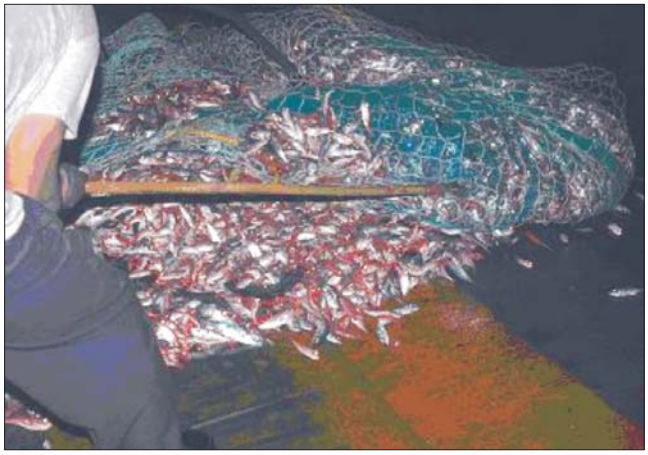
# Fish Production and Processing

## CAPTURE FISHERIES

### Marine sector

**Deep-sea fisheries resources:** The deep-sea fishing survey by FORV *Sagar Sampada* conducted during 2005–06 revealed that the shelf-break area between 500–1,000 m depth off southwest and southeast coast of Indian EEZ is rich in a diverse group of organisms. Nearly 77 species of non-conventional deep-sea demersal finfishes, shellfishes and other organisms were recorded. Dense and profuse growth of the deep-sea glass sponge *Hyalonema* sp. was located in extensive mud plateau at 900 m depth off Mangalore. The species has high commercial value as the bio-



Deep-sea resources being released from the bottom trawl on board FORV *Sagar Sampada*

silica extracted has a wide range of applications in medical field. Eight species of deep-sea shrimps indicated commercial concentrations. These resources remain under exploited as at present the private trawlers exploit only a small portion. The important species are *Aristeus alcocki, Acanthophira armata, Oplophorus* sp., *Heterocarpus woodmasoni, H. gibbosa, Plesionika spinipes, Hymnopenaeus equalis* and *Solenocera hextii,* which showed a catch rate varying from 10–25 kg/h.

**Pelagic fish production:** Pelagic finfish production during 1985–2005 fluctuated from 0.78 million tonnes (mt) in 1985 to 1.4 mt in 2002 forming 54% of the total marine fish production. Mechanized sector contributed about 45% to the total pelagics

- Deep sea fisheries resources in southwest and southeast coasts of Indian EEZ assessed
- Possible negative influence of the global climate change on themarine fisheries indicated
- Studies conducted on the impact of water flow on the ecology and fisheries of rivers : management strategies formulated on its basis
- Sediment load affected the breeding and recruitment process of commercially important fishes in the river Ganga
- A scoring chart using index of biotic integrity (IBI) developed and tried for assessing the state of the riverine ecosystems
- Multiple breeding *Labeo fimbriatus* achieved paving the way for restocking this important medium carp in peninsular rivers
- Successful breeding of *Ompok pabda* achieved
- Protocol developed for captive breeding of *Chitala chitala*
- Floating feed prepared for rainbow trout
- Pelleted feed was more economical in crab culture
- Fibreglass reinforced plastic (FRP) protected the wood of boat from marine borer
- *Eichhornia crassipes* found to be the most promising source for bioactive substances
- Tuna red meat proved useful in preparation of edible fish powder
- DNA bar-coding of 32 Indian marine fish species were completed
- DNA sequence of marine mammals deposited in gene bank

followed by motorized (38%) and non-motorized (17%). In 2005, 62% of the production of pelagics was obtained from the west coast and 38% from the east coast. In total landings, major pelagic finfish groups were those of oil sardine (14.4%), carangids (6.2%), ribbonfish (5%), mackerel (5.5%), Bombay duck (5.3%), lesser sardines (3%), anchovies (4.7%), seerfish (1.8%), Hilsa (1.7%) and tunas (1.7%) of the total production. The Indian mackerel showed signs of recovery from the progressive decline in catches experienced since 2001 as the catches in 2005 were 1.25 lakh tonnes.

**Oceanic climate change:** A national network project "Impact, adaptation and vulnerability of Indian fisheries to climate change" was carried out during the year 2006 and the salient findings are:

Southern Oscillation Index had a negative influence on Sea Surface Temperature along the northeast, southeast and northwest

### Biodiversity shift in Hooghly estuary

The salinity regime of the estuary has changed and major portion in its middle stretch has almost changed into a freshwater zone, due to increased freshwater discharge from the Farakka barrage. The biodiversity changes reflected that a sizeable length of Hooghly Estuary has lost its estuarine characteristics. The Barrackpore stretch of the estuary is dominated by freshwater mullet *Sicamugil cascasia*. The brackishwater fish species, *Liza parsia, Scatophagus argus, Mystus gulio, Osteogeneiosus militaris, Hemiramphus gaimardi,* are no longer available in large stretches of the estuary. The plankton composition of this estuary, has changed. The once dominant marine diatoms like *Chaetoceros, Bacteriastrum* have been replaced by the freshwater plankton species *Scenedesmus, Pediastrum* and *Microcystis*.

coasts of India. Trend of the sea surface temperature during the period 1960–2002 along the maritime states showed a significant increase. In the northeast coast sea surface temperature showed a negative correlation with total landings, demersal, cephalopod and crustacean landings resulting in low catches in the succeeding year with increase in current year SST. Along the southwest coast, the sea surface temperature revealed positive correlation with pelagic and total landings resulting in high catches in the succeeding year with increase in the current year SST. The oil sardine distribution has extended towards the northern latitudes and the catch has increased with increase in SST.

Database on coral bleaching events was generated based on published literature and classification made based on bleaching effect as low, medium and high. In India coral-bleaching events reported in 1998 and 2002 coincided with the coral bleaching monitoring products such as Hotspots and Degree Heating Weeks. The severity was high in 1998 and medium in 2002. Mangalore coast revealed the shift of peak abundance of copepods and fish eggs and larvae towards the earlier months of the year indicating phenological changes.

## Inland sector

**Ecology and water flow impact on riverine fishery management:** The impact of water flow changes on riverine ecology is an important issue and the relevant studies are being made at the river Ravi at Punjab. In the upper zone fish species are represented by carps, *Tor putitora*, *Schizothorax richardsonii, Labeo dero, L. dyocheilus* and *Cyprinus carpio.* To sustain fish stocks in this stretch natural recruitment areas of *T. putitora* and *S. richardsonii* are to be protected. High rate of water abstraction in the river stretched between Modhopur barrage and Kathlour results in significant reduction in water flow, which adversely impacts commercial fishery. It is estimated that this zone would require a regular water flow of at least 300 cusecs during lean season to enable bottom feeding fish population to develop and sustain. Stocking of minor carp seed can also restore the fishery in this zone. The lower stretch from Kathlour, Gurdaspur to its exit point at Amritsar, receives sufficient water influx from perennial tributaries. This augmented water flow, helps this stretch to sustain reasonable fish production of 1.16 tonnes/month on an average. On the basis of data generated, different management practices are suggested, for each zone in the river Ravi vis-à-vis fishery restoration.

**Changes in the Fisheries of Ganga and Yamuna:** The most important hydrological change observed in river Ganga is the sharp increase in sediment load during current decade by almost 20-times at Allahabad and 30 times at Varanasi. This change has resulted in considerable reduction in discharge rates, seriously impacting the breeding and recruitment process of commercially important fishes and significant shift in species composition in favour of miscellaneous and exotic species. Fish landings at Sadiapur and Daraganj centers were estimated at 56.89 tonnes and 29.51 tonnes respectively. The fish catch data from Ganga river system at Allahabad indicated dominance of miscellaneous fish group (54.3%) followed by common carp (24.4%). The landings of major carps and catfishes declined sharply and presently these are contributing only 9.5% in the total landings.

### Community fish smoking kilns

Eight community fish smoking kilns (CoFiSmki) were successfully erected for the benefit of fishermen community which included one in Junput, Kontai, East Midnapur, West Bengal, two in NEH region, viz. Amranga (Kamrup district) and Morigaon (Nawgaon district) in Assam and five in the remote fishing villages adjoining Hirakud reservoir, viz. Kurumkel, (Bargarh district), Pujaripali (Jampali), Thebra and Rampaluga all three in Jharsuguda district and Sapne in Sambalpur district of Orissa.

Smoked tuna is seen through pouches

**Mapping of water bodies of Orissa and Rajasthan**

Water bodies above 10 ha were mapped for 15 districts of Orissa state and all the districts of Rajasthan. In Rajasthan, 807 water bodies above 10 ha have been identified having a total water spread area of 91,705.26 ha, during the post monsoon period.

The correlations between different water quality parameters and digital values of different bands of remote sensing image and various indices like normalized difference vegetation index (NDVI), normalized difference water index (NDWI) were analyzed. Water quality parameters like temperature, specific conductivity, total alkalinity, sulphate, silicate, calcium, magnesium and hardness showed significant correlation.

**Index of biotic integrity developed for riverine ecosystem:** The anthropogenic impact on the fishery of degraded river Churni was assessed by the index of biotic integrity (IBI). A scoring chart using IBI metrices was developed for the riverine ecosystem. The number of native species and families, species in the column, benthic species, intolerant species and percentage of herbivores declined. But the percentage of tolerant species, omnivores and carnivores increased indicating impairment of the ecosystem. The IBI was significantly lower at stressed sites, based on the IBI score of 3. About 60% of sampling sites supported fishery in acceptable condition in the Churni river.

**Design and development of eco-friendly tunnel fish dryer**

A solar tunnel dryer having an efficient heat absorbing and utilization system was designed and developed. Special quality toughened glasses are used in the system to enhance the absorbvity of solar radiation and to reduce the emissivity. The solar heating system is well insulated to prevent loss of thermal energy. Continuous flow of hot air is maintained by a forced circulation system with the help of photo voltaic cells to enable faster drying rate. Perforated plastic trays are introduced in the drying tunnel to get uniform drying. Training and demonstration programmes were conducted among fisherwomen and other users.

Tunnel fish dryer

**Evaluation of visible implant elastomer tags (VIE tags) in juvenile freshwater prawn *Macrobrachium rosenbergii***

The suitability of a visible implant fluorescent elastomer tag (VIE) as a method to identify juveniles of *Macrobrachium rosenbergii* (mean weight 1.25 ± 0.21 g) was evaluated. Fluorescent colours, such as red, orange, yellow and green tags, were tested for tag retention and readability during the grow-out of 100 days in outdoors fibreglass tanks. Tag retention was 96–100% in survived prawns. Tag visibility was fair after 100 days of grow-out culture and tags could be easily seen with the naked eye. Red tags were most visible followed by orange and green. No significant differences in growth or survival were observed between the tagged and untagged prawns. These results indicated that *M. rosenbergii* can be effectively tagged with VIE tags, and it can be used as batch tag to identify families in a selective breeding programme.

**Application of microbes for trichloroethylene (TCE) degradation:** TCE is a common industrial contaminant in water. Methods were standardized for detection of microbes having capacity to degrade TCE. A total of 9 TCE degrading bacteria could be isolated and tested using plate and flask culture method. Pure cultures of TCE degrading isolates were preserved in glycerol at –20°C for further tests and identification.

**Effect of deltamethrin on common carp:** In common carp negative growth of –4.3% was recorded with diet containing sub-lethal exposure of deltamethrin for 45 days. Histopathological studies of gill, liver and intestine of fish exposed to deltamethrin with control diet containing ascorbic acid showed that the ascorbic acid acts as an antidote for pesticide.

**Microbial diversity:** Under the project on Application of Micro-organisms in Agriculture and Allied Sectors, water and sediment samples collected from the sea off Mumbai were subjected to microbiological analysis and 11 species/groups were tentatively identified. These are: *Chromobacterium violaceum, Enterobacter cloacae, Pantoes* sp., *Photobacterium damsela, Pseudomonas stutzeri, Rhizobium radiobacter, Shewanella putrefaciens, Sphingomonas paucimobilis, Vibrio alginolyticus, V. fluviatilis,* and *Yersinia enterocolitica*.

## CULTURE FISHERIES

### Freshwater aquaculture

**Multiple breeding of *Labeo fimbriatus*:** The medium carp, *Labeo fimbriatus* was successfully bred in the pond ecosystem twice in a season. After first breeding in March, spent brooders were maintained separately in a pond and fed with special maturation feed. They were once again bred for a second time in August and 1.52 lakh spawn were obtained from 2 sets. Multiple breeding of

this threatened species will be a major boost in attempts to restock this medium carp in peninsular rivers.

**Development of sexual maturity in *Puntius pulchellus* under captivity:** The peninsular carp, *Puntius pulchellus*, which had been successfully incorporated in culture conditions, achieved sexual maturity under capacity. More than 80% of the 3-year-old males were mature, which started oozing milt upon gentle pressure. In addition, the males which had hitherto not shown any secondary sexual characters, exhibited clear papillary growth on dorsal surface of snouts, giving them a rough texture.

Snout of male showing rough rosy papillomatous growth

Smooth snout of female

**Evaluation of *Puntius gonionotus* for polyculture system:** The growth of silver barb was better than the three Indian major carps, thereby showing possibility of its incorporation in grow-out carp culture system. The mean growth and survival rates

A haul of *P. gonionotus*

of silver barb, *Puntius gonionotus*, in 10 ponds of 0.08 ha each for 10 months, were 380–427 g and 81.9–95.8%, respectively.

**Breeding and mass seed production of *Ompok pabda*:** Successful breeding of the *Ompok pabda*, popularly known as *pabda* was achieved by using ovaprim as inducing agent @ 0.5 ml to 1.5 ml/kg weight of fish. A total of 2 lakh spawn of *pabda* were produced, and are being reared in yard and earthen ponds. The fry attained an average size of 8.5 cm/2.72 g in a period of 60 days rearing period.

**Captive breeding of freshwater fish *Chitala chitala*:** A significant breakthrough was achieved in up-scaling the protocol for captive breeding of *Chitala chitala,* with two different hormones, based on repeated successful trials. A larval rearing experiment for *C. chitala* for 30 days indicated that the larvae actively fed on live organisms (tubifex and chironomus larvae, plankton), artificial diets (*Spirulina, Daphnia* and dry tubifex) and other non-conventional feed (fish egg and boiled egg yolk). Highest mean survival rate was recorded in larvae fed with live tubifex (94%) and chironomous larvae (92%), than (88%) with *Spirulina* and *Daphnia* and the lowest (66%) with boiled egg yolk. Owing to its hardy nature, *C. chitala* seed can easily be transported and fish seed can survive up to 5–7 days, without any artificial feeding. This technique can successfully be applied for ranching in the habitat for stock enhancement, and seed production for aquaculture.

The fertilized eggs of *Chitala chitala*

**SUCCESS STORIES**

**Collapsible fish Trap for Inland Fishing**

The CIFT has designed and fabricated a collapsible fish trap and crab trap for helping the poor fishers operating fish traps. The new crab trap is fabricated using two rectangular SS frames having 0.9 m × 0.4 m size. The upper frame is made using SS rod of 6 mm dia whereas the lower one is made using 10 mm dia rod to make the trap sink. Black nylon (PA) multifilament netting (210D × 8 × 3) with 60 mm mesh size is used to cover the frames. Entrance funnels are fabricated using PA multifilament netting (210D × 6 × 3) with 40 mm mesh size. Eight PVC floats of 50 × 20 cm are attached to the four corners of the top frame to lift the upper body of the trap. The floats and weight are balanced which enable the trap to achieve a box shape under water. A bait bag is suspended inside the trap between the entrance funnels. An openable window is provided at one side of the trap to remove the catch. Crab traps were operated in Cochin backwater with fish and chicken waste as bait. The catch was much better in the trap operated with chicken waste (Plate). With an average soaking time of 2 h the trap with chicken bait caught 1kg of *Scylla serrata*. Mud crab weighing about 700 g fetches about Rs 250/kg.

### Quality seed production of freshwater prawn freshwater prawn

Under the National Seed Project 8.3 lakh of quality seed of giant freshwater prawn *Machrobrachium rosenbergii* were produced. Nearly 6 lakh were supplied to prawn farmers from different parts of the state and to those from Chhattisgarh and Haryana generating revenue of Rs 2.9 lakh.

**Artificial propagation of catfish, *Pangasius pangasius* for diversification of aquaculture:** Attempts were made for induced breeding, seed rearing, and suitable feed development of the catfish, *Pangasius pangasius*. During July–August, free oozing male and gravid female were selected for induced breeding. The

A haul of *P. pangasius* fingerlings

fertilization and hatching rates were 61% and 25%, respectively, during the spawning trial. The hatched larvae were initially fed on mixed zooplankton and slowly weaned with formulated feed. The larvae grew to 15–21 mm during 15–20 days of hatchery rearing. These fry grew to 1.5–2 g in length in 30 days of growing period

### Upscaling of seabass seed production

Breeding trials were conducted to produce quality seed of seabass *Lates calcarifer*. Eight million eggs were produced with an average fertilization rate of 60%. The average hatching rate was 78% and the total yield of hatchlings was 3.74 million. The hatchlings were reared @ 20–40 no./litre. After 21 days of rearing 5.72 lakh fry in the size range of 1–1.5 cm were produced. Nursery rearing of seabass fry was carried out in tanks @ 500–2,500 no./$m^2$ for 25–40 days in tanks. The average survival rate was 58%. The nursery rearing was also carried out in hapas wherein the fry was stocked @ 5,000 no./$m^2$. After 45 days of rearing a survival rate of 65% was achieved and the fry had reached average size of 7.5 cm. During nursery rearing, grading was done once in three days to avoid cannibalism.

### DNA bar-coding of Indian Marine Fishes—a new initiative in the Asian region

Over 1,300 samples covering 270 marine fish species from Mumbai, Kochi, Vishakhapatnam, Andaman and Nicobar Islands and Mandapam regions, were cultured and DNA isolation and PCR amplification were carried out for more then 250 samples. The DNA barcodes (DNA sequence profile of 655 bp fragment of cytochrome c oxidase I) of 32 marine fish species were completed, for the first time in India.

under artificial feeding resulting in 50–60% survival during fingerling raising programme.

**Evaluation of kalbasu for polyculture system:** Study on performance of kalbasu (*Labeo calbasu*) stocked along with the three Indian major carps showed 73.23% and 53.3% higher yield in treatment provided with fertilisers + feed + periphytic substrate and feed + fertilizers, respectively, over treatment with provision of fertilizer alone. Only rohu and kalbasu showed significantly higher growth and biomass production with provision of periphytic substrates.

## Upland aquaculture

**Feed for coldwater fishes:** The nutritional requirements of golden mahseer (*Tor putitora*) were 40% protein, 15% lipid and 25% carbohydrates, as these gave better growth performance and feed efficiency. Floating feed prepared for rainbow trout, was accepted by them and their growth performance was significantly better.

## Brackishwater aquaculture

**Development of formulated feed for grow-out culture of mud crabs:** Field trial of the crab feed was conducted in six ponds of 0.08 ha each. In 113 days, the production and survival obtained from the ponds fed with pellet feed were 372 kg/ha and 34% indicating that the pelleted feed can be used for crab culture profitably compared to the conventional trash fish feed.

Scylla serrata crabs cultures using pellet feed

### Mariculture

**Hatchery production of marine ornamental fishes:** The seed production technology of marine ornamental fishes such as orange clown (*Amphiprion percula*), false clown (*A. ocellaris*),

Hatchery produced *Amphiprion ocellaris* – False clown fish

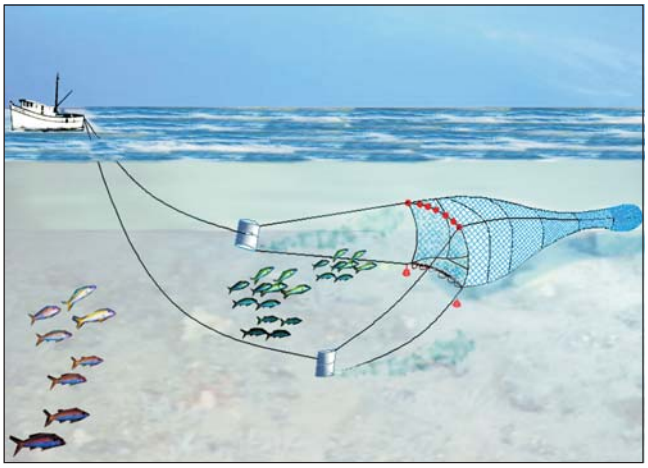
blue damsel (*Pomacentrus cearuleus*), spot damsel (*Dascyllus trimaculatus*) and Humbug damsel (*Dascyllus aruanus*) was standardized.

**Mabe pearls from Blacklip pearl oyster:** Mabe pearl production technology was extended to the blacklip pearl oyster (*Pinctada margaritifera*) at Port Blair. The technology was further improved by standardizing the narcotization and adhesion methodologies. New designs of images were made locally and a design for converting mabe-on-shell to a decorative table souvenir was finalised in consultation with local shell-craftsmen.

Mabe pearl from *Pinctada margaritifera*

## FISH HARVEST AND PROCESSING TECHNOLOGY

**Cod end selectivity of trawls for fish resources off south-west coast:** In the trawl cod end selectivity experiments off Kochi, using 18 m semipelagic trawl fitted with 100 mm diamond mesh cod end and 30 mm cover, about 94% of the catch components, predominantly juveniles and sub-adults, were found excluded from 100 mm diamond mesh codend, while large size individuals of *Pampus argenteus* (FL 105-180 mm), *Portunus pelagicus* (CL 110 mm), *Charybdis feriatus* (CL 140 mm), *Megalaspis cordyla* (TL 215-220 mm), *Parastromateus niger* (TL 175-190 mm), *Rastrelliger kanagurta* (TL 110-242 mm), *Uroteuthis*



(*photololigo*) *duvauceli* (ML 110 mm) and *Congresox* sp. (TL 1,300 mm) were retained. The $L_{25}$, $L_{50}$, $L_{75}$, selection range and selection factor for *Trichurus lepturus* in respect of 40 mm square mesh cod end were determined as 307.5 mm, 362 mm, 416.5 mm, 109 mm, and 9.05, respectively, based on selectivity experiments off Visakhapatnam.

**Fibreglass reinforced plastic (FRP) as a physical barrier for chemically treated wood for boat construction:** Studies carried out at Cochin estuary, showed that the rate of leaching of copper from unsheathed and FRP sheathed wood panels were 0.687 and 0.0026 mg/cm$^2$/day respectively. For chromium it was 1.3 and nil, and for arsenic it was 1.02 and 0.15 mg/cm$^2$/day respectively. FRP sheathing accorded a 100% protection from the attack of marine borers. X-ray radiography showed that after one year of exposure in the test site, the untreated panels showed failure with borer tunnels covering more than 50% of the area of the exposed specimen whereas in FRP no sign of attack was observed. Sheathing the CCA treated wood with FRP proved effective in reducing leaching.

**Bioactive substances from aquatic sources:** *Octopus vulgaris*, *O. variabilis* and aquatic weeds, viz. (*Vallisnaria spiralis, Euchemia cottoni* and *Eichhornia crassipes*) were screened for the presence of bioactive substances. *E. crassipes* was the most promising source for substances with antipyretic, anti-inflammatory, antiulcer, wound healing and hypoglycemic effects.

### Fish drying

Two fishermen associated with dry fish marketing and export to Sri Lanka were trained in scientific methods of drying fish in the sun at the CIFE, Mumbai. After the training, they are developing high quality dry fish at Madh Island of Mumbai and Veraval in Gujarat. These trained fishermen have already exported 50 tonnes of dry fish of higher quality at a premium price to Sri Lanka.

Further detailed investigations were made with extracts from different parts of *E. crassipes*. Triterpenoids, saponins and flavanoids were present in these extracts. The analgesic effect of the extract was compared with paracetamol. Analgesic activity of the extract from root was higher than that of paracetamol. Extract from leaves did not show any significant analgesic activity. The root extract was more effective than leaf extract.

**High value products from fish and fish processing waste:** Tuna red meat, which is discarded as a processing waste, was used for the preparation of edible fish powder. The dried powder had a chocolate brown colour with 86.15% protein. It can be stored at

Fish powder incorporated cookies

ambient temperature for a month without any change of quality. Cookies were prepared using standard recipes by incorporating edible fish powder at different levels. Edible fish powder prepared from *Nemipterus* (whole fish) was compared with red meat of tuna. Cookies prepared using tuna powder was rated to be good at 5% level. Purified Carrageenan was prepared from cultured sea weed, *Kappaphycus alwarizi* with a yield of 33%. Gel strength, sulphate content and clarity were determined. Fish calcium was extracted and purified from sardine and rohu scales after removing protein with a yield of 9.5%.

**Preparation of marinade:** Safe and quality improved marinades were prepared from tuna, mackerel and shark. At ambient condition of 28 to 30°C, the storage life was 12 weeks, and at 10°C, it was 18 weeks. After this period, the product was found unsuitable due to turbidity of the liquor, colour change of meat and very soft texture and flavour changes. Biochemical, bacteriological and sensory evaluations revealed they were acceptable for 12 to 18 weeks at 10°C.

**Ready-to-cook freshwater fish steaks:** A ready-to-cook product with a shelf life of 16 days under refrigeration temperature of 1°–2°C with excellent sensory properties was prepared from *Labeo rohita*. The product in the form of 40–50 g steaks is presented in an optimized packaging, which also serves to display the product. The product has been treated using a special process by which the fish steaks can be directly taken for frying or curry preparation.

**Commercialization of portable FRP carp hatchery**

The technology of portable FRP carp hatchery of 1 million capacity designed and developed for small fish farmers by CIFA, Bhubaneswar has been commercialized.

**Storage studies of fish sauce:** Storage studies of the three samples of fish sauce prepared from anchovy (*Stolepherous* spp.) were carried out for one year. The colour comparator readings indicated that there was not much variation in the colour of the fish sauce samples. The characteristic taste and flavour of the sauce remained unchanged. The TVN (total volume nitrogen) values after 12 months of storage were 98.7, 184, 166.6 mg/100 ml. Peroxide content was below the detectable limit and the histamine content was negligible, being 2.88, 2.68 and 3.27 mg/100 ml respectively. The nitrogen content appeared to be stabilized at 14 g/litre in all samples. No fungal growth or other signs of spoilage was observed. The fish sauce can be kept well for more than 12 months storage, and it may be attributed to the high content of salt (28%).

**Fish meat-bone separator:** A fish meat-bone separator was designed and the prototype was fabricated. The meat yield of the machine was about 60%. The capacity of the fish meat-bone separator is 100 kg raw material/hour and approximate cost of the machine is Rs 2 lakh.

## FISH GENETIC RESOURCES

**DNA marker technology:** Development of microsat DNA markers is in progress for generating a low resolution genetic linkage map in rohu. So far, more than three dozens of microsatellite markers have been isolated and characterized from rohu genome.

**Cloning and characterization of vitelogenin cDNA in catla:** cDNA fragments were amplified by PCR and 5'RACE from induced catla liver RNA using vitellogenin specific primers of carp.

**National Marine Fisheries Census, 2005**

Recognizing the need for a strong real time and reliable database on various aspects of marine fisheries and the expertise and experience of the CMFRI, Kochi, in conducting such massive census surveys, the DAHD&F, Ministry of Agriculture, Government of India, entrusted the task of conducting the All India Marine Fisheries Census in the mainland to CMFRI. The entire census operation was carried out from 15 April to 15 May 2005 for the maritime States except Tamil Nadu and Pondicherry where the census was carried out during November–December 2005. The major findings were that there are 3,202 marine fishing villages with a total population of 3.52 million living in 756,212 households. Nearly 56.5% of fisherfolk are educated with varying levels of education. About 46.8% (1,645,919) of fisherfolk are occupied with active fishing and fishery related activities. About 25.7% (889,528) of the fisherfolk are actively engaged in fishing of which 80.7% (717,999) have fishing as a fulltime occupation. About 21.5% of fisherfolk are engaged in fishing related activities. Of this, those working as labourers form 29.2% and those associated with marketing are 27.4%. Among males, the major fishery related occupations are: labour (39.2%), mending of nets (28.6%) and marketing (14%). Among women, the major fishing associated activities are, marketing (41.8%), labour (18.4%) and curing/processing (18%). In 10% of the fisherfolk families of Maharashtra, only women are involved in fishing or fishing allied activities and in all India level it is about 5%. There are 238,772 craft in the fishery of which 58,911 are mechanized, 75,591 are motorized and rest are non-motorised/non-mechanised. Out of 29,241 trawlers in the fishery, Gujarat (8,002) accounts for the maximum followed by Tamil Nadu (5,300), Maharashtra (4,219), Kerala (3,982) and other states. The maritime states on the east coast account for about 73% of the non-motorised/non-mechanised craft—Andhra Pradesh (24,386) and Tamil Nadu (24,231) being the lead States. Out of 185,438 craft owned by fisherfolk, 35,806 are mechanised, 52,971 motorised and 96,661 are non-motorised/ non-mechanized. Nearly 47% of the fisher families involved in fishing neither own any craft nor gear. In the maritime states, Kerala has 66% of such families, followed by West Bengal (49%), Tamil Nadu (46%) and others.

The amplified cDNAs were cloned in pGEMT vector and sequenced. The sequences when BLASTed in gene bank database, showed significant similarities with the vitellogenin I sequences of *Pimephales promelas, Cyprinus carpio* and *Danio rario* both at the nucleotide as well as amino acid level.

**Gene expression studies in fish exposed to pollution:** Endocrine disruption is a common squeal to exposure to pollutants that lead to changes in population structure. Vitellogenin gene expression at transcriptional level was studied using reverse transcriptase PCR (RT-PCR) method in male *Labeo rohita* subjected to 17-ß estradiol exposure and this could serve as a biomarker to detect pollution-induced endocrine disruption in fish.

**DNA sequences of marine mammals deposited in gene bank:** Till date, 20 PCR products (cytochome b and control region of mt DNA) from 10 individuals of seven species were cycle sequenced using ABI AmpliTaq FS dye terminator cycle sequencing chemistry, aligned using ClustalW Multiple alignment (*Bioedit*) and deposited in the GenBank (NCBI). Sequencing of mitrochondrial DNA of two species of baleen whales and dugong is also completed.

**PCR-based gender identification of marine mammals:** A PCR-based sex determination technique was developed based on the amplification of genomic DNA extracted from their skin tissues. This is done by amplifying a 444 bp Y-chromosome specific region (*SRY* or Sex-determining Y chromosome gene) in the genome using specific PCR primers. A 220 bp ZFX/ZFY (zinc finger protein genes located on X and Y chromosomes, respectively) band is also amplified using another pair of primers in this multiplex PCR as positive controls for absolute confirmation of sex. Molecular sexing was standardized in bottlenose dolphin, spinner dolphin, Indo pacific humpbacked dolphin, Risso's dolphin, finless porpoise, dugong, blue whale and Bryde's whale.