Strategies and way forward to augment seafood production through finfish mariculture

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The marine capture fisheries scenario in India is characterized by excessive fishing effort, overexploitation of certain resources and conflicts among the different stakeholders in the sector. Due to the larger dependency on inshore fisheries over the years, the production from these waters has reached a plateau and hence ensuring sustainability is inevitable. It has to be admitted that many of the management options are not practical to be implemented due to the multispecies nature and continuous spawning strategy which are characteristics of most of the tropical fish stocks. It is understood that any fisheries management regulations can be implemented only by taking into consideration the livelihood issues and other social aspects of the sector. It is also accepted that the increased demand in seafood cannot be met from capture fisheries alone. In this context, it is the need of the hour to resort to resource augmentation methods through mariculture and allied techniques.

Mariculture has been contributing around 30.3% of the global aquaculture production by quantity and 29.2% of the total value. Finfish culture in the sea is expanding rapidly with an average annual rate of 9.3% from 1990 to 2010. The commercial level production of marine finfish from mariculture is still in its infancy in India. The chief farmed seafood production from in India is by coastal aquaculture of shrimps. Shrimp farming started in a big way in India in the early 90s especially in the coastal districts of Andhra Pradesh and Tamil Nadu. So far, shrimp remains as the single largest and maximum value earner among the seafood exported from the country. Shrimp farming in India, till 2008, was synonymous with the monoculture of tiger shrimp, *Penaeus monodon*. Since 1995, culture of *P. monodon* is affected by White Spot Syndrome Virus (WSSV) and the development of shrimp farming has become stagnant. Later in India, pilot-scale introduction of *L. vannamei* was initiated in 2003 and after risk analyses large-scale introduction was permitted in 2009. Of late *L. vannamei* farming is being threatened by outbreak of new diseases namely Early Mortality Syndrome (EMS), Acute Pancreatic and Haematopoietic Necrosis Syndrome (APHNS) and many viral diseases. Hence, a crop rotation with a commercially viable finfish species can be one of the best options for a long term solution for sustaining aquaculture sector. The major constraints for initiating and developing marine finfish farming in the country is the lack of seed production technologies for suitable high value species and the non-availability of commercially viable farming techniques. Now, with the development of indigenous technology for seed production and farming of cobia and silver pompano by Central Marine Fisheries Research Institute (CMFRI), there is great scope for diversification of farming practices. CMFRI has contributed to the development of following technologies/ facilities for initiating a sustainable mariculture production in the country

(i) Seed Production of Cobia

Fast growth rate, adaptability for captive breeding, cost effectiveness in production, good meat quality and high market demand are some of the attributes that makes cobia a candidate species for mariculture. Envisaging the prospects of cobia farming in India, broodstock development was initiated at the Mandapam Regional Centre of CMFRI

Indigenously fabricated RAS Unit

Marine finfish broodbank

Cobia fingerlings reared in the cage

Silver Pompano fingerlings

in sea cages during 2008 and the first successful induced breeding and seed production was achieved in March – April 2010. The Centre has also developed protocols for captive breeding, larval production and cage farming of cobia. Sub-adult cobia were collected from wild and stocked in sea cages and fed with squids, oil sardines and lesser sardines with vitamin premixes for developing as broodstock. Fishes weighing 9 kg and above were transferred and stocked in 60 tonne capacity FRP tanks/ 100 tonne capacity cement tanks with recirculation system in an on-shore hatchery facility at a male: female ratio of 2:1. Cannular biopsies were periodically taken to assess ovarian maturation. Usage of different hormones namely Luteinizing hormone-releasing hormone (LHRHa) and Human Chorionic Gonadotropin (HCG) were studied at different dosage levels to standardize the optimum dosage for spawning induction. Once the ova reach a size of 700 µm diameter, they were induced with HCG at the dose of 500 IU/kg body weight. The males are administered with a dosage of 250 IU/kg body weight. After spawning the fertilized eggs which are floating at the surface were collected and incubated in 2 tonne capacity rectangular/ circular tanks. The newly hatched larvae are stocked in 2 tonne capacity tanks containing filtered seawater at a stocking density of 5-10nos/ litre. The tanks are provided with mild aeration and microalgae at a density of $1x10^7$ nos./ml. The mouth of the larvae opens on 3rd day and the mouth size is around 230 µm and are fed with enriched rotifers upto day 10 at a density of 10-12 nos. per ml. Co-feeding of rotifers with enriched *Artemia* nauplii is carried out from 8 to 10 days of hatching. The *Artemia* nauplii are provided at a density of 5-6 nos/ml up to day 19. Weaning to larval inert feed is started from day 15 along with co-feeding of Artemia. From day 20, the feeding is entirely on inert larval feeds and frequent grading is needed to control cannibalism. Metamorphosis of the larvae starts from day 18th and all the larvae metamorphose into juveniles by day 21. Nursery rearing is carried out till day 55. During this stage, the fingerlings will be initially provided with artificial feed of 800µ size. After this the fingerlings of 3-4 inch size are supplied to the farmers for stocking in sea cages/ ponds for further rearing and grow-out culture.

(ii) Farming of Cobia

The farming protocols for the hatchery produced cobia fingerlings in sea cages with different feeding strategies were developed, tested and validated. This farming method has been adopted by private entrepreneurs, fishermen groups and farmers. The nursery reared juveniles were transferred to the grow-out sea cages at a stocking density of 3.0-5.0 kg/m^3 or 750 nos of juvenile cobia per 6m diameter cage of 3 metre depth. The juveniles were fed @ 5% total biomass of fish with chopped low-value fishes once in a day. The grow-out period was optimized for a period of 6- 7 months. The juveniles reached an average weight of 1.0 kg in 4 months and 2.5 – 3.0 kg in 6- 7 months.

(iii) Seed production of silver pompano Trachinotus blochii

Realizing the aquaculture potential of pompano in India, broodstock development was initiated in the year 2008 at the Mandapam Regional Centre of CMFRI. Wild collected 250 to 500 gm size pompano were stocked in sea cages of 6 m diameter and 3.5 m depth. The fishes were fed once in a day with trash fish. In April 2011, 4 numbers of cage reared adult pompano (1 female and 3 males) were selected and transferred to an indoor FRP tank of 10 m^3 capacity with photoperiod control facility (14 L: 10 D) for pre-conditioning the fishes to induced spawning. The brooders were fed with squid meat and fish roe once a day. Water quality was maintained by providing a flow-through system throughout the period. Periodic cannulations were carried out to assess the maturity of the fishes for induction of spawning. On 5th July 2011, intra-ovarian eggs of diameter above 500 µ were observed and the brooders were administered with HCG (350 IU per kg body weight). Spawning was recorded on 07/07/2011 after 38 h of hormone induction. The total number of eggs spawned was 1.30 lakh and 50 % were fertilized. The eggs hatched after 18 h of incubation at a temperature range of 30-31°C.

The newly hatched larvae were reared in FRP tanks of 2 m^3 capacity provided with mild aeration and green water at a cell density of 1 x10^5/ml. Copepods were introduced into the larviculture tanks to facilitate the first feeding of the larvae. On 3 dph (day post hatch), mouth opening was formed and the larvae were fed with enriched rotifers till 9 dph. Co-feeding with enriched *Artemia* nauplii was done during 10-13 dph and thereafter upto 19 dph with enriched *Artemia* nauplii alone by maintaining a density of 1-2 nos. per ml. Weaning to larval inert feeds was started from 20 dph till 24 dph. From 25 dph only inert feeds were provided. The metamorphosis of the larvae had started from 18 dph and all larvae were metamorphosed into juveniles by 25 dph. During 20-25 dph gradings were done to separate the shooters. It was also noted that after the critical stage mortality during 3-5 dph, mortalities were rather negligible.

Thereafter, the fingerlings were fed with progressively higher size range of larval inert feeds. The first phase of nursery rearing was done upto 35 dph in the hatchery with inert feeds and proper water quality management. On 35dph, the fingerlings with size range from 33-40 mm were ready for farm rearing. The survival as on 35 dph was estimated as 12%.

(iv) Pond Farming of silver pompano

The first farming demonstration from the hatchery produced seed was carried out in a coastal pond at Antharvedi in East Godavari District, Andhra Pradesh and the growth performance, survival and productive capacity were evaluated. About 3,400 fingerlings of silver pompano (30.59 ± 0.24 mm mean length and 2.00 ± 0.04 g mean weight) were stocked into a one acre pond (0.4047 hectare) having 8 ± 1.2 ppt salinity. The salinity was gradually raised to

24 + 1.8 ppt during the farming period. The fish were fed with extruded floating pellet feed containing 30% to 50% crude protein and 6 % to 10 % crude fat. After 240 days of culture, 1305 kg of silver pompano were harvested and the survival rate was 91.32%. The FCR was 1:1.83.

(v) Marine finfish brood bank

The availability of required quantities of biosecure seed is the major prerequisite for the initiation and expansion of mariculture in the country. The major bottleneck in achieving commercial level seed production is the non-availability of a facility where the biosecure broodstock can be maintained and controlled spawning can be obtained year round. Broodstock management usually include collection and domestication of brooders as well as maturation control, spawning and egg production. Cobia being a very active fish which grows to large size, broodstock development is mostly practiced in sea cages. However, the broodstock developed in sea cages are susceptible to the changes in the water quality of the cage site and impact of harmful algal blooms. Consequently the broodstock developed in sea cages is not biosecure and hence can lead to spreading of diseases while farming is taken up on a commercial basis. If the broodstock can be maintained onshore in controlled facilities the loss of broodstock can be minimised and controlled breeding by manipulating the photo thermal regimes and spawning all through the year can be achieved. Based on this concept a marine finfish broodbank has been established at Mandapam Regional Centre of CMFRI.

(vi) Recirculating Aquaculture System (RAS)

Recirculating aquaculture systems (RAS) are tank-based systems in which fish can be grown at high density under controlled conditions. They are closed-loop facilities that retain and treat the water within the system itself. Recirculation systems use land based units to pump water in a closed loop through fish rearing tanks and consist of a series of sub-systems for water treatment which include equipments for solids removal, biological filtration, heating or cooling, dissolved gas control, water sterilization and photo-thermal control. Sustainable production of biosecure cobia seed all through the year employing photo-thermal conditioning is possible only in RAS. At Mandapam Regional Centre two RAS are installed for controlled broodstock development and breeding. The first successful off-season spawning of cobia through thermal regulation has been achieved in the RAS on 2nd December 2013. During this season the temperature in source seawater was 25.1 to 26.0°C and it was raised in the RAS to 29.7 to 30.3 °C, using titanium heaters.

Way forward

Seed availability is the major constraint for initiation of commercial level farming of marine finfishes. At present limited quantities of seeds of seabass, cobia and pompano are available from CMFRI, CIBA and RGCA. The huge demand for cobia and pompano seeds received at CMFRI from fish farmers and entrepreneurs is indication on the priority of the sector. Hence there is an urgent need to establish finfish hatcheries by fisheries development agencies/private sector to ensure the seed availability. In addition, it is required to intensify research programmes for the development of seed production techniques for at least one dozen species of high value marine fishes. In this context, CMFRI has already taken up broodstock development and seed production of orange spotted Grouper *Epinephelus coioides*, Indian Pompano *Trachinotus mookalee* and Malabar red snapper *Lutjanus argentimaculatus*. Initial success has already been obtained in broodstock development and seed production of *E. coioides* and *T. mookalee* at the Vishakapatnam Research Centre of CMFRI. Broodstock development of *L. argentimaculatus* is being pursued by CMFRI at Cochin and Karwar.

Development of farming systems especially sea cage farming deserves prime attention. Sea cage culture has been expanding in recent years on a global basis and it is viewed by many stakeholders in the industry as the aquaculture system of the millennium. Cage culture has made possible the large-scale production of commercial finfishes in many parts of the world and can be considered as the most efficient and economical way of growing fish. The rapid growth of the industry in most countries can be attributed to (i) suitable sites for cage culture (ii) well established breeding techniques that yield a sufficient quantity of various marine and freshwater fish juveniles (iii) availability of supporting industries such and feed, net manufacturers, fish processors etc. (iv) strong research and development initiatives from institutions, governments and universities and (v) the private sector ensuring refinement and improvement of techniques/ culture systems, thereby further developing the industry.

When compared to many countries in the Asia-Pacific Region, India is still in its infancy in sea cage farming. For the first time in India as part of R &D a marine cage of 15 m diameter with HDPE frame was successfully launched in 2007and operated at Visakhapatnam, in the east coast of India by CMFRI. Even though it cannot be taken as a commercially successful venture, a lot of lessons were learnt on designing and fabrication of cages and mooring systems. This has led to the development of better designs of cages of 6m diameter with improved mooring systems that can withstand rough sea conditions. Subsequent demonstrations of cage farming were undertaken along different parts of the Indian coast under a participatory mode with the local coastal fishermen. Successful sea cage farming demonstrations were conducted at Kanyakumari, Vizhinjam, Kochi, Mangalore, Karwar, Veraval, Mandapam, Chennai and Balasore. Cobia, Sea bass and spiny lobsters were the major groups employed for farming. These demonstrations have created an awareness regarding the prospects of sea cage farming in India. Many entrepreneurs, fishermen and farmers are coming forward to take up this venture. In this regard, the initiative taken by the Cobia Aquaculture Fishermen Welfare Association is worth mentioning.

Cobia Fisherman Welfare Association, a self help group from Rameswaram took up sea cage farming under the technical support of Mandapam Regional Centre of CMFRI. Ten cages of 6m diameter and 3.5m depth were fabricated and floated by them. All the investments in the fabrication of the cages, the cost of seeds, feeds and managing the sea cage farm were borne by the association. A total of 6400 fingerlings of hatchery produced cobia were supplied from Mandapam Regional Centre. The farming was initiated during November 2013. A total of 10 tonnes of fish was harvested during the fishing ban period and the fish weighed from 1.0 to 2.3 kg and the farm gate price was ₹ 270/ kg. This has created widespread interest among fishermen communities for taking up sea cage farming in the area.

To promote sea cage farming in the country, identification of suitable sites with proper depth, water quality and water current are required. Site selection survey and identification of suitable sites for cage farming by the entrepreneurs and farmers deserves urgent attention. Availability of logistic support for cage farming and it must be given careful consideration if a profitable business is to be established. Cage farming has to be promoted away from the human settlements, discharge points of industrial and municipal waste, so as to maintain ideal water quality for sea farming. Further, policy for leasing the suitable sites, bank finance, and governmental support through subsidy assistance are need of the hour.

The development of seed production technologies for at least a few species of high market value finfishes, establishment of hatcheries by fisheries development agencies, identification of appropriate cage farming sites, development of economically viable farming protocols, formulation of suitable grow-out feeds, health management protocols, development of mariculture policies, appropriate marketing strategies can go a long way to promote mariculture as a substantial contributor of sea food production of India.