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Marine Fisheries Information Service Technical & Extension Series

The Marine Fisheries Information Service, Technical & Extension Series (MFIS) is a quarterly publication of ICAR-Central Marine Fisheries Research Institute disseminating latest research information on marine fisheries and mariculture in India. Research based technical articles, reporting significant new information, knowledge and understanding of marine fisheries and ecosystems as well as new concepts/technologies in marine fish nutrition, hatchery and larval rearing, fish pathology, fish health management, application of genetics in fish conservation and farming, sea farming technologies, seafood trade and fisheries governance are published. To see all issues since 1978, visit:

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Harvest of farmed Indian Pompano ready for transport to markets (photo credits: Sekar Megarajan)

Marine Fisheries Information Service Technical and Extension Series envisages dissemination of information on marine fishery resources based on research results to the planners, industry and fish farmers and transfer of technology from laboratory to the field.

Marine Fisheries Information Service
Technical & Extension Series

From the Editorial Board

Warm greetings to all our esteemed readers

Wild capture fisheries and mariculture contribute substantially to the global seafood trade and is an important contributor to global nutrition security. Due to focussed policies, India's fisheries sector is making rapid strides and increasing contribution to the country's GDP as well as foreign exchange earnings. Enhancing fish production and productivity, developing infrastructure for post-harvest activities as well as critical value chains, implementing effective fisheries management frameworks and substantial measures for fishers' welfare are key areas which are being addressed through central government schemes such as the Pradhan Mantri Matsya Sampada Yojana. This enables meeting the targets of Sustainable Development Goals (SDGs) set out by the United Nations that aim at overall well-being of all nation states. In the present MFIS issue, several contemporary developments in the marine fisheries sector are presented for the benefit of our valued readers.

Marine Fisheries Information Service
Technical & Extension Series

Contents

Research Communications

Status of eel fishery along the Odisha coast

Swatipriyanka Sen[1], Madhumita Das[1], [1]Menaka Das, Gyanaranjan Dash[1], Rajesh Kumar Pradhan[1], Biswajit Dash[1] and Shubhadeep Ghosh[2]

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Abstract

Estimated landings of eels along the Odisha coast during 2007- 2021 ranged from 561 to 5194 tonnes. In 2021, the total eel landings of 1752 tonnes contributed 1.7 % to the total marine fish catch of the state. Multiday trawlers were the major crafts operated for eel resources with highest landings observed during October-December (47.7%) along the Odisha coast. Six species regularly landed during the period were *Anguilla bicolor*, *Muraenesox bagio*, *Muraenesox cinereus*, *Congresox talabon*, *Congresox talabonoides* and *Strophidon sathete* with rare landings of *Gymnothorax* sp. and *Congresox* sp. also recorded. During 2007- 2021, *M. cinereus* (36 %), *M. bagio* (35%), followed by *A. bicolor* (21%), *Congresox* sp. (3%), *C. talabonoides* (3%), *C. talabon* (1%) and *S. sathete* (1%) dominated amongst the eel species landed during all the years. *M. bagio* followed by *S. sathete* were the dominant and targeted species landed at Puri during 2021. The length range for *M. bagio* and *S. sathete* were 95-190 cm and 60-240 cm respectively. The market price is ₹300-350 for *M. bagio* whereas *S. sathete* which comes as bycatch is sold at ₹50-60 per kg in fresh condition.

***Keywords**: east coast, airbladder, sustainability, resource, slender giant moray*

Introduction

Eels belong to the order Anguilliformes comprising of eight suborders of which, Congroidei is the most diverse one having 5 families, 97 genera, and 498 species (McCosker, 2010). Eels are a delicacy food in many countries like China, Japan, Malaysia, Russia, United States and Ukraine and form targeted fisheries of many countries including India, for the high market demand of airbladders. India exports the airbladders of eels to Hong Kong, China, Singapore, Thailand, United Arab Emirates, United States, United Kingdom and Canada. Apart from that, eels are exported as live, dried eel's maws, live aquarium fish, frozen fish to China, Hong Kong, Germany, Vietnam, United States, and United Kingdom from India.

In India, eels are generally prevalent in the southwest coast of Gujarat and Maharashtra and to some extent in the northeastern states of Odisha and Andhra Pradesh (Menon *et al*., 1998). The estimates of landings of eels accessed from the National Marine Fishery Resources Data Centre (NMFDC) of the ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI) showed Karnataka was the top most state in eel landings (4667 tonnes) followed by Andhra Pradesh (2415 tonnes) and Gujarat (2064 tonnes) during 2021 (Fig. 1).

The all India landings of eels were estimated at 15047 tonnes from which the landings of Odisha were 1751 tonnes contributing 8.6% to the all India eel landings. Till date 30 species of eels are known to occur along the Odisha coast. Eels reported to be landed in large quantities along Odisha coast are *Anguilla bicolor* (Indonesian shortfin eel), *Muraenesox bagio* (Common pike conger), *Muraenesox cinereus* (Dagger tooth pike conger), *Congresox talabon*

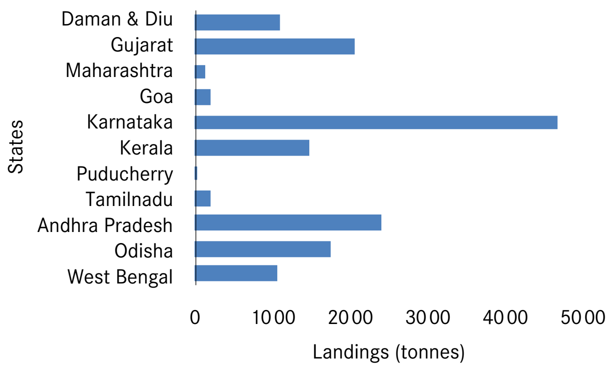

Fig. 1. State- wise landings of eels across India during 2021

(Yellow pike conger), *Congresox talabonoides* (Indian pike conger), *Strophidon sathete* (Slender giant moray) and rare landings of *Congresox* sp. and *Gymnothorax* sp. New species of eel recorded from Odisha are small eye snake eel *Allips concolor* and dark-shouldered snake eel *Ophichthus cephalozona* (Mohanty *et al*., 2020, 2021) and short brown moray eel *Gymnothorax odishi* sp. nov (Mohapatra *et al*., 2018).

Eels contribute significantly to the total demersal landings of Odisha and constitute a targeted fishery in multiday trawl nets, longlines and some other gears. The landings of eels in six different maritime districts i.e., Ganjam, Puri, Jagatshingpur, Kenrapada, Bhadrak and Balasore contribute significantly to the total landings of the state.

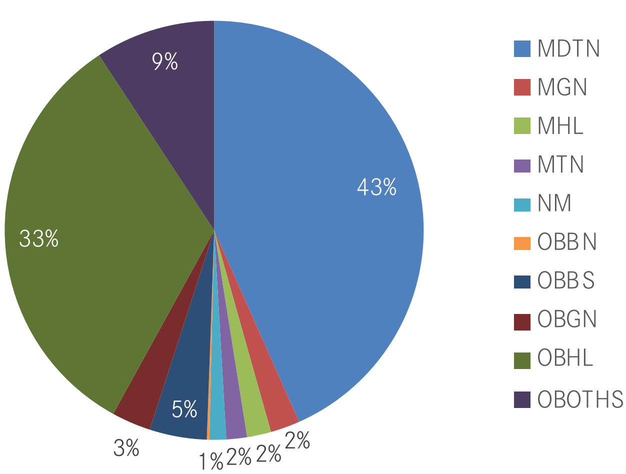

Fig. 2. Gear-wise landings of eels along Odisha coast during 2007-2021(MDTN: mechanized multiday trawl nets, MGN: mechanized gillnets, MHL: mechanized hooks and lines, MTN: mechanized single-day trawl nets, NM: Non-mechanized, OBBN: outerboard bagnet, OBBS: outboard fiberglass bottomset gill nets, OBGN: outboard gillnets, OBHL: outboard hooks and lines, OBOTHS: outboard other units)

The major crafts and gears chiefly employed in eel harvest during 2007- 2021 period in Odisha waters were multiday trawlers (43 %), outboard hook and line (33 %), out board other units (9%), outboard fiberglass bottomset gill nets (5 %), outboard gillnetter (3%), mechanized hook and line (2%) and others (5%) (Fig. 2). During 2007- 2021, *Muraenesox cinereus* (36 %) dominated amongst the eel species landed followed by *Muraenesox bagio* (35 %), *Anguilla bicolor* (21%), *Congresox* sp. (3.4 %), *C. talabonoides* (2.6 %) , *S. sathete* (1 %) and *C. talabon* (1%) and other eel species in a very lesser proportion during all the years (Fig. 3).

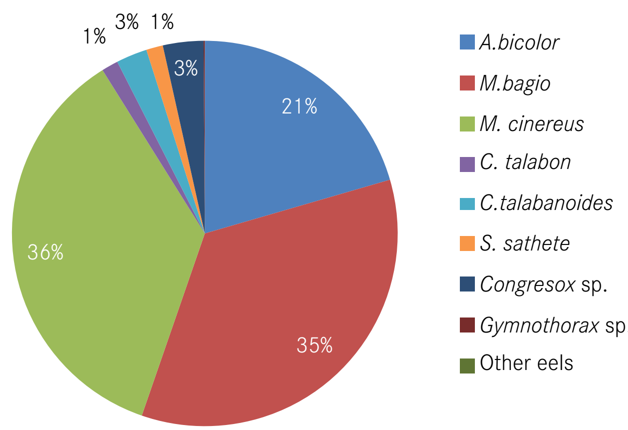

Fig. 3. Species composition of eels along Odisha coast during 2007-2021

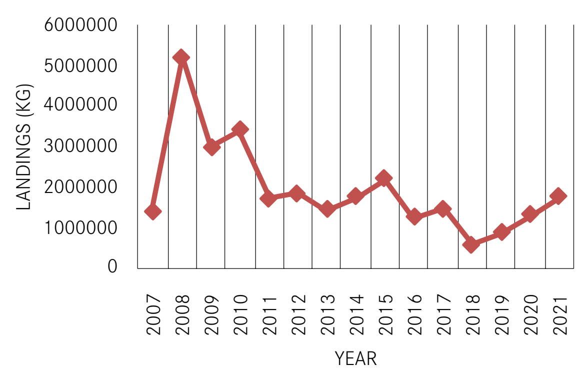

Fig. 4. Landing trends of eels along Odisha coast during 2007-2021

The estimated average annual eel landings during 2007- 2021 were 1189 tonnes and ranged from 561 to 5194 tonnes. The highest landing was recorded in 2008 (5194 tonnes) and the lowest of 561 tonnes in 2018 (Fig. 4). During 2021, the total eel catch was recorded to be 1752 tonnes, showing a 25% increase in landings compared to 2020 and contributing about

1.7 % to the total catch of the state. With an average annual catch per hour of 0.47 kg, the CPUE was 5.5 kg/unit. The highest landings of major eel species landed in 2021 were *Muraenesox bagio* (77.7%), *Strophidon sathete* (8.5%), *Congresox talabonoides* (8%) and *Congresox talabon* (5.8%). The landings were high during October-December, contributing about 813 tonnes (47.7%) followed by 493 tonnes (28.9%) during July-September period. The lowest of 123 tonnes (7.2%) was landed during mechanized fishing ban period (April-June) followed by January-March period (16.1%) along the coast (Fig. 5).

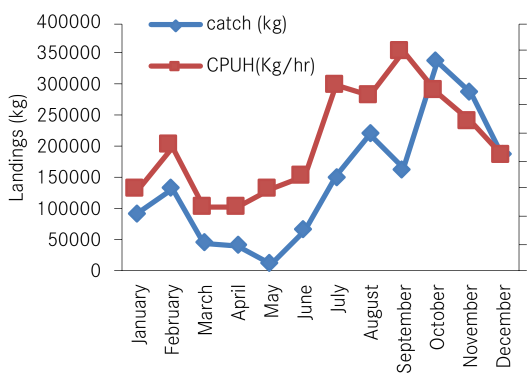

Fig. 5. Catch and effort trend of eels along Odisha coast during 2021

Puri district with the longest coastline (155 km) has eel landings dominated by *Muraenesox bagio* and *Strophidon sathete* in the longline operations at Pentakata and Chandrabhaga. Length range for *M. bagio* and *S. sathete* were 95-190 cm and 60-240 cm respectively. Longline fishing is targeted for eels, catfishes, grunters, seerfish and croakers. Bigger-sized eels are caught in longline operations in southeast direction at 35-50 km from Puri. The longline is operated by outboard fibre-glass boats of OAL (Overall Length) 9-10m with engine power of 9 HP at 30-40m for 3-5 hours in a day. During fishing, small pelagics such as *Sardinella fimbriata, Rastrelliger kanagurta, Thryssa* sp., *Setipinna* sp., *Alepes kleinii* and *Decapterus* sp. are used as bait.

The eels landed in Paradip fishing harbour, the major fishing harbour and in other landing centres of Odisha are processed and auctioned at the rate of ₹50-350 per kg. *Muraenesox bagio* is mainly targeted by the fishermen for its high market demand, which fetches a good market price of ₹300-350/kg and the airbladder of

Fig. 6. Deskinning of eels for dry fish preparation

this species is usually used for pharmaceutical purposes and sometimes discarded. *Strophidon sathete* which comes as a by-catch is sold at ₹50-60/kg in fresh. As there is less demand in local markets most of these eels are packed in plastic and thermocol boxes along with ice and transported to nearby states. The low valued eel, *Strophidon sathete* are first cleaned and then the skin is removed and degutted (Fig. 6). The rest body is dipped in salt water for 7-10 days then dried in sunlight by traditional method. The salted dried eel is sold at a price ₹100-150 in local markets. Dried eels are sent to states like West Bengal, Andhra Pradesh, Kerala and Tamil Nadu. Promotion of improved processing and packaging methods would help to fetch better economic returns to the fishermen families engaged in eel fishery. Assessments of the stock, its sustainable potential and collect data on the biological parameters of this group for proposing a Minimum Legal Size for fishes landed, will assist in formulation of fisheries management plans.

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Prawn or shrimp? Resolving the question

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The confusion in the usage of terms "prawn" and "shrimp" is existing since a long time among the common people as well as the scientific community. It is hard to differentiate between these two based on their size, habitat, texture, nutritional value etc. as there are no existing standards to classify these two into separate groups. In reality, both the terms are widely and similarly used in all arenas of fisheries whether it is capture, culture, post-harvest or in the trade and do not have any particular scientific basis.

When we look into the etymology of the term "prawn", it was first applied in early 1400s as various Middle English forms prayne, prane, praune, and prawne, which present no clear cognates in languages other than English. It looks as though for at least six hundred years seamen have used the word pran- ~ parn- denoting "prawn". It is not clear where the term "prawn" originated, but early forms of the word surfaced in England in the early 15th century as prayne, praine and prane. Its origin remains unknown, but it hardly goes back to Old English or Old French and may be dealing with an obscure Mediterranean term, ultimately traceable to some substrate language of that area (Etymology posts by Anatoly Liberman, 2012). The term "shrimp" and seems to have originated around the 14th century with the Middle English shrimpe, akin to the Middle Low German schrempen, and meaning to contract or wrinkle; and the Old Norse skorpna, meaning to shrivel up, or skreppa, meaning a thin person (Wikipedia).

The terms "shrimp" and "prawn" are not related to any known taxonomic group. Although the term "shrimp" is applied to smaller species, and "prawn" to larger forms, there is no clear distinction between both terms and their usages, often confused or reverse in different countries or region (Chan, 1998). For instance, in North America, the term "shrimp" is used much more frequently, while the word "prawn" is most often used to describe larger species or those fished from fresh water. While in the UK, Australia, New Zealand and Ireland, "prawn" is the general term used to describe both true prawns and shrimps (Holthuis, 1980). Richardson & Yaldwyn (1958) stated that "shrimp" and "prawn" are names of unknown origin and of no strict zoological reference in New Zealand. There in common usage, "shrimp" are small, some three inches or less in length, taken for food by netting, usually from shallow water. "Prawn" are larger, up to twelve inches long, taken by trapping and trawling.

The erstwhile Crustacean Fisheries Division of ICAR-CMFRI right from its commencement decided to use the term "prawn", based on the decision taken at the Prawn Symposium held in connection with the Sixth Session of Indo-Pacific Fisheries Council (IPFC) held in Tokyo in 1955. In this report it is highlighted that the term "prawn" should be applied to the Penaeids, Pandalids and Palaemonids, while the term "shrimp" should be restricted to the smaller forms belonging to the other families. Later, in 2011, during a national workshop on taxonomy of Indian commercial prawns during 14-19th February, at ICAR-CMFRI, Kochi, based on detailed discussion on this topic the forum took the unanimous decision to continue usage of prawn in all the publications (Handbook of prawns–Radhakrishnan *et al*., 2011and Handbook of Marine prawns of India – Rao *et al*., 2013) from the division. It is also good to analyse, in the course of time how the usage of shrimp has adapted in to our system. The term “shrimp” gradually got established with the commencement of export of Indian prawns to United States, as it was essential to follow the buyer’s preference in the labels. They prefer to use “shrimp” rather than “prawn” and as US was the major importer of Indian prawns, this term become popular in export market.

The other reason is related with the scientific publications. In this context also, US based journals/ publications are insisting authors to use “shrimp” in their research papers and so the usage of shrimp become inevitable for the acceptance of research papers. These two issues mainly forced the stakeholders to use “shrimp”, otherwise there is no taxonomic or scientific evidence to change to “shrimp” from the regular use of “prawn”. As these two terminologies are synonymous we may continue the usage of both, and while publishing the author can appropriately include a disclaimer/ note about the usage of the term. Hence, scientists in the former Crustacean Fisheries Division decided to use the term “prawn”, except wherever, the usage of “shrimp” is obligatory.

Brief Communications

Grow-out farming technology for Indian Pompano in marine floating cage

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Marine cage culture is widely recognized as one of the promising intensive culture methods for finfish. The Indian pompano, *Trachinotus mookalee*, has recently been introduced as part of species diversification approach for enhancing marine fin fish production through mariculture. The species is considered as a suitable candidate species for cage culture because of its amenability to captive breeding, adaptability to different culture conditions, tolerance to wide range of salinity, fast growth rate and high consumer preference. Captive breeding and large-scale seed production technology for the species was standardized under All India Network Project on Mariculture at Visakhapatnam Regional Centre of ICAR-Central Marine Fisheries Research Institute (CMFRI), during the year 2016-17. Following this, marine cage culture technology was also developed, standardized and demonstrated among fishermen, fisheries societies and small entrepreneurs with financial support from National Fisheries Development Board (NFDB), Government of India under Blue Revolution scheme and Pradhan Mantri Matsya sampada Yojana (PMMSY) in different states. The standard steps involved in cage culture of the species are explained below

Cage site selection

Indian pompano being a tropical species, the selected site should meet the following criteria: Water temperature: 26-30ºC, water depth 6-10m, continuous water movement for sufficient dissolved oxygen, away from polluted waters and industry run offs and easy site access, with jetty facilities.

Cage structure

With the objective of better stability against adverse weather conditions in the sea, especially on the north east coast and also to provide congenial environment for the cultured fish, certain specifications are recommended. Circular shaped HDPE cages of 6.0 meter diameter inner collar and 8 meter diameter outer collar pipes are supported by 8.0 numbers of base pipe, vertical and diagonal supports each are to be used. HDPE braided nets are suitable with following specification: Outer nets of 7.0m diameter and 4.0m depth, 40mm mesh of 3.0mm twine thickness; Inner nets of 6.0m diameter and 4.5m depth with 25.0mm mesh. Bird net of 80mm nylon mesh is preferred. The cage structure is stabilized in the sea with the help of mooring systems supported by 2-3 tonnes capacity cement blocks/gabion boxes/ anchor systems with the help of mooring chain (long link alloy steel chain of 14mm diameter with 22 tonnes shearing strength), D-shackles and swivel. Ballast pipes help to maintain the cage structure intact in proper shape against the water movement. In order to provide sufficient space for fish movement, the inner net has to be tied with two ballast pipes at bottom and middle and outer net with single ballast pipe at the bottom.

Nursery rearing

Usually, size of the fish fixed for stocking is 20 to 25g and it takes nearly 10 months to attain the market size of 750-850 g. However, the culture duration can be reduced if bigger size (up to 100g) fish is stocked. Hence, nursery culture of Indian pompano is considered important for reducing the culture duration. Two types of nursery systems are suitable for Indian pompano with respect to cage culture: Flow-through based FRP or concrete tank culture and Recirculating Aquaculture System (RAS) based nursery systems. Artificial floating pelleted feed with high nutrient (45% Crude Protein & 10% Crude Fat) is recommended in nursery systems. These nursery facilities should be established near cage site for ease of fish transportation and reduce fish mortality while shifting to grow-out cages. The nursery reared fish seeds are transported to cages either in oxygen filled polythene bags or in containers supported with oxygen. The suitable transportation strategy is depending on the distance and size of the fish. The fish size above 10.0 g is recommended to shift via containers supported with pure oxygen (~10 ppm) for better survival after stocking.

Grow-out culture

After reaching the cage site, the transported juveniles should be slowly released for acclimatizing. The optimum stocking density suggested is 25 numbers/m^3, and thus, 6 meter cage with 4 meter net depth will have to be stocked with 2500 -2750 numbers of fish seed. Artificial floating pelleted feed with high nutrient (40% Crude

Fig. 1. Cage culture site for Indian Pompano off Visakhapatnam Coast

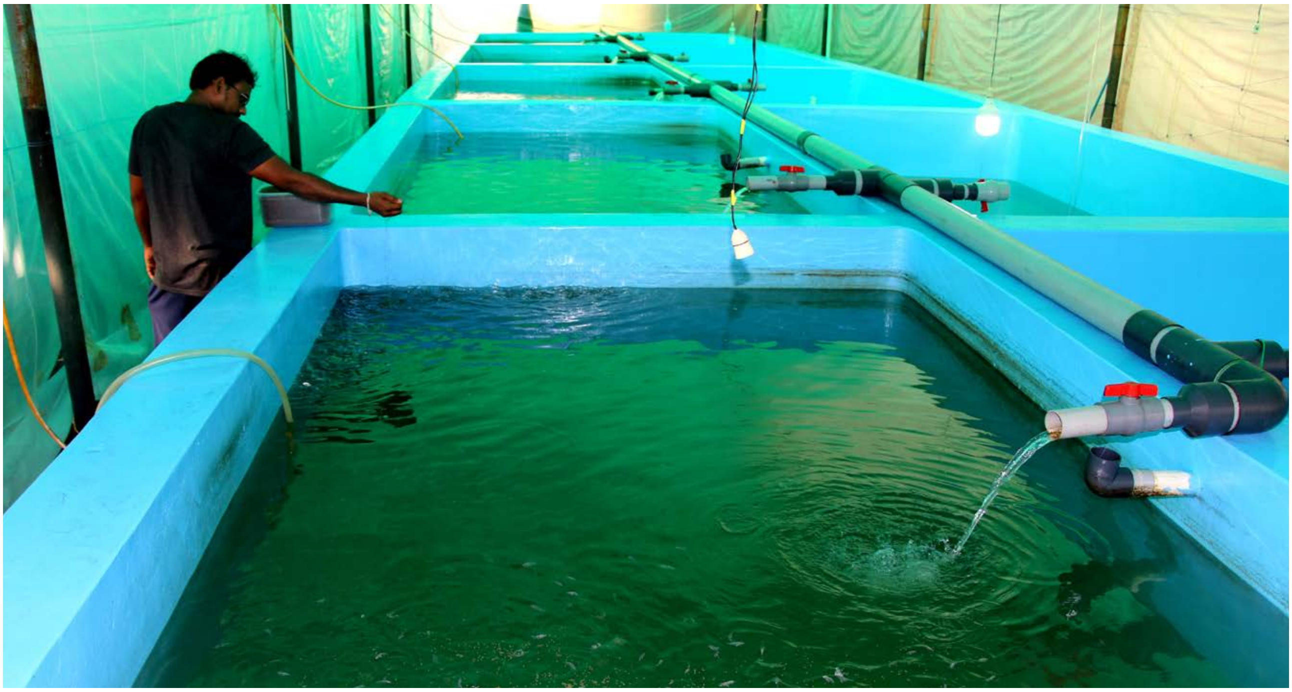

Fig. 2. Indian pompano nursery rearing in concrete cement tank

Protein & 10% Crude Fat) is recommended in grow out systems. To avoid feed wastage while feeding via meshes of inner cage net, feed mesh (small mesh (1.0mm) net) of 1.0 meter depth should be attached in the inner cage net at water and air interface. For better feed digestion and assimilation, a minimum time gap of 3 to 4 hours should be given between two feeding schedules, thus the feeding frequency should be decided accordingly. In grow out culture, fish growth should be monitored fortnightly and feeding rate to be adjusted based on the weight gain after every sampling. Based on several demonstrations, if the fish fingerlings of 20 to 25g are stocked at 25 numbers per m^3, then it takes nearly 10 months to reach the size of 750-850g, whereas if it is stocked at 100g size, it takes 5 to 6 months to reach the same size. The fish growth and optimum feeding rate is given in the Table.1.

Cage maintenance

Cage culture of Indian pompano is at lead for 10 months, and the cage structure should be managed well with net exchange, cage frame cleaning and periodic checking of mooring systems. The cage net is prone to settlement of barnacles, algae and silt accumulation depending on the season and the location of the cages. The net should be exchanged at least once in two months to avoid net damage. Cage frame which is prone to accumulation of barnacles requires monthly cleaning. Cage mooring which keeps the entire cage structure in position and mooring chains requires monitoring at least once in a month. The mooring system specified for the cages will remain without much of a problem for a minimum of two years, and then slowly it starts eroding and may have to be changed.

Table 1. Fish growth and feeding at different growth stages in grow-out

DOC	Fish Size (g)	Feed Size (mm)	Feeding Rate	Frequency (times/day)
0-30	25 -50	1.2 to 1.8	8-7%	4-5
30-120	50-100	1.8 to 3.0	6-5%	4
120-180	100-300	3.0 to 4.0	5-4%	4
180-210	300-500	4.0 to 6.0	4-3%	3
210-300	500-750	6.0 to 7.0	2.5%	3
300-360	750-1100	7 to 10.0	2%	2

Fig. 3. Indian pompano grow-out culture in floating marine HDPE cages

Fish management

The cage cultured fish should be periodically checked for its feeding and health status by fortnightly sampling. Daily observations on feeding behavior, which is a good indicator for the health status of the fish is helpful. The major diseases associated with marine cage fish farming are vibriosis by certian species of Vibrio bacteria and parasitic infestations by ecto-parasites. Fish affected by vibriosis, moves to the water surface and its eyes and fins become reddish in colour. In parasitic infestations, visible ulceration appears on the external surface and parasites attached on the body surface can be noticed, which ultimately kills the fish. Vibriosis in fish is controlled by the use of probiotics and medicated feeds. Parasite infestations can be controlled by freshwater dip treatment or using medicated feed with Praziquantel.

Fish harvest and marketing

While harvesting, the fishes are removed with the help of a hand scoop net from the cages. Immediately after harvest, washing in clean water and chill killing is recommended to maintain the freshness and quality of the harvested fish. Harvested fishes are packed in plastic trays or thermocole boxes by adding layers of ice at the bottom and top of the fish. The cultured fish can be

Fig. 4. Cleaning of cage frames

Fig. 5. Harvest of Indian pompano

harvested based on the demand, and most preferably during the lean fishing or the trawl-ban season. The states like Kerala, West Bengal, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Goa have good market demand for Pompanos. Some of the selected buyers are Maxwell exporters, Kochi, Kerala; MATSYAFED, Kerala; West Bengal Fisheries Development Corporation, Kolkata, West Bengal.

Economics

The total operational expenditure and profit for culture of the fish in a battery of 10 cages is given in the Table 2. Culturing the fish for 10 months at the stocking of 25/m^3 will support the farmer with net profit of approximately ₹16.9 lakhs with an average minimum price realization of ₹325/kg at farm gate. The farm gate price varied with market demand and maximum of ₹380/kg was realized for domestic marketing.

Best Management Practices (BMP) for cage culture of Indian pompano

The following important BMP must be implemented while practicing grow-out culture in floating marine cages for better production and economic returns.

Cage should be installed where the water movement is adequate for getting optimum concentration of dissolved oxygen and for washing away the accumulated waste generated from cultured fish

- Fish fingerlings of > 30g should be stocked to obtain maximum survival
- Feed mesh of 1mm mesh size should be attached with inner cage net for avoiding feed wastage
- Inner cage net should be additionally supported with a middle ballast pipe for maintaining the round shape and for avoiding net folding.
- Feed should be broadcasted slowly in cages to ensure that all the fishes get the required feed and for avoiding feed wastage.
- Periodical monitoring of fish, cage net and other cage system is essential.
- Continuous observation for vibriosis and parasitic infestation to ensure the fishes are free from the disease, and immediate treatment of infected fishes.
- Demand based fish harvest is recommended for better profit.

Table 2. Cost and revenue data of cage culture

Head of expenses	Cost ₹ (lakh)
Depreciation value on cage and accessories with an average life of 10 years for cage frame, five years for cage mooring and nets (Cost of cage and accessories including installation: ₹300,000/unit) and depreciation is ₹43,000/unit/year	4.3
Cost of 32,500 numbers of pompano seeds @ ₹20/seed (including nursery rearing expenses)	6.5
Cost of 35.7 t of extruded pelleted feed (Survival 85%; Average Body Weight 750 g at harvest) @ FCR 1:1.70 @ ₹100/kg	35.70
Labour charges @ ₹30,000/ month for 10 months	3.00
Boat hiring and fuel charges @ ₹6000/ month for 10 months	0.60
Charges for net exchange @ 500/person for 3 persons, five times in the production cycle for each cage	0.75
Miscellaneous expenditure feed medicines and probiotics	0.5
Total Expenditure	51.35
Total income Production of 21 tonnes @ 85% survival with harvest size of 750g at selling price of ₹325/kg	68.25
Net profit: (Total Income-Total Expenditure)	16.90

Livelihood enhancement through cage farming -A success story

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Cage culture is an emerging technology suitable to a wide range of freshwater ecosystems, brackish water ecosystems or in open seas through which freshwater or brackish water or marine fishes are reared from fry to fingerling, fingerling to table size or table size to marketable size under captivity in an enclosed space that maintains free exchange of water with the surrounding water body. It is estimated that there are 12.40 lakh ha of brackish water resources in India, comprise of backwaters, estuaries, lakes, tidal creeks, canals, coastal lagoons, mudflats, etc. and the estuarine waters in India are highly productive. Cage fish farming in the estuarine waters can be recommended as an alternative livelihood and income generation programme for the coastal population. Recently, Central Government and Kerala State Fisheries department are providing financial assistance for promotion of cage farming.

With successful demonstrations, cage culture was introduced in the estuarine and coastal waters in different parts of North Kerala. At present, more than 150 cages are installed across various estuarine water bodies of North Kerala with the technical support from ICAR-CMFRI. In North Kerala, seabass, pearl spot and mangrove red snapper have been introduced recently for brackish water cage culture and the culture is gaining popularity among the aqua farmers.

The most popular cage dimension introduced to the estuaries in the North Malabar is 4x 4 x 3m^3 with GI pipe as frame and netlon net as inner and outer net cages. During the initial year of fish farming, both technical and financial assistance were provided followed by technical support alone throughout the subsequent farming years. The cage dimensions adopted by the farmers varied widely for farming in the coastal waters from 2x1x2m (4m^3), 3x 3 x 3m (27m^3) and 4x4x3m (48m^3). The recommended size of cages in the coastal waters considering the operational efficiency and profitability is 48m^3 (4x4x3m). The major species selected for farming are Asian seabass (*Lates calcarifer)*, pearlspot (*Etroplus*

Onsite demonstration of cage fabrication to farmers of North Kerala

Floating cage of dimension 3x 3 x 3m installed for culture of fishes

suratensis), tilapia (*Oreochromis* sp.) and red snapper (*Lutjanus argentimaculatus*). Seed production techniques for red snapper is not developed in the country and these fishes are cultured through capture based aquaculture, whereby the juveniles of the fishes are caught alive and allowed to grow to marketable size in cages. The stocking density varied depending on the cage volume and species of fishes selected for farming in the coastal areas.

The coastal water resources of our country have been widely utilized for fish production by cage culture and ICAR-Central Marine Fisheries Research Institute (CMFRI) has played a vital role in disseminating the coastal cage culture technology. The success story reported is a part of ICAR-CMFRI in house project "Innovations in sea cage farming and coastal mariculture" and CMFRI-NFDB project on "Integrated coastal water Cage Culture in selected districts of Kerala and Karnataka (Proj. Code 1010222)".

Mr. Sathyan, from Mujukunnu, Moodady grama Panchayat, Kozhikode engaged in masonry work and fishing activities in estuarine waters for the past 40 years, had passion for fish farming practices too. He resides near Akalapuzha backwater, one of the ecotourism sites in Kozhikode district. During 2016, he had initiated a small scale cage farm with 40 numbers of 2×2m PVC cages stocked with 250 numbers of 5 cm size Asian seabass *Lates calcarifer* in each cage. But, due to lack of technical knowledge, he lost the entire stock due to cannibalism.

During 2017, Mr. Sathyan was identified for the participatory cage fish culture under the ICAR-CMFRI in-house project. Cage culture was undertaken at Mujukunnu (11°50'12.4"N 75°66'86.4"E), in Akalapuzha backwater, Moodady Grama Panchayat, Kozhikode District, Kerala. Field demonstration on cage fabrication and installation were conducted at Mujukunnu by Calicut Regional Station of ICAR-CMFRI and technical and financial assistance for cost effective Galvanized Iron (GI) cage culture also provided. A floating cage of 3m x 3mx 2m was stocked with 250 numbers of Pearl spot, *Etroplus suratensis* (5-10g) in the identified site on during February 2018. The fish were fed with commercial floating pellet with 20% crude protein. All technical support including net change, feeding, growth and health monitoring of fishes were provided by Calicut Regional Station of ICAR-CMFRI. Growth parameters were recorded at monthly intervals and average growth rate was assessed. Fishes attained 175- 225 g with 95 % survival in the 12 months culture period. Mr. Sathyan could obtain a production of 50 kg from the single cage (18m^3 volume) and the fish were sold at ₹550/kg.

During 2019, with the technical support from CMFRI an attempt for capture based aquaculture was done using juveniles of mangrove snapper, *Lutjanus argentimaculatus* and pearl spot, *E. suratensis* collected from Kadalundy and Korapuzha estuaries by local fishermen using traps. The seeds thus collected were stocked continuously for 30 days in 3m x 3m x 2m cage. A total of 125 numbers of *L. argentimaculatus* measuring 10±3 cm and 500 numbers of 10±2.5 cm *E. suratensis* juveniles were stocked in the cage during January 2020. Locally available low-value fishes were used for feeding the fish. After a grow-out period of six months, the fish were harvested in July 2020, during the COVID-19 lockdown period. Red snapper had attained 500-700 g with an average weight of 655 ± 45g and pearl spot 100-150 g with an average weight of 125 ± 25g. A survival of 60% for red snapper and 90% for pearl spot were recorded. Total production from the cage was 90 kg (40 kg snapper and 50 kg pearl spot). The fishes were sold at farm gate itself @ ₹600/ kg for snapper and ₹550/kg for pearl spot and the revenue generated was ₹51, 500.

Further Mr. Sathyan got an opportunity to attend the three days training programme on "Open Sea Cage Farming and Mariculture" conducted by Calicut Regional Station of ICAR- CMFRI under the NFDB Skill Development Programme for the beneficiaries of Kozhikode district at Anapara (Atholi, Kozhikode) from 29-05-2019 to 31-05-2019. Under this scheme Mr. Sathyan has installed a GI cage of 4m ×4m x 3m during 2019 for farming of seabass, *L. calcarifer* along with pearl spot, *E. suratensis* with financial and technical support from ICAR-CMFRI. During, January 2020 the cages were stocked with 600 numbers of seabass and 500 numbers of pearl spot fingerlings (8-10 cm) in the cage and were fed with low-value fishes. The outbreak of pandemic covid-19 during the cage operational period has brought forth significant changes and operational challenges in the cage fish farming activities. During lockdown, the farmer had faced difficulties in feeding fishes due to scarcity of low value-fishes and the price hike of the available fishes. Six months culture period recorded an average individual weight of 600-1450 g for seabass and 100-125g for pearl spot. About 50% survival of seabass and 95% survival of pearlspot were observed in cages. A production of 175 kg of seabass and 50 kg of pearl spot was obtained from the cage (48m^3 volume) after the farming period of 8 months. Seabass were sold @ ₹720/kg and pearl spot 550/kg at the farm gate itself. The 225 kg harvested fish had fetched an income of ₹1,53,500/-. Even though the total production from the cage was less, the cage fish culture carried out during the COVID 19 lockdown turned out to be a livelihood support to the farmer since the farmed fish had a great market demand due to the scarcity of marine fish landings during the lockdown.

During 2018-2019, farming was initiated in two GI cages provided by ICAR-CMFRI, and later on, with the support from Department of Fisheries, Kozhikode, the number of cage units have been increased to 6 in 2020, 8 in 2021 and 18 by 2022. Currently, Mr. Sathyan has 36 cages out of which 33 cages are used for stocking seabass, one cage for pearl spot, one cage for red snapper and another one cage for chitralada. Thus convinced that cage fish farming is a lucrative business with proper planning, information and management he has moved from being a mason to a full time cage fish farmer. During 2021, he could get

Cage farm at Mujukunnu, Kozhikode during 2022 a profit of ₹8,00,000/- with an average production of 350 kg/cage from 8 cages within the farming period of 8 months.

This success has inspired many fish farmers and non-farmers at Moodady Panchayath to initiate the cage farming in Moodady gram panchayath with 37 individuals in four self help groups operating 76 cages at Moodady. The economic performance of cage farming of different species of fishes were calculated for comparing the profitability. Depreciation on cage frame and accessories were calculated using straight line method with an expected life of 5 years and the financial indicators such as NPV, BCR and IRR were calculated for a project period of 5 years at 15% discount rate as per the method followed by Aswathy *et al*. (2020).

Experience shared by Mujukunnu fish farmers in fish farming

The farmers prefer monoculture of fish species like Asian sea bass (*Lates calcarifer*), pearl spot (*Etroplus suratensis*), Red snapper (*Lutjanus argentimaculatus*) and Nile tilapia (Chitralada) in cages.

Species farmed	Number of cages	Reason for culturing
Lates calcarifer (seabass)	55	Fast growth rate, good market price and availability of good quality hatchery produced seeds
Etroplus suratensis (pearl spot)	15	Good market price
Lutjanus argentimaculatus (red snapper)	3	Good market price, easy to culture
Oreochromis niloticus (Chitralada tilapia)	3	Fast growth rate in 6 months culture period

Sea bass culture

The farmers prefer the farming of *Lates calcarifer* locally known as Kannikan or Kalanji because of their faster growth rate, good market price and availability of good quality hatchery produced seeds. They prefer low stocking density farming of *Lates calcarifer* by stocking 300 numbers of hatchery produced *Lates calcarifer* fingerlings of 5.0 – 5.5 cm size purchased @ ₹30/

Species farmed	Size of the cage	Stocking density/ cage	Culture period	Harvest size of the fish	Production/ cage (kg)	Average selling price (₹/kg)	Constraints
Lates calcarifer (seabass)	3×3m	300 numbers	8 months	1.5-2.0 kg	300-350 kg	₹500/kg	Higher price for fish seeds from private hatcheries
Etroplus suratensis (pearl spot)	3×3m	500 numbers	12 months	225-250 gm	75-100 kg	₹500/kg	Slow growth rate in cages
Lutjanus argentimaculatus (red snapper)	3×3m	300 numbers	8 months	850-1500 gm	250-300 kg	₹500/kg	Non availability of hatchery produced fish fingerlings
Oreochromis niloticus (Nile tilapia/Chitralada)	3×3m	500 numbers	6 months	850-900 gm	400-450 kg	₹250/kg	Low market price

fingerling in 3m x 3m x 3m cages. During the first two months of culture, they fed the fishes with pellet feed (Growel) initially at15 percent of the body weight, then reducing to 5 percent of the body weight as the culture progressed. From 3-8 months, the feed given is low-value fishes. Fishes reached 1-2 kg within 8 -9 months culture period with 100 percent survival and the fishes were sold at the rate of ₹500-700/kg. The farmer's could get an average production of 300-350 kg of seabass from a single cage of $27m^3$ earning a gross income of ₹1,50,000-2,00,000 per cage.

Feeding schedule adopted for Asian seabass in 3×3m GI cage (Stocking density- 300 numbers):

Month	Fish size (g)	Feeding rate (%)	Pellet/fresh fish	Protein content	Size	Quantity	Price (₹)
1st	10-20	15	pellet	45%	1.2 mm	20 kg	2,500
2nd	25-50	12	pellet	45%	1.2 mm	40 kg	5,000
3rd	50-100	12	Fresh fish			75 kg	1,500
4th	100-200	8	Fresh fish			100 kg	2,000
5th	200-500	6	Fresh fish			150 kg	3,000
6th	500-700	5	Fresh fish			200kg	4,000
7th	700-1000	5	Fresh fish			250kg	5,000
8th	1000-2000	5	Fresh fish			250kg	5,000
TOTAL						1,085 kg	28,000

Economic performance of cage farming of seabass (Cage Dimension 3x3x3m ($27m^3$) Culture period: 8 months):

Particulars	Amount (₹)
I. Capital Investment	
1. Cost of cage frame (1.25 inch B class pipe with ISI)	25,000.00
2. Cost of nets	30,000.00
3. Cost of floats (8 numbers for each cage) and accessories	10,000.00
4. Mooring (2 numbers of 20 kg GI anchors) and installation charges	5,000.00
5. Deep freezer	15,000.00
Total fixed cost (1+2+3+4+5)	85,000.00
6. Depreciation (20%)	17,000.00
7. Interest on fixed capital (12%)	10,200.00
Annual Fixed cost (6+7) (A)	27,200.00
II. Operating costs	
8. Seed (Cost of 300 numbers of seabass seeds @ ₹30/seed & Transportation charges)	9,000.00
9. Feed (Trash fish) 1085 kg@ ₹20/kg and 60 kg pellet feed	28,000.00
10. Labour 2 hours/day @ ₹1200/month for 8months	9,600.00
11. Harvesting & Miscellaneous Expenses	2,000.00
Total operating cost (7+8+9+10) (B)	48,600.00
Total cost (A+B)	75,800.00
III. Returns	
12. Production	300 KG
13. Gross revenue @ ₹500/kg for 300 KG	1,50,000
14. Net profit	74,200
15. Cost/ kg of fish (₹)	252
16. Price/ kg of fish (₹)	500
17. Operating ratio	0.32
18. NPV	2,31,256
19. BCR	1.92
20. IRR	99.5%

The 27m^3 cage with a stocking density of 300 numbers of seabass yielded a gross revenue of ₹1.5 lakhs and net profit of ₹74,200 in an 8 months culture period. The internal rate of return was 99.5% with a benefit cost ratio of 1.92.

Red snapper culture

The farmer's prefer the farming of *Lutjanus argentimaculatus* locally known as "chemballi" because of their faster growth rate and good market price. One of the major constraints in red snapper farming is the non-availability of hatchery produced seeds. Farmers usually collect the snapper fingerlings from the estuary and stock them in cages. About 300 numbers of wild collected snapper seeds were stocked in 3m x 3m x 3m cages. The fishes were fed with low value fishes initially at15 percent of the body weight then reducing to 5 percent of the body weight as the culture progressed. Fishes reached 1-1.5 kg within 8 months culture period with 99 percent survival and the fishes were sold at the rate of ₹500-700/kg. The farmer's could get an average production of 250-300 kg of seabass from a single cage of 27m^3 earning a gross income of ₹1,25,000-1,50,000 per cage.

Pearl spot culture

The pearl spot required longer culture duration of 12 months in cages at Mujukunnu to reach marketable size (200-250 gm). Five hundred fingerlings (4 cm) purchased @ ₹10/ fingerling were stocked in 3m x 3m x 3m size cages. During the twelve months of culture,

Red snapper weighing around 1 to 1.5 kg harvested from the cages

Culture protocol for Red snapper in 3×3m GI cage (Stocking density- 300 numbers):

Month	Fish size (g)	Feeding rate (%)	Pellet/fresh fish	Quantity	Price (₹)
1st	10-20	15	Fresh fish	25 kg	500
2nd	25-50	12	Fresh fish	50 kg	1,000
3rd	50-100	12	Fresh fish	75 kg	1,500
4th	100-200	8	Fresh fish	100 kg	2,000
5th	200-500	6	Fresh fish	150 kg	3,000
6th	500-700	5	Fresh fish	200kg	4,000
7th	700-1000	5	Fresh fish	250 kg	5,000
8th	1000-1500	5	Fresh fish	250 kg	5,000
TOTAL				1,100 kg	22,000

Economic performance of cage farming of red snapper (Cage Dimension 3x3x3m ($27m^3$) Culture period: 8 months):

Particulars	Amount (₹)
I. Capital Investment	
1. Cost of cage frame (1.25 inch B class pipe with ISI)	25,000.00
2. Cost of nets	30,000.00
3. Cost of floats (8 numbers for each cage) and accessories	10,000.00
4. Mooring (2 numbers of 20 kg GI anchors) and installation charges	5,000.00
5. Deep freezer	15,000.00
Total fixed cost (1+2+3+4+5)	85,000.00
6. Depreciation (20%)	17,000.00
7. Interest on fixed capital (12%)	10,200.00
Annual Fixed cost (6+7) (A)	27,200.00
II. Operating costs	
8. Seed (Cost of 300 numbers of red snapper seeds @ ₹35/seed & Transportation charges)	10,500.00
9. Feed (Trash fish) 1100 kg@ ₹20/kg	22,000.00
10. Labour 2 hours/day @ ₹1200/month for 8months	9,600.00
11. Harvesting & Miscellaneous Expenses	2,000.00
Total operating cost (7+8+9+10) (B)	44,100.00
Total cost (A+B)	71,300.00
III. Returns	
12. Production	280 KG
13. Gross revenue @ ₹500/kg for 300 KG	1,40,000
14. Net profit	68,700
15. Cost/ kg of fish (₹)	254
16. Price/ kg of fish (₹)	500
17. Operating ratio	0.31
18. NPV	2,12,819
19. BCR	1.74
20. IRR	93.19%

The $27m^3$ cage with a stocking density of 300 numbers of red snapper yielded a gross revenue of ₹1.4 lakhs and net profit of ₹68,700 in an 8 months culture period. The internal rate of return was 93.19% with a benefit cost ratio of 1.74.

Harvest and local sale of pearl spot

the fishes were fed with pellet feed (Growel) initially at12 percent of the body weight then reducing to 3 percent of the body weight as the culture progress. Pearl spot is also having very good market demand (about ₹500-600/ kg) in local market. An average production of 100 kg/cage with a gross income of ₹50,000 could be obtained.

Nile Tilapia culture

The farmer opined that Nile tilapia locally called as chitralada requires only 6 months culture duration and two crops could be harvested annually. The farmers stocked around 500 number of Chitralada fingerlings (4.0 cm) purchased @ ₹8/ fingerling in 3m x 3m x 3m

Feeding schedule adopted for Chitralada in 3×3 GI cage (Stocking density- 500 numbers):

Month	Fish size (g)	Feeding rate (%)	Pellet/fresh fish	Size	Protein (%)	quantity	Price
1st	4-5	10	pellet	1.2 mm	40	10 kg	1,200
2nd	10-15	8	pellet	3.0 mm	40	40kg	4,800
3rd	250-500	5	pellet	3.0 mm	40	75 kg	9,000
4th	500-650	3	pellet	6.0 mm	40	75 kg	9,000
5th	650-700	3	pellet	6.0 mm	40	50 kg	6,000
6th	750-900	3	pellet	8.0 mm	40	50 kg	6,000
TOTAL						300 kg	36,000

Economic performance of cage farming of chitralada (Cage Dimension 3x3x3m^3 Culture period: 8 months):

Particulars	Amount (₹)
I. Capital Investment	
1. Cost of cage frame (1.25 inch B class pipe with ISI)	30,000.00
2. Cost of nets	25,000.00
3. Cost of floats (8 numbers for each cage) and accessories	10,000.00
4. Mooring (2 numbers of 20 kg GI anchors) and installation charges	5,000.00
Total fixed cost (1+2+3+4)	70,000.00
5. Depreciation (20%)	14,000.00
6. Interest on fixed capital (12%)	8,400.00
.Annual Fixed cost (5+6) (A)	22,400.00
II. Operating costs	
7. Seed (Cost of 500 numbers of chitralada seeds @ ₹8/seed & Transportation charges)	4,000.00
8. Feed(pellet feed) 300 kg	36,000.00
9. Labour 2 hours/day @ ₹1200/month for 6months	7,200.00
10. Harvesting & Miscellaneous Expenses	2,000.00
Total operating cost (7+8+9+10) (B)	49,200.00
Total cost (A+B)	71,600.00
III. Returns	
11. Production	450 KG
12. Gross revenue @ ₹250/kg for 450 KG	1,12,500
13. Net profit	40,900
14. Cost/ kg of fish(₹)	159
15. Price/ kg of fish(₹)	250
16. Operating ratio	0.43
17. NPV	1,22,713
18. BCR	2.36
19. IRR	70.9%

The 27m^3 cage with a stocking density of 500 numbers of chitralada yielded gross revenue of ₹1,12,500 and net profit of ₹ 40,900 in 6 months culture period. The internal rate of return was 70.9% with a benefit cost ratio of 2.36.

size cages. The fishes were fed with pellet feed (Growel) throughout the culture period. Fishes reached 800-900 g within 5-6 months culture period with almost 100 percent survival. They could obtain an average production of 400-450 kg of Chitralada from cages of 27m^3 within a farming period of 6 months and the fishes were sold at the rate of ₹250/kg. They earned a gross income of ₹1,00,000-1,10,000 per cage.

Technology upgradation introduced by farmers of Mujukunnu in cage farming

Surveillance

The farmer's installed surveillance unit at cage site for continuous monitoring of culture activities. The fish cages are fitted with solar panels, cameras and sensors to collect data and monitor images. The data and images are transmitted to the shore station via a mobile phone network. This system allows the remote monitoring of fish and the installation of surveillance unit costs around ₹80,000.

On-field feed storing shed-cum-watch shed

The farmer's fabricated and installed an on-field feed storing shed-cum-watch shed for feed storage, management and monitoring of culture activities. The fabrication and installation of feed-cum-watch shed unit costs around ₹50,000.

On-site marketing facilities

The partial harvest of fishes was undertaken as per the demand from consumers. The support through social

Fish Cage farmers of Mujukunnu felicited by ICAR-CMFRI on the occasion of KISAN DIWAS on 23rd December, 2023

media like Facebook, Whatsapp etc. played an important role in achieving good sales for the farmer. The harvest of fishes are planned to coincide with occasions like Onam, Vishu, Bakrid etc.

According to the farmers, cage fish farming is a profitable venture and vast unutilized areas in the estuarine and brackishwater region offer promising scope for augmenting fish production through cage farming in North Kerala. The constraints listed as major bottlenecks for large-scale cage fish farming were, lack of credit facilities, lack of insurance, high seed cost, natural calamities, attack of otters and conflict with tourism boats operated. For increasing adoption of cage culture technology, farmers suggested establishment of finfish hatchery in North Kerala for continuous supply of hatchery produced good quality fish seeds, financial support from the government to initiate cage farming, meeting insurance needs for cage farming

Conclusion

Cage farming with proper planning, information and management offers tremendous scope for boosting the fish production in North Kerala, mainly from the estuarine water bodies. The vast unutilized water resources and conducive environmental conditions in the coastal waters are excellent for large-scale cage farming. Cage culture appears to be a rapidly expanding industry and it offer opportunities even on a small-scale. Recently, due to the frequent occurrence of flood in Kerala farmers are unsure about the returns from cage farming. Therefore, insurance schemes for mitigating risks due to natural calamities or anthropogenic activities are also necessary for large-scale commercialization of cage farming in the coastal waters. In addition, there is an urgent need for the formulation of leasing policies and regulatory measures for large-scale promotion of cage fish farming.

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Successful region specific coastal mariculture activities towards achieving Sustainable Development Goals – A report

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In the face of growing demand for animal protein sources, aquaculture continues to contribute immensely for sustainable development. A record high of 114.5 million tonnes of fish production including 32.4 million tonnes of aquatic algae, 26,000 tonnes of ornamental fish, clams and pearls, and 82.1 million tonnes of farmed fish were produced in 2018 (FAO, 2020). Aquaculture accounts for nearly half of the global fish production and human fish consumption and is expected to increase in the future. Fish is a major source of protein for over 3.3 billion people worldwide with 20% of the average per capita intake of animal protein (FAO, 2020). The United Nations upholds 17 Sustainable Development Goals (SDGs) that act as a framework for global collaboration to support the well-being of people and the planet (Morton *et al*., 2017). The UN's 2030 Agenda for Sustainable Development Goals (SDGs), such as SDG 1 (No Poverty), SDG 2 (Zero Hunger), and SDG 14 (Life Below Water), emphasize ensuring global food security, given emphasis to the importance of aquaculture and fisheries resources in achieving sustainable food systems, developing economic advantages, and providing nourishment. These 17 goals are primarily intended to combat poverty, inequality, and climate change. When aquaculture is developed appropriately, it has a significant role in achieving a number of the UN's SDGs by 2030. Coastal mariculture activates can play a major role in contributing to these SDGs directly or indirectly. Importance of coastal mariculture to achieve these SDGs and the possible interventions are discussed herewith. Also, the region-specific initiatives taken by Karwar Regional Station of ICAR-CMFRI to contribute to these SDGs through coastal mariculture activities also deliberated.

Coastal mariculture activities involve the farming of marine organisms such as fishes, mollusks, crustaceans and seaweeds in marine and in land facilities such as cages, Pens, ponds, tanks and Recirculating Aquaculture Systems (RAS). In India, ICAR-CMFRI has standardized major coastal mariculture activities such as marine fish farming in coastal cages, Integrated Multi-Trophic Aquaculture (IMTA), RAS farming, mussel farming and seaweed farming.

In 2018, an approximate 59.51 million people were employed (full-time, part-time, or on an occasional basis) in the fisheries industry, with 20.5 million working in aquaculture, a modest rise from 2016 (FAO, 2020). Coastal mariculture will provide immense opportunities for employment for coastal fisherfolk which may ultimately help to reduce poverty. Coastal farming also may enhance employment opportunities for workers in other associated sectors such as fish processing, fish marketing, and feed and equipment manufacturing. Thus this sector can play a significant role in the overall socio-economic upliftment of poor people, especially the coastal population. Nearly half of the fish consumed worldwide comes from aquaculture. Due to rising population and food consumption as well as ongoing global degradation of the environment (land, water, and the climate), food security is crucial. Coastal aquaculture production needs to be enhanced further to meet the demands of the growing population which will lead to improved nutrition and food security for all communities.

The essential amino acids, vital fats including omega-3 fatty acids, vitamins and minerals are present in ample quantity in fish, which is a good source of protein. Coastal mariculture can provide economical and nutritious food for the world's poorest people, whose diets lack most of the essential nutrients. Since men are involved in the production of majority of farmed fish, aquaculture is presumed to be gender biased. Women are mainly involved in fish feeding, harvesting, fish processing and marketing in local areas. Promoting increased women involvement in coastal aquaculture while ensuring equal pay and career prospects for valuing the industry and offering working women a respectable job coastal mariculture can involve in gender equity. Coastal mariculture has greater potential for women's employment as women can manage fish ponds and cages, feed mills and fish processing units which can help to improve livelihoods. Coastal mariculture activities by bringing the socially backward communities to this field can reduce the inequalities in society.

Aquaculture will be one of the most environment-friendly approaches for food production if it is being done carefully and responsibly. Efficient use of water bodies from a production perspective will reduce pollution of coastal waters. RAS, Biofloc systems, Aquaponics, and IMTA are some of the coastal mariculture technologies which provide higher production with less negative environmental impact. At present, many of the fish stocks were negatively affected by mechanized fishing and the exploitation level is well above the maximum sustainable yield. As an alternative to less sustainable marine capture fisheries, rapid growth in coastal mariculture may contribute immensely to reduce fishing pressure and thus to replenish natural fisheries resources, as well as their ecosystems. Some of the coastal maricuiture activities will have direct implications on climate action. For example, Seaweed culture plays a significant role, including potential CO_2 mitigation on climate action. Aquatic macro-algae offer a way to cut back the carbon emissions that cause climate change. Environmental carbon capture by aquatic organisms through sequestration can aid in lowering atmospheric CO_2 levels, addressing climate change implications and SDG 13. By defending shore lines, boosting pH levels, and adding oxygen to the water, seaweed culture helps to restore natural habitats and mitigates the local consequences of ocean acidification and oxygen depletion. Additionally, it balances the major nutrients in the water that cause algal bloom and lowers the rate of mass fish mortality in the ocean. Oysters, clams, and mussels are examples of bivalves that are crucial to the stability of the aquatic ecosystem.

Table 1. Region-specific interventions initiated by Karwar Regional Station

Goal	Title	Region-specific interventions by Karwar Regional Station	References*
1	No Poverty	Standardized the open water cage farming of various candidate species	Loka *et al*. (2019); Anuraj *et al.* (2022).
2	Zero Hunger	Demonstrated open water cage culture in a subsidized mode (161 cages) in Karnataka in collaboration with financial support received from the National Fisheries Development Board (NFDB), Hyderabad	Suresh Babu *et al.* (2021)
3	Good Health and Well-being	Under the All India Network Project on Mariculture from 2015-16 to 2021-22, around 25 marine cage culture demonstrations for 13 SHGs were carried out including mussel-fish integration (IMTA). Standardized seed production of new candidate species such as seabreams and rabbit fishes.	Anuraj *et al* (2021); Suresh Babu *et al.* (2022)
4	Quality Education	The NFDB subsidy beneficiaries informed that the livelihood has enhanced by the scheme	Suresh Babu *et al.* (2021)
5	Gender Equality	Under the NFDB scheme around 47 cages were issued for women beneficiaries in Uttara Kannada. Honorable Prime Minister of India, distributed the Kisan Credit Card to Mrs Supriya Sudhir Sarang who is the first fisher folk in Karnataka to receive the same	Suresh Babu *et al.* (2021)
6	Clean Water and Sanitation	For fish rearing, advanced feed management practices using artificial diets have been standardized for replacing the conventional low-value fish feeding practices for all the species introduced by ICAR-CMFRI Development of land-based farming practices such as RAS, Aquaponics, and tank-based nursery rearing systems for reduce pollution. Promoted farming of filter feeders such as mussels and oysters to reduce water pollution.	Suresh Babu *et al.* (2022) Anuraj *et al.* (2022)
7	Affordable and Clean Energy	Recommended coastal fish farmers to use solar lights and solar powered CCTVs for monitoring cages	

8	Decent Work and Economic Growth	Imparted training programmes to fisherfolks on recent production techniques such as seaweed farming, Mussel-fish integration, RAS systems etc for enhancing their income	
9	Industry, Innovation and Infrastructure		
10	Reduced Inequality	For social upliftment, several coastal water cage culture demonstrations for the scheduled cast community were conducted under NFDB scheme and the Scheduled Cast Sub-Plan (SCSP) programme in UttaraKannada district	Anuraj *et al.* (2022)
11	Sustainable Cities and Communities		
12	Responsible Consumption and Production	Recommended the farmers to use artificial diet instead of low value fish. Also suggested the fishermen to use the trash fish as feed for the fishes in cages that is otherwise thrown out	
13	Climate Action	The station has been involved in the popularization of seaweed farming in coastal belts of Karnataka and Goa and has conducted several training programmes on seaweed farming for farmers and entrepreneurs	
14	Life Below Water	Suggested to reduce the pollution by adopting better management practices for fish farming	
15	Life on Land		
16	Peace and Justice Strong Institutions	Educated the fisher folk regarding the availability of several government schemes such as PMMSY, SCSP Programmes etc.	
17	Partnerships to achieve the Goal	Taken lead for collaborating with other government agencies for the upliftment of fisher folk through coastal water cage farming	

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Region-specific interventions toward achieving SDGs

Aiming the upliftment of coastal fish farmers in Karnataka, Karwar Regional Station of ICAR-CMFRI has initiated several programmes which are in the line of achieving the sustainable development goals.

Enhanced fish production through coastal aquaculture can be attained through diversifying aquaculture systems, introduction of various new candidate species and optimum utilization of available water resources. In Karnataka, Karwar regional station of ICAR-CMFRI is involved in the popularization of marine and coastal water cages with standardized methodologies for openwater cage farming of various species such as cobia, silver pompano, Indian pompano, orange spotted grouper, red snapper, seabreams and seabass. Open water cage culture activities were carried out in 8 thaluks of three districts for 98 beneficiaries with 161 cage units. Majority of the cage units were stocked with Asian seabass (152 cages) and red snapper (8 cages) and cobia (1 cage). Under the All India Network Project on Mariculture from 2015-16 to 2021-22, around 25 marine cage culture demonstrations for 13 SHGs were carried out for demonstrating the farming of Asian Seabass, Silver pompano and for demonstration of Integrated Multi- Trophic aquaculture for mussel-fish integration. Recently the diversification of farmed species was done by standardizing the seed production of seabreams and rabbit fish. Around 47 cages were issued for women beneficiaries in Uttara Kannada district under the NFDB subsidy scheme for openwater cage culture aiming at social upliftment of this section of society. Several coastal water cage culture demonstrations for the scheduled caste community were conducted under NFDB scheme and the centrally sponsored Scheduled Caste Sub-Plan (SCSP) programme in the Uttara Kannada district. Under the SCSP scheme, during the period 2019 to 2022, around 10 coastal water cages for 4 self-help groups (SHGs) consisting of 5 members in each SHGs were deployed for Asian Seabass farming which helped economically backward farmers to earn profits.

To reduce pollution, several mitigation measures were introduced in coastal water cage culture practices. For fish rearing, advanced and precise feed management practices using balanced artificial diets have been standardized for almost all the candidate species introduced by ICAR-CMFRI to replace the conventional low-value fish feeding practices. Development of land-based farming practices such as RAS, aquaponics, and tank-based nursery rearing systems could drastically reduce pollution. The station has developed a low-investment RAS farming system for silver pompano farming. Farming filter feeders such as mussels and oysters also will reduce water pollution. IMTA demonstration cage was also harvested at Koderi, Udupi. Under the technical guidance of Karwar Regional

Station a fishers' self-help group, Karavali Friends, carried out integrated farming of seabass and green mussels in a 6m diameter GI cage.

The popularization of seaweed farming is progressing in coastal belts of Karnataka and Goa with several training programmes on seaweed farming for farmers and entrepreneurs being conducted. Several attempts to demonstrate seaweed farming have been taken up and the successful standardization of farming of seaweed for the first time on this coastline is in the pipeline. Also, efforts on micro-propagations of native species of seaweeds are being attempted for the first time.

As a way forward, the institute is planning to upscale the seed production of new candidate species for enhancing the production of fish farming. Also doing research for prolonging the seed availability of commercially important marine finfishes for which the seed production is already standardized. Selection of locally available seaweeds for climate resilient farming is in pipeline. Micro-propogation of seaweeds for continuous supply of seaweed seedlings for farming is being attempted. Development of better management package of practices for commercially farmed species is being carried out. Extensive training and awareness programme for adopting scientific technologies by the farmers is also being planned with the aim to attain the envisaged SDGs.

Brief Communications

Technology for nursery rearing of Indian pompano, *Trachinotus mookalee*: Different culture systems approach

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Introduction

Coastal marine aquaculture is one of the emerging area for marine food fish production, and is mainly performed in the sea and in coastal ponds. Mariculture and coastal aquaculture collectively produced 30.8 million tonnes (USD 106.5 billion) of aquatic animals in 2018, and they are mainly from marine cages, coastal cages and coastal earthen ponds. Increasing marine food fish production through innovative and intensive culture methods has increased demand for marine finfish seeds either from wild collection or hatchery based production. In this context, nursery raring plays an important role in supplying of sufficient numbers of fingerlings at ready to stockable size in grow–out culture for better survival and faster growth. Larval rearing ends after the larvae achieved the full metamorphosis, and the metamorphosed early fry harvested from larval tanks are often not strong enough for direct stocking in grow-out farms. Thus, nursery rearing of fish larvae is of important for production of grow-out culture of stockable size fish. It is evidenced that healthy seeds are key for healthy grow out culture with better economic returns. Thus, maintaining healthy and disease free stock is of prime importance for achieving better production in grow-out system. So, nursery raring concept gives better opportunity to maintain large numbers of fish fingerlings in small area, which facilitate for effective management. Nursery rearing practices are majorly classified into two major categories; indoor and outdoor systems; where indoor based culture is performed either by flow through or recirculation based concept in FRP (Fibre Reinforced Plastic) /concrete/collapsible tanks. Outdoor based system is performed either running or moving waters in hapa erected or installed in earthen ponds, coastal cages and marine cages. All these culture systems having its own merits and demerits with respect to management and advocating these systems are based on the size of stocking and method of grow–out systems will be implemented for the species.

Nursery rearing of Indian pompano

Indian pompano (*Trachinotus mookalee*) is a marine fish, considered to be one of the good candidate species for coastal aquaculture and suitable species for species diversification. The fish is having important characters like ease of breeding in controlled condition, faster acclimatisation to different culture conditions, and better acceptance to artificial feed, pleasant appearance, good meat quality and high consumer preference. All these characters are together contributed and credit the fish as one of the new alternative candidate species for commercial coastal aquaculture operation in coastal ponds, costal cages and marine cages. Breeding and seed production technology for the species was standardized by ICAR-CMFRI, Visakhapatnam Regional centre, and subsequently culture technology was developed. The culture technology for the species has been standardised, disseminated and presently being practised in different coastal states in marine cages, coastal cages, and coastal ponds. In order to perform for grow-out culture in these systems, the fry produced in hatchery should be nursery reared till attaining the size at which the larvae tolerate different environmental conditions in the grow-out environments. Depending on the culture systems and locations, the nursery rearing is performed in different culture conditions with different suitable management practices. In general, 25-30 g size fingerling are considered as an optimum size for stocking in grow-out culture systems, but stocking of bigger size fingerlings will help in reducing the grow-out culture period, and will enhance the culture performance of the stocked Indian pompano seeds. The nursery reared fingerling are to be transported to the culture site, and thus the size of the nursery reared fingerlings are depending on the distance between nursery and grow-out site, and mode of transportation. This fish is sensible to transportation stress, and thus establishment of nursery facilities in proximities of grow-out culture environment is highly recommended. Common nursery rearing systems recommended and adopted for the species includes indoor based flow through systems (FRP and concrete cement tanks), recirculating based indoor system (RAS); hapa in coastal pond, coastal cage and marine cage based outdoor systems. More importantly, the growth rate for Indian pompano is <0.1 to 1.0 g/ day during early growth phase till attaining 100 g and then the growth rate increases up to 7.0 g /day in the later growth period. Therefore, maintaining nursery in small confined area for long time is recommended to save time, energy and expenditure in the grow-out culture operations.

Indoor based nursery rearing systems

Flow-rough based nursery system

Flow through based nursery rearing is the low density based extensive rearing method, performed in FRP or concrete cement tanks. In this system water filled once in the rearing tank and then same water is discharged along with faecal matters and unused feed after particular time period without treating. This system is suitable for the early fry stage, immediately after larval rearing. This system is mainly practiced in circular or square shaped tanks of 1-10 tonnes capacity with 1.0 meter water depth and central drainage system. Tank colour plays an important role in smooth functioning of daily activities, where light blue colour is the preferred for clear visibility of the fish fingerlings and other faecal matters. The concrete tank should be coated with nontoxic epoxy paint for smooth tank surface. Indian pompano larvae attain an early fry (1.5-2.5 cm; ~0.2 g in size) stage after 35-45 days and at this stage it can be shifted to Indoor based flow through nursery facilities. Fry of this size is preferably should be stocked in indoor based flow through facilities for better survival. The early fry stocked in this facility reaches 2.5 to 3.5 g in size approximately after a month, then it can be shifted to outdoor nursery systems. While shifting, the early fry can be shifted to nursery facilities by small containers (plastic buckets) with or without oxygen if the nursery facilities are available within the proximities of hatchery complex. However, shifting with help of oxygen will help to keep the fry in better conditions without stress. The transported fry is directly released to nursery rearing tank at 1500-2000 numbers/m^3 and maximum carrying capacity should be of less than 5.0 kg/m^3. After transfer, the stocked fry is fed with feed of 500 μ in size and 100% water exchange is recommended. While in daily operation, the central drain in the tank is covered with PVC pipes of small slits or drain covers. These pipes and drain covers should be wrapped with small mesh size nets according to size of stocked fry, which will avoid the escape of fry while in water exchange. Recommended feeding for the stocked fry is 4-6 times per day at 5-6% of body weight or till satiation. As feeding frequencies is more at initial stage, thus it is recommended for 100% water exchange in two different spells in the morning and evening at 50% in each time. As water is exchanged every day, the dissolved oxygen is consider as critical point than any other water quality parameters and ideal salinity is 10-35 ppt. Concentration of oxygen should be maintained always above 4.0 ppm and 1.5 ppm is considered as critical oxygen limit. While rearing, one feet gap between water surface and rim of the tank is necessary as the Indian pompano respond to the light variation, thus the stocked fry jumps out of water if disturbed either by light variation or sound. Thus, enough gap is required to avoid the larvae jump out of water or the tank surface should be covered with small sized mesh. The advanced fry takes nearly one months to reach an average of 3.0 g and survival varies between 75-95%, depending on nursery management practices.

Feeding in FRP tanks

RAS based nursery raring

The major limitations in nursery rearing and other aquaculture operation are land and water availability, gradual deterioration of aquatic ecosystems, frequent disease outbreaks and difficulties with sediment and waste water treatment. Therefore, it is very important to develop new culture methods to decrease the ecological impact in terms of waste production and water use. One important and effective method to solve these problems is the rearing of fish in re-circulating aquaculture systems (RAS). RAS is indoor tank-based water recirculation systems in which fish are grown at high density under controlled environmental conditions to maximize fish fingerlings growth year-round. The system is having the flexibility to locate the production facilities near grow–out culture site, complete and convenient harvesting and quick and effective disease control. These systems can be used to maximize production where suitable land or water is limited, or where environmental conditions are not ideal for the particular species to be cultured. It is a land-based aquatic system where the water is mostly re-used after mechanical and biological treatment process to reduce the consumption of water and energy. The system offers advantages where temperature and other water quality parameters can be controlled and provides conducive environment in order to maximise the growth and maintain fish health. Most of the modern RAS systems are generally consisting of the components like solids collecting systems (drum filter/sand filter), foam fractionation unit (protein skimmer), bio-filter, carbon dioxide degasser, nitrate filter, sterilisation point (usually UV sterilizer), temperature control, oxygen injection system and pH control and alkalinity dosing system. All these

Fingerlings during sampling

Sampling of fishes for recording various parameters components together helps to maintain good water quality parameters, and create conducive environment for the stocked fingerlings to grow. Recommended seed stocking size is 1.0 to 3.0 g and stocking density can be increased up to the total biomass of ~15 to 20 kg/m^3, increasing and decreasing in stocking number is depending on the size of stocking. Since, the system is stocked with high stocking density and water is continuously recirculated and thus, maintaining proper water quality with saturated level of dissolved oxygen is highly essential to maintain high survival in the culture system. Feeding in the system in similar to tank based flow through system and survival varies between 80-95% depending on stocking size and management practices. The preferred tank size is 5.0 to 10.0 tonnes capacity with 1.5m water depth.

Outdoor culture system

Indian pompano grow-out culture is practised in coastal ponds, coastal cages and marine cages in the specified locations, and these locations are generally away from hatchery facilities. Thus, nursery reared fingerlings are to be shifted to the respective culture system by different mode of transportations. In this circumstances, outdoor based nursery rearing in the respective grow-out culture system is recommended to reduce transportation related stress and expenditure. Also, performing nursery rearing in the respective grow-out culture facility helps to grow the fingerlings to required bigger size to reduce length of the grow-out period.

Hapa based nursery rearing in coastal pond

Coastal based pond farming is one of the important culture systems for Indian pompano culture. The optimum stocking size for the species in grow out coastal pond culture is 25 to 30 g, and if the available size is small (~1 inch), then nursing of the fry should be done before stocking in the grow-out pond. Pond based nursery culture in hapa is recommended to perform in the same grow-out pond or in separate nursery culture ponds. In general, less than 10% of the total grow-out culture area is recommended for nursery rearing in pond based culture. Rectangular hapas are installed in the pond and are supported with bamboo or casuarina poles. Customised hapa sizes are used, and the recommended sizes can vary from 2 x 2 x 1.5m to 4 x 4 x 1.5m with mesh sizes of 0.5mm. However, the size can be still bigger, but requires more manpower to manage while net exchange and other management practices. The suitable seed size in this system is 1.0 to 2.0 g in size and immediately stocking in the hapa, the newly stocked fry fed with floating pellet feed after acclimatisation. The mesh size of the hapa can be increased at time interval depending on the growth of stocked fry/fingerlings. The installed hapa should be stitched with mosquito mesh of one feet height at water interface for avoiding feed wastage through hapa mesh. Nylon net is preferred material for hapa in nursery rearing since it is softer than HDPE net. The ideal stocking density varies from 250 to 450 numbers/m^3 for the fingerlings of 3.0 to 20.0 g in size and grading of stocked fry based on size should be followed on a fortnight basis, to achieve uniform growth. Hapa change during nursery period is recommended preferably once in a month based on the waste/algae accumulations. If not exchanged at particular interval, it may affect water flow and dissolve oxygen deficiency for the stocked fingerlings. The fish accepts artificial feeds, and the diet with high nutrient content (Crude Protein 45% and Crude Fat 10%) is suggested for the nursery rearing. Feeding frequency of 4-6 times/day at 5-8% of body weight is recommended during the initial phase. The commonly available supplier for nursery feeds are Skretting (Norway), Lucky star (Singapore), Uni-President Enterprises Corporation (Taiwan), Growel Feeds Pvt Ltd (India). The fry stocked at 2.0 to 3.0 g in size should be culture for 60 to 75 days till it reaches 30-40 g, which is an ideal size for stocking in grow-out pond. The expected survival for the fish during hapa based nursery rearing is around 80-95%, and depends on efficient management. Maintaining good water quality is paramount in nursery rearing and thus, adequate aeration should be provided in the nursery pond as the fish fry are stocked at high densities in the hapa. Maintaining dissolved oxygen level of 4 to 6.0 ppm is recommended through use of paddle wheel aerators in the pond. The recommended salinity for good growth is 15-35 ppt. Water pH can vary from 7.5 to 8.5, but high fluctuations in daily pH due to algae in the pond increases the toxicity of ammonia, ultimately impacting the stocked fry, and therefore, has to be avoided. After attaining the stockable size, the nursery reared fingerlings are directly release into the grow-out systems.

Hapa based nursery rearing in coastal cages

In India, huge estuarine resources are available bordering the coasts and this potentially available under-utilized high saline water bodies, could be efficiently utilized by culturing the different species of finfishes in cages installed thereof. Optimum size of initial stocking for the fish in coastal cage is 20 to 25g. The fish stocked at the optimum size takes nearly 10 months to attain the market size of 750 g. However, the culture duration could be further reduced if the fish stocked are of bigger sizes. Thus, nursery culture of Indian pompano is considered an important aspect in cage culture for reducing the culture duration in cage culture operation of the fish. If ambient culture conditions existing in backwater culture farm facilities, nursery rearing can be performed in a few cage itself by use of hapas. Hapa based backwater nursery is performed, especially where the distance between land based culture and backwater cage is far away. Keeping the culture situation in consideration, backwater cage based nursery rearing is recommended for reducing seed transportation related issues and to stock bigger size fingerlings for initial stocking. Unlike, indoor tank based nursery facilities, the initial stocking size should be 3.0-5.0 g in size due to rough climatic conditions. In general 5x5x3m GI cages are used for grow-out culture, and therefore, a hapa of either 2x2x2.5 or 3x3x2.5 size are recommended for nursery in cages. The mesh size of the hapa should be 5mm in size, and should be stitched with feed mesh of 1.0 feet height at water and air interface to avoid feed wastage through hapa mesh. Optimum stocking density is 350-500 numbers/m^3 and this stocking density can be maintained till 25.0g in size. Immediately after stocking, the fingerlings can be fed with floating pelleted feed of 0.8 to 1.0mm in size, at 5-6% of body weight. Feeding frequency should be 4-6 times and minimum of 4 times /day is highly recommended at initial stage. As, backwater is prone for bacterial load due to domestic waste accumulation, the nursery reared fingerlings should be continuously monitored and necessary medications with feeding should incorporated based on requirements. The estimated survival in this system is varied from 75-80% and more mortality is encountered during initial stage of nursery rearing, and especially more at the time of net exchange.

Hapa based nursery rearing in marine cages

Cage farming technology is widely recognized as one of the most important culture technology in mariculture for increasing fish production. Different species of marine finfishes are cultured in marine cages and Indian pompano is considered as a suitable potential candidate species for marine cage culture system. Cage culture is operated in isolated locations at 1-5 km distance from the coast. Thus, seldom transportation of the bigger seed is problematic to

Coastal backwater cages

Seed stocking in coastal backwater cages

Hapa installed in coastal backwater cages transfer for long distance, and in this situation performing nursery rearing in marine cage itself using small hapa is preferred if conducive environmental conditions are exist in cage farm site. Similar to coastal cages, hapa of 2x2x2.5 or 3x3x2.5 or other optimum size is preferred for nursery rearing and hapa should be prepared by HDPE materials to withstand in rough weather in sea. Recommended initial seed stocking size should bigger (~ 5.0 g), as wave action and water current are high in sea cage site. The recommended stocking density is less than 10 kg/m^3 (400-500 numbers/m^3 till 20.0 g) and then slowly the stocking density is reduced as fingerling grow. Stocked fingerlings fed at 5-6% of body weight with minimum of 4 times/day, and floating feed is recommended. Feed mesh by mosquito mesh should be attached at water and air interface to avoid wastage of floating feed due to wave actions. While in culture, hapa should be exchanged once in a month in order to avoid blockage of water movement due to fouling in the net. Hapa installed in cage is prone for folding due to high wave action and thus use of ballast pipe in happa is preferred, which will avoid net folding due to wave action. The survival of nursery reared fingerling in this system is ranged between 70-80%.

Effects of different nursery rearing environment on growth

Growth performance is one of the important traits which determine long time existence of a species in commercial culture operations. Fish growth is a complex process in which the ingested energy is converted to biomass and is regulated by genetic growth potential of the fish and several other abiotic factors provided by culture systems. Indian pompano is nursery reared in different culture systems and growth in all these systems is influenced by the different environmental factors brought by the respective culture systems. In comparison with indoor culture environments, outdoor culture system exhibit better growth due to availability of natural feed in addition to merely pelleted feed. The natural water movement also found to enhance the growth. However, outdoor systems are more prone for bacterial and other kind of infections, which seldom reduce survival. Growth rate and feeding details in nursery rearing of Indian pompano in different culture system (Table 1).

Seed transportation

It is preferred to establish the nursery raring unit near to grow-out culture site for ease of transportation. Advanced fingerlings to nursery rearing or nursery to grow-out culture system is transferred via polythene bags filled with oxygen or sintex / FRP tanks supported with oxygen. When fingerlings are to be shifted at more than 5.0g in size, preferably they should be transported via a container supported with pure oxygen for achieving maximum survival and smaller sized advanced fry of less than 1.0 g in size can be transported via polythene bags. Fingerlings transported in stressed condition (overcrowding and less dissolved oxygen) are more susceptible to bacterial infection after stocking. Thus, adequate care should be given to keep the animals under stress-free conditions. Based on the observations; the optimum fish size, stocking density and mode of transportation (Table 2).

Points to be considered in nursery rearing of Indian pompano

- Rearing fish larvae through the early life stages is performed in nursery, and this is the phase between hatchery and grow-out. Thus, before stocking for grow-out, culture species needs to be nursed for attaining optimum stocking size.

- Nursery rearing of Indian pompano is essential in cage culture for reducing the culture duration during grow-out. Two major types of nursery systems are preferably used: Indoor and outdoor based systems and use of these systems are depending based on the nature of the grow-out culture.

Table 1. Growth rate and feeding protocols in nursery rearing

	Pond	Cage	Tank	RAS	Feed Size	Frequency	Feed Weight
Days (DOC)	Weight (g)				(mm)	(Time/day)	% of BW
0	3.5	3.5	3.5	3.5	0.8 to 1.2	4-6	5-6
30	19.35	27.7	10.55	18.8	1.2 – 1.8	4-5	4-5
60	48.05	48.4	21.35	35.55	1.8 to 2.0	4	4
90	73.3	90.5	39.8	73.6	2.0 to 3.00	4	4
Survival (%)	80-90	70-80	85-95	80-95			

Table 2. Desirable protocols for Indian pompano culture

Fish Size (g)	Duration (hr)	Stocking (numbers/lit)	Mode of transportation
> 0.25	24-36	50-60	Polythene bag filled with oxygen
1.0 to 2.0	15-30	20-25	Polythene bag filled with oxygen
2.0 to 5.0	12-24	10-15	Sintex tank supported with oxygen
5.0 to 15.0	12-20	5-6	Sintex tank supported with oxygen
25.0 to 30.0	12-20	2-2.5	Sintex tank supported with oxygen

- Feed used in nursery should have a high nutrient profile; 45% crude protein and 10% crude fat. Feeding frequency of 4-6 time/day at 5-8% body weight is recommended. The feeding rate varies with size of the fingerlings reared.

- Indian pompano, being a fast-moving pelagic fish, dissolved oxygen requirement is very high; therefore, during nursery, the dissolved oxygen concentration should always be above 4.5 ppm.

- With proper feeding and water quality management, expected survival in indoor tank-based cultures is 80-95%, whereas in hapa-based outdoor culture systems it is 70-85% and survival is mainly depending on the management practices.

- Fishes are very active during nursery rearing; therefore, they tend to jump to at-least 15.0 cm above the water level. Thus, water level should be at least 30.0 cm below the tank surface for avoiding fish fingerlings falling out of water. It is suggested to cover the tank surface with fish net to avoid fish jumping out of the tank.

- Vibriosis is the most common bacterial infection occurring during nursery, because of stress. Minimising stress in nursery will help to keep the fishes free from bacterial infection. Possible stressors are: overcrowding, more waste accumulation in tank bottom, rough handling, higher water temperature and lower dissolved oxygen.

Brief Communications

Mapping of marketing channels and value chain analysis of some commercially important shellfish species landings in the East Medinipur district, West Bengal

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West Bengal with a coastline of 158 km, two coastal districts, 171 marine fishing villages, 49 marine fish landing centres, 3.7 lakh fisher folk population (CMFRI Census, 2016) has contributed 2.6 lakh t of marine fish landings during 2020 registering an increase of 4.6% compared to 2019. The marine landings during the period were dominated by pelagic resources with landings of 1.25 lakh t (49%) followed by demersal (82,000 t, 32%), crustacean resources (41,000 t, 16%) and molluscan resources (8,000 t, 3%). The major resources contributed to the total crustacean landings of the state during the period were penaeid shrimps (66%) followed by non-penaeid shrimps (21%), crabs (13%) and lobsters (<1%). Similarly the major resources contributed to the total molluscan landings were cuttlefishes (71%), followed by squids (28%). Octopus formed a meagre landing, contributing nearly 1% of the total molluscan landings of the state. The major gears contributing to the total marine landings of the state were mechanized multi-day trawlers (54%) followed by mechanized gill netters (12%) and inboard bag netters (7%). Other gears such as mechanized bag netters, inboard gill netters, hook and liners and shore seiners together contributed about 27% to the total marine fish landings of West Bengal (CMFRI, 2020).

This study reports the marketing systems with its value chain analysis of selected shell fish resources landings along the coast of West Bengal. Value chain which comprises full range of activities required to bring a product or service from the stage of conception, production and distribution to consumers. It is the preliminary step in the mapping of market (FAO, 2013) and can be used as a management tool to reduce processing costs, improve quality and productivity of the product and reduce distribution costs (Jeyanthi and Chandrasekar, 2017). This study mapped the various marketing channels and value chain analysis of some commercially important shell fishes landing in Purba, Medinipur.

Sankarpur landing centre, Digha Mohana auction point and 10 fish markets including wholesale cum retail, retail and terminal fish markets were covered under the study conducted during January to June, 2022. Value chain analysis was conducted by mapping the product value chain from the landing centre till the consumer. Sample survey was conducted among 45 fishermen, *beparis* and depot owners, 40 middlemen and marketing agents, and 35 retailers using personal interview method with semi structure questionnaires and combination of participatory, qualitative and quantitative methods for data collection. The interviews focused on channels of marine fish distribution, price spread and marketing constraints following a stakeholder meet and field visits made to fish landing centres, whole sale markets, fish salting and dry fish yards in Digha Mohana and Sankarpur.

A large number of stakeholders find employment in the fish marketing chain as fishermen, assemblers, processors, traders, wholesalers, retailers, transporters and loading and unloading workers. The market chain encompasses primary, secondary and retail markets with fishermen as the primary producers. The marine fish marketing operations were performed by a large number of intermediaries with good network on fish trade and other facilitating functions. The fish market channels have wholesalers buying fish in bulk quantities from auctioneers or from regional suppliers and selling it to retailers or other traders. The wholesalers imparted value addition in terms of sorting, grading, cleaning, icing and packing fish prior to sale. Subsequently, the retailers sold the fish directly to consumers over the counters or with the help of vendors. Retailers mostly bought fish from the wholesaler, but in several cases, groups of retailers also participated in the auction process for buying fish directly from the auctioneers. The sources of finance for various operations of the value chain came from the private sector, cooperative societies, fishermen associations, and also institutional finance.

There are two main fishing seasons for shellfishes, the peak and the lean season. Apart from the ban period (April–May), which is fixed, the concepts of ‘lean’ and ‘peak’ are subjective. On an average, the peak season lasts for about five months from October to February, and the lean season for about seven months from March to September, including the monsoon fishing ban period. The price changes across the channels for the selected resources of penaeid shrimps, lobsters, crabs and cephalopods are documented below.

Market chain mapping of giant tiger prawn *Penaeus monodon*

Once the landings from Sankarpur landing centre reaches the Digha Mohana auction centre, four marketing chains were found to be prominent in the *Penaeus monodon* marketing chain such as assemblers/ regional suppliers, wholesalers, retailers and export units. In the marketing chain, the giant tiger prawn reach the export market from fishermen through the channels *viz.,* landing centre, auction centre, regional suppliers and processing units.

Table 1. Commercially important shellfish species traded in the various markets

Name of the Market	Name of shellfish species traded	Quantity traded kg/ day	Daily market capitalization value (₹)
Old Digha Nehru Market	*Penaeus indicus*	40	26,000
	P. monodon	40	40,000
	P. japonicus	60	51,000
	Portunus sanguinolentus	160	16,000
	P. pelagicus	50	15,000
	Charybdis feriata	25	4,500
	Panulirus polyphagus	25	35,000
	Parapenaeopsis hardwickii	50	10,000
	P. stylifera	50	10,000
	Solenocera crassicornis	25	3,750
Digha Sabuj Market (New Digha)	*P. monodon*	60	60,000
	P. japonicus	40	34,000
	P. hardwickii	70	14,000
	P. stylifera	60	12,000
	P. polyphagus	10	14,000
	P. sanguinolentus	160	16,000
	P. pelagicus	50	15,000
	C. feriata	25	4,750
Ramnagar Mecho Bazar	*P. indicus*	15	5,250
	P. monodon	25	17,500
	P. sanguinolentus	35	5,600
	P. pelagicus	10	3,500
	S. crassicornis	20	3,200
	Acetes spp.	30	2,400
	P. sculptilis	20	4,000
	P. stylifera	20	4,000
	P. hardwickii	10	2,000
Deulihat Fish Market	*P. stylifera*	25	5,000
	Acetes spp.	30	2,400
	P. hardwickii	20	4,000
	S. crassicornis	25	4,000
Balisai Market	*P. sanguinolentus*	60	7,200
	P. pelagicus	20	7,000
	C. feriata	15	2,700
	S. crassicornis	75	12,000
	Acetes spp.	40	3,200
	P. stylifera	25	4,500
Kathi Nona Bazar	*S. crassicornis*	300	48,000
	P. sanguinolentus	450	58,500
	P. pelagicus	150	52,500
	P. indicus	150	67,500
	P. stylifera	350	63,000
	P. hardwickii	350	63,000
	P. monodon	150	2,25,000
	P. japonicas	60	48,000
Kathi Super Market	*P. stylifera*	35	6,300
	P. hardwickii	35	6,300
	P. monodon	30	36,000
	P. japonicus	25	22,500
Mukundapur Market	*P. stylifera*	25	3,750
	P. hardwickii	25	3,750
	S. crassicornis	35	4,200
	Acetes spp.	60	3,600
Hirapur Market	*P. sanguinolentus*	40	4,800
	Acetes spp.	60	3,600
	P. hardwickii	5	800
	P. stylifera	5	800
Gobra Market	*P. sanguinolentus*	25	3,500
	P. hardwickii	7	980
	P. stylifera	7	980
	Acetes spp.	60	3,600
	S. crassicornis	35	4,550

The commodity reaches the domestic consumers through local and distant markets via wholesaler and retailers. The price spread of *P. monodon* was found to be ₹400-1200 per kg at the auction centre level to ₹750-1600 per kg at the level of retailers.

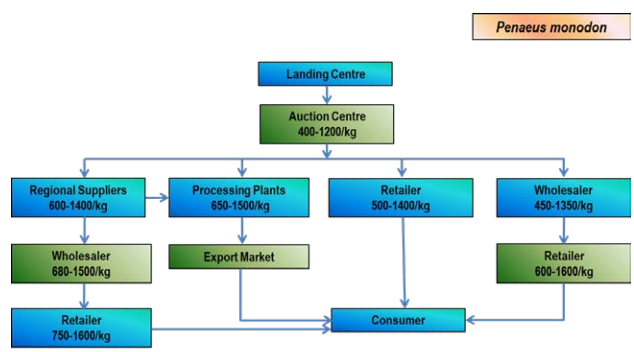

Fig. 1. Market chain mapping of *Penaeus monodon* in the areas surveyed

Market chain mapping of mud spiny lobster *Panulirus polyphagus*

Once the landings of mud spiny lobster reach the Digha Mohana auction centre, assemblers/ regional suppliers are found to be the predominant channel for distributing the commodity to distant domestic markets such as Chennai, Mumbai and Kolkata. The commodities reach the export markets through assemblers and processing units. The price spread was found to be ₹400-1300 per kg at the auction centre level to ₹850-2000 per kg at the level of retailers (Fig. 2).

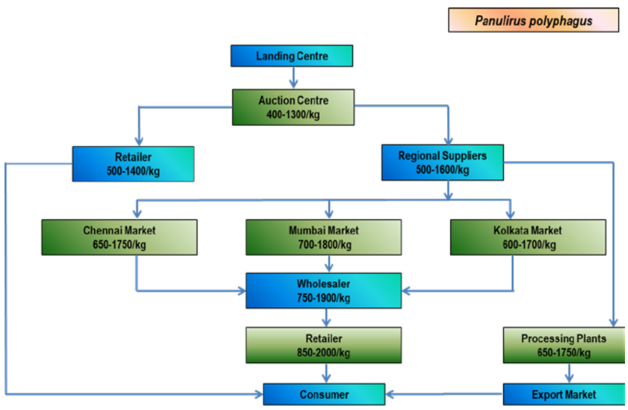

Fig. 2. Market chain mapping of *Panulirus polyphagus* in the areas surveyed

Market chain mapping of three spot swimming crab *Portunus sanguinolentus*

The marketing chain for *Portunus sanguinolentus* was found to be a simple chain with traditional actors such as wholesalers and retailers, as in any other market chain. The distant domestic market for this commodity was found to be Chennai and Bangalore markets, for which the regional suppliers/ assemblers play a major role in its distribution. The export market channel was not to be found for this three spot swimming crab from this coastal district. The price spread was found to be ₹50 -100 per kg at the auction centre level to ₹250-350 per kg at the level of retailers (Fig. 3).

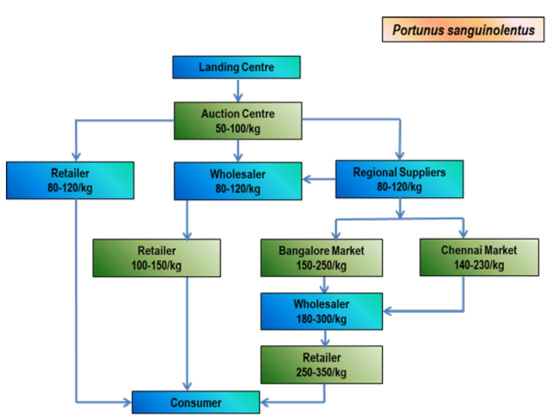

Fig. 3. Market chain mapping of *Portunus sanguinolentus* in the areas surveyed

Market chain mapping of Pharaoh cuttlefish *Sepia pharaonis*

Commission agents and assemblers/ regional suppliers are the predominant marketing channels found to play a major role in distributing these cephalopod landings from auction centre to export units. The major export market was found to be China, for this resource from West Bengal, and its distribution was found to be nil among the domestic markets. The price spread was found to be ₹200-250 per kg at the auction centre level to ₹240-350 per kg at the level of processing units (Fig. 4).

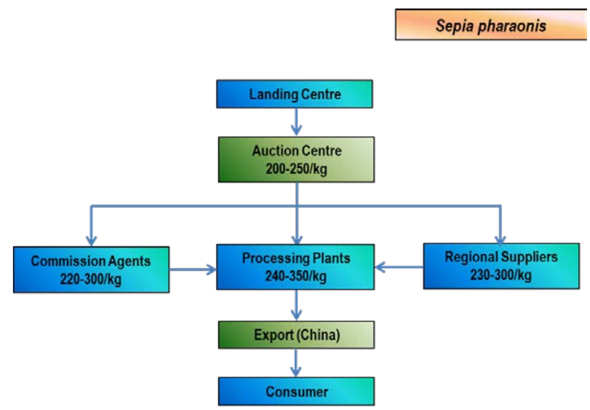

Fig. 4. Market chain mapping of *Sepia pharaonis* in the areas surveyed

The market chain analysis exposed the range of actors required to bring the product from landing centre through the different phases of distribution and delivery to final consumers. A large number of intermediaries are involved in the process of marketing from the landing centres to retail markets, and ultimately the consumers. The price depends on quality, size and weight, season, market structure, supply and demand, etc. Prices also vary from market to market. The marketing channels for different shellfish resources were different from each other. Some resources had the long marketing channel with more intermediaries and some had short marketing chain.

Perceived marketing constraints

In general, infrastructural facilities at landing centres, auction centres and fish markets were found to be inadequate including cold storage facilities. Proper approach roads and transport facilities are also generally inadequate, to bring the landings from landing jetties to auction centres. Further, standard operating procedures are also needed for various operations such as handling, washing, sorting, grading, cleaning and icing of fish. At the primary market level, the major constraint expressed by the fishermen was lack of bargaining power and inadequate market information. The major sources of finance for various operations along the value chain are from private money lenders, hence improved access to institutional finance was also a perceived need. The problems related to distribution to export markets are long distance transportation, wherein the vehicles are often charged at several checkpoints during the transportation. During the stakeholder interfaces, it was reported that the immediate needs are cold chain and storage facilities, insulated vehicles and hygienic markets. Adequate infrastructural facilities in the fishing harbour is needed to minimize post-harvest losses (it was reported by fishermen respondents that on an average, a trawler is incurring a loss upto ₹20,000/trip due to inadequate infrastructural facilities pertaining to approach roads, insulated vehicles and other harbour facilities).

This study aimed to analyze the flow of selected shellfish landings on the value chain by mapping the selected shell fish value chain, and documenting the responses of value chain actors. It also explored the contributions of shellfish landings among value chain actors by exposing the price spread at various nodes which will be useful for stakeholders to streamline their operations in a cost effective way, increase earnings in the value chain actors and which have impacts on credit repayment processes.

Brief Communications

Note on an albino spadenose shark, *Scoliodon laticaudus* from the north-east coast of India

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Albinism is a genetically inherited condition where the pigment protein melanin is either missing or nonfunctional. Individuals with total albinism exhibit total absence of melanin involving the entire body while partial albinism (or leucism) is phenotypically characterized by absence of melanin in parts of the body or reduction of melanin in the entire body or a part of it. It is rare in elasmobranchs as compared toteleosts. To date, 61 species of elasmobranchs have been reported with albinism globally and *Carcharhinidae* is no exception to this. The spadenose shark *Scoliodon laticaudus* Müller & Henle, 1838 (Family: *Carcharhinidae*) is a small shark landed all along the Indian coast in considerable numbers. Leucism has been reported in this species from India (Veena *et al*., 2011) while this report is on partial albinism in a specimen of *S. laticaudus* landed at Digha landing centre (East Midnapur, West Bengal, India) by a trawler that operated at a depth range of 30-50m (21°35'52"N 87°54''47"E). The specimen was collected during routine field sampling on 21st December, 2020, and body measurements were recorded. Morphometric comparisons were made with a normal specimen of the same sex and similar length. Tissue samples were processed for further detailed genetic analysis.

Out of fifty samples of *Scoliodon laticaudus* collected

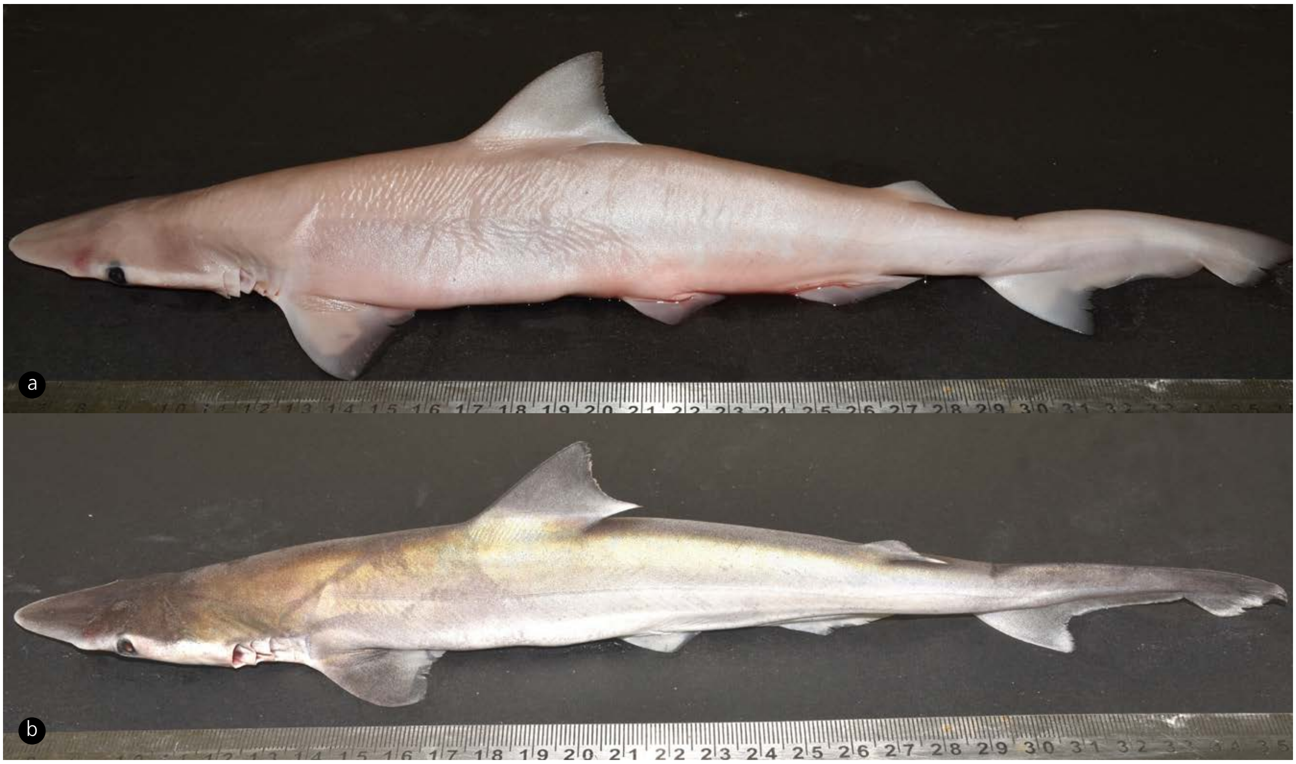

Fig. 1. (a) Albino *S. laticaudus* (b) Normal *S. laticaudus* landed at Digha, West Bengal, India

for observations on the biology, one specimen was found to be a partial albino. Changes in tyrosinase and P genes located in autosomes are reported to be the most prevalent causes of total or partial albinism. The albino *S. laticaudus* recorded in this instance was a female, measuring 34.9 cm in total length and weighing 162 g (Fig. 1a). The morphometric measurements are presented in Table.1. Key morphometric features of the selected specimen were found to be well within the range of a normal specimen with same sex caught in the same region except the colour pattern. Unlike normal bronze grey body, the specimen was fully cream-coloured dorsally (Fig. 1a, b). The fins were also cream in colour without any conspicuous markings but the retinal coloration was normal from which it was confirmed that the shark was a partial albino. The specimen was found to be devoid of any signs of disease and completely free from parasites and was absolutely healthy.

Table. 1. Morphometric measurements for the albino and normal specimen of *S. laticaudus*

Measurements (cm)	Albino specimen	Normal specimen
Total length	34.9	32.6
Total weight(g)	162	121
Sex	female	female
Fork length	29.5	27.8
Snout to first dorsal	12.8	12.7
Snout to 2nd dorsal	23.4	21.8
Snout to pectoral	8.4	7.2
Snout to pelvic	17.2	16.3
Snout to anal	21.3	29.8
Snout to caudal	27.2	25.7
Snout to nasal	2.8	2.4
Snout to mouth	3.3	2.9
Snout to eye	3.7	3.4
Snout to 1st gill	6.7	6.2
Snout to last gill	8.6	7.9
Distance between 1st & last gill	1.9	1.9
Height of 1st gill	0.9	1
Height of last gill	0.9	1
Inter dorsal	7.8	7
Inter nasal	2	1.9
Inter orbital	3.1	3
Eye diameter	0.62	0.71
Mouth width	2.4	2.6
Body depth	5.1	4.6
1st dorsal height	4.2	3.9

Measurements (cm)	Albino specimen	Normal specimen
2nd dorsal height	3.4	3.2
1st dorsal base	1.4	1.3
2nd dorsal base	1.1	1.1
Pectoral height	3.4	3.5
Pectoral base	2.4	2.2
Pelvic height	1.9	1.8
Pelvic base	1.9	1.7
Anal height	1.7	1.6
Anal base	2.6	2.5

Measurements (cm)	Albino specimen	Normal specimen
Caudal height(upper)	7.9	7.5
Caudal height(lower)	3.4	3.1
Caudal depth	1.6	1.5
Trunk length	11	10.5
Tail length	16.9	15.8
Eye	Normal	Normal

References

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Kaleidoscope

Rare occurrence of cirrate octopod *Opisthoteuthis* sp.

Fig. 1 Dorsal (a) and ventral (b) view of *Opisthoteuthis* sp. from Sakthikulangara fisheries harbour

A single specimen of cirrate octopod *Opisthoteuthis* sp. was collected from Sakthikulangara Fisheries Harbour in Kollam district on 12th April 2022 (Fig.1). It was a by-catch in a bottom trawl operated at a depth of 200m. Three species of *Opisthoteuthis* are currently known to occur in the Indian Ocean. These are *O. phillipi, O. extensa* and *O. medusoides*. All these species have been described from only a few individuals, making detailed comparison among the species in the genus difficult. More detailed morpho-meristic data, detailed description and molecular taxonomy approaches such as DNA barcoding, is required to clarify its identity. Cirrate octopods are considered to resemble the ancestor of all octopuses, inhabiting deep waters of all oceans of the world (Villanueva *et al.*, 2002). The family Opisthoteuthidae, which includes the cirrate octopod genus *Opisthoteuthis*, is home to the majority of cirrates.

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Report on incidence of Cepheid jellyfish

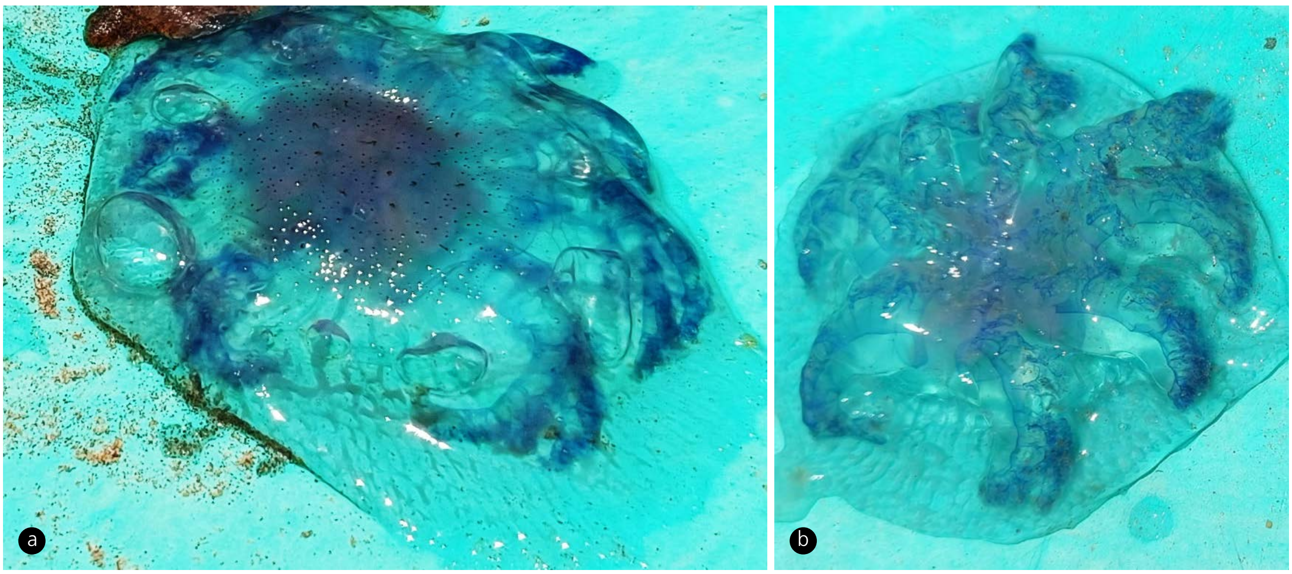

Fig. 1: Cepheid jellyfish, *Marivagia stellata* (a) Dorsal view (b) Ventral view

Unusual landings of a Cepheid jellyfish was observed at Jeerupalem landing centre , Srikakulam, northern Andhra Pradesh on 11th and 12th April 2023. Based on enquiry, it was found that mass swarming of the Cepheid jellyfish was observed from inshore coastal water. Jellyfish was caught in ring seine operated by outboard FRP boats (OAL-7.5-9.8m; engine capacity: 15HP) at a water depth of 20-30 m and discarded. Altogether 50 boats were operated per day, and each unit discarded an average of 25-30/kg of Cepheid jellyfish. Average commercial catch (mainly *Stolephorus commersonnii, Sardinella longiceps* and *Rastrelliger kanagurta*) landed was 60-70 kg/ unit. As per fishermen's view, there is 20-30% reduction in commercial catches per unit due to swarming of jellyfish, and also increase in sorting time. This swarming mostly happens in summer seasons and it is a great menace for the ring seine fisheries along the coast.

Twenty jellyfish samples were collected, photographed, and identified as the Cepheid jellyfish, *Marivagia stellata* Galil and Gershwin, 2010 (Fig.1 a&b). The species is characterized by translucent bluish-white bell without a central dome, warts, or knobs on the ex-umbrella surface but with a conspicuous pattern of stars, dots, and streaks clustered on the centre of the exumbrella. Sub-umbrella lacks filaments on the oral disk and between mouths. The bell diameter of the species varied from 90 mm to 120 mm. The sudden appearance of vast numbers of specimens of the species at the same time may be attributed to the fact that the local population have been already established in inshore coastal water and the presence of cryptic sessile, asexually reproducing polypoid stage, which can produce ephyra that grows into free-swimming medusa. The swarming incidence was observed for the first time along the northeast coast of India.

Marivagia stellata was first described from the southeastern Levantine coast of the Mediterranean Sea in 2010. Globally, the species was reported from the Indus River, Pakistan, Israel, Syrian, Srilanka and in Lebanese waters. In India, the species has been reported from the coast of Kerala and Palk Bay, Tamil Nadu. This report indicates that *M. stellata* is distributed in the western Bay of Bengal also..

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