overall length of the gear varies from 1.3-1.5 m and the width at the base is 1.3 m. The major catch includes *Chanda* spp., *Mystus* spp., small fish and prawns.


A chalonee.

Seining: Nets shot in such a position so as to enclose a definite body of water containing fish and then hauled toward the shore or to a vessel.

Double stick seining nets: This gear is operated in shallow water bodies, paddy fields, *beels* and other derelict water bodies impounded with water during flood. The gear is rectangular in shape with two bamboo poles fixed to its shorter sides. The webbing of the net is made of a material used in mosquito nets measuring 3.5-4.0 m length and 2 m in depth with a mesh size of approximately 1 mm. Two fishers (mostly women) operate the net by holding the bamboo vertically. The net is dragged for a distance into the water to encircle a certain area and the fish inside are caught. The catch is usually comprised of small sized fishes such as *Puntius* spp., *Colisa fasciatus, Mystus* spp. etc. The net is locally known as *tana jal* or *muglai jal* in different districts of Assam.


Gill nets for operation in Brahmaputra valley.

Ber jal or *maha jal:* This is one of the biggest nets used in Assam. This net is rectangular in shape and is composed of a number of pieces with different mesh sizes and joined together to form a single big wall net, as long as 200-450 m. The width of the net is adjusted according to the depth of the water to be netted, ranging from 6.8-18 m. The webbing material is made of polyamide. The head rope is 0.6-1.0 cm thick and is made of HDPE. The head rope may be single or double. Floats are made of plastic cans, pieces of wood or bamboo and are attached to the head rope by polyamide or polyethylene twines at regular intervals. The foot rope is 18-35 mm thick and is made of jute. The net is attached to the foot rope with a 1.5-12 mm thick polyethylene rope. The foot rope is either provided with sinkers made of burnt clay (28 x 18 x 0.5 mm) or iron (58 x 30 x 10 mm) or devoid of sinkers in thicker foot ropes. The net is operated in fast flowing areas of rivers and beels during rainy season with a peak from April-June. Depending upon size, the net is operated with 1-2 boats and 8-20 persons operated both during day and night. The catch of the gear comprised of *Catla catla, Labeo gonius, Labeo rohita, Wallago attu, Catla catla, Cirrhinus mrigala, Sperata aor, Chitala chitala, Rita rita, Bagarius bagarius* and other such large sized fishes. The cost of the gear ranges from Rs 40,000 to Rs. 100,000. The life span of the gear is 2-5 years.


A berjal of the Brahmaputra valley.

Lifting net: Lift nets are sheet of net, usually square but may sometime conical stretched by several rods, ropes, or a frame, set either at the bottom or in mid water for some time and then lifted to trap the fish swimming above it.

Lift net (dheki jal) in operation.

Pole and line.

A Fixed lift net (porongi jal).

V shaped lift net (dheki jal).

Porongi jal: This lift net is a common sight in Assam and is locally known as *porongi jal* or *dharma jal* and are made of two split bamboos crossing each other and fixed in the form of an arch. To this frame is attached the square shaped net which has an uneven mesh size ranging from 15-60 mm. The intersecting point of the cross bars or splits are fastened to a handle made of a whole bamboo piece of desirable length. The cross bars are approximately 2.4 m in length. The web material of the net is made of polyamide 210/1/3. The net is operated by hand or ground to shore. The net is frequently dipped in water and lifted to get the catch. A single person can operate the net. Women take part in fishing during floods with this gear, which is used throughout the year. Small fish are its usual catch such as *Danio* spp., *Puntius* spp., *Rasbora* spp., *Clupisoma garua, Eutropiichthys vacha, Gudusia chapra, Setipinna phasa* etc.

Dheki jal: This net is a lift net consisting of a 'V' shaped frame to which the webbing is attached. The frame is constructed by securing bamboo poles at an angle between 45-90°; the two arms of the 'V' forming the sides (13-15 m in length) of the mouth and the side opposite the angle being the base. The width of the mouth is 15-16 m. The webbing is divided into different mesh sizes from 18-60 mm. This gear is locally known as *dheki jal, jata jal, khora jal* and *ghat jal* in different parts of state Assam. The net is fixed on a bamboo platform down the riverbank and is operated against the water current throughout the day and night. The net is installed in such a manner that its base comes out of water for 1-1.5 m in height when weight is applied on its angle during lifting. The net is mostly operated in rivulets, channels and beels during the flood season when the water is advancing or receding. At certain places, split bamboo or tree branches are installed as barriers in front of the net in 'V' shape to direct the fish into the net. This net is non selective in its catch ranging from the Indian major carps, minor carps, *Wallago attu,* clupeids etc.

Plunging baskets: The principle is to catch the fish by dropping gear down from above. These are bell-shaped entrapping devices with an opening both at the base and the apex. The gear is locally known as *polo* and is made of finely woven bamboo strips. The strips are 0.5 cm thick and are stitched at a spacing of 0.5-1.5 cm and 5-12 cm within vertical and horizontal strips respectively. The height of the gear varies from 47-155 cm with a diameter of 57-125 cm at the base and 15-25 cm at the apex. The gear is operated in *beels,* shallow water bodies, inundated paddy fields, etc. The fisher carries the trap in hand, slowly wades and plunges it into the water in a probable place. The fisher firmly presses the pot, insert one hand through the top or apex and takes out any fishes caught inside. Very small sized fishes like minnows and barbs and medium sized fishes are caught in this gear. In certain locations, feed such as rice bran, flour is applied over a small canopy in shallow water areas to attract fishes before operating the gear. Cost of the gear ranges from Rs. 80.00-400 and the life span of the gear depends on its usage.

Cast nets: These cast nets are conical in outline and their lower edges are folded or turned up inwardly and stitched to the webbings at regular intervals to form peripheral pockets.

Pulling water hyacinth (meteka tana).

Traps operated in flood waters of Assam.

The nets are heavily weighted around the base by fixing iron weights to the free edges of the pockets and each is provided with a retrieving line attached to the apical portion. As soon as the net is thrown, it is pulled down by the marginal weights. The disturbed fishes enter the pockets and are hauled. Based on the mesh number and net size the cast net is known by various local names viz., *khewali jal, asra jal, rekh jal, pachon jal, afolia jal, jhaki jal, athar jal* and *angtha jal.* The principle catch includes *Labeo bata, Cirrhinus reba, Labeo gonius, Tor* spp., *Sperata aor, Channa marulius, Channa striatus, Chitala chitala, Labeo rohita, Labeo calbasu, Cirrhinus mrigala, Bagarius bagarius* etc.

Gill nets: These are rectangular shaped nets employed as walls in which the capture of fish is affected by actual gilling in the meshes of the net. The meshes of the nets vary with the types and size of fish to be caught. To the head ropes are attached floats while the ground ropes may or may not have any sinkers fastened to them. The floats and sinkers are so adjusted that the nets can remain in vertical position at any desired depth. Gill nets may be set gill nets or drift gill nets based on the mode of operation. The set gill nets are locally known as fasi jal, langi jal and current jal and are used throughout the year and the catch is miscellaneous. Some of the drift gill nets are locally known as *current jal, gosaila jal, bagar jal, bhasan jal, bagh jal, fesi jal* and *sessa jal.*

Conclusion

Fishing areas in the state Assam are mostly river basins, often associated with extensive areas of floodplains and their connecting channels and an array of smaller streams, irrigation and drainage canals and a variety of seasonal or permanent small water bodies. Floodplain wetlands constitute a very significant resource of Assam and are considered as one of the highly productive ecosystems in terms of biomass and fisheries production potential[13]. Food and nutritional security is the primary concern of fishers, since large proportions of their efforts are invested in fetching them. Fishing activities are more prominent for a considerable part of the year, in the water bodies flooded during monsoon season and fishers operate alternate gears of fishing. It was observed that the advent of new fabrication materials has led to rise of many efficient fishing techniques and the ones that were efficient in the past have become non-remunerative and unattractive, and hence they are naturally being phased out[14]. Bamboo made fishing implements and traps are widely being operated in Assam due to low cost and readily availability of materials[15]. Fishing in the flood waters as a whole is a disarranged sector and therefore the livelihoods systems of fishers associated with floodwater are complex, diverse and intricately associated with many issues outside the fisheries management systems.

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Tubular shaped traps (Seppa) in operation.

Fisherwomen empowerment: Shedding light on the invisible gender

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Womens engagement in fisheries can be viewed from social, political and technical perspectives, all of which show that the role of women is often underestimated. This inadequate recognition of women's contributions hampers the sustainable development process, resulting in increased poverty and food insecurity. According to The State of World Fisheries and Aquaculture published in 2018 by FAO:

"in the period 2005–2016, the quality and frequency of reporting on engagement by gender improved slowly. Official statistics indicate that 59.6 million people were engaged in the primary sector of capture fisheries and aquaculture in 2016 – 19.3 million in aquaculture and 40.3 million in capture fisheries. It is estimated that nearly 14 percent of these workers were women. About 25% of the labour force in pre-harvest activities, 60% in export marketing and 40% in internal marketing are done by women. About 0.5 million women are employed in the pre and post harvest operations in marine fisheries sector, out of the total 12 million workforce. A recent publication estimates that, globally, when primary and secondary fisheries sector engagements are combined, women make up half of the workforce. As reporting improves and policies directed at increasing women's decision-making capacities in the sector develop, it is expected that both reporting and actual engagement of women in the sector will increase."

FAO estimates that, overall, fisheries and aquaculture assure the livelihoods of 10–12 percent of the world's population (FAO, 2018). In most regions, the large boats used to fish offshore and deep-sea waters have male crews, while women manage smaller boats and canoes in coastal or inland water – harvesting bivalves, molluscs and pearls, collecting seaweed and setting nets or traps. Mostly women are well recognised in areas such as financial management, processing, record keeping and trading.

Women - a mirror for rural development and government policies

Rural development in a democratic society cannot be achieved by plans and statistics, technology and methods, target and budgets, agencies, organisations and professional staff to be employed. Rather it needs an effective

Table 1: Direct contribution of fisherwomen in the marine sector

Category	Total No. of workers	No. of women workers	Percentage
Beach workers	20,843	5,612	26.92
Small scale fish traders	67,527	20,220	29.94
Fish curers	21,103	14,028	66.47
Peeling workers	43,620	39,397	90.31
Processing plant workers	11,051	6,504	58.85
Total	**161,144**	**85,761**	**53.22**

(Source: Velayutham, 1999)

use people in such a way that help them to attain economic and social improvement. The success of rural development programmes will make a breakthrough when women are faithfully trained in the field of their interest. Under the village development programme, the Mahila Matsya Utpadak Mandal is to be established, which will help in providing direction in antipoverty programmes. Rural women are not to be educated by teaching only, but also through exchange of ideas, facts, feeling or impressions in ways that each of them gains knowledge and techniques for self-employment. In situ conservation of fish genetic resources and their habitat restoration can be strengthened by training of rural women on supply of fresh fish feed, trash fish collection and supply, net weaving and mending, making of fish traps making fish toxicants and through establishment of Mahila Matsya Utpadak Mandal. The economic status of women is widely accepted as an indicator for assessing the exact stage of development of societies. Although the involvement of women is limited in capture fisheries, their supportive role in active fishing has increased manifold with the advent of mechanisation and enhancement of multi-day fishing in marine fisheries. The occupational pattern of women has further undergone a structural change with the shift from net mending to fish marketing and processing. The irregularities in the earning patterns of their male counterparts, coupled with the needs for livelihood sustainability, force most of the women to earn from a variety of fishery related activities. The diversity of women's role in the fisheries sector includes "apart from the activities as wife, mother and homemaker, fisherwomen market fish as retailers, auctioneers or as agents of merchants; make and repair nets; collect prawn seed or seed from backwaters to supply fish farmers; work as laborers for shrimp processing firms; dry and salt fish; and prepare a variety of fish products".

Diversity of women's involvement in fisheries sector

Fish and fish products are an integral part of many cultures and an important economic enterprise and women are active in both artisanal and commercial fisheries. In such a wide range of activities women are important contributors to both national and household food security.

In the fisheries sector, participation by women may only become visible after landing of the catch. This may be a tradition evolved around the need for rest and relief for the men folk after long spell of hard toil in the water. Until a decade back, fish retailing has mainly been the domain of women all over the country, both in the inland and marine sector. In the coastal belts, after the fish haul, women lend a big hand in sorting, grading and processing the catch, and constitute a substantial work force in export-oriented marine products processing units. Women are also involved in processing of aquatic proceeds, such as the high value aquatic nut "makhana" grown in swampy ponds of north Bihar and are conspicuous by their total non-involvement in fish farming and rearing activities. With no involvement in other

cultivation input or farming husbandry, there is now growing awareness about the need for women's involvement in other input components including water quality monitoring, seed release and harvesting. Between lab and field a composite package of technology has not gone home to fish pond farmers in the rural sector, expect in some pockets. These additional components of fish farming can very conservatively augment fish production from rural ponds considerably, thereby boosting the rural economy in a sustainable manner. Some areas of aquaculture where women can play effective and more prominent role, and some of the current gender issues, are highlighted below.

Aquaculture in ponds integrated with livestock and agriculture

Women can undertake indoor jobs like milking, feeding, cleaning etc. with management of male animals and fodder production. In many cooperative societies, the membership is in the name of men and women cannot be paid although the milk is delivered by women. Appropriate technologies for farmwomen in livestock production include milk production technologies such as crossbreeding and improvement of breeds, urea treatment of straws, animal care and management technologies, reproduction technologies such as health and fodder production, milk processing and marketing of milk products, integration of milking production and production system, goat and wool production technologies, poultry and rabbit production technologies. For ponds within their management reach, rural women can participate in upkeep of animals being reared on the embankment or plants under cultivation, also lending hand to aspect of the pond fish culture integrated with livestock rearing and horticulture cultivation on bank of the ponds.

Fresh water pearl culture

Freshwater pearl culture is a diversified activity in aquatic farming systems. It is a nascent technology developed at Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar. The three identified pearl mussel species are *Lamellides marginalis, L. corrianus* and *Parreysia corrungta.* Through three types of surgical procedures, different varieties of pearl are cultured. Presently, the technology has attracted several rural, artisanal and enterprising communities including women. The production of pearls from freshwater mussels has been picked up by women in some parts of the country; mussels are currently mainly collected from shallow ponds for meat and also for lime production from the shell. Selected groups of women can be taught the art of pearl culture for an alternative source of income.

Backyard ornamental fish culture

The backyard small-scale culture of ornamental fish is relatively stable and claimed to be a lucrative business by women in remote villages, generally willing to adopt innovations to improve their economic situation. Ornamental fish culture has been ventured as an option among landless rural women for supplementary income. Women are providing with livebearing fishes such as guppies, platies, mollies and swordtails. Rural landless women can earn an average of Rs. 300-500 per month as an additional supplementary income. A local women fish grower's self-help group has been formed to manage the feed, the marketing issues in order to attain economies of scale.

Integrated aqua farming

This is vast scope for improving inland fish production through modern aquaculture techniques. The availability of seed and feed become a major constraint in spreading aquaculture techniques. Women entrepreneurs can play an important role and can be trained in induced breeding techniques and

in fish seed production. Appropriate production models for freshwater prawn culture that are environmentally sound have been demonstrated to women self-help groups though participatory approaches. Women from hilly areas from the villages of Kangra District in Himanchal Pradesh were trained in complete package of farming techniques including soil testing, procurement of grass carp and silver carp fry and their rearing up to fingerling stage, and benefited in sustained income generating activities.

Community pond aquaculture

In coastal areas there are a large number of small and backyard ponds being used for bathing, washing and also as dumping grounds, creating environmental problems. Recognising that women could be employed in making use of such neglected water bodies for raising short term crops of fish fry, fingerlings and even table sized fish at very low operational costs, there are plans to demonstrate the feasibility and the range of benefits in term of economic gains, labour efficiency, self-employment opportunities and multiple choice of vocations that aquaculture could offer to rural women. Thus the intensification of activities in and around the ponds can help in building sustainable livelihood opportunities for rural poor women.

Freshwater prawn culture *(Macrobrachium rosenbergii)*

The programme follows the principles of low external input sustainable aquaculture (LEISA). The freshwater prawn, *Macrobranchium rosenbergii*, commonly called as 'scampi', is one the major candidate species for freshwater aquaculture. Despite the decline in capture, there is an upsurge of economic interest in increasing production through freshwater prawn culture.

Paddy-cum-fish culture

Paddy-cum-fish culture is a co-activity of agriculture, in which the drained out water from the paddy farming is prudentially utilised for fish farming. Women play a major role in agriculture, particularly in paddy cultivation operations such as transplanting, weeding and harvesting. The introduction of the fish culture in paddy cultivation can enhance the labour absorption potential of women, during post-harvesting and marketing.

Technology intervention in seed collection

In West Bengal, seed collection from nature is an activity that provides self-employment to large number of men and women. The Konkan coast is rich in seed availability of number of commercially important species. Women can be trained in seed collection of mullets, mainly *Liza parsia*. The supply of trash fish for culture of *jitada* or Asian seabass, *Lates calcarifer*, and crabs are other areas that could engage them profitably. It is therefore proposed to establish backyard hatcheries that could be a source of income for the family. It would be possible for women to attend the rearing of the larval stage along with their household responsibilities.

Fattening of crabs, mussels and oyster culture

Crabs *(Portunus pelagicus* and *P. sanguinolentus)* are high value resources abundant in region. Small crabs fetch only Rs. 5/- each but larger ones can be worth as much as Rs. 200/-. The time taken to fatten them is about three months. The technology of mussel and oyster culture is now available and to begin with would be portaged at selected sites through group management and women' cooperative. Where possible, mussels and oysters could also be cultured in shrimp ponds where they would act bio-filters and reducing the level of suspended solids. This would also lead to enhanced income.

Post-harvest processing and value addition

Opportunities already exist and are being exploited in fish processing industries, which are mainly located in cities like Mumbai or Ratnagiri. Most of the women employed in these plants are from outside the state. Marketing of fish and shellfish is almost the sole province of women in the Konkan region. The entire processing sector is highly dependent on women, who represent more than 90 percent of workforce in prawn peeling and 70 percent in the processing of other fisheries products. While 65% of the landings are sold fresh by women, certain species of fish and surplus catches are dried or salted.

Credit option and micro planning

Involving womenfolk in aquaculture programmes is beset with problems. The prominent among them include credit facilities to be made available to rural womenfolk through and innovative procedures so that funding reaches in the hands of the poorest of the poor. In India, certain success stories of micro credit though self-help groups report from the state of Tamil Nadu in India, where there are numerous examples of women successfully adopting micro credit in various aquaculture activities. The rural poor have two assets - time and labour. It is hoped that adding value to these assets would leads to livelihood security. The M.S. Swaminathan Research Foundation has played a catalytic role in promoting job-led sustainable economic growth in rural areas and particularly in agriculture sectors through the Eco-aquaculture Programme. The women's eco-aquaculture movement is based on a self-replicating social mobilisation process that aims to strengthening the role of women in aquaculture.

Training, demonstration and technology transfer

In rural areas fish culture and fish seed production generate self-employment, wealth and protein rich food. Aquaculture programmes are gaining popularity with farmers in areas where lands are water logged. Farmers, through soil and water level management, divide farms between paddy and fish culture. On embankments they may grow vegetable such as ladies fingers, tomatoes, pulses and fruit plants like coconut, papaya and banana.

Shrimp farming

Shrimp farming creates value added employment opportunities. Women are involved in the collection of juveniles through simple hand picking techniques in estuaries and backwaters during high tide. They transport the juveniles from the natural water bodies to nearby private farms in polythene bags.

Fish/prawn feed manufacture

Preparation and production of balanced fish feed utilising locally available raw materials, organic wastes and other non-conventional resources of villages is a technology that could be transferred to poor rural women.

Women in marketing and distribution

Traditionally, large numbers of women are involved in fish marketing in all the maritime states of India, mainly engaged as retailers, selling fresh and dried fish and other fishery items. The catch brought by menfolk is sold by the women in wholesale at the landing centre itself or in wholesale markets. Some of the women also buy fish from auctioneers in large quantities, pack them and send it to other places.

Conclusion

Fisheries is a key sector of the Indian economy witnessing progressive and drastic changes over the years both in production and marketing. The ever increasing domestic and export demand for fish and fisheries products has not only enhanced earnings but also triggered an increase in employment opportunities in primary, secondary and tertiary sectors. Aquaculture is emerging as a multi-billion industry having enormous scope for further expansion. Women are involved more in aquaculture production than in capture fisheries. Increasing entrepreneurial activities in the post-harvest segment of fisheries is also skewed towards women in providing more employment opportunities. Due to the emergence of nuclear families with increased cost of living, women are increasingly taking up small business and trade to supplement their income and standard of living.

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Integrated multi-trophic aquaculture systems: A solution for sustainability

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Marine aquaculture is increasingly seen as an alternative to fishing to provide a growing human population with high-quality protein. Capture fisheries output is falling short of world demand, and annual consumption of seafood has been rising and doubled over the last three decades (FAO, 2000). Aquaculture production has surpassed supplies from capture fisheries and contributed around 51% to global fish production in 2014. Over the past three decades aquaculture production increased from 6.2 million tonnes in 1983 to 73.8 million tonnes in 2014 (FAO, 2016). This achievement was possible mainly because of the commercialisation of farm produced aquatic animals such as shrimp, salmon, bivalves, tilapia and catfish. With the diminishing availability of freshwater, the expected growth of aquaculture may increasingly take place in the marine environment. The rapid growth of the aquaculture industry has already led to growing concerns over environmental impacts and conflicts with other coastal usage in Europe, North America, Australia, and Asia.

Marine aquaculture of high value species (e.g. fish in cages) is reliant on external food supplies and has a negative impact on water quality. Marine aquaculture generates high organic and nutrient loadings, mainly from feed wastage, fish excretion and faecal production. Feed wastage may range from 1 to 38%, depending on the feed type, feed practices, culture method and species and constitutes one of the most important pollution sources (Ackefors and Enell, 1990; Seymour and Bergheim, 1991). It is noteworthy that feed wastage is much higher in open-sea cage culture systems where trash fish is used as feed. Deposition of organic waste was estimated at 3 kg per m² per year in the vicinity of a farm and 10 kg per m^2 per year or 1.8-31.3 kg C per m^2 per year underneath (Gowen and Bradbury, 1987).

Nutrient loading due to fish farming can be considerable (Wang et al. 2012) and can negatively impact the benthic environment due to smothering and increased organic enrichment, leading to alterations in sediment chemistry with knock-on effects on benthic biodiversity. Many attempts to reduce nutrient loading surrounding fish farms have been made by improving the digestibility of fish feeds, computerised feed-management systems and such. however, such technological improvements have not yet eliminated the problem of nutrient pollution associated with fish farming (Wang et al. 2012). One solution to reducing the environmental impact of fish farming is the use of integrated multi-trophic aquaculture (IMTA).

Integrated multi-trophic aquaculture

Integrated multi-trophic aquaculture borrows a concept from nature; namely, that in the food chain, one species always finds a feeding niche in the waste generated by another species. IMTA is a practice in which the by-products (wastes) from one species are recycled to become inputs (fertilisers, food and energy) for another. IMTA can be used to potentially recycle these nutrients by cultivating additional commercially relevant organisms. These 'extractive species' are able to intercept and assimilate aquaculture-derived waste (both organic and inorganic) when cultivated alongside fed fish species (Chopin et al. 2001; Neori et al. 2004; Troell et al. 2003).

Fed aquaculture species (e.g. finfish/shrimps) are combined, in the appropriate proportions, with organic extractive aquaculture species (e.g. suspension feeders/deposit feeders/herbivorous fish) and inorganic extractive aquaculture species (e.g. seaweeds), for a balanced ecosystem management approach that takes into consideration site specificity, operational limits, and food safety guidelines and regulations. The integrated in IMTA refers to the more intensive cultivation of the different species in proximity of each other (but not necessarily right at the same location), connected by nutrient and energy transfer through water. The aim is to increase long-term sustainability and profitability per cultivation unit (not per species in isolation as is done in monoculture), as the wastes of one crop (fed animals) are converted into fertiliser, food and energy for the other crops (extractive plants and animals), which can in turn be sold on the market. The goals are to achieve environmental sustainability through biomitigation, economic stability through product diversification and risk reduction, and social acceptability through better management practices. The major aim is to increase long-term sustainability and profitability per cultivation unit.

Selection of species

Environmental sustainability is the major consideration in IMTA, therefore the criteria guiding species selection include understanding the limitations of the natural ecosystem. When establishing which species to use in an IMTA system, one must carefully consider the suitability of the species in a particular habitat/culture unit. In order to ensure successful growth and economic value, farmers should understand its compatibility and future impact on the ecosystem.

Fed organisms, such as carnivorous fish and shrimp are nourished by feed, comprising of pellets or trash fish. Extractive organisms extract their nourishment from the environment. The two economically important cultured groups that fall into this category are bivalves and seaweed. Combinations of co-cultured species will have to be carefully selected according to a number of conditions and criteria:

1. Complementary roles with other species in the system: Use species that will complement each other on different trophic levels. For example, species must be able to feed on the waste products of others in order for the newly integrated species to improve the quality of the water and grow efficiently. Not all species can be grown together efficiently.

2. Adaptability in relation to the habitat: Native species that are well within their normal geographic range and for which technology is available can be used. This will help to prevent the risk of invasive species causing harm to the

local environment, and potentially harming other economic activities. Native species have also evolved to be well adapted to the local conditions.

3. Culture technologies and site environmental conditions: Particulate organic matter and dissolved inorganic nutrients should be both considered, as well as the size range of particles, when selecting a farm site.

4. Ability to provide both efficient and continuous bio-mitigation: Use species that are capable of growing to a significant biomass. This feature is important if the organisms are to act as a bio-filter that captures many of the excess nutrients and that can be harvested from the water. The other alternative is to have a species with a very high value, in which case lesser volumes can be grown. However, with the latter, the bio-mitigating role is reduced.

5. Market demand for the species and pricing as raw material or for their derived products: Use species that have an established or perceived market value. Farmers must be able to sell the alternative species in order to increase their economic input. Therefore, they should establish buyers in markets before investing too heavily.

6. Commercialisation potential: Use species for which regulators and policy makers will facilitate the exploration of new markets, and not impose new regulatory impediments to commercialisation.

7. Contribution to improved environmental performance.

8. Compatibility with a variety of social and political issues.

IMTA system design

An effective IMTA operation requires the selection, arrangement and placement of various components or species, so as to capture both particulate and dissolved waste materials generated by fish farms. The selected species and system design should be engineered to optimise the recapture of waste products. As larger organic particles such as uneaten feed and faeces settle below the cage system they are eaten by deposit feeders such as sea cucumbers and sea urchins. At the same time, the fine suspended particles are filtered out of the water column by filter-feeding animals such as mussels, oysters and scallops. The seaweeds are placed a little farther away from the site in the direction of water flow so they can remove some of the inorganic dissolved nutrients from the water, like nitrogen and phosphorus. IMTA species should be economically viable as aquaculture products, and cultured at densities that optimise the uptake and use of waste material throughout the production cycle. The IMTA concept is very flexible. IMTA systems can be land-based or open-water systems, marine or freshwater systems, and may comprise several species combinations (Neori et al., 2004). Some IMTA systems have included such combinations as shellfish/shrimp, fish/seaweed/shellfish, fish/shrimp and seaweed/shrimp (Troell et al., 2003).

Integrated multi-trophic aquaculture and trophic levels in aquaculture

The use of filter-feeding organisms as nutrient extractors (inorganic and organic) has proven to be a valid alternative for nutrient bioremediation. The most frequently tested organisms are molluscs, which filter organic particles and phytoplankton, and macroalgae, which have the capability of inorganic nutrient uptake (Marinho-Soriano et al. 2011).

Integrated multi-trophic aquaculture has been proposed to achieve environmental sustainability through biomitigation of aquaculture wastes that, as compared to other accompanying methods, has advantages that may include practices (Troell et al. 2009; Barrington et al. 2009). Furthermore, IMTA is the only practical remediation approach with a prospect for additional farm revenues by adding commercial crops, while all other biomitigation approaches have generally involved only additional costs to the producer (Troell et al. 2009).

One of the differences of IMTA from the traditional practice of aquatic polyculture is the incorporation of species from different trophic or nutritional levels in the same system. In traditional polyculture, organisms may all share the same biological and chemical processes, with few synergistic benefits; they may, in fact, incorporate a greater diversity, occupying several niches, as extensive cultures (low intensity, low management) within the same pond.

In the last fifteen years, the integration of seaweed with marine fish culturing has been examined and studied in Canada, Japan, Chile, New Zealand, Scotland and the USA. The integration of mussels and oysters as biofilters in fish farming has also been studied in a number of countries and significant benefits observed.

Seaweeds

The ability of macroalgae to respond to availability of anthropogenic nutrient (nitrogen and phosphorus) input makes them an efficient instrument for bioremediation. Biofiltration by plants, such as algae, is assimilative, and therefore adds to the assimilative capacity of the environment for nutrients. With heavy growth of mariculture activities along the Indian coast, integrated multitrophic approaches primarily focused on algae are becoming of increasing importance along the coast. Commercially viable and economically important seaweed species such as *Kappaphycus alvarzii, Gracilaria dura,* and *G. edulis* can be cultivated with fishes like cobia, Indian pompano, grouper, seabass and also with lobsters. Seaweeds will act as biofilters in the present IMTA system. The red algae *Gracilaria* spp. and the green algae *Ulva* spp. have also been found to be efficient biofilters. *Gracilaria* spp. have been examined for their usefulness in laboratory studies. An efficient algal-based integrated mariculture farm maintains optimal standing stocks of all the cultured organisms, considering the respective requirements of each for water and nutrients and the respective rates of excretion and uptake of the important solutes by each of them. This allows the profitable use of each of the culture modules with minimum waste in the environment.

Open-sea IMTA in India is very recent; however, various investigations have been carried out on the beneficial polyculture of the various mariculture species. Combined culture of compatible species of prawns and fishes is of considerable importance in the context of augmenting yield from the field and effective utilisation of the available ecological niches of the pond system. Finfish culture, *Etroplus suratensis,* in cages erected within the bivalve farms (racks) resulted in high survival rates and growth of the finfish in the cages.

Co-cultivation of *Gracilaria* sp. at different stocking densities with *Feneropenaeus indicus* showed nutrient removal from shrimp culture waste by the seaweed. A ratio of 3:1 was found suitable for the co-cultivation, with 600g of seaweed able to reduce 25% of ammonia, 22% of nitrate and 14% of phosphate from 200 g of shrimp waste. Polyculture of shrimp with molluscs helps in breaking down organic matter efficiently and serves as an important food source for a range of organisms and also either directly or indirectly provides shelter or creates space for associated organisms, thus increasing the species diversity of the ecosystem. Studies have shown that an individual mussel can filter between 2-5 l/h and a rope of mussels more than 90,000 l/day. The culture of mussels could thus be used in the effective removal of phytoplankton and detritus as well as to reduce the eutrophication caused by aquaculture. Along the east coast of India, the introduction of IMTA in open sea cage farming yielded 50% higher production of seaweed, *Kappaphycus alvarezii,* when integrated with finfish farming of cobia *Rachycentron canadum*.

Invertebrates

The reduction of suspended solids and microbial pollution within aquaculture can be achieved by the use of living organisms. Literature also reveals the potential capability of some invertebrates to remediate heavy metals, microbial contaminants, hydrocarbons, nutrients and persistent organic pollutants (Khoi & Fotedar 2012; Stabili et al. 2006). Filter-feeding marine macroinvertebrates filter large volumes of water for their food requirements and exert high efficiency in retaining small particles including bacteria (Stabili et al. 2010). Detritus feeder species have also been proposed as a means for recycling the particulate organic and inorganic nutrient wastes from fish cage farming (Lander et al. 2013).

In a conceptual open-water integrated culture system, filter-feeding bivalves are cultured adjacent to meshed fish cages, reducing nutrient loadings by filtering and assimilating particulate wastes (fish feed and faeces) as well as phytoplankton production stimulated by introduced dissolved nutrient wastes. Waste nutrients, rather than being lost to the local environment, as in traditional monoculture, are removed upon harvest of the cultured bivalves. With an enhanced food supply within a fish farm, there is also potential for enhancing bivalve growth and production beyond that normally expected in local waters. Therefore, integrated culture has the potential to increase the efficiency and productivity of a fish farm while reducing waste loadings and environmental impacts.

A native bivalve species must be consider to suit the local ecology, potential markets, and the need to engineer IMTA systems to accommodate them. Literature shows that 95% of particles released from aquaculture systems, fish farms, and closed recirculation systems are ~20 microns diameter (5-200 micron range), and that they will settle. There is evidence that filter-feeders are selective in extracting particles from the water column, rejecting the rest. Thus, it is important to know the particle size of wastes from an IMTA system and to choose from among the wide range of bivalves that will select the required particle size and type.

The green mussel, *Perna viridis* and oyster *Crassostrea madrasensis* that are commercially produced along Indian coast, can economically mitigate eutrophication in integrated aquaculture. Open-sea mariculture of finfishes, when integrated with raft culture of green mussels, resulted in slight, but not significant reduction in nutrients along Karnataka.

The beneficial effect of combining bivalves such as mussels, oyster and clams as bio-filters in utilising such nutrient rich aquaculture effluents has been documented in estuaries. In a tropical integrated aquaculture system, the farming of bivalves *(Crassostrea madrasensis)* along with finfish *(Etroplus suratensis)* resulted in controlling eutrophication effectively (Viji et al, 2013, 2015). The filter feeding oysters improved the clarity of the water in the farming area; thereby reducing eutrophication. The optimal co-cultivation proportion of fish to oysters reported was 1 : 0.5 in this farming system.

Benefits of IMTA

The benefits of IMTA include:

- Effluent bio-mitigation: Mitigation of effluents through the use of bio-filters which are suited to the ecological niche of the aquaculture site. This can solve a number of the environmental challenges posed by monoculture aquaculture.

- Increased profits through diversification: Increased overall economic value of an operation from the commercial by-products that are cultivated and sold. The complexity of any bio-filtration comes at a significant financial cost. To make environmentally friendly aquaculture competitive, it is necessary to generate revenue from the activity. By exploiting the extractive capacities of co-cultured lower trophic level taxa, the farm can obtain added products that can outweigh the added costs involved in constructing and operating an IMTA farm. The waste nutrients are considered a resource in integrated aquaculture not a burden, for the auxiliary culture of bio-filters.

- Improving local economy: Economic growth through employment (both direct and indirect) and product processing and distribution.

- Form of ‘natural’ crop insurance: Product diversification may offer financial protection and decrease economic risks when price fluctuations occur, or if one of the crops is lost to disease or inclement weather.

- Disease control: Prevention or reduction of disease among farmed fish can be provided by certain seaweeds due to their antibacterial activity against fish pathogenic bacteria.

- Increased profits through obtaining premium prices: Potential for differentiation of the IMTA products through eco-labelling or organic certification programmes.

Challenges of IMTA

IMTA poses a number of challenges:

- Higher investment: Integrated farming in open sea requires a higher level of technological and engineering sophistication and up-front investment.

- Difficulty in coordination: If practised by means of different operators (e.g. independent fish farmers and mussel farmers) working in concert, it would require close collaboration and coordination of management and production activities.

- Increase requirement of farming area: While aquaculture has the potential to release pressure on fish resources and IMTA has specific potential benefits for the enterprises and the environment, fish farming competes with other users for the scarce coastal and marine habitats. Stakeholder conflicts are common and range from concerns about pollution and impacts on wild fish populations to site allocation and local priorities. The challenges for expanding IMTA practice are therefore significant although it can offer a mitigation opportunity to those areas where mariculture has a poor public image and competes for space with other activities.

- Difficulty in implementation without open water leasing policies: Few countries have national aquaculture plans or well developed integrated management of coastal zones. This means that decisions on site selection, licensing and regulation are often ad hoc and highly subject to political pressures and local priorities. Moreover, as congestion in the coastal zone increases, many mariculture sites are threatened by urban and industrial pollution and accidental damage.

Prospects

There are few doubts that IMTA is still in its infancy but presents great prospects towards becoming the aquaculture of the future, with increase production and product diversity, and also with increased quality, promoting environmental, economic and social sustainability. The use of these bioremediation organisms in co-culture with high-valued fish or shrimp species can reduce water exchange frequency and discharge of effluents as well as decrease the probability of disease occurrence in a symbiosis of environment and economic benefits – as reducing the costs in the treatment of effluent while producing biomass without spending in commercial feed is of great economic advantage.

There is tremendous opportunity to use marine macroalgae as bio-filters and to produce products of commercial value. The prospects for IMTA to become the aquaculture of the future are bright, with increased production and product diversity, increased quality, and through the promotion of environmental, economic and social sustainability.

Great opportunities come along with great challenges, and pinpointing the most suitable species to be combined in IMTA systems together with the need to create models to better assess the densities and conditions for co-culture to generate optimum revenue will require considerable research.

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Consultations address antimicrobial resistance risk in aquaculture

Participants in the regional consultations on antimicrobial usage and resistance.

Two consultations on antimicrobial resistance (AMR) risks in aquaculture were jointly organised in Bangkok from 4-7 September by FAO and NACA with much appreciated financial support from FAO and USAID. The consultations were attended by seventeen governments in the Asia-Pacific region, the World Organization for Animal Health (OIE), WorldFish and Chulalongkorn University.

Although control over the use of antimicrobial substances has been strengthened over the past twenty years, mainly from the perspective of international trade and food safety, they are still commonly used in livestock industries and controls over the use of antimicrobial substances in aquaculture production is still far from adequate or effective. Improper and imprudent use of these substances can significantly contribute to the development of resistance in microorganisms, due to the nature of the aquatic environment and the ways in which cultured animals are handled.

AMR is a growing issue with significant implications for both human and animal health. However, data on pathogen resistance in aquaculture and other livestock industries has not been routinely or systematically collected. The purpose of the regional consultations was to initiate action on this issue, identifying interventions to assess antimicrobial usage in Asian aquaculture and a strategy to minimise the long term AMR risks.

In this context FAO, NACA and USAID are working together to undertake a regional assessment on antimicrobial use (AMU) and the associated risks of AMR in aquaculture. This study will assess the current status of AMU in selected countries as well as their regulation and governance, and identify major issues, gaps and constraints in minimising AMR risks.

The purpose of the regional consultations was to identify actions and develop a strategy to address AMR risks associated with aquaculture, based on an assessment of the status of AMU and AMR. This initiative is part of a broader, coordinated "One Health" movement across the entire human health and agricultural sectors to address prudent usage of antimicrobial substances to reduce AMR risks.

The meeting was opened with welcome remarks from Ms Xiangjun Yao, Regional Programme Leader for FAO-RAP; Dr Daniel Schar, Senior Regional Emerging Infectious Diseases Advisor for USAID; Dr Chumnarn Pongsri, Deputy Director General of the Thai Department of Fisheries; and Dr Cherdsak Virapat, Director General of NACA.

The first consultation addressed the status of AMU and AMR in the region, current national initiatives and regulatory instruments, and the development of a regional framework for AMR surveillance. Issues discussed included:

- The status of antimicrobial usage and antimicrobial resistance in the region.
- Antimicrobial resistance surveillance initiatives in Asian aquaculture.
- Development of a framework for antimicrobial resistance surveillance in Asia.
- A regional overview of current laws and regulations relevant to antimicrobial usage and resistance.
- Antimicrobial resistance in important bacterial diseases of aquaculture.

The discussions paved the way for the second consultation, which concerned the development of a regional guideline on AMR surveillance in aquaculture. Issues addressed included:

- Developing the framework for antimicrobial resistance monitoring and surveillance in Asia, including harmonisation of national antimicrobial resistance surveillance and monitoring programs for aquatic animals under the OIE Aquatic Animal Health Code; risk analysis of foodborne antimicrobial resistance and the Codex Alimentarius; methods and performance standards on AST from aquatic bacterial isolates and the Assessment Tool for Laboratory and AMR Surveillance Systems (ATLASS).

- Establishing the principles, purpose and objectives of the AMR surveillance guidelines for aquaculture including design, priorities and sampling strategies, methods for bacterial isolation, development of antibiotic panels and isolate storage.

- Guidelines on data management, including tools, storage and sharing of AMR surveillance data and implementation plans.

The endpoint envisaged for this initiative is the development of a guideline and framework for AMR monitoring and surveillance in Asia that will include regional guidelines on sampling approaches, laboratory testing and data management. These are anticipated to contribute towards the development of evidence-based treatments guidelines for common pathogens in aquatic animals and to reinforce good veterinary practices in lieu of unwarranted metaphylaxis and broad-spectrum preventative treatments.

Video recordings of selected technical presentations will be made available on the NACA website in due course.

ASEAN consultation on emergency aquatic animal disease preparedness and response

Aquaculture production in Southeast Asia has grown rapidly over the past two decades, but the industry has been severely impacted on many occasions by infectious diseases. The recent outbreak of acute hepatopancreatic necrosis disease (AHPND) in shrimp, for example, caused severe economic losses in Vietnam, Thailand, Malaysia and the Philippines.

A key factor in the spread of infectious diseases has been the irresponsible and unchecked movement of live aquatic animals both within and between countries, with inadequate attention to biosecurity. A lack of capacity responding to disease emergencies has also been a factor, complicated by the fact that emerging pathogens of aquatic animals are often previously unknown to science, and may spread widely before they are recognised.

As a result of the AHPND outbreak, ASEAN member states identified the development of emergency preparedness and response systems and contingency planning for managing aquatic animal disease outbreaks as a priority action.

The ASEAN Regional Consultation on Aquatic Emergency Preparedness and Response Systems for Effective Management of Transboundary Disease Outbreaks in Southeast Asia was held in Bangkok, 20-22 August. The consultation was funded by Japan-ASEAN Integration Fund (JAIF) and organised by the Department of Fisheries, Thailand and SEAFDEC Aquaculture Department, Philippines.

The objective of the consultation was to bring together ASEAN member states and technical experts to discuss the current status of emergency animal disease preparedness and response systems, and to identify gaps and opportunities for regional cooperation in management of transboundary disease. The consultation was tasked with:

- Assessing the existing regulatory framework, operating procedures and national aquatic animal health management strategies of ASEAN member states.
- Assessing the need for a regional ASEAN emergency preparedness and response system.
- Identifying gaps and priority areas for R&D collaboration.
- Enhancing cooperation amongst member states, international organisations and other stakeholders in management of emergency aquatic animal disease outbreaks.

The consultation was opened with remarks from Dr Chumnarn Pongsri, Deputy Director General of the Thai Department of Fisheries, Dr Kom Silpajarn, Secretary-General of SEAFDEC, Dr Koh-ichiro Mori, Deputy Chief of SEAFDEC/AQD and Ms Janejit Kongkumnerd, Director of the Aquatic Animal Health Research and Development Division, Thai Department of Fisheries.

The consultation provided an overview of the current status of emergency disease preparedness and response systems and regulatory arrangements in the region, with presentations made by Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. Technical presentations included:

- A demonstration of DisasterAWARE, a web-based software system used by many agencies around the world to visualise data and manage response to different types of disaster and natural hazards, by Dr Chris Chiesa, Deputy Executive Director of the Pacific Disaster Center.
- A historical overview of transboundary disease incidents and impact, by Dr Eduardo Leano, NACA's Aquatic Animal Health Programme Coordinator.
- The trade implications of disease outbreaks, by Dr Jing Wang of the World Organization for Animal Health (OIE).
- The response to the recent examples of tilapia lake virus (TiLV) was described by Dr Seangchan Senapin, Deputy Director of Centex Shrimp and Head of the Shrimp Molecular Biology and Biotechnology Laboratory, National Science and Technology Development Agency, Thailand.
- Another recent transboundary disease emergency, AHPND in shrimp, was described by Dr Kallaya Sritunyalucksana, National Center of Genetic Engineering and Biotechnology (BIOTEC), Thailand.
- Presentations on import risk analysis and assessment and emergency preparedness and response systems as an element of an aquatic animal health management and biosecurity strategy, by Dr Melba Reantaso, FAO.

The consultation broke into a workshop session with participants tasked to identify gaps, make policy recommendations and highlight priority areas for collaborative research and development on regional emergency disease preparedness and response.

The consultation wrapped up with a field trip to the Nam Sai Farms tilapia hatchery, and to the Royal Sea Farming and Aquaculture Demonstration Project in Petchaburi Province.

The proceedings of the meeting will be published by SEAFDEC AQD and audio recordings of the technical presentations will be made available on the NACA website in due course.

Applications for the position of Director General, NACA

The incumbent Director General, Dr Cherdsak Virapat will be completing his term of office on 30 April 2019. The NACA Governing Council has instructed to call for applications from suitably qualified and experienced persons from NACA member states for the position of Director General, tenable from May 2019 for a fixed period of five years. The selected candidate is expected to assume the position by 1 May 2019 after a brief handover period.

Applications will close at 5 PM (Bangkok time) on 15 January 2019. Candidates must be less than 55 years of age on the closing date. Shortlisted candidates will be expected to attend an interview with the 30th NACA Governing Council meeting, which will be held 25-29 March 2019 in People's Republic of China. Only short listed candidates will be notified of the results of application.

Responsibilities

The Director General is responsible for developing and conducting a work programme over a five year period in accordance with the mandate of NACA. The position will be based in the NACA Secretariat, Bangkok, Thailand.

The incumbent will be expected to travel extensively within and outside the region. The responsibilities of the Director General will include management of the Secretariat staff in pursuit of the goals of NACA both in terms of technical and administrative performance standards, and will be the chief financial officer.

Further supporting information can be found on the NACA website https://enaca.org.

Qualifications

- A post-graduate degree related to aquaculture.
- A minimum of 15 years' experience in regional or international aquaculture development and research.
- An established track record of successful fund raising.
- Previous experience in management and administration.
- Excellent inter-personal skills and experience in human resource management.
- Must be a citizen of a NACA member state.

Remuneration

The remuneration package is commensurate with equivalent international / regional positions and includes health insurance, child education allowance, relocation and dependents allowances and a vehicle.

Applications

Those intending to apply for the position should submit the following via email to cherdsak.virapat@enaca.org with copies to hshakeel@mrc.gov.mv and lyj@cafs.ac.cn.

Applications should include:

- Detailed curriculum vitae, including publication list and proof of age.
- A short statement why you are seeking the position of Director General (not exceeding one page).
- A short statement of your aspirations for NACA (not exceeding three pages).

Aqua 2018 – #WeRAquaculture

Aquaculture has seen spectacular growth in recent years, and Aqua 2018 celebrated aquaculture's role as one of the most important food industries worldwide. Held 25-29 August in Montpellier, France, Aqua 2018 brought together scientists, practitioners, students, industry and civil society to highlight the latest global developments in aquaculture research and innovation. Video highlights are available for viewing online, courtesy of FAO: https://youtu.be/rwdH813SehU

Asian Aquaculture 2018: Celebrating Asian Aquaculture, 3-6 December, Thailand

Asian Aquaculture 2018 is the first major aquaculture conference organised by the Asian Institute of Technology dedicated to the sustained progress of aquaculture in the Asian region, with a better understanding of the systems practiced, highlighting regional needs and constraints, and imbibing the global progress on sustainable intensification of production systems.

The conference will bring together world's leading expertise in innovative aquaculture, present emerging technological advancements for better husbandry and feeding practices to stem the disease tides in aquaculture, and set the goal for a sustainable enhancement of output from aquaculture relevant to the Asia Pacific region. The event is designed to benefit participants by generating a wealth of information on innovative management practices that can be applied to improve production and profits from aquaculture enterprises.

It also provides an opportunity for entrepreneurs, academia, governments and administrators in the global industry to witness the success stories in Asian aquaculture and progress in sustainable intensification of aquaculture for enhanced product quality and safety.

The conference will be held at the Asian Institute of Technology Conference Center Hotel in Pathumthani, Thailand, nearby Bangkok.

Two pre-conference training programmes are available on Integrated Multi-trophic Aquaculture and Management of Parasitic Diseases in Aquaculture. A field trip to an integrated shrimp farm in Kakhon Nayok will be held on 6 December. Places are limited so please book early.

For further information, contact the Secretariat at info@asianaquaculture.org or visit the conference website, https://www.asianaquaculture.org/

Quarterly Aquatic Animal Disease Report, January-March 2018

The 77th edition of the Quarterly Aquatic Animal Disease Report contains information from nine governments. The foreword discusses an intensive seven-day training course on tilapia lake virus (TiLV) that was jointly organised by China's National Fisheries Extension Center, Sun Yat-Sen University and the Food and Agriculture Organization of the United Nations.

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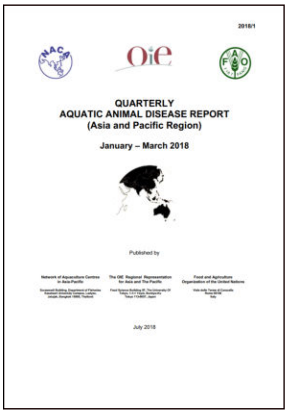
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QUARTERLY
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Training and Deans' Forum organised in China

Training workshop on advanced shrimp culture techniques enhances China-ASEAN collaboration on mariculture

A training workshop on advanced shrimp culture techniques was jointly organised by the School of Marine Science of Sun Yat-sen University, China, and NACA from 4-10 June 2018. The workshop was financially supported by the China-ASEAN Center for Joint Research and Promotion of Marine Aquaculture Technology (China-ASEAN MaquaTech Center), one of the key programs funded by the China-ASEAN Maritime Cooperation Fund of the Chinese government.

The training workshop brought together twenty two professionals from seven ASEAN countries including Cambodia, Indonesia, Malaysia, Myanmar, Thailand, the Philippines, and Vietnam to share information on shrimp farming practices, research and the latest innovations. Professionals from China showcased the latest advances in shrimp farming, including newly developed farm-proven shrimp-fish polyculture for biological control of shrimp pathogens, fully automated indoor recirculation systems, and shrimp pond culture with agro-ecological approaches.

The training workshop was conducted at Guangdong GuanliDa Marine Biological Co. Ltd., an agro-industrial agglomerate and biotech company. The company integrates research, development and commercial operation and has a vertically integrated production/value chain for marine shrimp including seed and feed production, grow-out, postharvest processing, and marketing.

Training Workshop on Marine Finfish Culture in China for ASEAN

A training course for ASEAN participants was held at Shanghai Ocean University (SOU), 11-14 June 2018 with financial support from the China-ASEAN Center for Joint Research and Promotion of Marine Aquaculture Technology, co-organised by SOU and NACA. Twenty-six participants from seven ASEAN countries attended the workshop. They shared country experience in marine finfish culture and discussed with Chinese resource persons on various production systems, issues, challenges and prospects of marine finfish culture. The workshop further consolidated collaboration between partners in China and ASEAN in research and development in marine aquaculture.

Deans' Forum on Fisheries Education and Postgraduate Workshop on Sustainable Aquaculture

The Deans' Forum on Fisheries Education, organised by Shanghai Ocean University and co-organised by the China-ASEAN Center for Joint Research and Promotion of Marine Aquaculture Technology and NACA, brought together professors and administrators of several higher education institutions from Asia, including SOU, Sun Yat-sen University, Huazhong Agricultural University, Ningbo University, Yellow Sea Fisheries Research Institute, Kasetsart University, Burapha University, Can Tho University and the University of Agriculture and Forestry, Nepal, to share and exchange the latest information and experiences on curricular development and education advances in fisheries and aquaculture. The forum was also attended by invited fisheries officers from China, Cambodia, Malaysia, Myanmar, Indonesia, the Philippines, Thailand and Vietnam, and postgraduate students of Shanghai Ocean University.

A Postgraduate Workshop on Sustainable Aquaculture was also held that featured presentations from postgraduates of Shanghai Ocean University from eight countries. The topics covered a wide range of technical aspects from fundamental research at molecular level on fish genetics, aquaculture technology, sustainability and climate change impacts.

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