CMFRI bulletin 44

Part Three

FEBRUARY 1991

NATIONAL SYMPOSIUM ON RESEARCH AND DEVELOPMENT IN MARINE FISHERIES

MANDAPAM CAMP

16-18 September 1987

Papers Presented
Sessions V, VI & VII

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
P. B. No. 2704, E. R. G. Road, Cochin-682 031, India

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CIFE CONTRIBUTION TO MARINE FISHERIES R & D

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ABSTRACT

The CIFE contributions to marine fisheries R&D are mainly in the areas of stock assessment, brackishwater farming, fishing and product diversification, fishery socio-economics and technology transfer. Stock assessment studies, limited to the west coast and particularly to the northwest coast include the stocks of *Coilia dussumieri, Otolithus cuvieri, Johnius glaucus, Polynemus heptadactylus, Harpodon nehereus, Arius thalassinus, Nemipterus japonicus*, all-northwest coast inshore species, penaeid prawns, *Rastrelliger kanagurta, Sardinella longiceps and xancus pyrum*. In respect of brackishwater fisheries, R & D activities are concerned with prawn hatcheries, seed banks, low input culture, live feed culture and fishery estates. Simple techniques for making laminated Bombay duck, fish wafers and minced meat have been developed for the purpose of product diversification. High opening bottom trawling has been experimentaly proven to be more productive than the traditional bottom trawling, and is being popularised. Studies on profitability of mechanised fishing indicate some prospects for additional investment. Small private owned brackishwater farms are more profitable than large government owned farms, indicating thereby the need to privalise the farm sector. The fisheries co-operative society at Versova investigated in detail by the CIFE for its success, is recommeded to be a model for other fisheries societies in the country. Technology transfer is effected through periodic short term training courses on subjects of critical importance to specific target groups including fish farmers, fishermen, processors, entrepreneurs etc.

OBJECTIVE OF CIFE

The Central Institute of Fisheries Education (CIFE) was established in the year 1961 at Bombay as a premier institute for fisheries education at the postgraduate level, under the Union Ministry of Agriculture. The Institute came under the administrative control of the Indian Council of Agricultural Research (ICAR), with effect from the first April 1979. Under the Ministry, the primary objective of the Institute remained as postgraduate fisheries education to the inservice personnel of the fisheries departments of various states. With the transfer of the Institute to the ICAR, the objectives were redefined to include fisheries research and extension, besides education.

The Institute's marine fisheries research programmes are modest and are carried out primarily at its headquarters at Bombay and at the Brackishwater Fish Farm (BWFF), Kakinada in Andhra Pradesh. The Institute's Inland Fisheries Training Centre (IFTC) at Barrackpore in West Bengal carries out some studies on the estuarine fisheries of the Sunderbans while its Operational Research Project unit at Sultanpur in Haryana has initiated culture of marine finfish and prawns in the saline soil areas in the hinterlands.

INFRASTRUCTURE FOR MARINE FISHERIES R & D

At the headquarters in Bombay, marine fisheries research programmes and projects are carried out through the departments of Marine Fisheries & Ocean Management, Fish Processing Technology, Fishing Technology, Aquaculture, Fisheries Economics and Project Planning & Evaluation. Two marine fishing vessels including a larger (120' overall length) sophisticated *M.V. Saraswati* and a smaller (38' overall length) *M.F.V. Narmada* are in active use in support of all marine fisheries research and training programmes particularly along the north west coast of India. The M.F.V. *Harpodon* (37' overall length) which was in active operation for 16 years from 1967 to 1982 was decommissioned and disposed off in 1986. The M.F.V. *Sunderbans* (55' overall length) at the IFTC Barrackpore is being used for the Sunderban esturine studies. Research data from the cruises of *M.V. Saraswati* are processed by means of a work horse level 4 computer (Hindustan Computers Ltd.) which is also used in fish stock assessment studies.

The department of Fish Processing Technology is equipped with deep freezers, vertical freezer, blast freezer, plate freezer, refrigerators, cold storage, Torry kiln, can seaming machines, cannery retort, mixers, filter, mincers, cutters, deboning machines, slicing machines, centrifuges etc. The fishing technology laboratory has a larger number of models of fishing craft and gear both artisanal and mechanised, meant primarily to serve as teaching and demonstration aids. There is a general and reference collectiom museum of marine fishes, attached to the department of Marine Fisheries. A small but well equipped outdoor aquaculture unit within the main campus at Bombay has facilities for small scale prawn breeding and seed production and for testing the growth effects of various formulated and natural feeds. This is a self contained unit with a brackishwater well, overhead tanks, biological filters, plastic pools, cement tanks, airblowers, pumps, aerators, airlift systems, machine for formulated feeds and plankton culture systems.

The Institute's brackishwater fish farm at Kakinada has a total farm area of 8.0 ha with ponds ranging from 0.14 ha 0.224 ha for the culture of penaeid prawns and brackishwater fish. A well equipped prawns hatchery has been set up at this centre for both seed production and demonstration purposes.

ONGOING RESEARCH PROJECTS

The major marine fisheries research projects that are being carried out currently were initiated in 1983 and 1984. They include : (1) The biology and dynamics of certain exploited marine fish populations; (2) Stock assessment of offshore fisheries resources off the northwest coast of India beteewn 19^0 and 20^0 N latitudes; (3) Fisheries oceanography of the northwest coast between 16^0 22^0 N latitudes; (4) Improvement in harvesting technology including highopening trawls for small scale fishing in the Bombay coast; (5) Biochemistry and spoilage dynamics of minced fish meat; (6) Marine fish product development; (7) Proteinases and polyphenolase enzymes in marine finfish and shellfish; (8) Breeding of penaeid prawns and larval rearing to stock size; (9) Culture of brackishwater fish and prawns; (10) Brackishwater fish and prawn seed prospecting; (11) Transportation of adult and seed fish and prawn under continuous aeration, and (12) Utilisation of wind energy in brackishwater farming.

MARINE FISH STOCK ASSESSMENT

Coilia dussumieri

The stock of *C.dussumieri* occurs mainly in the inshore area to a depth of about 50 m between 19^0 N and 21^0 N latitudes and between 71^0 E and 73^0 E longtitudes along the coasts of Maharashtra and Gujarat. For 1982-83, the annual total stock was estimated to be 29,162 t the average or standing stock 10,144 t, the absolute number of recruits 5.2×10^9 and the mean number of fish in the stock 1.8×10^9. The annual catch of 13922 t in 1982-83 represents 47.74% exploitation.

The fishing intensity was much lower in 1982-83 (F=1.4) than in 1963-64 (F=3.1) due to significant shift towards night trawling for the shrimp fisheries rather than for *C. dussumieri*. In night trawling *C. dussumeri* forms only stray catches as it ascends up with the zooplankton during nights. Fishing could be increased modestly from the 1982-83 level (f=1.40) to the optimum (F=2.5 to 3.0), keeping the size at first capture constent at 8.8 cm (=age 0.4 year) to increase the yield per recruit from 3.1 g to 3.4 g. Operation of dolnets of less than 15 mm codend mesh should be discouraged (Irene Fernandez, 1986, Irene Fernandez and Devaraj, MS).

Otolithus cuvieri

O.cuvieri forms about 25% of the sciaenid fishery along the northwest coast. The total annual stock for 1982-83 in the Maharashtra Gujarat inshore area to a depth of about 50 m was estimated to be 45,820 t, the standing stock 27,573 t, the number of recruits 0.459×10^9, the mean population number 0.39×10^9 and the yield in number 0.0959×10^9. The yield in weight of 6,873 t in 1982-83 formed only 15% of the annual total stock. The mean weight of fish in the catch was 72 g; the number of fish per kg was about 14. the maximum sustainable yield (MSY) of 20,783 t could be obtained at 65% exploitation (Gulati, 1987).

Johnius glaucus.

J.glaucus forms about 20% of the sciaenied fishery along the northwest coast. In 1983 the total stock in the Maharashtra-Gujarat in shore grounds to a depth of about 50 m was 14,624 t, the standing stock 5,645 t, the MSY 6,623 t, the number of recruits 244 x 10^6, the mean number of fish in the exploited phase 39 x 10^6, yield in weight 4,811, t yield in number 58 x 10^6 and the mean weight of fish in the catch 93 g. The annual yield of 4,811 t indicated that 36.4% of the stock was being exploited. Increasing the present yield to the level of MSY would require considerable increase in the exploitation rate from the present 36.4% to about 75% (Kamath, MS).

Polynemus heptadactylus

P.heptadactylus forms about 40% of the total polynemid (threadfins) catch along the northwest coast comprising Maharashtra and Gujarat. The annual stock of *P.heptadactylus* in 1982-83 in the inshore grounds along this coast has been estimated to be a meagre 4,794 t, the standing stock 2,936 t, the MSY 1,802, the number of recruits 49.0 x 10^6, yield in weight 1,606 t, yield in number 38.8 x 10^6 and the mean weight of fish in the catch 41.4 g. The annual catch of 1,606 t represents an exploitation rate of 33.5% while at the MSY of 1,802 t the exploitation rate is 88% for the present age of 0.43 year at first capture (Ivan, 1987).

Bombay duck (Harpodon nehereus).

The yield per recruit of 13.0 g at F=1 and E=0.42 (42% exploitation rate) in 1984-85 was also the maximum sustainable yield per recruit (Hameed Batcha, 1986). Therefore, the 1984-85 yield of 121,680 t for the northwest coast (61,256 t for Maharashtra and 60,424 t for Gujarat) should be the same as the MSY, and the exploitation rate of 42% be considered as the optimum for stabilising the fishery. The number of recruits into the fishable stock is estimated to be 9.0133 x 10^9.

Arius thalassinus.

A.thalassinus forms about 50% of the catfish catch along the Maharashtra-Gujarat coast where in 1984-85, the total catfish landing was 20,712 t. In the case of *A.thalassinus*, the exploitation rate in 1986 was found to be 37% for the present low levels of F=0.45 and age at first capture (t_c) of about one year. The annual yield per recruit (Y/R) can be maximised from the present 40 g to 55 g by increasing t_c to 2 years and F to 1.8 (Naik, 1987).

Nemipterus japonicus and "all-demersal".

Preliminary estimates by the swept area method applied to bottom trawl fishery data for *MV Saraswati* for 1983-85 indicate that the standing stock of *N.japonicus* in the 30-200 m deep grounds was 55,465 t for Karnataka-Goa, 266,006 t for Maharashtra and 1,053, 114 t for Gujarat. The standing stock of "all-demersals" was 308,958 t for Karnataka-Goa 1,213,854 t for Maharashtra and 2,820,588 t for Gujarat. Thus, the standing stock of *N.japonicus* forms 18%, 22% of the standing stock of all demersals in the 30-200 m deep grounds off the Karnataka-Goa, Maharashtra and Gujarat coasts respectively. The total area between the 30 m and 200 m depths is 3.341 x 10^6 ha for Karnataka-Goa 13.027 x 10^6 ha for Maharashtra and 16.418 x 10^6 ha for Gujarat. The standing stock of *N.japonicus* per hectare was 16.6kg, 20.4 kg and 64.1 kg while that of all demersals was 92.5 kg, 93.2 kg and 171.8 kg respectively in the Karnataka-Goa, Maharashtra and Gujarat grounds.

Potential yield estimates including the pelagics and the demersals for the northwest coast of India, using various methods, range from 0.15 x 10^6 to 2.64 x 10^6 t (Bapat *et al.*, 1982). Assuming the standing stock to be about the same as the annual stock, which in the 50-200 m grounds remains poorly exploited, the potential yield may be taken as 25% of the standing stock. On this yardstick, the potential yield of *N.japonicus* for the Maharashta-Gujarat continental shelf would be about 329,780 t (25% of 1,319,120 t), but the annual yield in 1984 was a meagre 8,940 to (4,682 t for Maharashtra and 4,258 t for Gujarat) by the inshore trawl fishery from grounds to a depth of about 50 m (Devaraj and Gulati, MS)

In an earlier study by Biradar (1987) based on *M.V.Saraswati* bottom trawl fishery data for April-May 1984, the standing stock of demersals in the 30-200 m deep grounds off the Karnataka coast was estimated to be 130,000 t comprising 38,000 t of *N.japonicus*, 19,000 t of *Arius* spp, 15,000 t of *Priacanthus macracanthus*, 11,000 t of *Saurida tumbil* and 47,000 t for other demersals. Eightyfive percentage of the demersal stock was limited to the 30-49 m and 50-99 m depth zones in almost the same ratio; 68% of the *N.japonicus* stock was available within the 50-99 m depth zone; catfish stocks were limited to the 30-49 m zone only; about 50% of the *P.macracanthus* stock was confined to the 100-200 m depth zone; and, 75% of *S.tumbil* stock was found in the 50-99 m depth. Out of the estimated stock of 76,450 t of demersals in the almost unfished 50-200 m depth grounds, 38,225 t was considered as the potential yield. The potential yield from *N.japonicus* stock in the 30-200 m deep grounds is 15,672 t which is 41% of all-demersals, but the yield in 1984 was only 1,525 t (Biradar, 1987).

Potential yield from inshore fisheries along the northwest coast

On the basis of time data comparising annual catch and effort for 1956-85, three levels of yields were identified for the Gujarat inshore fishery. The MSY was estimated to be 97,891 t for an optimum fishing effort (f_{msy}) of 24.076 x 10^6 manhours for the lowest level of yield comprising the years from 1956 to 1972, 146,465 t for 27.653 x 10^6 manhours for the middle level comprising 1973 and 1974 and 252,981 t for 42.472 x 10^6 manhours for the highest level comprising 1981 to 1984-85. The shift in the level of yield from the lowest to the highest reflects the shift in the quality of fishing technology from a purely traditional nonmechanised state from 1956 to 1972 to an essentially mechanised state since 1973 (Prabhu, 1987).

In the case o f Maharashtra inshore fisheries, two levels of yield could be identified - a high level with MSY 273,922 t for f_{msy}=48.563 x 10^6 manhours for 1956, 1957, 1964 to 1966, 1970 to 1974 and 1981 to 1984-85 and a low level with MSY=160,479 t for f_{msy}=39.674 x 10^6 manhours for 1958 to 1963 and 1967 to 1969. While the high yields in 1956, 1957 and 1964 to 1966 are attributable, *inter alia*, to above normal biological productivity, that for 1970 to 1974 and 1981 to 1984-85 is due to mechanisation (Lodhi, 1987).

The sum MSY of 512,659 t for the highest levels for Maharashtra and Gujarat is close to the potential yield of 540,000 t estimated by George *et al* (1977), indicating thereby that the entire inshore fishing grounds are being exploited to about the optimum since the early seventies. Realising the need to extent the fishery into much deeper grounds, the industry has introduced a fleet of about 250 second generation trawlers (47' overall length) operating from Veraval and Bombay bases since 1980 in the 50 to 100 m deep grounds.

Optimisation of the west coast penaeid prawn fishery.

From time series data comprising annual yield and effort for the west coast penaeid prawn fishery for the period 1971 to 1984-85, the annual MSY has been estimated to be 115,205 t comprising 54,277 t for Kerala, 7,399 t for Karnataka, 3,952 t for Goa, 36,649 t for Maharashtra and 12,928 t for Gujarat while the optimum effort in terms of annual number of trawlers operating daily for about 215 days a year is 4,594 comprising, 1,730 for Kerala, 760 for Karnataka, 553 for Goa 876 for Maharashtra and 675 for Gujarat.

Economic performance of the trawler fleet indicates the maximum economic yield (MEY) of penaeid prawns from the west coast to be 95,368 t including 44,931 t for Kerala, 6,125 t for Karnataka, 3,277 t for Goa, 30,338 t for Maharashtra and 10,702 t for Gujarat. The economically optimum effort (f_{mey}) in terms of number of trawlers operating daily for about 215 days a year is estimated to be 3,438 comprising 1,460 for Kerala, 641 for Karnataka, 467 for Goa, 739 for Maharashtra and 570 for Gujarat.

After the advent of commercial trawling by about 1968, the annual yield has stabilised at an average of 97,094 t and the annual effort at an average of 3,793 trawlers operating daily for about 215 days a year during 1971-85. The stabilised yield includes 43,471 t for Kerala, 5,924 t for Karnataka, 2,943 t for Goa, 34,111 t for Maharashtra and 10,645 t for Gujarat while the stabilised effort (number of trawlers) includes 1,546 for Kerala, 657 for Karnataka, 290 for Goa, 740 for Maharashtra and 560 for Gujarat.

Since penaied prawns are a near monopoly product, the difference between MSY and MEY and between f_{msy} and f_{mey} is insignificant, and the stabilised yield and effort show remarkable agreement with the biologically or economically optimum yield and effort (Kalawar *et al.*, 1985; Deveraj and Smita, 1988; Devaraj and Smita, MS).

Rastrelliger kanagurta

In 1972-75 when t_c was 0.3 year and F=2.1, Y/R was 16 g while the maximum Y/R of 20 g could be obtained by keeping the t_c value at 0.3 year and increasing the F value to 3.5 (Biradar, 1985). By increasing F from 2.1 to 3.5, the average annual yield of 69,557 t for 1972-75 could have been increased by about 25% to attain the MSY of 86,946 t.

For 1956-73 when the average annual catch was 81,095 t the estimated mean annual standing stock was 94,722 t (73,277 t for Kerala and Karnataka; 21,445 t for Goa to Ratnagiri), The mean annual total stock 242,592 t (198,084 t for Kerala and Karnataka; 53,508 t for Goa to Ratnagiri) and the mean annual MSY 121,296 t (94,367 t for Kerala and Karnataka; 26,926 t for Goa to Ratnagiri). The mean production gap of about 40,000 t was mainly due to under exploitation in 1956 (by 41%), 1969 (by 24%), 1972 (by 39%) and 1973 (by 37%), particularly in 1972 and 1973 when the MSY was very substantial at 419,414 t and 250,893 t respectively. Therefore, catches exceeding the MSY taken in most years, resulting in overexploitation by 11 to 40% over and above the 50% stock level (considered to be the optimum) could not reduce the production gap.

The mean annual number of 744.53 x 10^6 fish landed in Kerala and Karnataka during 1934-73 was comparised of 14.1% 0 year group (1 to 5 months), 70.36% 0.5 year group (6 to 11 months), 12.45% 1 year group (12 to 17 months) and 3.09% 1.5 year group (18 months and above). The length of 215 mm at the optimum age of exploitation (0.83 year or 9.9 months) at which the biomass of a given cohort is at its maximum belongs to the fully recruited 0.5 year group. The bell shaped (Ricker type) stock-recruitment curve shows that the recruits are at their maximum of 5.13 x 10^9 at a spawner (parent) strength of 230.856 x 10^6 fish. At F + M = Z = 0.68 +1= 1.68 the spawner population attains its optimum level (230.856 x 10^6). AT F = 0.68 the MSY in terms of recruits is 4.9 x 10^9 (=5.13 x 10^9 minus 0.23 x 10^6). Since the Y/R for M=1, t_c = 0.5 year and F = 0.68 is about 25 g, the MSY from 4.9 x 10^9 recruits is 122, 461 t (Kalawar *et al.*, 1985).

Sardinella longiceps.

For 1972-75 when F=2.5, t_c = 0.5 year and E =0.56, Y/R was 7 g as against the maximum Y/R of 8 g at F = 5 and t_c = 0.5 to 0.6 year. Thus, by doubling the present F, Y/R could be increased only by 14%. The age of oil sardine at first spawning is about one year which is higher than the age at entry into the exploited phase. Hence, fishing at higher intensities could lead to reduction in the spawning stock to levels at which recruitment could be affected (Biradar, 1985).

By doubling the present F=2.5, the average annual yield of 143,133 t for 1973-75 could have been increased only by 14%, that is, by 20,039 t to attain the MSY of 163,172 t. However, stock-recruitment relation of the Ricker type fitted for the population shows the maximum recruits to be 45 x 10^9 at F = 1.8, which could yield 297,000 t on a sustained basis (Biradar and Gjosaeter, MS).

The annual yield of oil sardine since 1956 for the southwest coast shows that the yield has more or less stabilised since 1961 with average annual yield of 173,424 t for 1961-65, 174,910 t for 1969-73, 153,312 t for 1974-78 and 177,631 t for 1979-83 closely agreeing with the MSY estimate of 163,172 t and the average annual yield of 267,906 t for 1966-86 agreeing with the MSY estimate of 297,000 t. It is likely that in 1966-68, F was close to 1.8 resulting in a near maximisation of recruits while during the other periods F was less or more than the optimum.

The Indian sacred chank (Xancus pyrum)

The average annual stock of adult chanks (>60 mm maximum shell diameter) in the Gulf of Mannar is estimated to be 2,009,454 of which 44.83% is exploited. The initial stock size, however, varies from year to year, and hence, there exists different levels of optimum yields (MSY) for different levels of initial stock size.

In the case of the central and southern Gulf of Mannar fishery operating from Tuticorin, six strata of stock abundance have been indentified. The MSY ranged from 143,016 adult chanks for the lowest (6th) stratum to 1,064,079 adult chanks for the highest (1st) stratum for optimum effort ranging from 18,768 diverdays (6 diverdays = 1 canoe day: diving seasons extends from November/December to March/April) for the lowest stratum to 51,195 diverdays for the highest stratum.

In the case of the northern Gulf of Mannar fishery operating from Ramanad, there were five strata of stock abundance, with MSY ranging from 69,160 adult chanks for the highest stratum for an effort of 14,619 diverdays.

The MSY (=a^2/4b where a and b are the constants in the regression of Y/f, i.e., the number of adult chanks per diverday on f,i.e., the effort in diverday) and the corresponding optimum effort (f_msy = a/2b) can be estimated in advance at the beginning of each diving season by substituting Y/f and f for the first few days of diving in the following equations (the general equations is Y/f = a - bf) to find out the value of a which is the index of initial stock size.

Y/f=a - 0.000401 f for Tuticorin fishery

Y/f=a - 0.00164 f for Ramnad fishery

Since the slope is constant and only the Y-intercept a varies, MSY and f_{msy} could be predicted once a is determined from the above relations. Advanced estimates of MSY and f_{msy} shall form the basis for regulating the fishery at its optimum level for any current season.

The yield cycle of four years comprising a peak, a vallely and a peak at intervals of two years, noticed in the Tuticorin fishery for over 100 years from 1876-77 to 1985-86, suggests the need for closing the fishery for an year, two years after each peak, in order to revive the stocks.

Chank fisheries in the Palk Bay and the Coramandel coast yield annually an average of 48,986 and 24,486 chanks respectively while in Kerala the average annual yield is 20,138 chanks.

The average annual stock of chanks in the intertidal Gulf of Kutch is 25,234 of which only 30.6% is exploited, but additional catch is possible only for the 60-80 mm diameter size chanks as the >81mm diameter size chanks are already well exploited. There is prospect for increasing the present supplies by introducing SCUBA diving in the 20 to 30 m deep grounds in the Gulf of Mannar and by exploiting the Gulf of Kutch beyond the intertidal zone (Devaraj and Ravichandran, 1987).

BRACKISHWATER FARMING

Prawn hatchery and seed production

The institute initiated studies on penaeid prawn hatcheries and seed production in 1977 at Bombay, it estabilished a hatchery at its brackishwater farm in Kakinada and set up a pilot hatchery at Okha in collaboration with the Department of Fisheries of Gujarat in 1979. Various species were successfully bred and their larvae reared upto PL 8 at Bombay. From 1978 to 1984, a total of 334,000 postlarvae were produced and a portion of it sold to farmers near Bombay and in Goa. Details of the hatchery designed and developed by the CIFE, experimental studies to determine optimum hydrographic conditions in hatcheries and production ponds, artificial feed and disease problems are available in Hameed Ali and Dwivedi (1977; 1981), Hameed Ali (1980), Hameed Ali *et al.*, (1982) and Dwivedi *et al.*, (1984).

Prawn culture

Under technical guidance from the Institute's Kakinada centre, five parties have set up prawn seed banks in coastal Andhra Pradesh for the supply of seeds to shrimp farmers in and outside this state. A high density rearing system for tiger prawn seed at the rate of one million seed/ha, with 85.45% survival over a period of one month has been developed at the Institute's Kakinada centre (Somalingam and Murthy, 1984). A simple method of low input culture was developed for the tiger prawn at the Kakinada centre. The survival rate from postlarval to crop state was about 50%, the yield about 250 kg/ha and the income about Rs. 18,750/- ha at the rate of Rs. 75/kg against a cost of Rs. 5,850. Two to three crops could be grown per year (Gopalakrishna, 1983). Under technical guidance and training from this Institute, well over 75 private brackishwater shrimp farms have come up in coastal Andhra Pradesh since 1984. The yield of prawns, mainly the tiger prawns, in these farms is about 300 to 400 kg/ha/crop of 3 to 4 months. The confidence gained through this experience is encouraging more and more private involvement in prawn culture in Andhra Pradesh.

Juvenile tiger prawns of 27.7 mm average size collected from low lying coastal areas near Kakinada were successfully acclimatised to freshwater conditions with 96% survival. In acclimatisation, the initial salinity of 30 ppt was progressively reduced by 10% per day for the first two days (i.e., to 25 and 15 ppt), by 5% per day for the next two days (i.e., to 10 and 5 ppt) and by 1% per day for the remaining six days (i.e., to 5,4,3,2,1 and 0 ppt) (Reddi *et al.*, 1984). Since 1985, the Kakinada centre has been able to successfully culture tiger prawns together with major carps in slightly saline soil areas inundated by freshwater, in Andhra Pradesh, This practice has now become very popular with the fish farmers in the State. At Jagannaickpur, near Kakinada, one seasonal 0.4 ha freshwater tank has yielded at the rate of 1.1 t tiger prwan/ha/year together with major carps and milkfish at the rate of 12 t/ha/year in a crop of 10 months. The tank was fertilised with raw cattledung, single superphos and rice bran at 10,000 : 250 : 100 kg/ha on 16.8.83 and then stocked with prawn and fish seed at 42,000/ha. After stocking, the above fertilizers were applied at 100 : 75 : 50 kg/ha at intervals of 10 days for the entire crop duration (Tiwari, *et al.*, MS).

Tiger prawn cultured in a 0.004 ha freshwater tank by stocking seed (15 mm; 0.01 g size) at the rate of 60,000/ha yielded at the rate of 312.45 kg/ha in a crop of 3 months and 15 days (Tiwari and Razivi, MS).

Fish culture

The method of low input culture for milkfish developed at the Kakinada centre involves : (1) manuring with cowdung, single superphos and urea at 5000 : 250 : 50 kg/ha/crop of six months, half this dose is applied five days before stocking while the balance is applied in five equal monthly instalments after stocking; and (2) stocking at the rate of 4000 fingerlings/ha. The yield per ha per crop of six months was 750 to 1000 kg, worth about Rs. 9,000 for an investment of only Rs. 1,700, as there was no artificial feeding. The income could be doubled by raising two crops per year. Low input milkfish culture is best suited to saline soil areas, tailends of canals under tidal influence and low lying water lodged areas unfit for agriculture (Gopalkrishna, 1983 b). Monoculture of *Mugli cephalus*, stocked under the above conditions at 2500 fingerlings/ha resulted in individual growth of 500 g and yield of 1000 kg/ha in one year. *Lates calcarifer*, stocked at 2000 fingerlings/ha and fed with trash fish, yielded 500 kg/ha/year.

Mass culture of live food organism

Brachionus plicatilis, inhabiting salt lakes and backwaters, is a nutritive plankton of optimum size (120-250 μ) suitable for feeding prawn and fish larvae. It can be cultured in 300 l tanks under air lift circulation and by using cheap inorganic manures like pigdung, cowdung, chicken manure, oil cake and super-phosphate. It is tolerant to 4 to 65 ppt salinity, but peak production is limited to 4 to 20 ppt. Continuous regeneration is ensured by the production of both mictic and amictic eggs. Under optimum conditions, the density of *B. plicatilis* rises upto 155 individuals/ml in 13 to 16 days; high density generally lasts for 4 to 6 days (Reddy, 1982).

Marine Planktonic ciliates such as *Fabrea salina* and *Euplotes sp* inhabiting saltwater impoundments and backwaters serve as excellent feed for crustacean and fish larvae. They are delicate and slow moving and are easily caputred by the feeding larvae. *F. salina* is 60-300 μ and completes the life cycle in 20 to 25 hours while *Euplotes sp* is 45-90 μ and the life cycle lasts for 10 to 11 hours. They can be cultured on inert feeds such as cowdung, chicken manure, rice bran etc, lack chitinous shells and are easily digestible. Both are euryhaline, *F. salina* being tolerant to 20-90 ppt salinity and *Euplotes* sp to 20-35 ppt salinity. *F. salina* forms cysts which can be stored for 2 to 3 months in hatchable condition. Mass culture with 60/ml density for *F.salina* and 1250/ml for *Euplotes* sp can be developed in 6 to 7 days (Parveen Rattan and Dwivedi, 1982).

Natural populations of the brine shrimp, *Artemia parthenogenetica*, have been located at the Bhayander and Meera Road salt pan complexes near Bombay. Significant quantities of *Artemia* cysts could be harvested periodically from these two areas. On a request, one kg of *Artemia* Bombay cyst (ABC) harvested and processed by this institute, was supplied to the Tamilnadu Fisheries Development Corporation, Madras on 20.4.1987. The Institute has developed a continuous mass culture method for the brine shrimp in 300 l cement pools, (Dwivedi, *et al.*, 1980). An ingeneous method has been developed for the automatic seperation of nauplii from the adult stock in order to ensure regular supplies of nauplii to prawn hatcheries (Ansari, 1987). Besides, a floating device has been developed for the automatic collection of zooplankton from intensive zooplankton production ponds. This device is recommended for adoption in aquaculture systems in India (Dwivedi, 1984).

Fishery estates

The concept of brackishwater fishery estates, as conceived by the CIFE, is one that aims at the construction of large brackishwater farm complexes to promote area development, gainful employment among the weaker sections and integrated farming (with prawn, fishes, cattle, poultry, pig, coconut, vegetable and fruit as its ingredients) in mangrove ecosystems which, without reclamation at enormous cost, are of little use for agriculture. The CIFE blueprint for a model farm involves a total coast of Rs. 11.2 million including Rs. 5 million for hundred farm ponds of one ha each, Rs. 3 million for a shrimp hatchery and seed bank, Rs. 0.5 million for technology training centre for the farmers and Rs. 2.7 million for civil amenities such as rural huts, hospital and school. After construction the farm ponds may be leased to farmer families on nominal rents. At the rate of one pond for every fish farmer family of four, one hundred families will be gainfully employed in each estate (Dwivedi and Ravindranathan, 1982).

The government of Maharashtra spends annually about ten million rupees for the reclamation of mangroves known locally as kharlands, to make them suitable for agriculture. Since reclamation is costly and the agricultural yield from reclamied lands poor, this amount could be spent in the construction of fishery estates at the rate of one per year. In Maharashtra the total kharland area is about 12,000 ha, which has a potential to develop into about 120 estates and employ 12,000 farmer families. However, in the interest of expediency, it will be necessary to equitably allocate the kharlands between fishery estates and entrepreneurs interested in shrimp culture.

Each one hactare pond has the potential of generating a minimum income of Rs. 28,750 per crop from aquaculture alone through the harvest of about 250 kg prawn (at Rs. 75/kg) and 2,000 kg fish (at Rs. 5/kg), using minimum input technologies. Since at least two crops could be raised per year, the annual income would be about Rs. 60,000 which is a fabulous Rs. 5000 per month per family. During their extra times, the members of the family can undertake alternative jobs such as in capture fisheries, processing, marketing, net making etc, besides collection of fish and prawn seed from the wild for their own use or for sale to the seed banks. Income from the other components of the integrated system would also be substantial while the wastes and refuses could be recycled back into the system as feed or fertilizers for the different components.

Aquaculture in hinterland saline soil areas

The Institute has been able to culture successfully on an experimental scale *Penaeus mondon, Mugil cephalus* and *Etroplus suratensis* in the saline subsoil waters at Sultanpur in Haryana. This success opens up considerable scope for the commercial culture of these species in the vast barren saline soil areas in Haryana, Punjab, Rajesthan and Uttar Pradesh. Experiments for one year have shown that in 0.03 to 0.05 ha ponds *P. monodon* (N=196) registered 16% survival, growing from 20 mm (0.5 g) to 240 mm (125 g), *M. cephalus* (N=90) recorded 50% survival, growing from 25 mm (1 g) to 522 mm (950 g) While *E. suratensis* (N=85) registered 90% survival, growing from 65 mm (35 g) to 150 mm (80 g). The salinity in the ponds was found to be 6.5 to 16 ppt, pH 7.02 to 8.75 and dissloved oxygen 5.8 to 10.16 ppm; however, the thermal regime (15 to 36^{0}C) limites the period of culture to the months of April to October (Dwivedi and Lingaraju, 1986). *E. suratensis* has bred in these ponds in mid July 1984, five months after stocking as fingerlings (Anon, 1984).

Windmill in shrimp farms

One windmill installed at the institute's brackishwater fish farm worked for 4,714 hours in 360 days lifting 17.701 m^3 water into cement cisterns stocked with tiger prawn seed. With continuous supply of water lifted by the windmill, the survival of tiger prawn was found to be 50-60% which was better than that in the other cisterns (Madhusudhana Rao, *et al.*, 1986).

DIVERSIFICATION IN FISHING AND PRODUCTS

Product diversification

The Institute has developed simple techniques for making laminated Bombay ducks, fish wafers and minced fish meat. At the instance of this Institute, a Bombay firm has developed a machinery for fish wafer at a cost of Rs. 150,000, with an installed capacity for 200 kg/day, requiring a daily labour of ten workers. The wafer making process consists of dressing, immersion in 20% brine for thirty minutes, autoclave cooking for twenty minutes, mixing with tapioca starch at 1 : 1 and adding sugar at 0.2%. The cost of production in 1977 was Rs. 6/kg of wafer and there was no consumer resistance upto a sale price of Rs. 12/kg. MS Spaceage Marine Food Products, Bombay conducted initial production trials, which however could not succeed as the necessary market linkages were not readily available then (Dwivedi, 1977).

Preliminary studies in 1977 showed that a small machinery for making minced fish meat (keema) would cost about Rs. 20,000 and the project would breakeven at a price of Rs. 6/kg of frozen fish keema. The demand for fish kemma depends on how popular fish bergres and cutlets become in sophisticated eating places (Dwivedi, 1977; Ramananada Rao, 1979).

In respect of canning, it was found that the nutritive value of canned *Otolithus argenteus*, as evaluated by the total nitrogen content and available lysine, did not alter much either during heat processing or during storage over a period of nine months at 28 $\pm$ 5^0 C (Ramananda Rao and Gadre, 1986).

Product quality

Prawns Landed in Bombay during the monsoon season are found to have black spots or melanosis which degrades the product and reduces its value significantly. Melanosis is caused by the action of the enzyme called polyphenalase ozidase, which can be prevented by the following treatment.

(1) removal of head as soon as prawns are landed;

(2) avoiding air pockets while icing or packing in ice-seawater mixture;

(3) immersing in 70^0 C water;

(4) or alternatively, treating with sodium metabishulphite and sodium bicarbonate solution to protect from atmospheric air and oxygen. The institute has worked on polyphenalase oxidase enzyes in India for the first time and studies their action on various species of shrimps and prawns (Madhusudhna Rao, *et al.*, 1986).

Fishing diversification

Fishing trails with a 20.7 m highopening two seam shrimp trawl and a 21 m traditional shrimp trawl off Bombay at 15 to 30 m depths have shown that the catch per hour was 28.18 kg for the former and 15.42 kg for the latter. The study thus indicates that the highopening trawl is 1.82 times more efficient than the traditional one. The catch in both the trawls is mainly of sciaenids, *Coilia dussumeri*, catfishes and skates (Anon., 1984). It is propossed to popularise highopening trawls, initially along the Bombay coast.

SOCIO-ECONOMICS

Boat profitability

Economic studies conducted in 1983 at the Sasson Dock, Bombay, indicated high profits accruing to boat owners on account of high prices of fish prevailing in Bombay. 40'trawlers with 66 Hp engines realised each in 230 days of fishing 18.28% return on the capital employed, gross profit of Rs. 593,496, net profit of Rs. 508,736, earnings of 1.86 per unit of investment, net profit ratio of 0.51 and gross profit ratio of 0.60 (Rao, 1984).

At Murud village in Maharashtra, 30' gillnetters with 16 to 20 Hp engines earned a net income of Rs. 33,800 each in 1983. Deducting the expense of Rs. 20,000 per family of four, there was a surplus of Rs. 13,800 to be used for loan payments in ten annual instalments (Rao, 1984).

Shrimp trawling operations conducted in 1980 off Tiruchendur in the Gulf of Mannar by mechanised vessels indicated supernormal profits. Comparative study of three 32' trawlers including one wooden, one wooden sheathed and one fully FRP, each with 66 HP Ashok Leyland engines, showed returns on capital employed (for 280 days) to be 36.35%, 44.60% and 99.36% respectively, while the cost-benefit ratio was 1.26, 1.33 and 1.60 respectively. The FRP boats were more economical to operate because of their lightness, higher speed, low fuel consumption and longer time spent in fishing (Rao and Anrose, 1983).

Economic analysis of two Mexican trawlers (23.16 m each) operating from Visahkapatnam indicated a net profit of Rs. 644,000 by both the boats in 1979-80 from a total earning of Rs. 3,144,000 realised from about 50 tons of prawns and 1200 tons of quality fish against an expenditure of Rs. 2,500,000. The rate of return on the net worth of Rs. 3,500,000 was about 0.92 (Rao, 1982).

Rapid growth in the fleet of small mechanised shrimp trawlers in Kerala from 769 trawlers per day in 1973 to 3,500 trawlers per day in 1980 resulted in considerable erosion in the annual net profit per trawler from a maximum of Rs. 537,500 in 1976 to a minimum of Rs. 5,805 in 1982. There is need to optimise the fleet at 1,460 trawlers per day at which the net profit per day for the trawler sector in Kerala will be Rs. 2.127×10^6 (or Rs. 457.305×10^6 per year of 215 fishing days). At this economically optimum level of fishing effort, the annual yield from trawl fishery would be 91,323 t comprising 44,931 t of shrimps and 46,392 t of finfish. The optimum number of trawlers may be chosen each year by about March or April by lot. The surplus vessels may be deployed in alternative fisheries such as for the whitebaits, rock perches, red snappers, breams, cephalapods, sharks and larger pelagics (Devaraj and Smita, 1988).

Observations on 377 marine fishermen households from different parts of the country indicated that the average annual net profit for a mechanised fishing boat (trawlers, gillnetters and purse seiners combined) was Rs. 31,070. The rate of return was about 20%. Expenditure included wages (31%), fuel (23%), repairs to craft and gear (13%), mobile oil, food and sales commission (13%) and depreciation (20%) (Rao, 1985).

Fibreglass mould boats (18' long) which work like catamarans were being built by MS Irwin Boat Yard at Visakhapatnam, at a cost of Rs. 13,000 each in 1980 price. On the basis of estimated sale income of Rs. 20,000 from 10 tons of fish and expenditure of Rs. 11,600 per year, the return on the capital employed was estimated to be 60% and the cost-benefit ratio 0.72 (Rao, 1982).

Versova: a sucessful fishing village

The Versova fishing village near Bombay has 3821 active fishermen among a total population of 7,120 fishermen (1985 census). Most of the fishermen are active workers in the fishing industry while about 600 fishermen are engaged in fish retailing in the Bombay city markets. Most of the boat crew are from Ratnagiri district, as the employment opprotunities and wages are much higher in Versova. There are about 265 mechanised boats, 39 sailing boats and 334 nonmechanised carrier boats, called dhonies. In 1982-83, 44,259 t of fish (accounting for 5.68% of the annual catch in Maharashtra) valued at 19.88 crores of rupees (16.56% of the value of the catch in Maharashtra) were landed.

The sucess of this fishing village is attributed to four major factors which include well organised local boat construction and supply system, a well managed fishermen co-operative society, abundant supply of labour from Ratnagiri district in southern Maharashtra and the proximity to the Bombay city markets. Evidently this village could serve as a good example for other Indian fishing villages.

The Versova fisheries co-operatives society, one of the very few successful societies in the country, had in 1983-84 a membership of 1,179, a turnover of Rs. 3.47 lakhs. As on the 30th June 1984, its share capital was Rs. 3.09 lakhs and its total fund Rs. 30.23 lakhs. The Society's assets include an ice plant and cold storage, diesel oil pump, transport trucks etc. Timely recovery of loans is ensured by linking credit with production and marketing. There is no interest on loans in the first year, but the commission on fish sold through the society is charged at 9% against the normal 7%. A part of the loan is deducted at source at about 10% of the sales on any given day and credited to the loan account. One of the factors responsible for the success of this society is the efficient marketing linkage it has developed to co-ordinate and guide production, assembly, processing, storage and distribution of fish, thus making marketing an integral part of the social system. Being nearer to the city markets, marketing costs are lower and net returns higher. As a result the fishermen enjoy much higher standards of living. Wages to crew are quite attractive, they range from Rs. 35 to more than 50 per day per head and are paid daily, monthly or annually. Share system is also in vogue. Although wages do not increase as much as the increase in fish prices, boat crew are given ample incentives in the form of free food, clothes, other daily allowances and paid leave for 15 days a year (Subbarao and Mathur, 1984: Anon, 1985: Kohli and Subba Rao, 1986).

NATIONAL AWARENESS AND TECHNOLOGY TRANSFER

National awareness

With view to creating national awareness on the need for the proper utilisation of the marine living resources and the need to have a comprehensive development programme for coastal zones, the institute organised a number of international and national symposia. They include: (1) Multiuse of Coastal Zone held from the 20th to the 22nd November 1975 (proceedings published in *Indian Fish. Ass.* 5 (1&2) 1975 issued in April 1975): (2) Lab to Land Programme and Workshop on Ocean Management held on the 5th and 6th April 1977 (proceedings published in *Indial Today & Tommorrow* 8 (3) 1979): and (3) Management of Marine Living Resources in the Exclusive Economic Zone on the 16th December 1981 (proceedings published in *India Today & Tommorrow)* 9 (2), 1982).

Technology transfer

The Institute has been conducting short term training courses periodically on various aspects on marine fisheries for the purpose of technology transfer among the users. In all, 14 courses, each lasting from 7 to 30 days, were conducted on the Management of Brackishwater Fish farms at Kakinada and over 250 farmers and technicians trained. Twenty entrepreneurs underwent a 15 day course on the Management of Prawn Hatchery at Bombay; 86 rural youth were trained through two TRYSEM (training rural youth for self employment) Programme in Brackishwater Fish and Prawn Culture at Kakinada. Under the same programme for two months, 21 rural youth were trained in Prawn Seed Collection and Seed Banks at Kakinada. 54 fish processors were given training on the utilisation of Low Prices Fish over two courses, each lasting 5 to 8 days at Bombay. 18 candidates underwent the courses on the Management programme for Executive of Fisheries Co-operatives, Institutional Finance for Fisheries Development and Fisheries Economics, lasting 1 to 15 days at Bombay. 21 bank officials underwent a 7 day course on Fisheries Development through Institutional Finance at Bombay. 17 higher secondary teachers participated in the 28 day NCERT Training Programme in Fisheries for Vocational Teachers.

REFERENCES

ANON., 1984 a. Live feed: automatic collection device. *Education, Research & Extension News Letters*, Cent. Inst. Fish. Edn., Bombay 2 (3) May/June 1984 : 2

ANON., 1984 b. *Etroplus:* an estuarine fish breeds in inland saline waters of Haryana. *Education, Research & Extension News Letter*, Cent. Inst. Fish. Edn., Bombay 2 (3) May/June 1984 : 2

ANON., 1984 c. Highopening trawl for fishing shrimp and small demersal fish *Education, Research & Extension News Letter*, Cent. Inst. Fish. Edn., Bombay 2 (3) May/June 1984 : 1-2

ANON., 1985. Economic status of wage earners in fishin operations at Versova village, Maharashtra. *Education, Research & Extension News Letter*, Cent. Inst. Fish. Edn., Bombay 3 (1) : 1

ANSARI, S. K. R. 1987. The brine shrimp, *Artemia* - ecology, cyst hatching, development and mass culture. Ph. D. Thesis, University of Bombay, pp. 367.

BAPAT S. V., V. M. DESHMUKH, B. KRISHNAMOORTI, C. MUTHIAH, P. V. KAGWADE, C. P. RAMAMIRATHAM, K. J. MATHEW, S. KRISHNA PILLAI AND C. MUKUNDAN 1982. Fishery resources of the exclusive economic zone of the northwest coast of India. *CMFRI Bulletin* No. 33 : 1-86

BIRADAR, R. S. 1985. Population dynamic of Indian oil sardine and Indian mackerel of the southwest coast of India. Dessertation submitted to the University of Bergen, Norway for the post graduate diploma in fisheries biology.

BIRADAR, R. S. 1987. Stock assessment of the demersal offshore resources off the Karnataka coast. Fishery Technology (in press).

BIRADAR, R. S. AND J. GJOSAETER, (MS). Population dynamics of Indian oil sardine, *Sardinella longiceps*, off the southwest coast of India (Communicated Fisheries Research).

DEVERAJ, M. AND K. GULATI, (MS). Assessment of the thredfin bream *(Nemipterus japonicus)* stock along the northwest coast of India.

DEVARAJ, M. AND V. RAVICHANDRAN, 1987. Dynamics of Indian Chank fisheries. In: *Proceedings of the national seminar on shellfish resources and farming, Tuticorin*, India 19-21 January, 1987, CMFRI, Cochin, In press (Abstract : P. 14).

DAVARAJ, M AND P.SMITA. 1988. Economic performances of mechanised trawlers in the State of Kerala, India. Fisheries Research.

DEVERAJ, M. AND P. SMITA, (MS). Optimisation of the penaeid prawn fishery along the west coast of India.

DWIVEDI, S. N. 1977. Convenience food products from fish. *Foods and Drinks Journal* 1 (9) : 3-4.

DWIVEDI, S. N. 1984. Live feed : Automatic collection device. *Cent. Inst. Fish. Edn. Extension Leaflet* No. CIFE-18 (12 : 84).

DWIVEDI, S. N., S. K. R. ANSARI AND M. Q. AHMED, 1980. Mass Culture of brine shrimp under controlled conditions in cement pools at Bombay, India. In: *The Brine Shrimp Artemia*, 1980. Vol.3 *Ecology, Culturing & Use in Aquaculture, University Press, Wetteren, Belgium.* : 175-183.

DWIVEDI, S. N. AND G. M. LINGARAJU, 1986. Strategy of prawn and fish culture in saline subsoil waters semiarid zone in Haryana. *Mahasagar, Bull. Nat. Inst. Oceanogr.* 19 (2) : 97-102.

DWIVEDI, S. N. AND V. RAVIDRANATHAN, 1982. Fishery estate - reclamation the of Kharlands, bays and backwaters to rehabilitate the landless through brackishwater culture. *India Today & Tommorrow* 9 (2) : 73-74.

DWIVEDI, S. N., D. V. REDDI AND M. IFTEKHAR MOHIUDDIN, 1983. Prawn seedign production - State of Art. In : *Proc. Nat. Symp. Shrimp Seed production and hatehery management*, MPEDA, Cochin: 139 - 149.

GEORGE, P. C., B. T. ANTONY RAJA AND K. C. GEORGE, 1977. Fishery resources of the resources of the Indian economic zone. In: *Souvenir Issued On the occassion of the Silver Jubilee celebrations of Integrated Fisheries Project, Cochin*, October, 1977 : 79-116.

GOPALAKRISHNA, G. 1983 A. Tiger prawn culture: low input technology yields 500 kg per hectare in a year. *Cent. Inst. Fish. Edn., CIFE* - Aq. T. T. - 6(12) 83 : 1-6 (extension leaflet).

GOPALAKRISHNA, G.1983 b. Milkfish culture: low input culture yields two tonnes of *Chanos* per hectare in a year at Kakinada, Andhra Pradesh, *Cent. Inst. Fish. Edn.*, CIFE-Aq-5 (10-83): 1-5 (extension leaflet).

GULATI, D K. 1987. Morphometry, biology and stock assessment of *Otolithus cuvieri* (Trwavas, 1974) off the Bombay coast, M. Sc. Thesis, University of Bombay, pp. 185.

HAMEED ALI, K. 1980. A new system for mass rearing of penaeid shrimp larvae. In: Proc. Ist Nat. Symp. Prawn Farming, Bombay 16-18 August, 1978, MPEDA, Cochin : 255-262.

HAMEED ALI, K. AND S. M. DWIVEDI, 1977. Acceleration of prawn growth by cauterisation of eye stalks and using *Acetes indicus* as supplementary feed. *J. Indian Fish. Ass.*, 3-4 (1-2): 136-138.

HAMEED ALI, K. AND S. N. DWIVEDI, 1981. Mass rearing of penaeid larvae in stored and treated water, with crustacean suspension as feed. *Bull. Cent. Inst. Fish. Edn. Bombay*, December 1981.

HAMEED ALI, K., S. N. DWIVEDI AND K. H. ALIKUNHI, 1982. A new hatchery for commercial rearing of penaeid prawn larvae. *Bull. Cent. Inst. Fish. Edn., Bombay*, 2-3 (82) : 1-9.

HAMEED BATCHA, 1986. Identification of unit stock and population dynamics of *Harpodon nehereus* (Ham.) off Bombay coast. A dissertation submitted in partial fulfilment of M. Sc. (Fisheries Management), University of Bombay, pp. 77.

IRENE FERNANDEZ, 1986, Stock assessment, dynamics and biology of the *Coilia dussumieri* (Cuvier and Valenciennes) resource in the Indian exclusive economic zone along the northwest coast of India. M. Sc. Thesis, University of Bombay, pp. 195.

IRENE FERNANDEZ AND M. DEVARAJ. (MS). Stock assessment and dynamics of the *Coilia dussumieri* resource in the Indian exclusive economic zone along the northwest coast of India (communicated to Asian Fisheries Science).

IVAN, R. T. 1987. Population biology of *Polynemus heptadactylus* (Curvier and Valenciennes) along the northwest coast of India. A dissertaion submitted in partial fulfilment of M. Sc. (Fisheries Management), University of Bombay pp. 109.

KALAWAR, A. G., M. DEVERAJ AND A. H. PARULEKAR, 1985. Report on the expert committee on marine fisheries in Kerala, submitted to the Government of Kerala, pp. 467.

KAMAT, S. S. (MS). Stock assessment, dynamics and biology of *Johnius glaucus* (Day) resource in the waters off the northwest coast of India. Synopsis of M. Sc. thesis sumbitted to the University of Bombay.

KOHLI, H. K. AND P. V. SUBBA RAO, 1986, Indigenous construction of fishing boats at Versova, village in Maharashtra State *Indian fish. Ass.* 14 & 15 (1984-85) : 59-63.

LODHI, R. B. 1987. Assessment of the exploited inshore fisheries along the Maharashtra coast. Dissertation submitted in partial fulfilment of D. F. Sc., *Cent. Inst. Fish. Edn., Bombay.*

MADHUSUDHANA RAO, K., R. S. BIRADAR AND P. ACHARYA, 1986. A decade of achievements. *Cent. Inst. Fish. Edn., Bombay.* CIFE-FAO/DANIDA (86 : 2), pp. 24.

NAIK, V. V. 1987. Morphometic studies and stock dynamics of *Arius thalassinus* (Ruppell) off Bombay coast. A dissertation submitted in partial fulfillment submitted in partial fulfilment of M. Sc. (Fisheries Management), University of Bombay, pp. 68.

PRAVEEN RATTAN AND S. N. DWIVEDI, 1982, Mass culture of live food: *Fabrea salina* and *Euplotes sp. India Today & Tommorrow* 9 (2): 79

PRABHU, S. A. 1987. Assessment of the exploited inshore fiseries along the Gujarat coast. Dissertation submitted in Partial fulfillment of D. F. Sc. *Cent. Inst, Fish, Edn,. Bombay.*

RAMANANDA RAO, D. 1979. Utilisation of cheap fish. In: *Proceedings of short term training course in utilisation of low priced fish,* December 10-15, 1979, *Cent. Inst. Fish. Edn., Bombay* : 97-100.

RAMANANDA RAO D. AND U. V. GADRE, 1986. Available lysine in canned fish. *J. Indian Fish. Ass.* 14 & 15 (1984-85) : 37-39.

RAO, P. S. 1982. Need for more investment in fisheries. Tranga, The Alumini Association of the College of Fisheries, Mangalore, Annual November 1981-82 : 41-48.

RAO, P. S. 1984. Economic viability of fishing trawlers in inshore regions. In: *Fisheries Development through Institutional Finance, Training Course by Central Bank for Rural Development in India and Central Institute of Fisheries Education*. CBRDI - CIFE/10 : pp. 9 (mimeo).

RAO, P. S. 1985. Survey report on fisheries in India. In: *Symposium on fishing Industry, Tokyo*, 12-18 November 1985, Syp/VII PS, pp. 11 (mimeo).

RAO, P. S. AND A. ANROSE, 1983. Mechanised fishing costs and earning from boats. *The Economic Times, Bombay*, Wednesday, May 18, 1983 : 9.

REDDI, D., V. G. GOPALAKRISHNA, B. N. TIWARI AND P. RAMI REDDI, 1984. Acclimatization of juveniles of marine prawn *Penaeus monodon* to freshwater. *J. Indian Fish. Ass.* 10 & 11 (1980-81) : 21-23.

SOMALINGAM, J. AND M. N. MURTHY, 1984. preliminary observations on the nursery management of postlarvae of *Penaeus monodon. J. Indian Fish. Ass,* 7 & 9 (1978-79) : 6-9.

SUBBARAO, P. V. AND S. K. MATHUR, 1984. Parameters for success of Versova multipurpose co-operative in Maharashtra. *J. Indian Fish. Ass.* 10 & 11 (1980-81) : 55-60.

TIWARI, B. N. AND S. S. H. RAZIVI, (MS). Growth and survival of tiger prawn *Penaeus monodon Fabricius in freshwater.*

TIWARI, B. N., A. K. SHARMA AND S. S. H. RAZIVI, (MS). Production of major carps, milkfish and tiger prawn in a seasonal tank at Jagannaickpur, Kakinada.