Possible areas for Public-Private Participation (PPP) in fisheries in Orissa with the intervention of Corporate sector

Base paper

1. Preamble

Orissa is one of the major maritime States, offering vast scope for development of inland, brackish water and marine fisheries. The State's 480 km long coastline covering an area of 24,000 sq. km has huge potential for marine fisheries development. The freshwater resources of the State include 1.16 lakh ha area under tanks and ponds, 2.56 lakh ha reservoir area, 1.80 lakh ha area under swamps & *jheels* , 1.55 lakh ha water area of rivers and canals. The brackish water resources include 2.98 lakh hectares of estuaries, 32,587 hectares of cultivable brackish area, 8100 hectare of backwater area and 9,000 ha of Chilka lake.

A conservative estimate of fish requirement in the State is about 3.23 lakh tonnes (as per WHO, consumption requirement is 11kg/ capita/ annum). However, the present level of fish production in the State is only about 2.595 lakh tonnes, leaving a net deficit of 1.435 lakh tonnes. Thus the potential for enhancing the availability of fish in the domestic market for local consumption is sizable coupled with increased livelihood security of the producers.

A white paper on public reforms in Orissa places the average per capita annual income of those involved in the fisheries sector at Rs. 6,787/- compared to the all India average of Rs. 10,204/-. Enhancement of the livelihood and enterprise opportunities in this sector therefore, need to focus on the poor workers involved in fisheries and the small / medium entrepreneurs.

Inadequate infrastructure facilities, information and communication channels, etc in the State, are identified as the limiting factors in promoting cost-effective and environmentally sustainable methods of harvesting and production; spread of know-how for maintaining high standards of storage and processing of produce for value addition; and effective linkages and networks for profitable marketing of products. As a consequence, Orissa is left with a huge untapped area for fish production covering varied ecosystems and open water resources like lakes, ponds, reservoirs, etc., which have not been harnessed to optimal levels.

2. Action Plan

The following action plan is suggested for the involvement of CII as a promoter/catalytic agent in bringing in a joint partnership between the entrepreneurs and the small-scale fishers in various fisheries/fishery related activities for harnessing the inland and marine resources and to provide them social security.

2.1 Ornamental fish breeding and rearing

The world trade in ornamental fishes is estimated at Rs 8,000 crore, and the developing countries are the major sources for imports. Over 80 per cent of the trade is dominated by freshwater fish and the balance by marine ornamental fish. While Singapore and other South East Asian countries account for 80% of the global trade. The main markets are the USA, UK, Australia, Belgium, Italy, Japan, China, and South Africa. According to the industry estimates, India's domestic annual turnover is about Rs. 15 crore, but the global market is much. Species like catfish, dwarf and giant gouramis, and bars are popular abroad and fetch good prices. India's contribution to the world trade in marine ornamentals is estimated to be less than 0.2%.

In India, Kolkata, Mumbai and Chennai are the major production centres with 150 business groups and 1,500 small entrepreneurs involved in the trade. The Chennai market alone is estimated at Rs 10 crore annually. This is despite the country's tropical climate, varied freshwater sources, and over 8000 km long coastline.

Indian ornamental fishes with their brilliant colours and unique features need no introduction to the World market. The freshwater and the brackishwater bodies and the seas around the Indian sub-continent abound in attractive varieties of fish which are dearer to the hobbyists the world over. India exports over three hundred varieties of freshwater fishes today. The tropical ornamental fishes from north eastern and southern provinces of India are in great demand in the hobbyists market. Prominent among the freshwater Indian Ornamentals are Loaches, Eels, barbs, catfish, Goby, etc. India also exports tank raised varieties of fishes such as gold fish, Mollies, Guppies, platties, Sword tails, Tetra, Angel, Gourami, African Cichlids and fighters. Different colours with various patterns of fishes are the hallmark of these varieties.

Kolathur village on the outskirts of Chennai is famous for ornamental fish cultivation by small scale producers. There are about 600 families earning their livelihood through ornamental fish cultivation in Kolathur and on an average each household in the village earns over Rs 5,000/- per month through ornamental fish farming. About 45 km from Kolathur, Gummidipoondi village is another hub of ornamental fish production where women SHGs have successfully taken up breeding and raising of ornamental to earn their livelihood.

The domestic trade is a mix of medium and small ornamental fish farmers. In Chennai, many farmers grow fish in their backyards and sell the stock. Govt undertaking Tamilnadu Fisheries Development Cooperation (TNFDC) joined the field in 2000. It rears popular varieties like goldfish, angelfish, modalities and fighters in its farm near Coimbatore. The ornamentals are sold in the local markets.

A Rs 20-crore infrastructure park for breeding and culturing of aquatic plants and ornamental fish is planned to be set up at Chembarampakkam tank area near the Chennai-Bangalore highway on the western outskirts of Chennai. A team of experts from Agri Food & Veterinary Authority (AVA), Singapore, and INFOFISH of Malaysia, visited various potential sites, identified the location for the park, and has submitted a report to the Tamil Nadu Government. The team also discussed the modalities for setting up a park with leading breeders and marketers of ornamental fishes in Chennai.

The park is proposed to be set up by the Tamil Nadu Industrial Development Corporation (TIDCO) and the Marine Products Export Development Authority (MPEDA) jointly with private partners - Indian or foreign. Those concerned are likely to seek the State Government's assistance, through the Fisheries Department, to obtain 100 acres of land on a long-term lease for the project, sources say.

The park is envisaged to provide infrastructure of international standards for 50 production units to breed and multiply ornamental fish or aquatic plants. The project seeks to address the major bottlenecks faced by entrepreneurs in the areas of research and development and post-production as packing and transportation, according to the sources. The ornamental park is expected to enlarge the scope of business activities of the small players and is set to exploit the export market.

To popularise ornamental fish production and trade in Orissa, the success story of Tamil Nadu, particularly of Kolathur is an excellent example to try. It provides a god mix of domestic as well as commercial scale production, which largely caters to the export market.

CII could play a key role in creating conducive atmosphere and confidence among the entrepreneurs of Orissa for venturing in to ornamental fish breeding and export trade. As in Tamil Nadu, the entrepreneurs with investments from their own resources or lead commercial banks or financing institutions could set up the basic infrastructure facilities such as brood stock ponds/tanks, hatcheries, rearing facilities, feed mill, packaging and marketing and involve SHGs and unemployed youth in the production cycle, following the concept of satellite farming, to provide them alternate sources of employment and income.

2.2 Coastal Aquaculture in the corporate sector in Orissa

The Water Base Limited (TWL) is the largest and the only integrated aquaculture unit in India located at Nellore, A.P. The company which began its operation in 1993 is today a US $ 18 million company (Rs 1 Billion) with facilities that comprise a shrimp hatchery, feed plant, grow out farms and an ultra modern processing plant. The two popular and commercially important marine shrimp viz. black tiger (*Penaues monodon*) and white (*P. indicus*) and the freshwater prawn (*Macrobrachium rosenbergii*) are raised in the farms of the company. The company sells shrimps in various forms such as cooked, beheaded, deveined, IQF, etc., depending on the customer requirements in the export as well as domestic markets. Apart from its own stock of shrimp, the company also sources it from other farmers to meet orders. The company is among the few Indian companies that have FDA approval for export of marine products to USA.

The company exports shrimp in different forms to the quality - conscious markets of Japan, USA, and Europe. It has a 50:50 joint venture with Handy and Son of US, which is exporting pasteurised crab meat that is considered a delicacy in west. The company has also made a retail foray with a specialty and a popular sea food restaurant in Bangalore called Tiger Bay (recently a second outlet in Bangalore has been opened) and proposes to take this concept to other cities soon. The company has recently entered into an R&D Alliance with INVE of Belgium.

The Govt. of India has recently permitted the company to initiate a long term programme on domestication of tiger shrimp. The company is also in the process of perfecting the technology for breeding and raising of mud crab (*Scylla serrata*), which has a lucrative domestic and export market.

M/S Waterbase Limited is today the only corporate sector in shrimp farming and its integrated unit at Nellore is an excellent example of corporate sectors contribution to the development of seafood industry in general and shrimp farming in particular.

Considering the vast potential Orissa has for development of coastal aquaculture and entrepreneurship, re-introduction of the corporate sector in sustainable (eco and user friendly) coastal aquaculture could be considered. The technology developed by M/S. Waterbase could be replicated in Orissa with the concept of cluster farming creating a conducive atmosphere for public-private partnership in farming, processing and marketing. The basic requirement for such a corporate sector involvement such as land, electricity, communication, water supply etc., should be provided by the State Government. CII could initiate a dialogue with the entrepreneurs within and outside Orissa including Waterbase to invest in this sector in Orissa. The policy initiatives which are required including amending the existing policy on brackishwater leasing, if it warrants, from the State Government side could be considered.

2.3 Infrastructure development for domestic marine fish marketing and export

As already stated in para 1 above, the estimated potential for marine fish production along the 480 km coastline of Orissa is around 1.26 lakh tonnes and the freshwater fish is around 3.22 lakh tonnes totaling 4.48 lakh tonnes, the present level of fish production is around 3.07 lakh tonnes (2003-04), leaving a net deficit of about 1.40 lakh tonnes. The marine products exported from the State on an average is 11,000 tonnes valued at about Rs. 360 crore per annum. The State Government is visioning to enhance the value of fishery exports to Rs. 1000 crore in the next 5 years. This calls for creating adequate infrastructure facilities for landing and berthing of fishing vessels, preservation, processing, transportation and marketing (export) from the shores of Orissa. This also calls for augmentation of fish production from the State from the marine, brackishwater and freshwater resources. Even though there are 3 major fishery harbours, 7 fishing jetties, 67 fish landing centres, 15 fish landing platforms, 75 ice-plants with an installed capacity of about 760 tonnes, 33 cold storages with a capacity of about 3815 tonnes, peeling sheds with a capacity of 39 tonnes and processing plants with 225 tonnes capacity, this is grossly inadequate when compared to the fish production and the quantum exported.

While over 90% of the freshwater and marine fish goes for domestic consumption within and outside Orissa, the entire high value marine fish and black tiger and white shrimp have the lucrative export market. Over 75% in terms of quantity and 90-95% in terms of value of exports from Orissa is contributed by shrimp, as per the figures available from MPEDA Orissa office.

Lack of adequate post-harvest infrastructure facilities in the State for fish processing and export has lead to the fish being processed and exported from Kolkutta or Visakhapatnam ports, depriving the State Government of the valuable foreign exchange earning and export Cess.

Development of state-of-the-art facilities for landing and berthing of fishing craft, cold storage, processing and transportation for marketing/export either by upgrading the existing three major fishery harbours in the State viz. Astarang, Gopalpur and Dhamara, besides the Paradeep Port or construction of a new fishery harbour with modern facilities in a strategic location along the coast, therefore is the need of the hour. CII could act as a catalytic agent in promoting the private sector initiative in this field for construction and operation of a modern fishery harbour with all the state-of-the-art facilities for promotion of seafood processing industry in the State. This could be on Build, own, operate and transfer (BOOT) basis and the facilities could be allowed to be used by the fishermen and fish processors by collecting the requisite fee as user charges for reducing post-harvest losses and augmenting the availability of quality and hygienically processed and packed fish and fishery products for both export and domestic markets.

If we have to augment the marine products export to the levels of Rs. 1000 crore from Orissa, the marine fish production through capture and culture fisheries should be suitably enhanced. This requires diversification of capture fishing efforts beyond the 200 m depth zone for pelagic tunas (yellow-fin and skipjack), deep sea squids, cuttlefish, lobster and shrimp besides some demersal myctophids and small pelagics, which hitherto have been under-exploited. Industrial establishments/entrepreneurs involved in deep sea fishing could finance upgrading/modifying the existing multi-day mechanised fishing vessels and make them suitable for fishing of tunas, deep sea prawn/shrimp etc., the resources of which are either unexploited or underexploited. The exploited fish catch could be taken for processing by the processing units linked to the industrial chain on buy-back basis and the fishermen be given a share of the earnings.

Similarly commercial mariculture of lobster, mud crab, shrimp, sea bass, sea bream, grouper, pearl oysters, etc., which have very high potential in export market, needs to be initiated with technological back up from elsewhere for large-scale breeding and rearing of these species under controlled conditions. The seed thus produced could be used for sea ranching and mariculture operations in the open sea and estuaries or on land in recirculatory systems. In this activity also the private-public participation is possible, particularly in mariculture related activities.

CII could be a facilitator in this activity by bringing together different clients and evolving a workable programme.

2.4 Commercial scale Fish Seed Production

Even though the Working Group Report on Fisheries for the 10^{th} Five Year Plan of the Planning Commission, Government of India, indicates that India is self sufficient in carp seed production to support aquaculture, still a lot remains to be done. At the end of the 9^{th} Five Year Plan period the country was producing nearly 16,600 million fry. The carp seed production infrastructure in the country is inadequate and ineffective particularly in the public sector and is localized in certain states only, particularly in West Bengal, Assam, Andhra Pradesh, Tamil Nadu and Uttar Pradesh, the combined quantum of seed produced by these five states amounting to 13,360 million (85%). The fish seed production (fry) in Orissa is reported to be 346 million during 1999-2000 contributing to about 2% to the total fry production of the country. For meeting the stocking requirements of the vast freshwater resources of the country including tanks and ponds, lakes and reservoirs, swamps, derelict water bodies and riverine systems, the present level of fish seed production is grossly inadequate.

Disease free and disease resistant seed availability is still a reality and there is also no seed certification scheme in position to ensure the quality of carp seed, unlike in the case of shrimp seed for which there are certain seed quality certification measures in place. Brood stock maintenance is another major area which needs to be given a serious attention, as the quality of seed depends on the health, quality and fecundity of brood stock of different species.

The 10th Five Year Plan target for fish seed production in the country is fixed at 25,000 million. The facilities so far created both in the public and private sector are concentrating on production of Indian major carp seed alone and technologies for raising the seed of minor carps, air breathing fishes, a wide spectrum of freshwater ornamental fish species, etc., are yet to be developed/standardized, to fill the supply and demand gap in fish seed. The stocking of reservoirs needs advanced fingerlings/yearlings for which there is no facility in the country. Genetic upgradation of candidate species for aquaculture through genetic selection process is an immediate necessity so that better performing fish seed stock is made available to the aquaculturists.

An analysis of the fish seed production sector in Orissa reveals that the average survival from spawn to fry stage is hardly 26% (spawn produced 1064 million of which fry is 274 million). Presently there are 46 fish seed hatcheries in Orissa with the designed capacity for production of 1519 million carp seed (spawn) (in terms of fry at 26% survival 395 million), of which 19 are under the Fisheries Department, 5 under Orissa Pisciculture Development Corporation (OPDC), and 22 in the Private sector. All these hatcheries are producing seed below their designed capacity (1064 million spawn equivalent to 274 million fry) as of 2000-01.

In so far as Orissa is concerned the total seed requirement in fingerling stage (5 cm length) to stock the 87000 ha tank/pond area in the next 5 years will be around 435 million (almost equivalent to 575 million fry @75% survival from fry stage). For stocking the reservoirs (minor, medium and major) we need advanced fingerlings of 10-15 cm size (yearlings), we may require an additional 126 million advanced fingerling (2000/ha for minor reservoirs, 1000/ha for medium reservoirs and 500/ha for major reservoirs), which should come from about 250 million fingerlings (330 million fry). In addition if the entire stretch of rivers and canals (7220 km) and 1.80 lakh ha of swamps/ bheels are to be stocked with fingerlings we will need an additional 187 million fingerlings at the rate of 1000/km rivers & canals and per ha. for swamps and bheels.

Thus, the futuristic requirement of fingerlings (5-6 cm) for Orissa, if culture fisheries is to be promoted in an optimal way, the total requirement will be around 935 million fingerlings (a part of it to be raised into advanced fingerlings of 10-15 cm) equivalent to about 1250 million fry. The present level of fish fry production in Orissa, therefore, has to be augmented by at least 4½ times. Apart from the major carp, technologies which have been developed by ICAR fisheries research institutes and private entrepreneurs in West Bengal, Andhra Pradesh and Tamil Nadu for producing on commercial scale the seed of other commercially important freshwater fish species and freshwater prawn need to be taken to the field and commercialized. All these, require enormous amount of investment for creation of basic infrastructure in the form of hatcheries, pen/cage enclosures and trained manpower and personnel for fish breeding and rearing of fish seed to fingerling/advanced fingerling stage. Such a huge investment has to necessarily come from the private/corporate sector. The CII could play a catalytic role in attracting private partnership in fish seed production in Orissa jointly with public including small scale fish seed producers.

2.5 Freshwater Aquaculture

Andhra Pradesh, Haryana and Punjab have emerged as the most progressive states with respect to the development of freshwater fish farming in the country. While A.P was to some extent a traditional fish farming state, Haryana and Punjab are non-traditional states and fish farming started only during the early seventies. Today, freshwater fish from A.P is marketed in about a dozen other states (all the states in the NE Region, West Bengal, Orissa, Bihar and Eastern U.P) and also in the neighbouring countries – Bhutan and Nepal. Similarly fish produced in Punjab and Haryana is marked in the neighbouring state after meeting their own requirements.

In A.P the Kolleru lake area is the hub of freshwater fish farming. Besides, Indian major carps (IMC) such as catla and rohu, farmers also raise catfishes like African Magur (*Clarias gariepinnus*) and *Pangasius sutchi*. The average productivity from the farms in Kolleru Lake area is around 5-6 tonnes per ha and scientific methods of farming are deployed to maximize the returns from the ponds. The seed and feed inputs are well organised in the area, which is a big support to the fish farmers. Similarly the marketing infrastructure is a big support and is also well knit that takes care of the fish transportation by refrigerated vans to far–flung areas of the country. Per hectare production in Haryana and Punjab is close to 4000 kg and besides Indian major carps, the farmers are also raising freshwater prawn. In these two states , the markets are close to production centres and therefore, the per kilogram realisation to the fish farmer is much higher as compared to what the farmers get in A.P.

Freshwater carp farming in the above-referred states exemplifies the innovations and ingenuities of the small scale fish farmers and the medium level entrepreneurs in optimising per hectare yield from the fishponds and are worth replication in a State like Orissa where the water area covered and productivity are lower.

Orissa is blessed with a resource in the form of freshwater tanks and ponds which extends to over 1.16 lakh hectares. There are 30 district level Fish Farmers Development Agencies (FFDAs) which have brought under scientific fish farming about 39000 ha. (2000-01) tank/pond area out of about 52000 ha area developed for fish/prawn farming. This is hardly one-third of the available resources for aquaculture production. Moreover the culture practice predominantly followed in Orissa is either three species (Indian major carps) or in combination with freshwater prawn in some cases. The average productivity is around 1.85 tonnes/ha. Private sector participation or entrepreneurial participation in fish culture in Orissa is yet to be recognised as a viable option. While capture fisheries do not have scope for expansion, the commercial aquaculture is the only viable means for augmenting fish production from the freshwater resources. If in the next five years, if the water area coverage under the FFDAs and in the private sector for scientific freshwater fish/prawn culture is increased from the present level to around 87,000 ha (75% of the existing potential) and the productivity is also augmented to a minimum level of 3 tonnes per ha./annum following the package of practices adopted in AP or Punjab/Haryana then the fish production from the tanks and ponds would increase by three fold from the present level of about 75,000 tonnes to 261,000 tonnes.

Here again the cluster approach or satellite farming approach can be adopted, where there will be a balance between the people and private participation in fish production. This itself will give a big boost to total fish production of the State and will help in wiping out the deficit in fish production, stopping the import of over 40000 tonnes of fish from other states and improving the socio-economic status of the fish farmers and the State. CII could play a role in enthusing the entrepreneurs for venturing into commercial aquaculture in Orissa, on the pattern of the best practices prevailing in AP/Punjab/Haryana.

2.6 Freshwater Prawn culture

Ten species of freshwater prawns of the genus, *Macrobrachium* are commercially important, since they support at least a subsistence fishery in one part of the country or the other. Of the 10 species, *M. rosenbergii, M. malcolmsonii and M. choprai* are considered candidate species for aquaculture in India. Even out of these three species, from the commercial aquaculture point of view the giant freshwater prawn *M. rosenbergii* (scampi) is very important. This species is by far the most extensively distributed one in the country and elsewhere.

M. rosenbergii is the best species for aquaculture since it can be grown in both fresh and brackishwater(low saline), is compatible for polyculture, omnivorous and hardy, has the maximum growth potential among the cultured prawns, has no serious problems of diseases and has good consumer preference and demand in the local as well as export markets. Because of these qualities and its aquaculture potential the species was introduced from its native places to the other parts of the world. *M. rosenbergii* is now farmed in commercial aquaculture systems in many parts of the world. In India also in a number of States freshwater prawn farms are being established particularly in the private sector.

The development of a low-cost technology of freshwater prawn seed production and subsequent establishment of a few hatcheries in the public and private sectors in the late 1980s and early 1990s, the increased research on prawn farming, the nutritional requirements of prawns and culture management techniques, human resource development through training and exchange of information and provision of financial incentives in the form of subsidy by the Government, etc., has given a fillip to freshwater prawn farming in the country in the recent years.

The aquaculture production of freshwater prawn in the country increased from 198 metric tonnes in 1990 to 500 tonnes in1997 and from then on with in 6 years it has jumped to a record level of 30,000 tonnes in 2003. Considering the freshwater aquaculture resources in the country and the opportunities available for including this species in the aquaculture practices either as monoculture or polyculture with Indian carps is yet to be given adequate importance. The major bottleneck, however for further expansion of freshwater prawn culture is the lack of adequate supply of post-larvae of scampi for stocking the freshwater resources. CIFA has estimated that the projected requirement of scampi seed for development of 200,000 ha water area in the country in the coming years is around 10,000 million.

Many of the over 235 shrimp hatcheries set up in the coastal states have diversified into production of scampi (*M. rosenbergii)* seed during the last 5-6 years, after a temporary decline in shrimp culture activity in the country owing to multifarious reseasons. Most of the modern and state-of-the-art hatcheries are located either in Kakinada area of AP or in the Chennai-Marakkanam belt of Tamil Nadu. There are also a number of exclusive freshwater prawn hatcheries in the country most of which are in AP, Tamil Nadu and Kerala in the private ownership. These hatcheries are an excellent example of the efforts that have gone towards the development of commercial scale shrimp and scampi farming in the country and any further development envisaged in this sector has to keep in mind the hatchery infrastructure set up so far.

In Orissa there are 10 shrimp/prawn hatcheries, of which 2 are in the Government sector and 8 in the private sector with a designed capacity of 315 million shrimp/prawn seed per annum. There is no separate statistics to show either how much scampi seed is produced or what is the area under scampi farming in mono or polyculture with carp, in the State.

Introduction of scampi in the pond fish culture as one of the candidate species with major carps in Orissa could boost up the production of scampi for export purposes. The technology developed by CIFA and also those adopted by the entrepreneurs in AP, Tamil Nadu and elsewhere has shown that a productivity of around 1.5 tonnes of scampi per ha. per crop is possible at a stocking density of 40,000 post-larvae in monoculture. In polyculture with other Indian major carps a productivity of 400 kg/ha is possible at a stocking density of 10,000 scampi larvae/ha. Even though a beginning has been made in Orissa, it is still a long way to achieve the desired results in scampi farming.

A major intervention, therefore, is required from the private sector in Orissa for establishing exclusive scampi seed hatcheries and rearing systems for augmenting the availability of scampi seed in the State and for ensuring an organised growth of freshwater prawn farming in tanks and ponds. The SHGs in the coastal areas could be involved in raising the scampi seed from the larval to post-larval stage in small backyard earthen nurseries by obtaining the early larval stages from the entrepreneurs. This way we can integrate the private-public participation in scampi seed production.

2.7 Seaweed farming

Seaweeds or marine algae grow abundantly in the shallow seas, estuaries and backwaters. They flourish wherever rocky, coral or suitable substrata are available for their attachment. They belong to four groups namely green, brown, red and blue-green algae based on the pigmentation, morphological and anatomical characters. Seaweeds are one of the commercially important marine living and renewable resources of our country. They contain more than 60 trace elements, minerals, protein, iodine, bromine, vitamins and several bioactive substances.

Seaweed uses

The phytochemicals namely agar, carrageenan (agaroid) and algin are manufactured only from seaweeds. The red algae such as *Gracilaria, Gelidiella, Gelidium, Pterocladia* and yield agar. Some other red algae viz., *Hypnea, Eucheuma, Chondrus* and *Gigartina* are the major sources for production of *carrageenan*. The algin can be obtained from brown algae like *Sargassum, Turbinaria, Hormophysa, Cystoseira, Laminaria, Undaria, Macrocystis* and *Ascophyllum*. These seaweeds are used as gelling, stabilizing and thickening agents in food confectionery, pharmaceutical, dairy, textile, paper, paint, varnish industries, etc. Apart from these biochemicals, other chemical products such as mannitol, iodine, laminarin and fucoidin are also obtained from marine algae. Many protein rich seaweeds such as *Ulva, Enteromorpha, Caulerpa, Codium, Monostroma* (Green algae); *Sargassum, Hydroclathrus, Laminaria, Undaria* and *Macrocystis* (brown algae); *Porphyra, Gracilaria, Eucheuma, Laurencia* and *Acanthophora* (red algae) are used as human food in countries like Japan, China, Korea, Malaysia, Philippines and other southeast Asian countries in the form of soup, salad, curry etc. Jelly, jam, chocolate, pickle and wafer can also be prepared from certain seaweeds. The food value of seaweeds depends on the minerals, trace elements, protein and vitamins present in them. They also control goiter disease.

Marine algae are also utilised in different parts of the world as animal feed and fertilizer for various land crops. In India, freshly collected and cast ashore seaweeds and seagrasses are used as manure for coconut plantation either directly or in the form of compost especially in the coastal areas of Tamil Nadu and Kerala. Seaweed manure has been found superior to the conventional organic (farm yard) manure. The high amount of water soluble potash, other minerals and trace elements present in seaweeds are readily absorbed by plants and they control deficiency diseases. The carbohydrates and other organic matter present in seaweeds alter the nature of soil and improve its moisture retaining capacity. The liquid seaweed fertilizer obtained from seaweed extract can be used as foliar spray for inducing faster growth and yield in leafy and fleshy vegetables, fruits, orchards and horticultural plants. The trace elements and growth homones (cytokinin) present in the liquid seaweed fertilizer act as growth promoters and increase the yield by 20 to 30%. It gives successful results on potatoes, cauliflower, cabbage, brinjal, lady’s finger, chillies, grapes, etc. In India, seaweeds are now used mostly as raw material for the production of agar and sodium alginate. They are also consumed in the form of agar jelly and porridge.

Seaweed distribution and resources in India

India with a long coastline of 7500 sq. km has a vast resources of seaweeds along her open coasts and estuarine areas. The luxuriant growth of several species of green, brown and red algae occur along the southeast coast of Tamil Nadu from Rameswaram to Kanyakumari, Gujarat coast, Lakshadweep and Andaman & Nicobar Islands. Fairly rich seaweed beds are present in the vicinity of coastal lakes like Pulicat and Chilika in Orissa.

About 1150 species of marine algae have been recorded from different parts of Indian coast, of which, nearly 60 species are commercially important. It is estimated that the total standing crop of all seaweeds in Indian waters is about 91,340 tonnes (wet weight) consisting of 6000 tonnes (wet weight) of agar yielding seaweeds, 16000 tonnes (wet weight) of algin yielding seaweeds and the remaining quantity of edible and other seaweeds.

Since 1980 many agar and algin extracting industries have come up in India. As the demand for raw material of agar yielding seaweeds is more and their natural resources along the east coast are less, there is paucity in supply of raw materials to agar industries. This can be overcome by exploiting the agar yielding seaweeds from Orissa and also by cultivating them on large scale. The quantity of algin yielding seaweeds *Sargassum* and *Turbinaria* available in the Indian coast is quite adequate to meet the raw material requirement of algin industries as only about 50% of standing crop is harvested that too from Tamil Nadu coast only.

Methods for cultivation of seaweeds

Seaweeds are cultivated for supply of raw material to the seaweed industries and for their use as human food. There are several advantages in the cultivation of seaweeds. In addition to a continuous supply of alga, crops of single species could be maintained continuously. By adopting scientific breeding and other modern techniques of crop improvement, the yield and quality of the seaweed could also be improved. Further, if seaweed culture is carried out on large scale, natural seaweed beds could be conserved purely for obtaining seed materials. There is no environmental adverse impact, because no chemical or other inputs are used.

There are two methods for cultivation of seaweeds; one by means of vegetative propagation using fragments from mother plants and the other by different kinds of spores such as zoopores, monospores, tetraspores and carpospores. In the vegetative propagation method, the fragments are inserted in the twists of ropes, tied to nylon twine or polypropylene straw and cultured in the nearshore areas of the sea. The fragments are also cultured by broadcasting them in outdoor ponds and tanks. The fragment culture method is a simple one and gives quick results. In the culture of seaweeds from spores, the spores are first collected on nets, bamboo splits, polypropylene straw and other suitable substrata; reared to seedlings or young plants in the hatchery/nursery and then transplanted to the desired sites where they grow to harvestable size plants. In this method the spores take more period for their development to harvestable size plants when compared with the growth of fragments in the vegetative method.

In India cultivation of a number of agar, carrageenan, algin and edible seaweeds such as *Gracilaria, Gelidiella, Hypnea, Cystoseira, Hormophysa, Caulerpa, Ulva* and *Acanthophora* is attempted since 1964 by the Central Marine Fisheries Research Institute (CMFRI), Central Salt and Marine Chemical Research Institute (CSMCRI) and other research organisations at different field environments using various culture techniques. These experiments reveal that *Gracilaria edulis, Hypnea musciformis* and *Acanthophora spicifera* can be successfully cultivated on long line coir ropes and coir rope nets. In these experiments a maximum yield of 14 fold increase and an average yield of 3 fold increase over the quantity of seed material introduced have been obtained after 80 days and 60 days, respectively.

In this method one kg of seed material would yield on an average 3 kg/m^2 of net after 60 days. In one hectare area of nets (1000 nets) 30 tonnes of fresh *G. edulis* could be obtained in one harvest. Six harvests could be made in a year.

For cultivation in one hectare, 1000 nets of 5 x 2 m size, 2000 bamboo poles of 1.5 m height and 10,000 kg of fresh seed material (for initial introduction) are required. The cost of 2000 bamboo poles is Rs. 16,000 and cost of 1000 coir rope nets is Rs. 80,000. The seed material will be collected for the initial introduction from the natural beds and from the cultured crop for subsequent seeding. Wages for fabrication, seeding, harvesting and maintenance of the seaweed farm for 4 persons at the rate of Rs. 30 per day for 360 days works out to Rs. 43,200. The total expenditure for one year would be Rs. 140,200 including miscellaneous expenditure of Rs. 1000.

The estimated cost is arrived at on the assumption that a minimum of four harvests could be made in a year. A total of 120 tonnes (wet weight) of crop could be obtained from four harvests in a year when the yield is 3 kg/m^2. If the seaweed is dried (75% moisture) and marketed at a rate of Rs. 6000 per ton, the gross earning would be Rs. 180,000 with a net profit of about Rs. 39,800 for one year. The profit will be high when agar is produced from the cultured seaweed and then marketed.

This carrageenan yielding red alga is cultivated by the CSMCRI in the Krusadai island. Vegetative fragments of *H. musciformis* are used as seed material and cultured in long line ropes. Four fold increase in biomass can be obtained after 25 days growth. Recently *Euchema* and *Kappaphycus*, other carrageenan yielding sea weeds are being cultivated in different parts of the east coast including Orissa. Kappaphycus has been taken up for experimental culture in the Chilika lake by Delhi University Professor. The Aquaculture Foundation of India, Chennai a private agency has taken the initiative of introducing Kappaphycus culture in certain parts of Tamil Nadu by involving the local SHGs, particularly in Mandapam, Tuticorin, Parangipettai, etc. M/S PepsiCo has taken up a Euchema culture project in the Palk Bay area near Pamban Bridge in Tamil Nadu by involving the local fishers including fisherwomen with a buy back arrangement. The edible and carrageenan yielding red alga *Acanthohora spicifera* is cultivated by the CMFRI in the nearshore area of Hare Island near Mandapam following vegetative propagation method. The plants reach harvestable size in 25 days and the yield is 2.6 fold increase over the weight of seed material introduced. This plant is also cultured successfully in ponds at Mandapam.

The percentage of moisture content and purity decide the price for seaweeds. The rate for dried *Gelidiella acerosa* ranges from Rs.7000 to 9000 for *Gracilaria* from Rs.2500 to 3000 and for *Sargassum* and *Turbinaria* from Rs.1200 to 1500. The agar fetches a price of Rs.220 to 400 per kg and sodium alginate Rs.80 to 100 per kg depending on the grade and their qualities.

The sea weed culture, particularly agarophytes and carragenophytes in the corporate sector by involving the coastal community with a buy back arrangement is another area for consideration in Orissa’s extensive estuarine and brackishwater areas and sheltered bays along the coastline.

2.8 Production of value added fishery products for exports

Live fish export

Capital investment required for a freezing plant or a chilling plant meeting international specification is higher than that required for handling live fish. In the case of freezing the investment is many times higher. The consumption of ice is quite high at various stages of chilling as well as processing.

During the process of production of various fishery products, fin-fishes are subject to gutting, beheading, filleting, de-skinning, etc., depending upon the type of product. The yield of product obtained after the above operations is considerably lower than the weight of whole fish. More over during the process of freezing and subsequent thawing the frozen fish loses weight due to the phenomenon of drip loss. In the case of chilled product the weight loss during the processing mentioned above occurs, though generally no drip loss occurs. In the case of live fish the above loss never occurs. However, there will be a certain percentage of mortality in the case of live fish but the dead fish fetches a certain price in the market whereby the loss due to mortality is substantially covered.

When frozen whole groupers for example are sold at a price of US $ 1.2 to 1.5 (C&F) the live grouper fetches a f.o.b value of a minimum of US$ 5 per kilo. The increased realisation encourages export of live fish to offer a higher price for the live fish caught by fishermen and it is noted that the price obtained by fishermen increases by 80 to 100%.

In the case of live fish export, quite often the buyer from the importing countries bring suitable vessel for carrying the live fish to the market. Therefore, the risk faced by the Indian exporter is lower. Harvesting of fish for live fish trade is not as efficient as harvesting for processing or for trade as chilled or fresh fish. In view of the fact that investment is low and returns are high, the possibility of many entrepreneurs investing in projects for live fish export is quite high. There should not be a threat to the resource as long as their entry is regulated and a quota is fixed for each product. Considering the above advantages as well as the need to regulate investment, projects involving export of live fish may be considered. Live fish is considered as a value added product and may be offered priority over chilled fish and frozen fish when investment decisions are made.

In order to encourage the entrepreneurs to venture into fish processing the Orissa Government may consider providing the requisite support in terms of land, communication, water supply, electricity, etc, on concession. The entrepreneurs can also avail the subsidy available for the purpose from MPEDA.

The Commercial Banks and financial institutions could extend term loans for investment in fish processing at concessional rate of interest to a limit of 50% of the cost of technical civil work and machinery or on the scales prescribed by Ministry of Food Processing Industries for similar schemes. The rest of the term loan may be at the interest rate charged for industrial projects.

Processing and allied facilities

There are 17 private concerns having facility for processing of seafood with a total capacity of 225 tonnes, cold storages capacity of 2600 tonnes, chill room capacity of 55 tonnes, peeling shed capacity of 39 tonnes and ice plant capacity of 65 tonnes in Orissa (Orissa Fisheries Statistics, 2000-01). This coupled with the limited facilities available in the Government sector are grossly inadequate considering the quantum of sea fish produced from the State. It is also not clear from the information available as to what are the value added products produced in these processing plants.

This calls for augmentation of the existing sea food processing infrastructure to international levels to meet the stringent standards prescribed by WTO and

EU for marine products exports. It is worth considering developing in Orissa itself the following value added sea food products for export as well as higher strata domestic marketing.

Frozen Prawns (Shrimp)

Raw Materials

Tiger shrimp

White shrimp

Types of Products

1. Whole
2. Headless
3. Fantail round
4. Fantail deveined
5. Butterfly
6. Raw peeled or peeled undeveined
7. Peeled and deveined
8. Cooked and peeled
9. Peeled and cooked
10. Peeled, deveined and cooked
11. Whole cooked.

Frozen Lobster

Raw Materials

Lobsters belong to *Palinurus spp., Peurulus spp*. and *Thenus spp*. Refined salt, citric acid and acetic acid.

Types of Products

Lobster tail (as shatter pack or individually as IQF).

Lobster whole (individual pieces in polythene and frozen immediately).

Lobster meat (as blocks, shatter pack or as IQF).

Cooked lobster whole (frozen individually).

Cooked lobster tails (wrap individually in polythene & freeze as IQF).

Frozen Crab Meat

Only active live mud crab (*Scylla serrata).* should be used.

Frozen cuttle fish

Raw Materials

Several species of cuttle fish *Sepia pharaonis, S. aculeate, thrustoni, S. brevinana, Sepiella inermis, Sepiella lidiolus Symplectoteuthis spp.*

Types of Products

Frozen Cuttle fish - whole (can be individually quick frozen or frozen as shatter pack.), fillets/flat pack (Packed in polythene line waxed duplex cartons.), rolled pack (as blocks, shatter pack or IQF), fillets with/without tentacles (as blocks, shatter pack or IQF), tentacles, wings/fins (as blocks), head meat.

Frozen Squid

Raw Materials

Several species of squid *Loligo hardwikki, L. indica, L. affinis.*

Types of Products

Frozen Squid – whole, whole cleaned, rolled pack, tube, tentacles, headless/squid tube skin on (all the products packed as shatter pack or IQF), cylinder (fillets arranged in an appropriately shaped container to get a cylindrical shape on freezing), wings/fins and fillets (as blocks), rings (packed as blocks or IQF).

Dried Squid

Raw Materials

Squid (*Loligo spp.*) Refined salt.

Fish Maws & Icinglass

Air bladder of a number of species of fish like Eel (U*raena spp.*), Cat fish (*Tachysurus spp.),* Kalawa (*Seramus spp.)* etc., constitute the raw material for fish maws and icinglass. Packing is normally done in polythene bags/woven HDPE gutless bags. These products are useful as clarifying agents for wine, beer and vinegar. They can also be used as an adhesive base for glass and pottery and a sizing agent in textiles, in Indian ink and confectionery.

Canned Crab Meat (In Brine)

Only actively live common mud crab (*Scylla serrata*) to be used. Refined salt, EDTA (Ethylene diamine Tetra Acetic Acid) and Citric acid are needed for preserving the meat.

Canned Sardines (Natural Pack)

Raw Materials

Oil Sardine (*Sardinella longiceps)*. Only fresh fish is to be used. If iced fish or fish stored in chilled or refrigerated sea water is used, the storage period should not have exceeded two days. Refined salt, citric acid and potash alum

Canned Tuna

Yellow fin (*Thunnus albacares)* Albacore (*Thunnus alalunga)* Blue fin (Thunnus thynnus) Big eye (*Thunnus mebachi*) Northern blue fin (*Thunnus tonggol)* Oceanic skipjack (*Katsuwonus pelamis)* are the raw material used. Fresh, fresh iced or fresh frozen fish can be used. Refined salt, double refined deodorized ground nut/cotton seed oil are the other requirements. S. R. lacquered cans of 301 x 203 (77 x 56 mm) or 307 x 113 (87 x 43 mm) size are used.

Fish Wafers

Fish with low fat content like thread fin breams (*Nemipterus japonicus*), croaker (*Johnius soldado*), jew fish (*Sciaena aneus*), perches (*Lutjanus spp*.) etc., could be used as the raw material. Refined tapioca starch, corn starch, refined salt, refined deodourised groundnut oil are used for producing ready to eat wafers.

Fish Fingers

Fish fillets/minced fish are used for this. Batter mix, bread crumbs are the raw materials used. The fish fillets or mince are frozen as compact blocks in trays. The frozen blocks are taken out from freezer and cut into rectangular fingers of size 7.5 x 2 x 1.5 cm. The finger is frozen individually using an IQF machine. The fingers are packed in polystyrene/polythene trays and sealed and stored in cold storage at – 23^{o} C or below.

Fish Meal

Low priced species of fish, filleting waste, canning waste, miscellaneous trash fish.

High Gel Strength Agar

Sea weeds belonging to the species *Gelidiella acerosa, Gracilaria edulis, Gracilaria crassa, Gracilaria corticata* serve as the raw materials

The dried seaweed should be soaked in water at room temperature for 24 hours. It is then agitated well to free it from adhering sand and other extraneous matter and the water is drained well. This is used in Bacteriological assay media, tissue culture practices, food, etc.

Value Addition in Finfish Processing

<u>1. Fillet and fillet blocks</u>

Large sized conventional fishes like perches, catfish and seer fish could be filleted, glazed, individually frozen and poly-wrapped. Some of these are good for skinless fillets also.

In the case of small fillets where individual freezing cannot be resorted to, laminated blocks can be made for further processing into fish finger. Meat recovery in this process can be improved by extracting the left over meat by passing through de-boners or mincing machines. Incorporating the mince thus recovered in the fillet blocks helps in improving the quality of fish fingers by providing better binding.

2. Composite fillets

In this process a number of small fillets are placed in a large fillet-shaped mould and then compressed with a low pressure ram to mould it into a single fillet piece. After freezing, battering and breading, this can be consumed as a large single fillet or further processed to fish fingers.

3. Steaks

Large sized fishes could be sliced into thin steaks of uniform thickness using a power meat cutter. The steaks can be individually frozen and vacuum packed. Uniformity of thickness and cutting slants are important factors determining the quality of steak. Seer fish, tuna and perches are the usual varieties amenable to this process.

4. Minced fish

Any white meat fish of fairly medium size and small size could be minced to extract practically all the edible flesh from it thanks to the de-boners which revolutionised finfish processing. Pre-processing such as gutting, gilling, beheading and washing are required in this method.

A variety of battered and breaded products like cutlets, burghers, balls and cakes can be formed from minced fish. This can be marketed either in a ready to cook or ready to serve form.

5. Surimi and extruded products

Texture modification of minced fish is the principle of surimi production. By carefully mixing mince from white fish with salt, dyes and flavouring agents and then extruding the mixture, it is possible to make excellent shell fish replicas. Pink perch, lizard fish, conger eel, barracuda, croakers, etc., are some of the white fish amenable to mincing, jelly formation and extrusion to form analogues. Imitation crab legs, shrimps, scampi, etc., are some of the products marketed worldwide. Both surimi and surimi derivatives are fit for long storage and export in frozen form.

6. Shell fish products

Mussel, oyster and clams are delicacies of the west. The scattered fishery for this can be profitably exploited to develop processed products. Battered and breaded, individually quick frozen, smoked and canned, and pickled are some of the forms in which these shell fish meat can be produced. Farming of edible oysters is emerging as an economically viable vocation in India which needs post-harvest and export back up to flourish.

7. By products

Process waste of fish processing industry was an accepted menace till recently. Increased production and added awareness about civic health and environmental degradation has made it incumbent on the processing industry to dispose off waste in such a manner that hazards to public are minimised.

R&D efforts have lead to gainfully convert the process waste into a variety of by-products such as chitin, chitosan and surgical sutures from shell fish waste, fish meal, fish feed, animal and poultry feed from finfish waste, bio-fertilizers, fish silage, pet foods.

Since the production of value added fishery products require state-of-the-art latest machinery/infrastructure private sector involvement in this sector is very much essential. The coastal community, particularly the women SHGs could be involved in various ancillary activities in the processing plants, thus providing them with a viable employment and income generating avenue.

2.9 Freshwater Pearl production

Natural freshwater pearls occur in mussels for the same reason that saltwater pearls occur in oysters. Foreign material, usually a sharp object or parasite, when enters a mussel it cannot be expelled. To reduce irritation, the mollusc coats the intruder with the same secretion it uses for shell-building, i.e., nacre. To culture freshwater mussels, workers slightly open their shells, cut small slits into the mantle tissue inside both shells, and insert small pieces of live mantle tissue from another mussel into those slits. In freshwater mussels that insertion alone is sufficient to start nacre production. Most cultured freshwater pearls are composed entirely of nacre, just like their natural freshwater and natural saltwater counterparts.

The Chinese were the first to culture a product from freshwater mussels called shell mabes, though their centuries-old practice. The first cultured freshwater pearls originated in Japan. Quite soon after their initial success with cultured saltwater pearls, Japanese pearl farmers experimented with freshwater mussels in Lake Biwa, a large lake near Kyoto. Initial commercial freshwater pearl crops appeared in the 1930s. The all-nacre Biwa pearls formed in colors unseen in saltwater pearls. Almost instantly appealing, their lustre and luminescent depth rivaled naturals because they, too, were pearls throughout.

However by 1984, Biwa's pearl farms were barely surviving, because of pollutants washing in from farms, resorts, and industries around the lake. As Biwa production diminished, China filled the vacuum. China has all the resources that Japan lacks: a huge land mass; countless available lakes, rivers, and irrigation ditches; a limitless and pliable work force that earns less than a dollar a day; and an almost desperate need for hard currency. In 1968, with no recent history in pearling, China startled the gem world with prodigious amounts of ridiculously inexpensive pearls.

China's Cultured Pearl Revolution

Starting in the 1990s, China surprised the market with products that are revolutionizing pearling. The shapes, luster, and colors of the new Chinese production are seen to be believed. As testimony to China's achievement, their freshwater pearls are round enough and good enough to pass as Japanese akoya. China already sells round white pearls up to 7mm for perhaps a tenth the price of Japanese cultured saltwater pearls.

Chinese pearls that are nearly white or mottled are usually bleached to make them whiter and more uniform. With the same methods perfected by the Japanese, the Chinese use a mild bleach, bright fluorescent lights, and heat. They polish surfaces by tumbling pearls in pumice or similar substances. The idea, as always, is to facilitate matching pearls for strands. Many Chinese pearls used to be dyed in the 1980s to bright red, blue, lavender, yellow or even black. In response to contemporary preferences, they now offer a selection of subtle natural colours.

India is importing a large amount of cultured pearl every year from the international market to meet the domestic demand. The Central Institute of Freshwater Aquaculture (CIBA), Bhubaneswar has developed the technology for freshwater pearl culture from common freshwater mussels. In India, three species of commonly available freshwater mussels viz. *Lamellidens marginalis, L. corrianus and Parreysia corrugata* have been found to produce good quality pearls.

The farming practice of the freshwater pearl culture operation involves six major steps sequentially viz. collection of mussels, pre-operative conditioning, surgery, post-harvest operative care, pond culture and harvesting of pearls.

Even though the CIFA has developed a technology for freshwater culture pearl production and a number of persons have been imparted training on culture of freshwater mussels and production of culture pearl, it is yet to reach commercial levels. Like China India in general and Orissa in particular has immense potential in the form of freshwater resources where freshwater mussels are in abundance. Since freshwater pearl production is a lucrative one with a lot of potential in India, if we have to reduce the dependence on imports from China or Japan, we need to have a commercial venture in the private sector with an investment of Rs 10 - 20 crore in Orissa. The added advantage is the CIFA which has the technology is in Bhubaneswar and the flexible and innumerable work force and fishers who could be directly involved in collection of mussels and implanting of the extraneous material into the mantle of the mussels for pearl production.

2.10 Marine finfish culture – *Lates calcarifer* (bhekti/sea bass) and *Epinephelus spp*. (Grouper)

There are a number of candidate marine finfish species for culture either in the cages in the sheltered bays of the sea or in the brackishwater areas.

Some of them are mullets, chanos, bhekti and grouper. Mullets and bhekti can be cultured even in freshwater conditions.

Any commercial mariculture programme cannot completely depend on the seed available in the wild for stocking the farms. Hatchery production of seed should form a component of farming. Marine finfish hatcheries will have to be established at selected centres for the production and supply of seed.

The CIBA has developed a technology for producing sea bass seed under controlled conditions in their field facility at Muttukadu near Chennai and has been supplying the seed to aquaculturists for farming of sea bass in Tamil Nadu and parts of Andhra Pradesh. In the case of Grouper, even though CMFRI has developed the technology for captive breeding and larval rearing, the technology remains to be standardized and commercialized for large scale culture of this species. Whatever culture fisheries of grouper is being carried out in India presently, mainly on experimental basis depends on natural seed supply.

Lates calcarifer (sea bass - bhekti)

The "sea bass" or the giant perch is of prime quality value fish suitable for export purposes as well as domestic consumption. In view of its easy adaptability to low saline water including freshwater conditions, this fish has assumed great value for culture in recent years. Popularly called "bhekti" in India, it is found along both the east and west coasts, but is more common in Bengal region where it is cultured in ponds, canals, bheries and paddy fields. Indonesia, Malaysia and Thailand are the major contributors to the culture production of bhekti in the world.

The seeds of this fish are available in coastal areas, intertidal ponds, bays, creeks, estuaries, mangrove swamps, etc., along the east coast of India during October-December. In Chilika lake, Orissa, the seeds are available in the channel area and central zone of the lake. The fingerlings usually range in length from 3 to 10 cm and can be collected by push/drag nets, shooting nets, scoop nets and cast nets.

Hatchery production of the seeds of sea bass has been achieved in Thailand, Singapore and lately in India as well by CIBA located at Chennai. Since sea bass is a predatory carnivore and cannibalistic in nature, they are to be segregated right from the fry stage and by providing adequate supplementary diet.

Sea bass has been cultured traditionally in brackishwater areas/ponds in Indonesia, the Philippines, Taiwan, Thailand, India, etc. But in recent times this fish has been cultured in floating net cages, as well. There has also been a refinement of the pond culture systems, as in Taiwan, where there are over

200-300 ha pond area under monoculture. In these systems with a stocking density of 10,000 to 40,000 sea bass seed and trash fish as feed, a production of even 100 tonnes/ha has been reported.

In India a beginning has been made for farming sea bass in pond culture systems along the east coast in Andhra Pradesh, West Bengal and certain parts of Tamil Nadu on small scale, in the shrimp farms, as alternative crop. This has tremendous potential for expanding it to certain parts of coastal Orissa.

Epinephelus spp. (grouper)
A number of species of groupers belonging to the family Serranidae are highly priced marine food fish having white, tender and tasty meat that make them much relished in many tropical and sub-tropical countries. They are fast growing, have good feed conversion rate and high adaptability in different culture systems. Groupers can be cultured in ponds, in open sea net cages, coastal enclosures and also in tanks. They can also be considered as a viable substitute for commercial culture in old shrimp farms. Of the many species of groupers cultured in the floating and fixed cages and the coastal ponds in different parts of the world, especially in the Southeast Asian countries, *Epinephelus tauvina and E . malabaricus* are the most preferred ones in India for culture.

The large scale culture of groupers mainly depends on sufficient quantity of seed. Several attempts have been made to spawn groupers. Groupers are protogynous hermaphrodites, reversing their sex from females to males at an older age. Naturally occurring males are larger in size, fewer in number and occur in deep seas. Holding large males under captivity for breeding is difficult and hence hormonally transformed males are often used. Mature *E. tauvina* spawn throughout the year depending upon the stage of gonad development. CMFRI in its Fisheries Harbour Laboratory at Kochi have developed spawners of *E. tauvina* from the fingerling stage, spawned in captivity and reared them to larval stages. Efforts are on to develop a viable technology package for larviculture and mass seed production of groupers in India. In Kuwait, Japan, Singapore and Saudi Arabia, the groupers have been spawned under controlled conditions, successfully.

Realisation of the mariculture potential of the State of Orissa will entirely depend on creating necessary infrastructure facilities. These would include land and farm development, shore establishments, energy and water supply, transport and communication, processing and storage and trade facilities. A planned approach to mariculture is necessary to take up integrated or closely linked up programmes to share common infrastructure facilities. Since farming of bekhti and grouper involves high technological inputs and capital investment, private sector participation in this activity is very much essential.

2.11 Desalination of sea/brackishwater for production of clean drinking water and waste water treatment

One of the major requirements of the fishing community living along the coastal belt is the potable drinking water. Invariably the ground water table along the coastline is saline or hard and not useful for any house-hold purposes. Clean water is not available even for cleaning the fish landing platforms or sheds. Fishermen depend on water supply made in small barrels brought from long distances, which invariably is contaminated resulting in health related problems in the coastal community.

Over the last few decades desalination technologies have been used increasingly throughout the world to produce drinking water from brackish groundwater and seawater, to improve the quality of existing supplies of fresh- water for drinking and industrial purposes, and to treat industrial and municipal wastewater prior to discharge or reuse. A number of technologies have been developed for desalination, including distillation (or evaporation), electro-dialysis, freezing, ion exchange, and reverse osmosis. Desalination technologies include distillation (multiple-effect evaporation (MED), multi-stage flash (MSF) distillation, vapor compression (VC), and solar distillation), reverse osmosis, electro-dialysis, ion exchange, and freeze desalination. The selection of the most appropriate desalination technology for a particular use depends on many site-specific factors.

Desalination processes are divided into (i) thermal methods, which involve heating water to its boiling point to produce water vapour, and (ii) membrane processes, which use a relatively permeable membrane to move either water or salt to induce two zones of differing concentrations to produce fresh water. The main thermal method employed is distillation, where saline water is progressively heated in subsequent vessels at lower pressures.

Besides conventional desalination technologies, Low Temperature Thermal Desalination (LTTD) is an attractive technology with vast potential. It makes use of Ocean thermal gradient across the oceanic depths for desalination of seawater. The temperature difference which exists between the warm surface sea water (28 – 30°C) and deep sea cold water (7 – 15°C) could be effectively utilised to produce potable water apart from power generation, air conditioning and mariculture/aquaculture. This technology is known as Low Temperature Thermal Desalination (LTTD). In this method relatively warm water is flashed inside a vacuum flash chamber and the resultant vapour is condensed using cold water. Though this concept of LTTD was known for a long time, due to practical difficulties it was never attempted. This approach of providing water is extremely useful for remote coastal areas including islands where there is no other source of freshwater and the environment is extremely fragile.

This technology has been utilised in the first ever LTTD plant which has been commissioned at Kavaratti in Lakshadweep. The plant is housed in a structure on the shore. The 13°C water which is available at a depth of 350 m at a distance around 400 m from the shore has been tapped and brought to the surface through a 600 m long cold water pipe. This technology was first demonstrated in a pilot project of 5000 litre/day at Chennai and is now being used for producing over 1,50,000 litre/day of clean and good quality drinking water for the use of the people of Kavaratti, for the first time. The average cost of production of 1 litre of water through this desalination plant is calculated to be around 6 paise. Moreover, this technology is eco-friendly and low cost as compared to the Reverse Osmosis technology in which the operational cost is high, as the plant requires frequent change of the membrane that is to be imported and disposal of a large quantum of high saline brine which comes out as the waste.

This is one technology which can be replicated by the private entrepreneurs along the coastline for production and supply of clean drinking water from the sea or brackishwater, to the coastal community and also by the industrial units for treatment of their wastes. The cold nutrient rich water taken from the deep sea to the surface could be used for sea farming, particularly culture of marine micro-algae such as dunaliella or spirulina or any other algae useful as fish feed, in which the local SHGs could be effectively involved.