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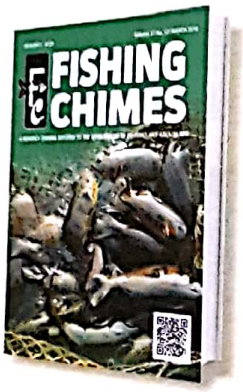

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A diverse fish basket is essential for sustainable aquaculture. In the article titled "Alternative Marine FinFish Species for Coastal and Open Sea Aquaculture in India - Current Status and Challenges", the authors list the potential species for commercialisation and the current status of Indian research in the area... page 18

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38th Year of Publication

Alternative Marine Finfish Species for Coastal and Open Sea Aquaculture in India - *Current Status and Challenges*

***Sekar Megarajan, Ritesh Ranjan, Biji Xavier, Muktha Menon, Loveson Edward, Narasimhulu Sadhu and Subhadeep Ghosh**

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Introduction

Aquaculture is one of the most rapidly growing food producing sectors in the world with a potential to meet the ever-growing demand for food and nutrition. Aquaculture production had reached 66.6 million tonnes in 2012 (FAO, 2014) and continues to grow every year. The world food fish aquaculture production has expanded at an average annual rate of 6.2% during 2000 - 2012. The Indian aquaculture scenario too mirrors the global picture, with an annual growth rate of 6-7% in the last two decades. This has made India the second largest producer of farmed fish in the world after China.

India has transformed an extensive system of aquaculture into an intensive and commercial enterprise in the last three decades. Currently, both freshwater and coastal areas are utilised for aquaculture purposes, with freshwater aquaculture contributing a major portion in the total production in India (FAO, 2014).

Global status of coastal and offshore mariculture

Global food fish production from inland aquaculture and mariculture were at the same level of 2.35 million tonnes in 1980. Subsequently, the growth of inland aquaculture has surpassed that of mariculture with an average annual growth rate of 9.2% (FAO, 2014). The total production in fish culture in 2012 was 66.6 million tonnes, which included 44.15, 6.45, 15.17 & 0.865 million tonnes of finfish, crustaceans, molluscs and other species, respectively. In the total production, the contribution by mariculture operations is 24.687 million tonnes (37.05%) including 5.55, 3.92, 14.88 & 0.34 million tonnes from finfish (22.48%), crustaceans, molluscs (60.15%) and other species, respectively. There are more than 20,000 listed finfish species available in the world, and it is estimated that around 350 marine finfish species are cultured worldwide for production using variety of farming systems and technology in freshwater, brackishwater & marine waters (FAO, 2014).

Marine aquaculture all over the world has been showing a steady increase in production of main species like marine plants (macroalgae) and molluscs in the recent decades, whereas finfish species show a slower rate of increase. Some of the important species farmed in marine and brackishwater areas are Atlantic salmon, Japanese amberjack, gilthead seabream, European seabass, large yellow croaker, rainbow trout, coho salmon, Japanese seabass, milk fish and silver bream. Among these, Atlantic salmon (*Salmo salar*) had contributed 40% and rainbow trout (*Oncorhynchus mykiss*) accounted to 8-10% of the farmed finfish in 2010.

Production is limited in case of several tropical marine finfish species including gropers and snappers and other species with high unit values. Marine finfish farming is mostly carried out in temperate waters along southern coasts. It is relatively new in tropical waters, with its expansion taking place steadily in the Asia-Pacific region on a commercial scale, with a total production of 2,556,553 MT in 2012. The commonly cultivable brackish and marine species/group in the Asia-Pacific region includes milk fish, sea bass, jacks, sea bream, flat fish, groupers, cobia, mullets, snappers, pompanos and other species such as eels, croakers & drums. Among these, most of the species are available in Indian seas, and they can be domesticated and could be cultured in the country.

The factors that play a role in the selection of candidate species for marine and brackishwater aquaculture include:

- Biological and behavioural adaptability to farm conditions
- Consumer preference
- Tolerance to farming conditions including handling and crowding

The major categories of mariculture species: *Seaweeds, molluscs (clams, oysters, abalone, scallops, and mussels), crustaceans (shrimp, crabs, lobsters, and crayfish), and finfish (FAO, 2014).*

Major players in mariculture: *China, India, Vietnam, Indonesia, Bangladesh, Norway, Thailand, Chile, Egypt, Myanmar, Philippines, Brazil, Japan, Republic of Korea & the United States of America (FAO, 2014).*

Norway - Exclusively finfish mariculture (mainly the cage culture of Atlantic salmon)

Chile - Finfish (mainly Atlantic salmon) and molluscs (mostly mussels)

Japan, Republic Korea - Marine molluscs (50% of food fish production), finfish production (mostly via marine cage culture)

Thailand - Crustaceans (50% of production, mostly of internationally traded marine shrimp species) Indonesia - Relatively large proportion of finfish production, which depends primarily on coastal brackish-water ponds.

Philippines - Finfish production is comparatively more than that of crustaceans and molluscs especially that of milkfish culture in marine cages and brackishwater ponds.

China - Finfish mariculture sector is comparatively weaker than the freshwater finfish sector (4.4% of the total finfish cultured)

- Acceptance for artificial feed
- Natural resistance to parasites and diseases
- Ready availability of seeds either from hatcheries or natural sources
- Faster growth rate
- Good meat quality (FAO, 2010).

Considering all the mentioned factors, few species of different varieties are found suitable for onshore and offshore culture in tropical marine waters.

Coastal Aquaculture in India

India is blessed with an umpteen number of mariculture resources that includes 8129 km of coastline, 2.2 million km^2 of Exclusive Economic Zone (EEZ) with 0.5 million km^2 of continental self, 1.2 million ha of brackishwater area, 8.5 million ha of inland saline area and 20 million ha for sea farming, etc (Modayil *et al.*, 2008). Coastal aquaculture has been prevalent in the low lying coastal areas such as *pokkali* fields of Kerala, *bheries* of West Bengal, *gazani* farms of Karnataka and *khazan* lands of Goa. These are the natural systems, operated with the tidal resources of water as well as natural supply of organisms, with different production capacities (Kutty, 1999).

Coastal aquaculture was initially practised in an extensive manner without proper regulation of inputs like feed, seed and fertilisers until 1973, when the Government of India took an initiative to improve the fish production system of the country by establishing an experimental brackishwater fish farm at Kakdwip, West Bengal by the Central Inland Fisheries Research Institute (CIFRI), under the Indian Council of Agricultural Research (ICAR). This was followed by an All-India Coordinated Research Project on brackishwater fish farming in 1975 by the ICAR with centres in West Bengal, Odisha, Andhra Pradesh, Tamil Nadu, Kerala and Goa in a research mode (FAO, 2000). Simultaneously, shrimp seed production studies were initiated in Narakkal, near Kochi, Kerala, by CMFRI. A major shift in shrimp farming took place during 1988-1989 with the establishment of commercial shrimp hatcheries by the Marine Products Export Development Authority (MPEDA). This changed the face of Indian coastal aquaculture (FAO, 2000). When entrepreneurs came to understand the lucrative returns through shrimp culture, they initiated scientific coastal farming in the early 1990s. Since then, shrimp farming has grown tremendously to such an extent that coastal aquaculture in India is dominated by the shrimp culture industry. At present, the estimated area under operation in shrimp farming is around 1.6 million ha. More than 500 hatcheries operate to cater to the needs of these farms.

In spite of extensive mariculture resources, India is still at the initial stage in mariculture production when compared to the global scenario. In 2012, fish production from mariculture was around 84,164 tonnes, which was 1.2% & 2.2% of the total aquaculture production and cultured finfish production in India and 1.5% of marine cultured finfish production from world (FAO, 2014). At present, in India only 13% of total available potential area is under coastal aquaculture operation, producing around 1.5 lakh tonnes of shrimp annually. The other aquatic animals which contribute to production from mariculture include mussels, edible oysters and to a lesser extent marine finfish.

Though shrimp farming has shown phenomenal growth, the sector is confronted with several issues like diseases, high production costs, environmental pollution and frequent price slump in international market. Existence of frequent problems in shrimp culture has led to questions on the sustainability of the industry as it is solely dependent on a single resource group i.e., shrimp. Therefore, to conduct sustainable and eco-friendly coastal aquaculture operations, species diversification is seen as one of the important components by different stakeholders.

The Central Marine Fisheries Research Institute (CMFRI) had initiated breeding and culture technologies for several marine organisms like mussels, clam, oyster and sea cucumber. However, some of these technologies became localised and restricted to small-scale activities in few states like Kerala, Tamil Nadu and Karnataka instead of spreading to all maritime states. Several fisheries research institutions like CMFRI, CIBA (Central Institute of Brackishwater Aquaculture) and RGCA (Rajiv Gandhi Centre for Aquaculture) have been striving to breed and culture several high value marine finfish. Species like seabass, cobia, silver pompano have been successfully developed and demonstration programmes have also been conducted in different maritime states. After their viability has been exhibited to the stakeholders, several farmers and fishermen welfare societies have taken up the culture of these species using hatchery produced and wild collected seeds.

Open sea cage culture for marine finfish species has been initiated in 2007 in India. The technology has been successfully demonstrated to fish farmers in most of the Indian maritime states under research and development mode. Species like sea bass, mangrove red snapper, pearl spot, mullet, cobia and silver pompano were used for culture at various centres of CMFRI with varying degrees of success. However, the significant progress in cage culture by CMFRI has convinced several government organisations, entrepreneurs and farmers to come forward and venture into cage farming using hatchery produced and locally available seed. The seed of several potentially cultivable marine finfish candidate species like rabbit fish, sea bass, groupers, snappers, pompanos, sea bream, mahi mahi, Indian halibut, mullet, milk fish and pomfret, etc are available in the wild. Though the culture of promising fish species like sea bass, grouper, grey mullet, pearl-spot and milk fish has been initiated, but they have not been commercially exploited till date.

Species diversification in India

Coastal aquaculture in India is mainly confined to brackishwater shrimp culture and marine finfish culture is yet to be taken up on a large scale.

In this scenario, diversification of marine finfish species would enhance marine fish production to meet the burgeoning demand of the growing population. The concept of species diversification in different parts of

the world has led to the introduction and culture of new species for the domestic and international markets. This is evident from the reports of the several newly introduced species and their production in different countries (Abellan & Basuco, 1999).

In the recent years, a number of studies have been carried out to introduce new species for mariculture. Some of these studies have proposed and used different selection methods for species selection; one of the most effective methods being the one proposed by Le Francois *et al.*, (2002)for the Province of Quebec, Canada.

Most of these methods have suggested that the criteria viz. culture potential, adaptation potential to environment, growing out potential, rearing potential, yield potential, appearance of the animal, flesh quality & consumer preference have to be analysed for selecting a species for diversification. In addition to the biological criteria, the particular species also needs to be examined for their price and acceptance in domestic and international markets in order to ensure its feasibility. Once a species is successfully established in the market, it may lead to increase in the cultured fish production, leading to surplus availability of cultured fish for consumers and economic empowerment of people involved in aquaculture and allied sectors. In India, however, the breeding and culture technology is available for a few selected species at present. Hence, there is a need to increase the number of species to enhance production through culture. India, with its available resources and technology like vast potential areas, seed resources, technology for breeding and seed production of finfish, research and development institutions, financing and supporting agencies and established market channels for fish marketing has huge scope for species diversification of marine finfish. All the aforementioned factors could be helpful for enhancing mariculture production, if combined together.

Stages from species selection to end user

There are different stages through which a selected species reaches the end user. These are as follows:

Stage 1: Preliminary search for species selection

This stage involves focusing on market search (price, demand in local and international market and their distribution, capture fisheries production, etc); Biological characters (growth rate, fecundity, size/age at maturation, etc) & habitat characteristics (ecological characters, feeding, etc).

Stage 2: Scientific and technical studies/Research and development phase

At this stage a study is carried out under the confined environment of a laboratory with a focus on possibility of brooder development, maturation, spawning in confined environment. Optimum culture environment for larval, post larval and grow out culture feed and disease management.

Stage 3: Pilot scale feasibility study for commercial production & Technology transfer

Culture of the species is undertaken in different culture systems, rate of seed stocking density, feed conversion ratio, survival and cost of production are all identified

Stage 4: Commercial scale production trials to predict market demands.

Stage 5: Technological transference of the best production process to the end user (Quemener et al., 2002).

Factors that influence species diversification

a) *Potential area for culture:*India is endowed with vast brackishwater areas (around 1.2 to 1.4 million ha) along the coastline which offer ideal conditions for sea farming and coastal mariculture (Pillai *et al.,* 2003). Presently, around 150,000 ha area is under farming, with the principal crop being marine shrimp. The rest of the coastal tracts remains under-utilised. These areas could very well be used for onshore coastal aquaculture using coastal earthen ponds for finfish as practised in most of the South East Asian countries. Off shore mariculture activities using cage culture technologies is also being practised in most of these South East Asian countries and Norway. India can also utilise its 8129 km of coastal line with 0.5 million sq.km of continental shelf for offshore mariculture activities.

b) *Fish culture technology:* Culture technologies for several finfish species have been standardised in India with many more on the way. Recently, culture of species like sea bass, silver pompano in ponds & cages and cobia in cages have been taken up by several welfare societies and individual farmers in addition to the demonstration programmes by the government research institutions. This has shown encouraging results leading to further expansion of fish culture in India. In addition, a number of experiments on culture of marine/brackishwater fish have been conducted by CMFRI since 1960s. The CMFRI has been using seed collected from the wild for coastal pond culture of milkfish and grey mullet at their Mandapam, Tuticorin, Calicut, Narakkal and Mangalore research centres since the 1970s and has made significant achievements (Gopakumar, 2009). Recently, cage culture of rabbit fish (*Siganus canniculatus* & *S. javus*), groupers (*Epinephelus coioides*, *E. hecxagonatus* & *E. malabaricus*), sand whiting (*Sillago sihama*), mangrove red snapper (*Lutjanus argetimaculatus*) & shrimp scad (*Alepes djedaba*) were also cultured in experimental cages in both west and east coasts by CMFRI using wild collected seeds. These studies have shown encouraging results which paves the way for marine fish farming of diversified species on a commercial scale in the near future.

c) *Seed production:* One of the major bottlenecks for any large-scale venture in marine finfish farming is the dearth of commercially produced seed. The availability of wild seed is often unpredictable and hence farming based on seed collected from the wild may not be sustainable over a long term. This led to the need for production of marine finfish seed on a commercial scale. The Indian research institutions initiated and standardised seed production technology for important high value finfish like cobia, silver pompano and sea bass.

The CMFRI has succeeded in the seed production of cobia and silver pompano, orange spotted grouper (*Epinephelus coioides*) and Indian pompano (*Trachinotus mookalee*), whereas CIBA has done the same in case of sea bass and milk fish and RGCA (Rajiv Gandhi Centre for Aquaculture) on tiger grouper (*Epinephelus fuscoguttatus*) in the past two decades. The seed of cobia and silver pompano are being produced on a large scale by CMFRI to supply to the farmers, societies and research institutions for grow out culture demonstrations. CIBA has been commercially producing the seed of sea bass for research purposes and also for commercial culture activities. However, large scale seed production of milk fish is yet to be standardised. Presently, sea bass and cobia seed are commercially produced by RGCA for commercial farming of the species in India, but seed production of tiger grouper is yet to be further standardised. In addition, other finfish species like snappers (*Lutjanus argentimaculatus* & *L. johni*), caranx (*Caranx ignobilis*), mullet (Mugil sp) etc, have been selected for seed production. CMFRI has standardised the brood stock development for these species. Recently, the National Fisheries Development Board (NFDB) has sanctioned a private Asian sea bass seed production unit at Urlagonditippa village in Krishna District, Andhra Pradesh, with the aim to enhance marine finfish seed production in India. Besides, research institutions like CMFRI & CIBA have signed MoU with several individual farmers and firms for knowledge partnership for breeding and culture of marine finfish.

d) *Research and development institutions:* Autonomous research institutions like CMFRI and CIBA under Indian Council of Agricultural Research (ICAR), New Delhi cater to the needs of mariculture and brackishwater aquaculture research activities in India, respectively. In addition, fisheries colleges under state agriculture or fisheries universities are equally contributing to the development of these sectors. RGCA is a technology development centre under Marine Product Export Development Agency (MPEDA) for sustainable development of aquaculture. In addition, there are about 642 Krishi Vigyan Kendras (KVK), operated through state agricultural universities (SAUs), ICAR Research Institutes and non-governmental organisations (NGOs) in the country. It conducts on-field testing and front line demonstrations of different technologies developed by the research institutions. They also undertake aquaculture development within their scope of activities (http://www.icar.org.in/en/KVK). The Coastal Aquaculture Authority (CAA), Chennai has been established to regulate the activities connected to coastal aquaculture, to protect the livelihood of various sections of people and also to maintain the sustainability of aquaculture in the coastal areas (http://www.caa.gov.in). The MPEDA, Cochin, under Ministry of Commerce, contributes towards the promotion of coastal aquaculture besides its role in the export of aquatic products (www.mpeda.org.in). These organisations are directly related to mariculture/coastal aquaculture development activities in India. In addition, there are several government and non-government organisations involved in the sector.

Fig 2: Orange Spotted Grouper

e) *Financing and other support agencies:* National Bank for Agriculture and Rural Development (NABARD) extends help in fisheries development activities by assisting in pilot scale demonstration of mariculture technologies under its research and development grant scheme and also encourages commercial scale projects through its refinance mechanism (Kumar *et al.*, 2008). In addition, the NFDB, Hyderabad supports mariculture activities by providing training to the needy people, granting subsidies for facilitating mariculture activities like establishing finfish seed production hatcheries, setting up open sea cage culture facilities and demonstration programmes to teach modern sea cage culture to traditional fishermen and other agencies. MPEDA also extends financial support/subsidies for hatchery development, new farm development to farmers for promotion of aquaculture.

f) *Marketing:* Fish production is highly dependent on the growth and development of demand driven domestic and international markets. In India, marine fish marketing channels have been well-established, and it has achieved tremendous development over the years by maintaining quality standards at international level (Joseph & Sathiadhas, 2006). The export of marine products has steadily grown over the years from a mere Rs 3.92 crores in 1961-62 to Rs 16,597.23 crores in 2011-12 (www.mpeda.org.in). This has been achieved with the establishment of several modern processing plants and development of infrastructural facilities along the coast, which helps in catering to the needs of the lucrative foreign markets (Joseph & Sathiadhas, 2006).

However, marketing system in the domestic scene needs to be worked upon to make it better organised. For this, several organisations have been established at the national level to promote the fisheries sector and help the fishermen. These organisations which include the National Cooperative Development Corporation (NCDC), the National Federation of Fishermen's Cooperatives Ltd. (FISHCOPFED) and the National Fisheries Development Board (Kumar *et al.*, 2008) assist fishermen to market their produce efficiently through hygienic retail fish centres in metropolitan cities. This enables the fish farmers to get remunerative prices for their produce. NFDB is also promoting domestic fish marketing through modernisation of wholesale markets, establishment of cold chains, popularisation of hygienic retail outlets and technology upgradation.

Fish marketing is thus moving towards greater efficiency, more so with the on-going species diversification.

Fig 3: Indian Pompano

Prospects of finfish mariculture and challenges in species diversification

Although marine finfish culture has long been practiced in India, its full potential is yet to be realised. The underlying factors that influence the growth of marine finfish culture is as follows:

a) *Hatchery produced fish seed:* One of the major bottlenecks in large scale finfish farming is the lack of availability of hatchery produced seed on a commercial scale. Marine finfish seed production is comparatively a complicated affair than freshwater fish and shrimp seed owing to the lengthy larval cycle and low survival rate. This restrains farmers and aqua-entrepreneurs from venturing into fish seed production. Understandably, several R&D organisations are frequently conducting training programmes which may help private entrepreneurs from foraying into hatchery seed production.

Nowadays, many countries like Taiwan, Thailand, Phillipines, Indonesia and Malaysia, etc., are developing the technology for hatchery seed production of several tropical marine finfish as a sustainable source of the seed. However, efficient way of transferring these hatchery

technologies to other countries remains an issue.

In addition, the efficient utilisation of available marine and brackishwater fish seed in the wild would help in species diversity and to enhance production. Recently, the CMFRI under the All India Network Project (AINP) on mariculture has taken the initiative of preparing a calender of marine finfish based on species availability, location and seasonality. This would help in drawing up a picture of available seed resources in the country and may help in culture programmes in future.

b) *Feed:* Feed is another leading constraint in marine finfish production, the major source being the trash fish that act as feed for the high value marine finfish (Yanamoto, 2006). With the depleting source of trash fish, artificial feeds have become an alternative. However, usage of artificial feed is limited due to its cost, availability, performance and other issues.

Recently, one of the Indian companies (Growel feed) has introduced sinking and floating feeds suitable for cobia, Indian pompano and sea bass. Initial demonstration of the feeds in several locations showed encouraging results and thereafter, the feed is being commercially used. Similarly, many Indian feed companies may come up with different feeds for marine finfish as it happened in case of shrimps.

c) *Consumer market :* Initially, the coastal population within the vicinity of 50 km from the coast was the main target group for marine fish consumption and the most popular varieties were the low cost ones like anchovy, sardines, barracuda and trevally, etc. However, in recent years, fish consumption in India has increased significantly due to lifestyle changes and higher cost of meat (Salim, 2014). In addition, the perception of fish as a healthy food with high levels of easily digestible protein, PUFA and cholesterol lowering capability has helped in its increased consumption. A study conducted in 2014 (Salim, 2014) showed that 35.3% of the consumers were willing to consume high-value fish at greater frequency if they are available and 70.8% felt that high value fish ought to be more available in the market for consumption. This shows the amount of scope present in the domestic and international market for finfish.

d) *Practical demonstrations:* The knowledge gap produced due to the lack of practical demonstrations of large scale farming systems like open sea cage culture and pond culture of finfish is being filled in by CMFRI's efforts in developing and installing open sea cages in different maritime states with different species. In addition to this, pond culture of finfish are also being demonstrated by CMFRI, CIBA and RGCA. These demonstrations have brought these technologies to the various stakeholders of the sector. As a result of this, pond culture of sea bass has been taken up by several fish farmers using wild collected and hatchery produced seeds in Indian states like, Andhra Pradesh, Tamil Nadu, Maharashtra, West Bengal & Kerala (Kandan, 2015).The silver pompano culture in pond is also being taken up by the different farmers from Andhra Pradesh, Tamil Nadu, Kerala, West Bengal, Gujarat using hatchery produced seeds (cmfri.org.in). These demonstrations have boosted the confidence of several farmers and aqua-entrepreneurs in venturing into finfish culture with diversified species.

Conclusion

There is a lot of scope in mariculture development in India through species diversification and understanding the role of mariculture in food security and income generation. The Government of India has taken several initiatives to boost this sector; the All India Network Project on Maricultue (AINP-M) funded by ICAR, the All India Coordinated Research Project (AICRP) on composite culture of Indian and exotic fish and AICRP on brackishwater fish farming to name a few. Apart from this, the combined effort of the aqua-entrepreneurs, R&D institutions and other allied agencies would make it possible to venture into marine finfish species diversification and enhance fish production. However, the disadvantages also have to be worked upon; possibility of spreading disease to the existing species, impact of effluents being released into the environment from the farms, competition between the new and existing species to name a few. Thus due care is to be taken by all the stakeholders in the sector for its sustainable development.

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Table 1: Important Candidate Species for Offshore and OnShore Mariculture

Species/group	Important characteristics
Milk fish (*Chanos chanos*)	• Omnivorous;Fast growth in both pond and sea cages • Seed available from the wild • High tolerance capacity to salinity fluctuations in culture system
Mullet ; (Main species: *Mugil cephalus* & *Liza vaigiensis*)	• Medium growth rate • Tolerance towards different water quality parameters • Suitable for cage and pond farming • Seed availability more in wild;Candidate fish for food security in low and middle income group
Sea bass;(Main species: Barramundi (*Lates calcarifer*) & Japanese sea bass (*Lateolabrax japonicus*))	• Faster growth rate • Suitable for cage and pond culture • High tolerance to salinity variations (freshwater to marine culture) • Well adopted hatchery technology • Easily acceptable for artificial feed
Cobia (*Rachycentron canadum*)	• Rapid growth rate (6–7 kg in 1 year) • Suitable for high-density cage culture • Well adopted hatchery technology; Easy to culture
Groupers (sub family Epinephelinae) ; (Diverse group of fish with a number of different species)	• High price in the live fish market • Suitable for cage and pond culture • Relatively faster growth rate for most of the species in this group • Hardy and easy to handle
Snappers Main species: mangrove red snapper (*Lutjanus argentimaculatus*),John's snapper (*Lutjanus johnii*) & Russell's snapper (*Lutjanus russelli*)	• Highly valued fish for both export and local markets • Suitable for cage culture • High to moderate growth • Hardy fish & tolerant to different water quality parameters
Asian or silver Pompano (Trachinotus blochii)	• Optimum growth • Suitable for intensive hatchery production • High retail price • Easily acclimatised to different ranges of salinity • Well adapted to artificial feed
Jacks; Major species: ; Japanese amberjack (*Seriola quinqueradiata*), golden trevally, white trevally and greater amberjack).	• Faster growth rate • Suitable for intensive hatchery production • High retail price; Easily acclimatised to different ranges of salinity • Well adapted to artificial feed
Seabream and porgies Major species: Blackhead seabream (*Acanthopagrus schlegeli*) & Silver seabream (*Pagrus auratus*).	• Faster growth rate • Hardy and tolerant to different water quality parameters • Well adapted to artificial feed

Major producers	Technology	Production
Indonesia, Taiwan Province of China , Philippines and Pacific islands.	**Culture**: Pond, pen & cage culture; **Seed production**: Captive breeding and standardised mass scale seed production	872,184 tonnes in 2012; Indonesia (major producer (482,930 tonnes) in 2012) and Philippines are traditionally the largest producers.
Indonesia, Republic of Korea, Taiwan Province of China & Singapore.	**Culture:** Pond, enclosures including cages.; **Seed production:** Full-scale commercial production not yet started. Induced spawning and production of fry has been achieved on experimental and semi-commercial basis.	13,890 tonnes in 2012; Indonesia – major producer with 6,547 tonnes.
Indonesia, Malaysia and Taiwan Province of China.	**Culture:** Pond, pen & cage culture.; **Seed production**: Seed production technology is well established.	185,073 tonnes in 2012 China is the major producer of Japanese sea bass (125,836 tonnes) & Malaysia is the major producer of barramundi (20,089 tonnes)
China, Taiwan Province of China, Bahamas, Belize, the Dominican Republic, Mexico, Philippines and Vietnam.	**Culture:** Near shore and offshore cages.; **Seed Production:** Seed production technology is well established	41,399 tonnes (2012) China – major producer: 37,210 tonnes.
China, Indonesia, Malaysia, Thailand, Taiwan and the Philippines.	**Culture:** Pond & cage culture;Seed production: **Seed production** technology is well established but has low survival rate	118,039 tonnes (2012)
Malaysia , Cambodia, Brunei, Darussalam, Hong Kong SAR, Singapore and the Philippines.	**Culture:** Pond & cage culture; **Seed production:**Seed production technology is not commercially established	7,283 tonnes (2012)
China, Taiwan, Indonesia, Vietnam, Malaysia & India.	**Culture method:** Cages and pond; **Seed Production:** Seed production technology is well established	110,000 tonnes (2011)
Japan and Republic of Korea.	**Culture:** Cage culture, pens & ponds; **Seed Production:**Seed production is standardised	177,909 tonnes (2012); Japan – major producer (160,215 tonnes)
Japan, China and Republic of Korea & Taiwan.	**Culture:** Cage culture, & ponds; **Seed Production**:Seed production is standardised	115,300 tonnes in 2012 Blackhead seabream : Japan was the major producer (56,653 tonnes in 2012); Silver seabream: China was the major producer52,328 tonnes) in 2012

CONTD...

Species/group	Important characteristics
Flat fish; Major species:; Bastard halibut (*Paralichthys olivaceus*) and turbot (*Psetta maxima*)	• High economic value in North China • Moderate growth rate; Well adapted to artificial feed
Tilapia in marine environments; Major species: Nile tilapia (*Oreochromis niloticus*) and Mozambique tilapia(*Oreochromis mossambicus*)	• Cultured in both fresh and brackish marine environment but are mainly freshwater species • Tolerance towards saltwater • Faster growth rate Hardy and tolerant to different water quality parameters.

Source: Modified from Hishamunda *et al.*, 2009 & FAO, 2014

Table 2. Status of marine finfish seed production and culture in India

Species	Organisations Involved	Seed Production		Grow-out Production	
		Research	Production	Research	Production
Asian sea bass (*Lates calcalifer*)	CIBA/ RGCA	✔	✔	✔	✔
Cobia (*Rachycentron canadum*)	CMFRI/ RGCA	✔	✔	✔	✔
Pompano (*Trachinotus blochii*)	CMFRI	✔	✔	✔	✔
Indian pompano (*Trachinotus mookalee*)	CMFRI	✔	✘	✔	✘
Orange spotted Grouper (*Epinephelus coioides*)	CMFRI	✔	✘	✔	✘
Tiger grouper (*E. fuscoguttatus*)	RGCA	✔	✘	✔	✘
Pearl spot (*Etroplus suratensis*)	CMFRI	✔	✔	✔	✔
Milk fish (*Chanos chanos*)	CIBA	✔	✘	✔	✘
Mullet (Mugil spp)	CIBA/ CMFRI	✔	✘	✔	✘

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	Major producers	Technology	Production
	China, Japan & Republic of Korea.	**Culture**: cage culture & ponds; **Seed Production** :Seed production is standardised and commercially produced	106,496 tonnes in 2012;Republic of Korea was the major producer of bastard Halibut (39,371 tonnes) & China produced64,000 tonnes of Turbot in 2012.
	Indonesia, Philippines and Taiwan Province of China.	**Culture:** ponds; **Seed Production:**Seed production is well standardised and commercially produced	64,947 tonnes in 2012; Indonesia (34,134 tonnes of Nile tilapia and 4,968 tonnes of Mozambique tilapia in 2012) and Philippines (10,786 tonnes of Tilapia nei and 3,741 tonnes of Nile tilapia in 2012).

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