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3

RECENT ADVANCES IN BRACKISHWATER FINFISH AQUACULTURE:
PROSPECTS AND CONSTRAINTS

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1. INTRODUCTION

Brackishwater aquaculture in India is an age old practice, which was traditionally followed in coastal regions and restricted mainly to the *bheries* (large manmade impoundments) of West Bengal and *pokkali* (paddy cum fish culture) fields along the Kerala coast. With almost no additional input, seeded with naturally trapped/collected juvenile fish and shrimp, these systems have been sustaining production levels of around 500 kg/ha/year with shrimp contributing $1/4^{th}$ to $1/3^{rd}$ of the total production. As growth of capture fisheries has dipped to its low in the recent years, fish availability is decreasing, proportionately to the expanding human population. High levels of expectations are pinned on aquaculture to meet the fish demand for human consumption. Fish and fish culture are the two important components not only as livelihood options but of culture and economy of the people in many parts of India. In the recent years, fish culture though considered being a high investment venture; is highly remunerative when best management practices are followed.

The importance of brackishwater aquaculture was recognized only after the initiation of an All India Coordinated Research Project, (AICRP) on 'Brackishwater Fish Farming' by ICAR in 1971. The project developed several technologies pertaining to fish and shrimp farming. However, scientific and commercial brackishwater aquaculture at present is restricted to farming of shrimps.

Although brackishwater aquaculture is mainly focused on farming of the shrimp species tiger shrimp *Penaeus monodon*, and the recent introduction of Pacific white shrimp *Litopenaeus vannamei* in India, occurrence of viral outbreaks and other diseases pose major threat to sustainability. To overcome these issues, diversification of farming practices to other species such as finfishes is suggested as one of the remedial measures. This would also help to provide sustainable livelihood option for the coastal community and entrepreneurs.

2. Potential for Brackishwater Aquaculture in India

India is bestowed with vast resources of brackishwater areas with 3.5 million ha consists of low lying, barren, unproductive or marginally productive coastal saline lands, swamps etc. India has coastal mangrove areas of about 0.5 million ha. The potential brackishwater area suitable for development of brackishwater aquaculture is about more than 1.0 million ha. In addition to this, around 8.5 million ha salt affected areas are also available, out of which, about 2.6 million ha area are unsuitable or marginally suitable for agriculture can be utilized for brackishwater aquaculture. It is evident that with the availability of plenty of physical resources, augmentation of fish production is easier since potential of biological resources is also high with the presence of variety of cultivable fish species in Indian waters. Although brackishwater farming in India is primarily synonym with shrimp culture, it is very important to diversify the farming practices with other finfish species so as to facilitate the crop rotation, which would ultimately help the better pond condition. Farming of herbivore fin fishes in the brackishwater systems not only helps the removal of organic matter deposits present at the bottom of the pond but also would facilitate the development of balanced microbial population and thereby maintaining better pond environment suitable for increased productivity.

The potential area available for brackishwater aquaculture in general is high (Table 1) and existing shrimp farming areas can be converted to fin fish farming in particular as the shrimp farming has become highly competitive and requires stringent bio security measures in place. More emphasis is laid on certification and traceability by consumer of importing countries making shrimp farming a complicated enterprise for small and resource poor farmers. About 1.0 million ha of potential brackishwater area and 50,000 ha of farming developed area are available for promoting fin fish farming in India.

Table 1. Potential area, area developed and area available for brackishwater aquaculture development in India.

Sl. no	State	Potential Area (ha)	Area Developed (ha)	Area Utilized 2009-10 (ha)	Developed Area available (ha)	Potential Area available (ha)
1	West Bengal*	400500	51,659	47,488	4,171	353,012
2	Orissa	31600	13,843	4,769	9,074	26,831
3	Andhra Pradesh	150000	58,145	33,754	24,391	116,246
4	Tamil Nadu	56000	6,109	2,381	3,727	53,618
5	Puducherry	800	Neg	Neg	Neg	Neg
5	Kerala	65000	15,099	9,544	5,555	55,455
6	Karnataka	8000	3709	1,484	2,225	6,516
7	Goa	18500	867	272	595	18,228
8	Maharashtra	80000	1,329	650	678.	79,349

(Source: MPEDA, 2011)

3. Potential Cultivable Finfish Species and Availability of Seed

Based on the market demand for the species, seed and feed availability, culture duration, adaptive nature against changing environment and disease resistance, fish species are being selected for brackishwater farming. Brackishwater finfish species such as Asian seabass *Lates calcarifer*, mullets *Mugil cephalus, Liza parsia, Liza macrolepis, Liza tade*, milkfish *Chanos chanos*, Cobia *Rachycentron canadum*, pearlspot *Etroplus suratensis*, Estuarine grouper *Epinephelues tauvina*, Spotted scat *Scatophagus argus* and saline tolerant *Tilapia* spp. are considered as candidate species suitable for farming in brackishwater systems.

Large scale commercial farming of any aquatic species is chiefly dependent with the availability of stockable size seed. However, fish seed availability in the wild is always season dependent and also directly synchronized with the spawning period of the species. Nursery fields such as coastal wetlands and creeks, low saline backwaters, estuaries, sandy beaches, river mouths, mangrove areas and other land locked low saline water bodies play major role as feeding grounds for juvenile fishes as they provide natural diets such as blue green algae, diatoms, filamentous green algae, variety of zooplankton, detritus matters etc. The varying nature of coastal climatic conditions in India has offered diversified nursery grounds, in which a number of fish species abundantly distributed in different seasons. The geographical distribution of brackishwater fish seed is presented below:

3.1. Milkfish-*Chanos Chanos*

Milkfish farming is being practiced traditionally in certain parts of India by stocking the wild seed along with other species such as mullets, seabass, shrimp etc. in polyculture mode. Milkfish seed availability has been reported in many places especially on the east coast of India from Vishakhapatnam to Rameswaram and Krusadai islands in Tamil Nadu (Basu and Pakrasi, 1976), Rushikulya estuary, lower Sundarbans (Patnaik and Misra, 1988) and Alampore coast on the western banks of Hooghly estuary in West Bengal (Saha *et al.,* 1964), and from Korapuzha to Kadalundi near Calicult in Kerala (Lazarus and Nandakumar, 1986). Milkfish fry is being collected extensively during March to May in places such as Rameswaram and Pamban coastal back waters of Tamil Nadu and Narzapur coastal waters of East Godavary District, Andhra Pradesh and transported to Kerala, West Bengal and Tamil Nadu for grow out culture.

3.2. Seabass-*Lates Calcarifer*

The Asian seabass *Lates calcarifer* commonly known as Bhetki in India is one of the most preferred candidate species for brackishwater aquaculture. Availability of seed from the natural water bodies has been reported from many coastal states. Seabass seed is abundantly available in Sundarban region, West Bengal, Coastal west Godavari and Machilipatnam coast of Andhra Pradesh, Muthupet coastal waters and certain parts of

Tuticorin coast, Tamil Nadu, Coastal Raigad district of Maharashtra and certain parts of Goa. The availability of seabass seed is always season dependent. Traditional farming is being practiced by collecting the wild and stocking in the pond along with other species. However, hatchery produced seabass seed is also available in the recent years in Tamil Nadu where the Central Institute of Brackishwater Aquaculture (CIBA) and Rajiv Gandhi Centre for Aquaculture (RGCA) have seabass hatcheries

3.3. Grey Mullet-*Mugil Cephalus*

Commercial importance of Mullet species for polyculture as well as monoculture in brackishwater systems has been reported. In Tamil Nadu, availability of mullet seed such as *Mugil cephalus,* and *Liza macrolepis* has been reported in Tuticorin backwaters (Marichamy *et al.,* 1990). Distribution of mullets seed *Mugil cephalus, L. macrolepis* and *L. cunnesius* in Madras coast have been reported (Nammalwar and Mohanraj, 1991). In Killai backwaters of Tamil Nadu, various species of mullets are available. In West Bengal, juvenile mullet seed such as *L. parsia, L. tade* and *M. cephalus* are available in large numbers especially in the Sundarban estuarine waters. Among the different species of mullet, *M. cephalus* has rapid growth rate. However, naturally available seed is a mixture of many species.

3.4. Pearlspot-*Etroplus Suratensis*

The pearlspot *Etroplus suratensis* is another commercially important brackishwater fish, which fetches higher prices in Kerala and West Bengal. This fish breeds in low saline waters natural and seed availability is reported throughout the year. *E. suratensis* is dominantly present along south west of India especially in Kerala, Karnataka, certain parts of Maharashtra and Goa. In the east coast, availability of this species has been reported in Pulicat Lake of Tamil Nadu, Nagayalanka, Krishna district of Andhra Pradesh, Chilka lake of Orissa and West Bengal. It is ideal candidate species for farming in low saline waters.

4. DIFFERENT CULTURE SYSTEMS OF BRACKISHWATER FIN FISHES

Farming of brackishwater fin fishes is always dependent on the availability of suitable physical resources, natural diets, availability of seed and its feeding habits, market demand etc. Different culture practices such as mono culture, polyculture, composite fish culture and integrated fish farming are followed either in the earthen pond, or in the cages or in the open water bodies in pens.

4.1. Mono Culture

Culture of single fish species either in pond based system or cages or in pen is known as ‘mono species fish culture’ or ‘monoculture’ in short. This practice can be applied for the culture of either high valued species or for the low value species based on the availability of the culture systems. Although, monoculture of fin fishes such as milkfish *Chanos chanos* can be taken up in the pen as extensive method, in the recent years, mono culture method is widely followed in cages for the high value carnivore species such as *Lates calcarifer*, grouper *Epinephelus* spp., and Cobia *Rachycentron canadum.* Since these fishes are highly carnivores, it can predate other species of smaller size fishes, it is suitable for monoculture. Herbivore species such as *M. cephalus, C. chanos* and pearlspot *Etroplus suratensis* can be taken up for mono culture separately in the pond based system. It is reported that milkfish production can be achieved in the pond based monoculture system with the range of 0.85 to 4.6 t/ha with the stocking rate varied from 4000-5600 nos/ha (Mohanraj *et al.,* 1983; Lazarus and Nandakumaran, 1987).

4.2. Polyculture

Culture of more than one fish species in enclosed water body such of pond or cage or pen is called polyculture. Fishes having the feeding habits as planktivore, herbivore and bottom feeders have to be selected for the polyculture. This method is practiced by the farmers in order to utilize the available phytoplankton, zooplankton, and benthic organisms in the pond as feed for the fishes. Fish species are selected and introduced in such a way so that they are mixture of the surface water feeders, column feeder and bottom feeder. In the polyculture ponds, organic and inorganic fertilizers can be added in order to enhance the productivity particularly the plankton production. These phytoplankton and zooplankton can serve as food for the fishes stocked in the ponds. Herbivore fishes can feed the micro algae, filamentous algae and other weed plants present in the pond. Fish like milk fish *Chanos chanos* can consume decaying organic substances present in the bottom of the pond. Shrimp can feed on the benthic organisms such as polychaetes, molluscan etc. from the sediment. Predatory fish like seabass is also cultured along with the tilapia *Oreochromis* spp. In this system, small tilapias were consumed by the seabass and small tilapia will be available continuously in the pond, since tilapia can breed throughout the year.

In the brackishwater culture system, fish species such as milk fish *Chanos chanos*, grey mullet *Mugil cephalus*, pearlspot *Etroplus suratensis* and tilapia *Oreochromis* spp. can be taken up together with the varying stocking densities. Along with the finfishes, shrimp species such as *Penaeus monodon, Fenneropenaeus indicus, Marsupenaeus japonicus* and *F. merguiensis* also can be cultured. In the polyculture ponds, manures and fertilizers are added heavily. This can cause over blooming of algae and thereby resulting in oxygen depletion, which is stressful to the fish. To overcome this problem, the bloom has to be monitored and controlled. Proper stocking densities of each species have to be maintained in order to utilize the pond productivity at different depths of pond water effectively.

4.3. Traditional Culture Systems

Traditional farming of fish species is an age old practice in India. Some of the traditional farming practices popularly known are *bheri* fish culture in West Bengal, the fish and shrimp culture in *pokkali* paddy fields of Kerala, *ghery* fish farming in Chilka lagoon of Orissa and *Khazans* of Goa. These methods of culture were aimed generally as polyculture mode by stocking the fish seed available from the natural water bodies during high tide. This extensive practice does not involve any input. Fish seeds are allowed to enter in to pond though sluice gate (auto stocking) during high tide. Seed stocking is done by this method during the season when fish seeds are available from the wild. Fish feed upon the natural diets available in the pond and no supplementary feed is provided. Farmers carryout this practice for about 6-8 months and productivity varied from 500 to 1000 kg/ha in a season depending upon the number of fish species entered in the pond as well as the availability of the natural diets in the pond.

4.4. Semi-Intensive/Intensive Culture

As the fish farming practices taken up on commercial basis during early 1990s, higher production was targeted with improved or semi-intensive/intensive farming practices. In this method, selective stocking of seed from hatchery and application of formulated pellet feed were carried out. Generally, fish can be stocked @ 6000-8000 no/ha. After pond preparation, feeding can be done with the artificial diet and proper water quality management is to be carried out. Water exchange has to be done according to the requirement as the fish grow, the biomass will also increase. Provision of aerators in the fish pond in order to improve the dissolved oxygen levels is required. All the activities are conducted based on the schedules to achieve the maximum production. In the improved pond culture method, fish production can be achieved from 4 to 6 t/ha.

4.5. Pen Culture

Fish pens can be built in shallow open waters with wooden poles and net to enclose stocks within a usually large area in varying sizes and shapes like square, rectangular and circular. The site selected for the installation pen should facilitate good water circulation, possess abundant natural food, better water and soil quality, easy to access and free from legal and social problems. Pen sizes vary from 1 ha or more. The pens are made using the locally abundant bamboo or casuarinas poles forming split bamboo screens or nylon nets. Depth of water in pens varies from 1.0 to 1.5 m. The fish stocked in the pen can forage the natural diets available at the bottom and can also feed on plankton. Supplemental diets can be also provided. Milkfish or mullet fingerlings (5 to 10 g) can be stocked in the pen @ 20000-30000 no/ha and after 6-8 months culture period annual potential yield of 3 to 4.5 t/ha can be achieved.

4.6. Cage Culture

Fish cages are smaller and more restricted enclosures that can be staked in shallow waters or set up in deep water with appropriate floats and anchors. Culture of finfish in cages is extensively practiced in South East Asian countries for grouper, cobia and seabass dominantly. Cages can be set up according to the water depth and two types of cages can be used for the culture purpose. They are floating and stationary cages. Floating cages are set up usually in the deeper water bodies where depth is more than two meters. Stationary cages can be fixed in shallow water bodies having water depth of 1.5 to 2.0 m. According to the adequate water flow and oxygen levels of the open water bodies, where cages are installed, high density fish farming can be taken up targeting the production rate of 25 to 50 kg/m^3, at the same time proper cage management is also required.

Cage culture is also having the advantages such as easy management in terms of feeding, sampling and harvesting. Cage culture can cause accumulation of sediments at the bottom over the years if the culture continued in the same site and therefore proper site selection is essential. Proper water leasing policies have to be framed to promote the cage farming as livelihood options for coastal fishermen community and poor people. In India, experimental trial on the cage culture of seabass in open water was carried out near Chennai by CMFRI. RGCA has conducted several farming trials of seabass in pond based cage systems. Cobia farming in cages is also taken by CMFRI in Karwar coast. Plenty of coastal low saline water bodies available along both east and the west coasts can be used for cage farming with suitable fish species following best management practices.

5. POTENTIAL FOR CULTURE OF FRESHWATER SPECIES IN LOW SALINE WATER

Freshwater species such as *Oreochromis mossambicus,* and *Oreochromis niloticus* are the potential species for farming in saline water bodies, since these species can tolerate the salinity range from 0 to 30 ppt.

6. ADVANCES MADE BY DIFFERENT INSTITUTES IN BREEDING AND DEVELOPMENT

CIBA: Central Institute of Brackishwater Aquaculture (CIBA) has conducted various culture trials in brackishwater farms with different fish species. CIBA has achieved successful breeding of Asian seabass *Lates calcarifer* using captive maintained broodstock fishes for the first time in India (Thirunavukkarasasu *et al.,* 2001) and standardized the seed production technology. Followed by, year round seed production of *L. calcarifer* was also achieved under Recirculation Aquaculture System (Arasu *et al*., 2008), and made possibilities of seed supply throughout the year.

6.1. Nursery Rearing of Asian Seabass Lates calcarifer

Several trials have been conducted by the CIBA on the nursery rearing of *L. calcarifer* in tank, hapa and pond based systems. It is reported that under tank based system, 25 days old seabass fry in the size range of 1.0-1.5 cm can be stocked @ 1000 no/m^3 in the nursery tanks of 5-10 t capacity and can be fed with *Artemia* biomass or minced cooked fish meat or mixture of both *ad libitum*. After 45-60 days rearing with flow through facility and weekly grading, the fry can reach to fingerling size with an average survival rate of 53% (CIBA Annual Report 2001-02). At Kakdwip Research Centre of CIBA, nursery rearing of seabass fry (26.0±4.6 mg) was performed in 12 double layered mosquito net hapas with four different feeding frequencies (1,2,3 and 4 times/day) and the fry were fed with formulated diet @ 8-10% body weight daily for 35 days. It is concluded that feeding with three times daily has resulted maximum growth (1.2g), survival rate (76.4%) and better FCR 2.2. (CIBA Annual Report 2008-09). CIBA has demonstrated the nursery rearing of Asian seabass *Lates calcarifer* under hapa based system in the farmer's pond in Andhra Pradesh. It is stated that 46-52% survival can be achieved in two months nursery rearing, where, the seabass fry of 1.0-1.5 cm were stocked in the hapas @ 250-300 no/m^2 and fed with formulated diet (CIBA Annual Report 2009-10).

6.2. Pond Based Seabass Farming with Trash Fish Feeding

Seabass can be cultured either in the earthern ponds or in the cages. Thirunavukkarasu (2000) have reported that grow out culture of seabass was undertaken by a farmer in two ponds at Nagapattinam under the guidance of CIBA with the stocking of seabass seed in the average size of 1.25g @ 4800 and 7828 nos./ha in Pond A and pond B respectively. Fishes in the pond A were fed with exclusively on supplementary feed mixture of fresh/ dry fish, ground nut oil cake, rice bran and starch @ 5% body weight daily, while the fishes in pond B were allowed to feed on live Tilapia (stocked in the pond prior stocking of seabass). Supplementary feed as mentioned above was also given in this pond @ 1.0% body weight daily. After 11 month culture period, the fish attained a size range of 0.5 to 1.2 kg in the pond A with the production rate of 4.36 t/ha and in the size range of 0.3 to 1.5 kg in the pond B with the production rate of 3.45 tonnes/ha and showed the viability of seabass farming under polyculture system with tilapia, in a prey-predatory relationship (CIBA Annual Report 1998-99; Thirunavukkarasu 2000). In another trial performed in the farmer's pond near Bhimavaram Andhra Pradesh under the technical guidance by the CIBA, it is observed that in 320 days of culture, a total production of 3740 kg could be achieved.

6.3. Seabass Culture Feeding with Formulated Diet

Seabass farming feeding with trash fish can be done only in the selected places where, trash fish availability is plenty and also cost less. This can limit the expansion of seabass culture and therefore it is essential to develop the formulated diet for seabass grow out farming. CIBA has demonstrated the seabass culture in the farmers' pond near Nellore, Andhra Pradesh using seabass grow out feed developed by the CIBA. Seabass juveniles with an average size of 80g were stocked @ 5800 no/ha earthen pond. Fishes were fed with CIBA formulated feed and after 258 days period of culture, the fishes have attained an average size of 733g with the total production of 3.66 t/ha and FCR worked out was 1.9. The culture trial has indicated the viability of seabass farming using CIBA formulated seabass grow out formulated feed (CIBA Annual Report 2009-10).

In view of suitability of grey mullet *Mugil cephalus* for polyculture as well as monoculture in pond based system, CIBA has taken up research programmes to develop captive stock of grey mullet *Mugil cephalus* and to standardize the breeding, larval rearing and seed production protocols. It is reported that tank based captive stock of *M. cephalus* was successfully induced bred through hormone treatment. Female grey mullet had oocyte diameter of above 500 μm were initially administered with carp pituitary extracts as priming dose and after 24 hrs injected with LHRHa as resolving dose The female fish was subjected to stripping and the eggs were fertilized with milt obtained from three males. The fertilized eggs were washed three times with fresh filtered sea water and incubated in two 500 l FRP tanks. Good floating eggs were separated and transferred to hatching tanks of 1.2 t and 6.8 t capacity. Eggs hatched after about 29 h at water temperatures of 25-29°C. The total length of the newly hatched larvae was about 1.96 mm. Mouth opening was observed after 48 h post hatch. Small sized rotifer (*Brachionus plicatilis*) and *Nannochloropsis* sp were provided before the mouth opening stage and continued every day. Mullet larvae were slowly weaned to take *Artemia* nauplii from Day 12 and micro particulate feed (100-300 μ) from Day 18. Larval rearing phase extends up to Day 35, post hatch, and the larvae measured 1.0-1.5 cm in length at 35 DPH. After Day 30, the fry were fed only dry commercial feed particles (CIBA Annual Report 2007-2008). Further trails in CIBA are under progress to standardize the breeding and seed production technology for Grey mullet *Mugil cephalus*.

Cobia *Rachycentron canadum* is a fast growing candidate species suitable for farming in cages. It is stated that CIBA has developed pond based captive stock at Muttukkadu experimental station. Induced breeding trials using matured females and oozing males through hormone administration such as HCG and LHRHa were also reported (CIBA Annual Report, 2010-11). Cobia larvae can be reared by initially feeding with rotifer, followed by *Artemia* nuaplii and formulated diet in fry stages. Recently, Cobia juveniles (50g) produced in CIBA has been handed over to farmers for grow out culture.

Wild caught juveniles of brown spotted grouper *Epinephelus tauvina* stocked in a stationary net cage installed in the brackishwater pond @ 6 nos/m^2 with an initial mean total length of 143 mm and mean body weight of 43.6g attained mean total length and mean body weight of 365mm and 618g respectively after seven months culture period has been reported (Kailasam *et al*., 2008). Biswas *et al.,* (2012) have described that increasing the stocking density of pearlspot *Etroplus suratensis* from 150 to 450 fish/m^3 significantly decreased the growth (average body weight and total length), daily weight gain, specific growth rate and survival and increased the feed conversion ratio. Further stated that significantly lower growth and survival were observed in treatment having soil base compared with that of without soil base and suggests that stocking density of 150 no/m^3 without soil base in tanks would be appropriate for raising pearlspot fingerlings in brackishwater indoor seed rearing system. Biswas *et al.,* (2011) have compared the production and economic performance of two polyculture systems with different species combinations in brackishwater tide-fed ponds and concluded that polyculture system would be viable and suitable farming options.

7. CMFRI

Central Marine Fisheries Research Institute (CMFRI) has made a breakthrough in breeding and seed production of Cobia *Rachycentron canadum* in its Mandapam Regional centre, Tamil Nadu. The broodstock cobia developed in cages was induced to spawn through hormone and seed production achieved. Cage culture of Cobia has been under taken in Karwar. The silver pompano, *Trachynotus blochii* an another important species for pond as well as cage culture also bred and seed produced by CMFRI in Mandapam (Abdul Nazar *et al*., 2012). The silver Pompano is also able to grow under low saline conditions and CMFRI demonstrated the culture in Andhra Pradesh. The FCR is reported as 1:1.8 and attained the weight of 450-550 g in eight months period. Culture of seabass in Sea cages has been also demonstrated near Kovalam, Chennai by CMFRI.

8. RGCA

Rajiv Gandhi Centre for Aquaculture (RGCA), Sirkali has also having the seabass hatchery facility in Tamil Nadu at Thoduvai village near Sirkali, and the seed produced here are supplied to the farmers for the culture practices. RGCA has conducted culture of seabass in pond based cages at their farm site, Karaikal, Puducherry. Breeding and seed production of Tiger grouper *Epinephelues fuscoguttatus* and cage farming of this species were also reported from Andaman waters. In Vizhinjam, Kerala, culture demonstration of Cobia *Rachycentron canadum* in sea cages by stocking the hatchery produced seed was conducted by RGCA.

9. OTHER INSTITUTES

Demonstration on the culture of pearlspot *Etroplus suratensis* was performed by the Kerala Agricultural University and training also provided by them for the self help groups.

10. TECHNICAL CONSTRAINTS AND WAYS TO ADDRESS THEM

Potential of brackishwater finfish farming in terms of availability of area, suitable species in India is very high. However, there are certain issues which are to be addressed effectively in order to promote large scale commercial production. Development of quality and viable fish broodstocks, holding facility and technology for year round seed production are some of the critical factors, which need to be evaluated. The approach towards multi-species seed production, which involves the establishment of location specific fish broodstock banks, hatchery facilities and multiple fish seed rearing centres, would help the adequate supply of fish species for the farmers need. Disease free brooders with good fecundity and quality eggs are always linked with the supply of broodstock diets incorporated with required nutritive value and proper maintenance. Adoption of RAS (Recirculation Aquaculture system) not only would help maintaining optimal water quality but also keep the fish free from external infestation. Availability and supply of appropriate live feeds to fish larvae would increase the early larval survival rate. Development of indigenous formulated fish larval diets, which not only enhancing the growth but also maintaining better water quality is needed. Establishment of nucleus fish seed rearing centres in various places would cater the stock size seed requirement, which would promote the large scale farming practices.

11. MARKET CONSTRAINTS AND WAYS TO ADDRESS THEM

The domestic fish demand is estimated to be growing at 2.3 % per annum in India. With bulging population, the aquaculture production is the most likely supplier for domestic food fish demand.

Table 2. Domestic fish demand and supply in India and growth rates

Parameter	1973	1997	Annual growth rate
Per capita fish consumption (kg/year)	3.1	4.7	2.3
Total production	1.7	2.9	2.8
Total aquaculture production	0.2	1.9	9.6

Estimates as made by Delgado *et al.,* (2003)

While the expensive shrimps are diverted for exports and low value fin fishes are consumed locally, the economic growth and increasing purchasing power of average Indian consumer may absorb a part of expensive items like shrimps produced in the country. Many times fish availability is inadequate in domestic markets. For example, demand for Seabass is observed high in east coast states of West Bengal & Orissa, Metros of Kolkata, and Bangalore & Mumbai (with Bengali migrant population) and to some extent in Chennai. A total domestic demand of 20,000 tonnes was estimated at the maximum level for Asian seabass (Ravisankar, 2011). Indian seabass catch is around 150 to 200 tonnes during 2007 and 2008 as estimated by CMFRI, though the actual catch may be slightly higher, as data for West Bengal and Gujarat are not available. India traditionally produces very small quantity-may be less than 100 tonnes- of seabass from traditional mono and poly culture systems. The total seabass supply to Indian consumer in any case may not exceed 1000 to 2000 t per year currently.

Many of the fin fish species have longer culture period extending beyond 6 months, which needs to be reduced by developing commercial nurseries. Technology refinement on sequential stocking and staggered harvest of seabass for size of 1 kg or more for urban domestic markets is needed. Technology should be developed for sequential harvest of seabass for selected size class say more than 1 kg. Production cycle should be synchronized with fishing ban period when price of fish is higher in domestic markets.

12. POLICY INITIATIVES FOR PROMOTING BRACKISHWATER FIN FISH FARMING

While the research institutes can focus on solving technical constraints as discussed earlier, other development agencies like MPEDA, NFDB and State Fisheries Departments can initiate supportive policy options to promote fin fish farming in India. A few of the available policy options are listed below:

- About 10 to 15 multi species fin fish hatcheries could be promoted in Coastal States either by public sector or in Public Private Partnership (PPP) mode providing subsidy backup for an initial period of two years.
- Feed mills with extruders could be promoted to produce sufficient quantity of cheaper fin fish feed.
- Finfish farming could be intensified in traditional shrimp farming areas of West Bengal and Odisha.
- Shrimp ponds in disuse as estimated to be around 40000 ha in Andhra Pradesh, Odisha, Kerala and Tamil Nadu states should be urgently rehabilitated.
- Mini cold storage facilities 10 to 20 tonnes fish capacity may be established in farming areas under the control of farmers' associations for storing and releasing the fish to domestic markets in sequential manner.
- NFDB should delink subsidy from bank credit , alternatively NFDB should promote seabass culture under contract farming by private agencies or by State Fisheries Development corporations
- MPEDA may facilitate live fish export to ASEAN countries for better market price through air/sea.
- MPEDA may explore new export markets in European union where large market exists for whole fish and fish fillets.

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