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A BIOECONOMIC EVALUATION OF THE DUAL-FLEET TRAWL FISHERY OF MANGALORE AND MALPE

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Background

About 40% of the average annual marine fish landings of Karnataka state occur at the Mangalore and Malpe fish landing centres, of which 56% is by trawlers. The development of the trawl fishery along this coast has been gradual since 1959, fuelled by the high demand for exportable penaeid prawns. The status of the fishery, with particular reference to resources, has earlier been studied by Kuthalingam *et al.* (1971) and Ramamurthy (1972).

During the late seventies and the early eighties, a conspicuous change in the trawl fishing pattern took place. Some trawl units 'especially larger boats' were fishing exclusively in the night using shrimp trawl (Sukumaran, 1985). These boats, popularly known as night boats subsequently extended their operations to the day (using fish trawl) and then another day and night and so on. By the mid-eighties, most of the bigger (>36 feet) boats switched over to this type of stay-over fishing bringing increased catches of highly priced large prawns (mainly *Metapenaeus monoceros* and some *Penaeus indicus* and *P. monodon*), squids and quality finfishes.

This method of fishing resulted in substantial increase in returns mainly due to savings in fuel cost. Moreover, these 'night boats' were continuously expanding the trawling grounds, going farther northwards/southwards and venturing into deeper areas. An in-depth study of the 'night boat' fishery made by Rao *et al.* (1993) suggested the total standing stock and potential yield from the 1980's trawling grounds. Since then, the multi-day trawl fishery (as it is now known) has expanded considerably and now it exists as a separate fishery from the old day boat (daily trips) fleet. In recent years, the success of the multi-day trawl fishery resulted in a spurt in the number of such vessels operating from Mangalore and Malpe with increased overall length and horse power. Besides, more than 35 purse seiners have also been converted into multi-day trawl boats. On the other hand, the day boat fleet has not witnessed more additions during the last 5-6 years and has been showing signs of recovery from over capitalization.

Keeping in view the duality and the rapid technological changes in the trawl fishery operations at Mangalore and Malpe, a comprehensive study has been made on the two fisheries with particular emphasis on their comparative economic efficiency.

Data base and methods

The period covered for the study was seven fishing seasons (from 1988-'89 to 1994-'95). Each fishing season commences by September and lasts till May (nine months). June to August (three months) is usually the closed season due to monsoon and associated rough weather conditions. In some years, fishing has commenced in August itself.

Data on catch (kg) and effort (hours) were collected based on weekly observations of trawl landings at Mangalore and Malpe landing centres. Because of stay-over fishing operations, effort was calculated based on the period of absence of each trawl unit from the port. Based on previous information (Rao *et al.*, 1995) all multi-day boats are found to have fished for 6.6 hours for every 12 hrs absence from port. In this manner, a single night boat would have spent 13.2 hrs in actual fishing and a 2-night boat 19.8 hrs and so on. Similarly, all single day trawl boats, by enquiry, are found to have fished for five hrs during every daily fishing trip. This basic data was used to compute annual and seasonal catch and catch rate (kg/hr) estimates for each species/group using the Lotus *1-2-3* software.

The annual value of the fishery was calculated for 1994-'95 season by collecting the average auction price of all commercial species from the landing centres. Data on costs (initial, fixed and operational) and earnings of both trawl fleets were collected through special surveys of boat owners and workers at Mangalore during 1994-'95, and therefore the economic data pertains only to this season. The annual catch/unit was obtained by

dividing the annual catch for 1994-'95 of the respective fleets by the number of boats in operation during the year. Details of trawl vessels (OAL, HP etc.) were collected from the boat registration section of the Port Office at Mangalore and Malpe.

RESULTS

The total catch by the dual fleet trawl fishery at Mangalore and Malpe centres together showed a general increasing trend during the study period (Table 1). The catch after registering a fall from 31,850 tonne (t) in 1988/'89 to 21,394 t in 1989/'90, gradually increased to 45,580 t in 1994/'95.

TABLE 1. *Year-wise catch, effort and catch rates of single day and multi-day trawl fleets from Mangalore and Malpe bases (pooled)*

Year	Catch (tonnes)			Effort ($*10^5$hr)			Catch rate (kg/hr)		
	SDF	MDF	Total	SDF	MDF	Total	SDF	MDF	Total
1988/'89	8,868	22,981	31,850	1.78	6.37	8.16	49.84	36.04	39.05
1989/'90	7,634	13,759	21,394	1.73	4.32	6.04	44.22	31.87	35.39
1990/'91	7,753	18,934	26,687	1.71	5.75	7.46	45.40	32.94	35.79
1991/'92	10,429	18,629	29,056	2.27	6.61	8.89	45.92	28.16	32.70
1992/'93	16,449	17,209	33,658	2.63	7.41	10.04	62.61	23.22	33.53
1993/'94	9,049	26,396	35,445	2.16	9.47	11.64	41.85	27.86	30.46
1994/'95	11,497	34,073	45,580	1.94	12.68	14.62	59.13	26.87	31.17

Nevertheless, the catch rate fell from 39.05 kg/hr during 1988/'89 to 31.67 kg/hr in 1994-'95. Out of the average total catch of 31,953 t for the study period, single day fleet (SDF) contributed 32% and multi-day fleet (MDF) 68%.

The annual landing by SDF showed fluctuations without any clear-cut pattern (Table 1). The catch after falling from 8,868 t in 1988/'89 to 7,634 t in 1989-'90, increased to 16,449 t in 1992/'93 and then fell to 9,049 t in 1993/'94 and finally stood at 11,497 t in 1994/'95. Regarding catch rate a similar trend was seen with the maximum during 1992/'93.

The landing by MDF fell from 22,981 t in 1988-'89 to 13,759 t during 1989/'90 and gradually incresed to the present catch of 34,073 t. However, the catch rate was the best during 1988/'89 (36.06 kg/hr), decreased to all time low during 1992/'93 (23.22 kg/hr) but, improved during the subsequent years.

It is found that these two trawl fleets have basic differences in the craft and gear employed, the grounds exploited, depth and duration of operation, species composition of the catch and cost and earnings.

Fleet strength and fishing grounds

The number of multi-day and single day trawlers operating from Mangalore and Malpe bases is given in Table 2. More number of multi-day units (398) are registered at Mangalore, while more number of single day units (440) are in operation from Malpe base. Totally there are 623 multi-day units and 752 single-day units operating from Mangalore and Malpe bases.

TABLE 2. *Trawl fleet strength at Mangalore and Malpe bases as on November, 1995*

Base	Multi-day fleet	Single day fleet	Total
Mangalore	398	312	710
Malpe	225	440	665
Total	623	752	1,375

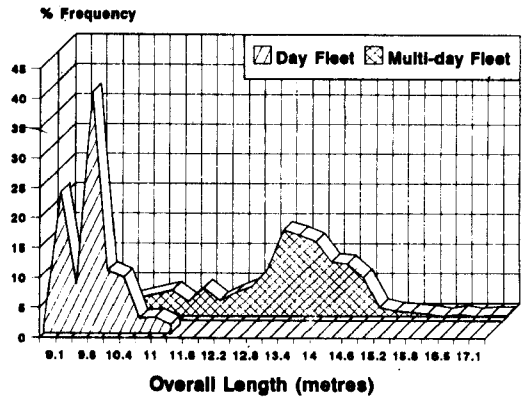

Fig. 1. The overall length (OAL) range of single day and multi-day fleets at Mangalore and Malpe.

The overall length (OAL) range (Fig. 1) of SDF was 9-11.5 m (30-38 feet). Most of the boats (60%) were 30 and 32 footers. However, the MDF boats had a wider OAL range (11-17.1 m; 36-56 feet). Majority of the boats were 44 and 48 footers. Latest additions to the fleet are a few steel trawlers of 16m OAL which can stay out at sea upto 8-10 days and equipped with modern navigational and fish finding instruments like GPS (global positioning system) and video fish sounders.

The SDF operations are confined within 10-15 km from the shore at depths ranging from very shallow to a maximum of 25 m (Fig. 2). They operate only for about 125-200 days/year, functioning as carrier boats for purse seine fleet during peak purse

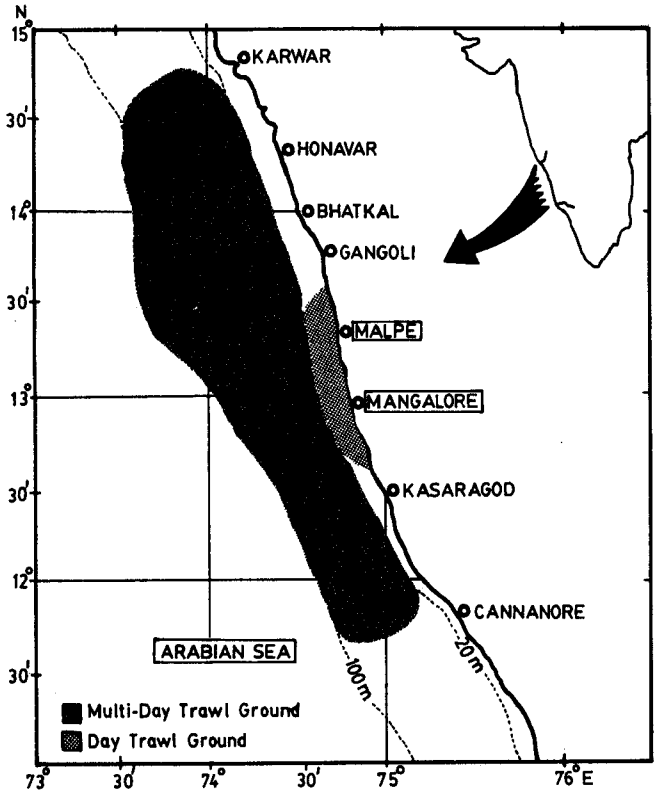

Fig.2. Map showing the extent of trawling grounds exploited by SDF and MDF from Mangalore and Malpe bases.

seine fishing months (September and October). Since they make daily trips, there is only slight overlapping of the grounds by Mangalore and Malpe based single day trawlers. The trawling grounds of MDF are shared by boats from both Mangalore and Malpe bases and encompass a very wide area covering a little more than the entire Karnataka coastline (Fig. 2). These boats operate almost throughout the season with less operation during September-October. In a fishing season each unit on an average will operate for 220 to 270 days. The northern limit of operation is Karwar and southern limit Cannanore. However, the extreme limits of the grounds are not as intensively exploited as next to the bases and besides, these grounds are also shared by similar trawlers operating from other bases in Karnataka (Fig. 2). The depth of operation is mainly confined to 25-60 m but in certain months like September and October the operation is extended upto 100 m for cuttlefishes.

Fleet operations

Single day fleet

Day trawlers are fitted mostly with Ruston engine of 35-75 HP and do not have any provision for fish holds (Table 3). They usually go for fishing with four men crew. These boats operate mainly

TABLE 3. *Specifications of the crafts deployed for trawling at Mangalore-Malpe*

Description	Single day boats	Multi-day boats
Overall length (OAL)	9 - 11.5	11 - 17.1
Breadth	3 - 4	3.5 - 5.0
Gross tonnage	9 - 20	15 - 40
Draught	1.4 - 1.7	1.6 - 2.0
Type of construction	Carvel planking with FRP sheath upto deck level	Same as day boat
Material used	Wood - mainly wild jack	Wood - mainly wild jack and few boats wholly steel
Engine make	Mostly Ruston	Mostly Ashok Leyland
Horse power	35 - 75	80 - 160
Fish-hold capacity	Nil	3 - 10 tonnes
Number of crew	4	5 - 6
Endurance	Single day	Upto 7 days
Navigational and other equipments	Magnetic compass	Few boats with GPS & video fish finders
Life of the boat	Upto 20 years	Upto 20 years

All length measurements in metres.

TABLE 4. *Specifications of the gears used by the trawl fleets at Mangalore-Malpe*

Description	Single day boats	Multi-day boats
Type of net	Shrimp net	Shrimp net Fish net
Length of head rope (m)	27	31 33-37
Length of foot rope (m)	31	35 38-41
Mesh size (mm):		
Body	25-30	30-38 35-40
Cod end	10-.20	15-18 22-24
Net material	Nylon	Nylon
Thickness (mm)	0.5-0.75	1.0-1.25 2.0-2.5
Otter board: shape	Flat-rectangular	Flat-rectangular & few V-shaped
Weight (kg)	100-130	170-190
Warp mateiral	16 mm synthetic rope	10-12 mm wire rope

shrimp nets with cod end mesh size of 10-20 mm. However, in certain months like September and October when faltfish are abundant in inshore waters, 'nangubale', a trawlnet of 10 mm uniform mesh size are also used. The details of the gear used are given in Table 4.

These units leave the shore during the early morning and return in the same day afternoon after fishing for 5-6 hours (Table 5), The number of hauls vary from two to four, each of 2-3 hours duration.

TABLE 5. *Details of trawl fleet operations at Mangalore and Malpe*

Description	Single day fleets	Multi-day fleets
Time of departure	0100 - 0600 hrs	1600 - 1800 hrs
Time of return	1300 - 1700 hrs	2000 - 0900 hrs
Duration of voyage	06 - 12 hr	12 - 156 hr (upto 7 nights)
Number of hauls:		
Day time	2 - 4	3 - 4
Night time	-	2 - 3
Duration of hauls:		
Day time	2 - 3 hrs	2 - 3 hrs
Night time	Nil	4 - 5 hrs
Depth of trawling	Shallow to 25 m	20 to 100 m
Area of operations (see Fig. 2)	Within 10-15 km	Northern limit: Karwar Southern limit: Cannanore

Multi-day fleet

Most of the multi-day trawlers are fitted with Ashok Leyland engine of 80-120 HP (Table 3). They carry a crew of 5-6 men for every voyage. These boats have insulated fish hold of capacity to 3-10 t and can stay out at sea upto seven days. Multi-day units carry two types of trawl nets (Table 4). They operate shrimp net with a cod end mesh size of 15-18 mm exclusively during night and larger fish trawl of cod end mesh size of 22-24 mm during day. The otter boards used are heavier (170-190 kg) than those used in day boats. The warp materials used are 10-12 mm steel wire rope which is a recent introduction in this area. These units leave the base in the evenings and return to shore after 2-6 days of fishing. Each unit makes 3-4 hauls per day and 2-3 hauls per night. The operational details are given in Table 5. They generally come back to the base in the night and remain till next day morning for removing and auctioning the catch and leave again in the same evening/night after loading ice, fresh water and fuel.

Fishery

Single day fleet

Catch and catch rate: The catch showed fluctuations over the years at both centres (Fig. 3). At Mangalore, minimum catch was observed during 1989/'90. The catch, after that showed upward trend except the year 1993/'94 (5,108 t) and again increased to a maximum of 7,547 t in 1994/'95. The effort was high during 1991/'92 and low in 1989-'90. The catch rate (Fig. 4) was the lowest during 1989/'90 (29.05 kg/hr) and showed increasing trend till 1992/'93 (63.26 kg/hr). The

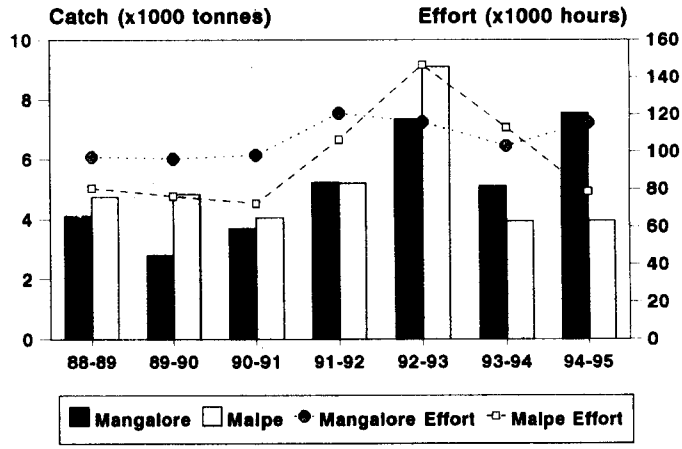

Fig.3. Annual catch and effort by SDF at Mangalore and Malpe bases.

catch rate fell in 1993/'94 (49.49 kg/hr) and increased to the highest during 1994/'95 (65.28 kg/hr). At Malpe, the catch increased from 4,745 t in 1988/'89 to 9,111 t in 1992/'93 and fell to 3,940 t in 1993/'94 and then showed marginal increase in 1994/'95 (3,950 t). The catch rate, however, was maximum in 1989/'90 (58.91 kg/hr), thereafter showed a declining trend till 1991/'92, improved in 1992/'93 to fall again to the all time low in 1993/'94 (34.88 kg/hr) and improved marginally in 1994/-'95.

The single day trawl landing at the two centres pooled together (Table 1) showed highest catch and catch rate during 1992/'93 (16,449 t; 62.62 kg/hr) and lowest catch during 1989/'90 (7,634 t) while the lowest catch rate during 1993/'94 was 41.85 kg/hr. The trend line fitted with catch rate of single day trawlers over the different years for the pooled data (Fig. 4) showed an upward shift during 1992/'93, down ward trend in 1993/'94 and improvement in 1994/'95. Heavy landing of flatfishes (7,372 t; 45% of total landing) accounted for the sudden increase in catch during 1992/'93 and bumper

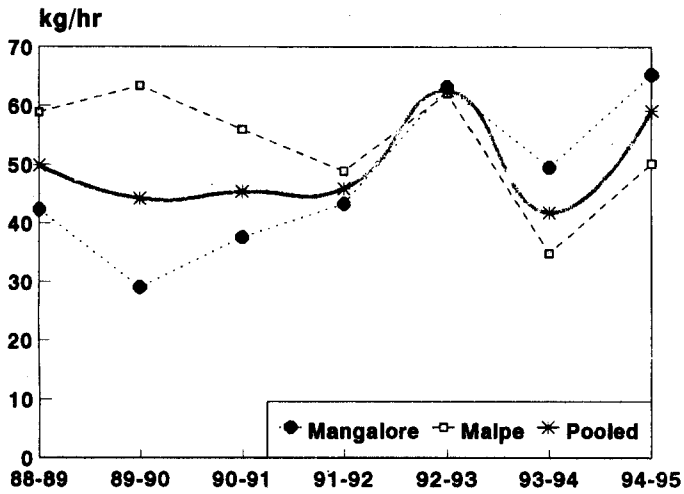

Fig.4. The annual catch rates of SDF trawlers with trend line fitted for the pooled data.

TABLE 6. *List of species occurring in single day fleet catch*

Prawns:	*Metapenaeus dobsoni* (A); *M. affinis* (L); *M. monoceros* (R); *Penaeus indicus* (L); *Parapenaeopsis stylifera* (A); *Acetes indicus* (R).
Lobsters:	*Panulirus spp.* (R).
Crabs:	*Portunus pelagicus* (A); *P. sanguinolentus* (A): *Charybdis cruciata* (L); *Scylla serrata* (R).
Stomatopods:	*Oratosquilla nepa* (A).
Cephalopods:	*Loligo duvauceli* (L); *Sepia aculeata* (R).
Flatfish:	*Cynoglossus macrostomus* (A); *C. bilineatus* (R); *C. arel* (R); *Psettodes erumei* (L); *Solea ovata* (L).
Anchovies:	*Stolephorus devisi* (L); *S. bataviensis* (L); *S. macrops* (L); *S. indicus* (R); *Coilia dussumieri* (R).
Silverbellies:	*Leiognathus bindus* (A); *L. splendens* (L); *L. equulus* (L) *Secutor insidiator* (A).
Scombroids:	*Restrelliger kanagurta* (L); *Scomberomorus commerson* (R); *S. guttatus* (R).
Perches:	*Epinephelus diacanthus* (L); *Terapon spp.* (L); *Pomadasys spp.* (R); *Ambassis spp.* (L) *Apogon spp.* (R).
Clupeids:	*Thryssa malabarica* (A); *T. mystax* (L); *Opisthopterus tardoore* (A); *Dussumieria acuta* (R); *Chirocentrus dorab* (R); *Escualosa thoracata* (R); *Hilsa ilisha* (R). *Kowla koval* (L).
Croakers:	*Johnius spp.* (A); *Johnieops spp.* (A); *Otolithes cuvieri* (A); *O. ruber* (L).
Sharks and rays:	*Scoliodon laticaudus* (L); *S. fasciatum* (L); *S. lewini* (R); *Himantura spp.* (L); *Aetobatus spp.* (R).
Carangids:	*Caranx kalla* (A); *Decapterus russelli* (L); *Scomberoides tala* (L); *Selar mate* (A); *Megalaspis cordyla* (L).
Pomfrets:	*Pampus argenteus* (A); *Parastromateus niger* (A).
Ribbonfishes:	*Trichiurus lepturus* (A).
Other Finfishes:	*Lactarius lactarius* (L); *Nempterus japonicus* (R); *Platycephalus scaber* (R); *Sphyraena jello* (R); *Gerres spp.* (R); *Sillago sihama* (L); *Crenimugil crenilabis* (L); *Mene maculata* (L); *Anguilla* (R); *Fistularia spp.* (L); *Sarotherodon spp.* (R); *Etroplus spp.* (R).

Key: Abundant (A); Less abundant (L); Rare (R).

landing of *Squilla* (4,511 t; 39% of total landing) was the reason for increased landing during 1994/'95. Except these unusual landings, the catch and catch rate by SDF remained at the same level during the study period.

Catch composition: A comprehensive list of the species landed by SDF is given in Table 6. There are about 12 species of crustaceans, two species of cephalopods and 58 species of fishes of which 17 are abundant, 28 less abundant and 27 rarely occur in the landings. The major components in single day trawl landing were finfishes (52%) and crustaceans (47%) whereas cephalopod formed only 1% of the catch (Fig. 5). Among crustaceans, *Squilla* formed 70%, prawns 24% and crabs 6%. Among finfishes, flatfishes formed over 49% followed by

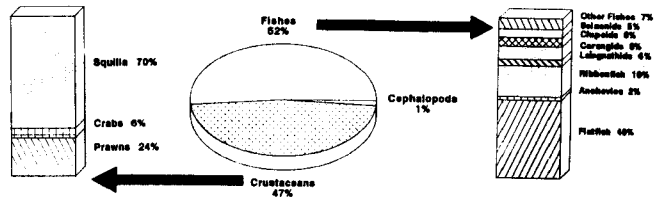

Fig.5. Composition of SDF trawl catch.

ribbonfishes (19%). Other prominent groups were carangids, clupeids, sciaenids and anchovies. Among all the groups the single most dominant species was *Squilla* forming 33%, followed by flatfishes (25.1%), prawns (11.2%) and ribbonfishes (9.9%). All these together constituted 79% of the day trawl catch.

Seasonal abundance: The data for the study period was pooled month-wise (Fig. 6). Peak catch occurred during December-January at Mangalore and November-December at Malpe. Lowest catch was seen during August-September at both the centres. Peak catch rate, however, ws observed during August at Malpe and during October at Mangalore and least during April and May. In the pooled data, good landings were noticed during December-March period, but, better catch rates were realised during September-October and December).

The landings of six important species were analysed to find their seasonal abundance in single day trawl (Fig. 7). Flatfish was abundant during August-September and modest landings were seen during the other months. Ribbonfish was plenty during October-November and afterwards disappeared from the fishery. Prawn landings were the least during August - September, rose to peak

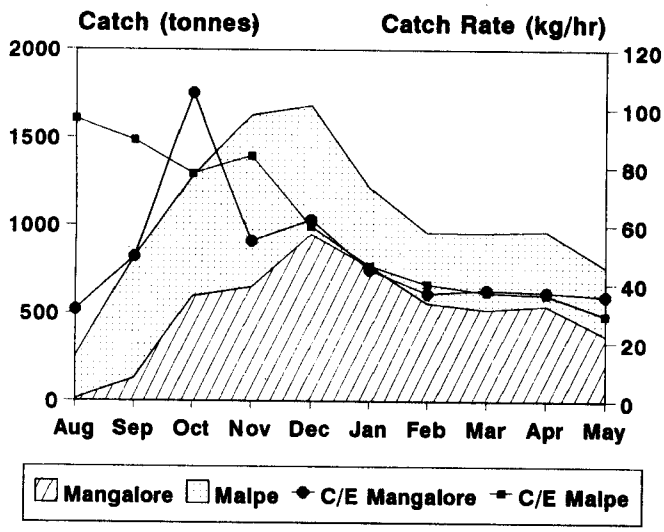

Fig.6. Seasonal variations in catch and catch rate of SDF boats at Mangalore and Malpe.

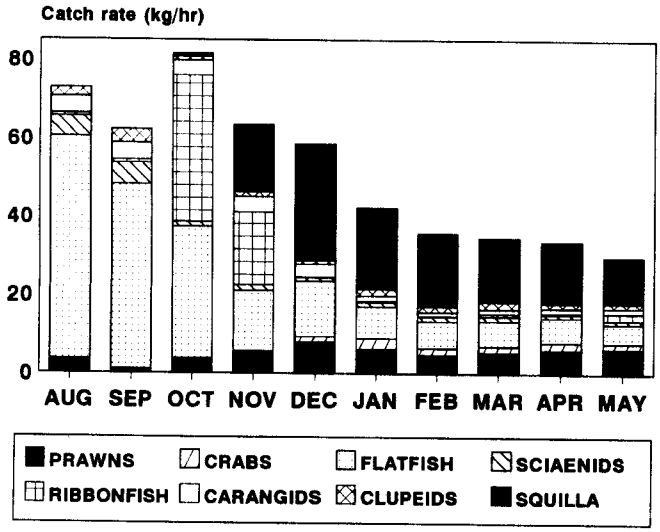

Fig.7. Seasonal abundance of key groups in SDF trawl catch (Mangalore & Malpe pooled).

during December-January. *Squilla* was totally absent in catches during August-September and peak landings were observed during December-January period. Sciaenids were more during August-September and carangids were abundant from August to December months.

Annual trends of key groups: The key groups showed interesting pattern in their abundance over the years (Fig. 8). Clupeids were present in catches throughout the period without much change in their landings. However, carangid catch has diminished over the years, from 851 t in 1988/'89 to 221 t in 1994/'95. The ribbon fish landing was better during 1990/'91 - 1992/'93 seasons; it failed in 1993/'94 but again increased during 1994/'95. Prawn catch remained steady and did not show any increase even with increased effort or increased total trawl catch. The catch was 1,221.8 t during 1988/'89 and remained almost the same (1,280.8 t) in 1994/'95. However, the catch of flatfishes showed a sudden spurt during 1992/'93, but, dwindled during 1993/'94 and 1994/'95. The *Squilla* catch plunged from 4,086 t in 1988/'89 to 2,762 t in 1991/'92 but again increased to 4,510.7 t in 1994/95.

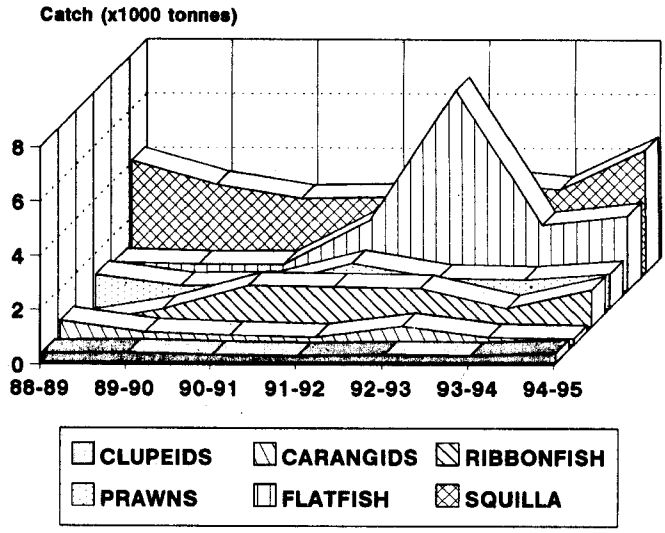

Fig.8. Annual trend in the catch of key groups by SDF boats (Mangalore & Malpe pooled).

Multi-day fleet

Catch and catch rate: The total catch by MDF during the study period showed an increasing trend at Mangalore whereas it showed wide variations at Malpe (Fig. 9). The catch increased from 11,375 t in 1988/'89 to 26,665 t in 1994/'95 at Mangalore except during 1989/'90 when it was low at 6,440 t. At Malpe, the maximum catch of 11,606 t was observed during 1988/'89 and the minimum of 3,691 t during 1992/'93. Maximum effort was seen during 1994/'95 and the lowest during 1991/'92.

The catch rate at Mangalore ranged between 24.94 kg/hr in 1992/'93 and 38.66 kg/hr in 1990/'91 (Fig.10). The catch rate increased from 27.96 kg/hr in 1988/'89 to 38.66 kg/hr in 1990/'91 and then showed a declining trend and stood finally at 28.94 kg/hr in 1994/'95. At Malpe, the catch rate fluctuated between the highest value of 50.29 kg/hr in 1988/'89 and the lowest of 18.55 kg/hr in 1992/'93. In general, the catch rates showed a declining trend except 1993/'94 when it improved remarkably to 30.92 kg/hr. The trend line fitted with the catch rate of multi-day fleet with the pooled

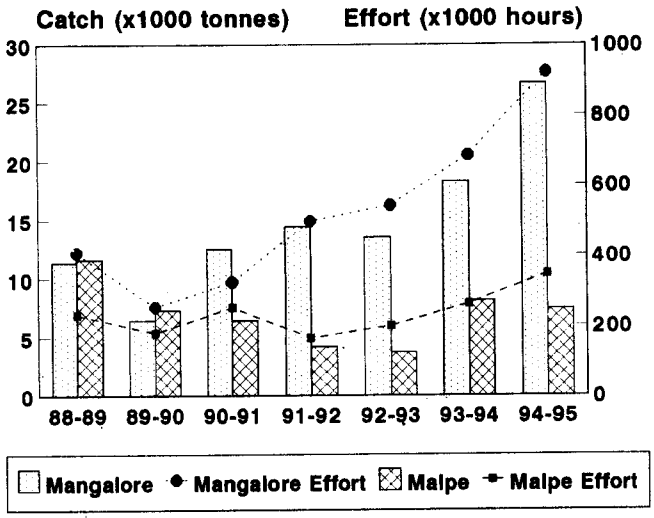

Fig.9. Annual catch and effort by MDF at Mangalore and Malpe bases.

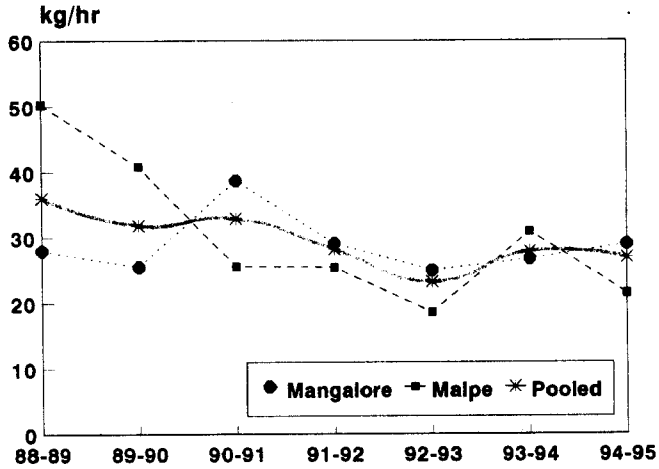

Fig.10. The annual catch rates of MDF trawlers with trend line fitted for the pooled data.

TABLE 7. *List of species occurring in multi-day fleet catch*

Prawns:	*Metapenaeus monoceros* (A); *M. affinis* (L); *Penaeus indicus* (A); *P. monodon* (A); *P. semisulcatus* (L); *P. canaliculatus* (L); *Solenocera crassicornis* (L); *Trachypenaeus spp.* (L); *Acetes indicus* (L); *Parapenaeus longipes* (L).
Stomatopods:	*Oratosquilla nepa* (A).
Crabs:	*Portunus sanguinolentus* (A); *P. pelagicus* (A); *Charybdis cruciata* (A); *Scylla serrata* (R).
Lobsters:	*Panulirus spp.* (R).
Cephalopods:	*Sepia aculeata* (A); *Sepia pharaonis* (A); *Sepiella inermis* (L); *Loligo duvauceli* (A); *Doryteuthis spp.* (L); *Sepioteuthis lessoniana* (R).
Threadfin : breams	*Nemipterus japonicus* (A); *N. mesoprion* (A); *Scolopsis spp.* (R).
Lizard fish:	*Saurida tumbil* (A); *S. undosquamis* (L); *S. isrankura* (L); *Trachinocephalus myops* (R).
Flatheads:	*Platycephalus scaber* (A).
Barracuda:	*Sphyraena jello* (A); *S. barracuda* (R).
Catfish:	*Tachysurus serratus* (L); *T. dussumieri* (L); *T. thalassinus* (L); *T. tenuispinis* (L).
Carangids:	*Caranx kalla* (A); *Decapterus russelli* (A); *Elagatis bipinnulatus* (A); *Megalaspis cordyla* (A); *Scomberoides tol* (A); *Selar mate* (A); *Alepes para* (A); *Atropus atropus* (A).
Flatfishes:	*Psettodes erumei* (L); *Solea elongata* (L); *S. ovata* (L); *Cynoglossus arel* (L); *C. macrostomus* (A); *C. bilineatus* (L).
Anchovies:	*Stolephorus bataviensis* (A); *S. devisi* (A); *S. indicus* (L); *Coilia dussumieri* (R).
Pomfrets:	*Pampus argenteus* (A); *P. chinensis* (R); *Parastromateus niger* (A).
Silverbellies:	*Leiognathus brevirostris* (L); *L. equulus* (L); *L. bindus* (A); *L. splendens* (L); *Secutor insidiator* (A).
Sharks and rays:	*Scoliodon laticaudus* (A); *Carcharhinus sorrah* (A); *C. limbatus* (A); *C. dussumieri* (L); *C. macloti* (L); *C. melanopterus* (R); *Rhiniodon typus* (R); *Rhizoprionodon acutus* (R); *Sphyrna lewini* (A); *S. zygaena* (R); *Himantura spp.* (L); *Aetobatus spp.* (R).
Goatfish:	*Upeneus sulphureus* (L); *U. vittatus* (L); *U. bensasi* (R); *Parupeneus cyclostomus* (L).
Croakers:	*Johnieops spp.* (A); *Johnius spp.* (A); *Otolithes cuvieri* (A); *O. ruber* (A); *Pennahia macrophthalmus* (A).
Ribbonfish:	*Trichiurus lepturus* (A).
Scombroids:	*Rastrelliger kanagurta* (A); *Scomberomorous commerson* (A); *S. guttatus* (A); *Euthynnus affnis* (R).
Bulls eye:	*Priacanthus hamrur* (A); *P. cruentatus* (L).
Clupeids:	*Chirocentrus dorab* (A); *Dussumieria acuta* (L); *Anodontostoma chacunda* (A); *Escualosa thoracata* (R); *Hilsa ilisha* (L); *Pellona ditchela* (A); *Opisthopterus tardoore* (A); *Sardinella longiceps* (R); *S. fimbriata* (R); *S. albella* (R); *S. brachysoma* (R); *S. gibbosa* (R); *Thryssa malabarica* (A); *T. dussumieri* (A); *T. mystax* (A).
Eels:	*Anguilla spp.* (L); *Muraenesox spp.* (L).
Perches:	*Epinephelus diacanthus* (A); *Epinephelus spp.* (L); *Therapon spp.* (L); *Pomadasys spp.* (A); *Lethrinus spp.* (R); *Holocentrus spp.* (R); *Lutjanus spp.* (R).
Whitefish:	*Lactarius lactarius* (A).
Half/full : beaks	*Ablennes spp.* (L); *Hemirhamphus spp.* (L); *Belone spp.* (L).
Other fishes:	*Gerres spp.* (L); *Exocoetus volitans* (R); *Psenes indicus* (L); *Polynemus spp.* (L); *Mene maculata* (L); *Sillago sihama* (R); *Rachycentron canadus* (L); *Echeneis remora* (R); *E. naucrates* (R); *Tetradon spp.* (L); *Coryphaena spp.* (R); *Neopinnula orientalis* (R); *Odonus niger* (R).
Mammals:	*Delphinus delphi* (R); *Sousa chinensis* (R); *Stenella longirostris* (R); *Neophocanoides phocanoides* (R).

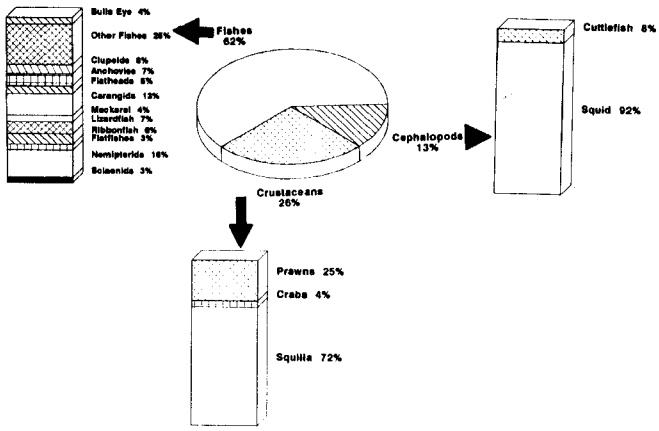

Fig.11. Composition of MDF trawl catch.

data (Fig.11) showed a downward trend till 1992/'93 after which it remained steady in later years. Best catch rates were seen in 1988/'89 and the lowest during 1992/'93.

Catch composition: The landings showed the occurrence of a wide variety of fishes; crustaceans and cephalopods in the MDF fishery compared to that of the SDF. There were about 15 species of crustaceans, six species of cephalopods and as many as 113 species of finfishes that occurred in the landings during one period or the other (Table 7). Out of this, 53 species occurred abundantly, 46 in less abundance and 35 rarely. Finfishes formed 62%, crustaceans made up 26% and cephalopods 13% of catches of multi-day trawl fleet (Fig. 10). Among finfishes, dominant groups in their order of abundance were threadfin breams (16%), carangids (13%), lizardfish (7%), anchories (7%), ribbonfish (6%) and clupeids (6%). The other important groups were flatheads (5%), bull's eye (4%), mackerel (4%), sciaenids (3%) and flatfishes (3%). Miscellaneous and other fishes formed 25%. The occurrence of deep water fishes like *Neopinnula orientalis* (sackfish), *Priacanthus spp.* (bull's eye) and *Psenes indicus* (Indian drift fish) is noteworthy and indicative of the deeper grounds exploited by this fleet. Among crustaceans the major component was stomatopods (72%). Prawns contributed 25% and the rest were crabs. The dominant species of prawns were the larger sized *Metapenaeus* spp. and *Penaeus* spp. as compared to the smaller metapenaeids and parapenaeopsids occurring in SDF catch. Squids were the predominant species accounting for 92% of the cephalopod landings and rest were cuttlefishes. Of late the percentage of cuttlefish in cephalopod landings has started to increase with heavy landings during September-October. Among all the groups, the dominant ones were stomatopods (18.3%) followed by cephalopods (12.8%), threadfin breams (10.1%), carangids (8.1%), prawns (6.3%), lizardfish (4.5%) and anchovies (4.5%).

Seasonal abundance: December to May period was the peak landing season for multi-day trawlers at both Mangalore and Malpe (Fig. 12). The catch was least during September-October. The catch rate, however, was found to be the maximum during October at Mangalore with 44 kg/hr compared with an average of 28.8 kg/hr. At Malpe, the catch rate peaked in October, December and April-May with an annual average of 29.74 kg/hr.

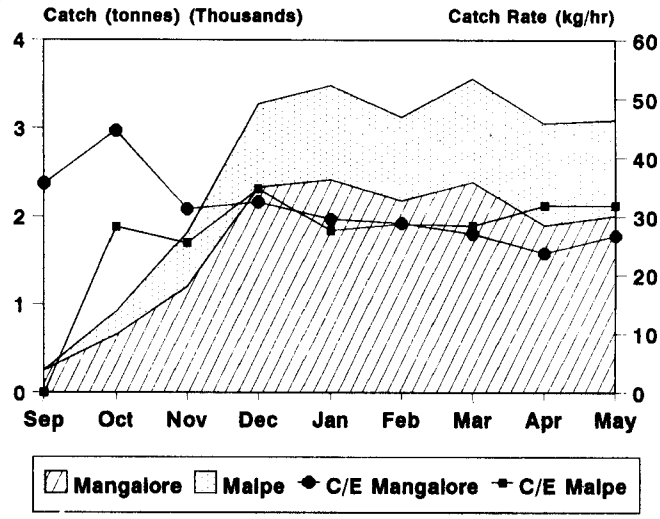

Fig.12. Seasonal variations in catch and catch rate of MDF boats at Mangalore and Malpe.

The seasonal abundance of eight important groups was analysed by taking the average catch rate during different months (Fig. 13). Prawns were absent in catches during September, appeared in the fishery by October and peaked during November-December period but continued to be present in the catches in good quantities till April. Cephalopods were present in the catches throughout the season with remarkable abundance in September-October. The ribbonfish catch was highly seasonal, with peak during October and again in May. Threadfin breams were most abundant during September, and moderately abundant during February-March period. The best season for carangids was during October-December and for mackerel during April-May. The deep water form, bull's eye was most abundant in October,

though present in fewer quantities throughout the season. Lizardfishes were abundant in October, and in February-May period.

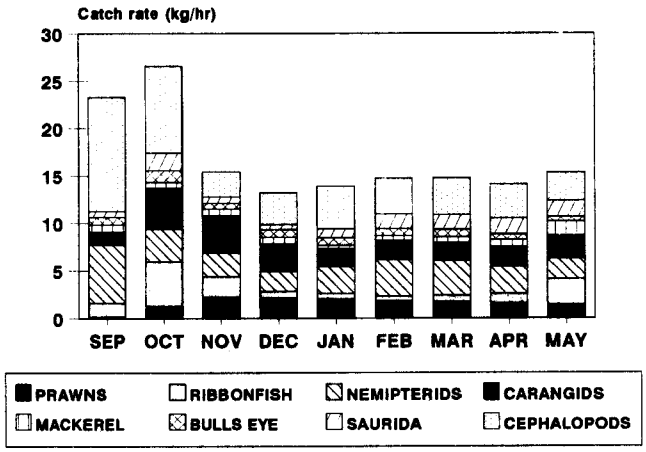

Fig. 13. Seasonal abundance of key groups in MDF trawl catch (Mangalore & Malpe pooled).

Annual trend of key groups: The landings of important groups by MDF during different years are shown in Fig. 14. The catch of different resources showed diverse patterns. The landing of priacanthids increased from 171 t (0.27 kg/hr) in 1988/'89 to 1,316 t (1.04 kg/hr) in 1994/'95. Another group that showed remarkable change in their landing was cephalopods. The catch increased from 1,662 t (2.6 kg/hr) in 1988/'89 to 4,653 t (3.74 kg/hr) in 1994/'95. For threadfin breams, the catch increased from 2,376 t into 3,677 t whereas the catch rate decreased from 3.73 kg/hr to 2.9 kg/hr. The catch of mackerel showed rising trend over the years with less catch during 1991/'92. Prawn landings increased moderately from 1,156 t in 1988/'89 to 1,838 t in 1994/'95 with slight fall during 1991/'92. The lizardfish catch also showed increasing trend although it is not as suggestive as with resources like cephalopods, threadfin breams or priacanthids.

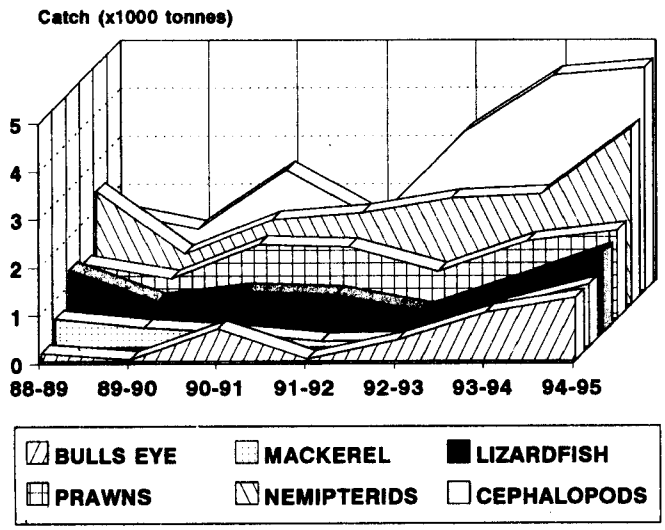

Fig. 14. Annual trend in the catch of key groups by MDF boats (Mangalore & Malpe pooled).

TABLE 8. *Comparative economic performance of the multi-day and single day units operating from Mangalore (all figures pertain to 1994-'95 season only)*

Particulars	Multi-day unit	Single day unit
INITIAL INVESTMENT		
Hull	Rs. 10,50,000	Rs. 5,70,000
Engine & accessories	Rs. 3,00,000	Rs. 2,05,000
Gear	Rs. 50,000	Rs. 25,000
FIXED COSTS		
Depreciation on hull (5%)	Rs. 52,500	Rs. 28,500
Depreciation on engine & accessories (8.33%)	Rs. 24,990	Rs. 17,077
Depreciation on gear (50% : MDF, 25% : SDF)	Rs. 25,000	Rs. 6,250
Interest on loan (@ 18% for 65% of initial investment)	Rs. 1,63,800	Rs. 93,600
Imputed cost of own Capital (@ 12% for 35% of initial investment)	Rs. 58,800	Rs. 33,600
Insurance premium (1.75%)	Rs. 24,500	Rs. 14,000
TOTAL	Rs. 3,49,590	Rs. 1,93,027
OPERATIONAL COSTS		
Fuel (less Rs.0.30/l subsidy)	Rs. 2,97,656	Rs. 48,688
Oil	Rs. 8,000	Rs. 1,800
Ice	Rs. 90,720	Rs. 3,375
Auction charges	Rs. 9,600	Rs. 3,125
Food for crew	Rs. 26,400	Rs. 12,500
Maintenace (including engine, hull, drydocking & net replacement)	Rs. 50,000	Rs. 23,000
Crew share & labour	Rs. 2,78,720	Rs. 1,23,017
TOTAL	Rs. 7,61,096	Rs. 2,15,505
TOTAL COSTS Fixed + Operational	Rs. 11,10,686	Rs. 4,08,352
INCOME EARNED Catch/unit/year (kg)	70,145	40,794
Income/unit/year	Rs. 12,32,000	Rs. 4,10,933
Other income (as carrier boat)	-	Rs. 15,000
Gross income	Rs. 12,32,000	Rs. 4,25,933
NET INCOME Income - Total cost	Rs. 1,21,314	Rs. 17,401

Value of the fishery

The estimated value realised from single day trawl fishery for the year 1994/'95 from Mangalore and Malpe together was Rs. 118.2 million for a catch of 11,497 t. Out of this, crustaceans contributed 57%, finfishes 42% and cephalopods formed only 1% (Fig. 15). Mangalore contributed 64.3% to the earnings (65.6% of landing) and Malpe the rest. The money earned from crustaceans was higher at Malpe compared to Mangalore as percentage occurrence of prawns with lower head count was more at this centre. Money earned per kg of landing was marginally better at Malpe (Rs. 10.69) than at Mangalore (Rs. 10.07).

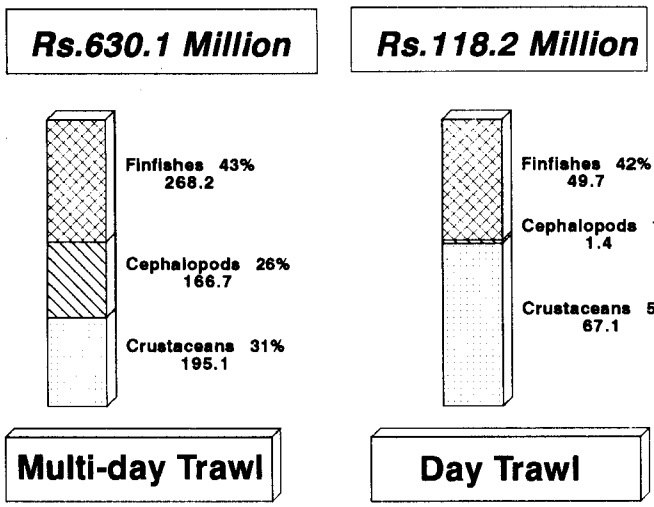

Fig.15. Value realized by SDF and MDF trawl fishery during 1994-'95 (Mangalore and Malpe pooled).

The amount realised from multi-day trawl fleet during the year 1994/'95 for the two centres together was estimated at Rs. 630.1 million (Fig.15). In this, the value realised from finfishes accounted for the maximum (43%) followed by crustaceans (31%) and the rest by cephalopods (26%). Out of the total value, Mangalore based trawlers earned Rs. 468 million (26,555 t) at a rate of Rs.17.6/kg and Malpe trawlers earned Rs. 162.1 million (7,418 t) at Rs. 21.85/kg. The realization of better prices at Malpe was because prawns that yield better prices were comparatively more in the landings at Malpe (5.8%) than at Mangalore (5.3%). For prawns itself Malpe earned better price per kg (Rs.115/kg against Rs.95.5/kg at Mangalore).

Comparative economics of fleet operations

The annual cost and earnings of a 50 foot (15.2 m) trawler (representative of multi-day fleet) operating for 240 days/year (48 trips) and a 32 foot (9.75 m) trawler (representative of single day fleet) operating for 125 days/year are given in Table 8. It may be mentioned that the initial investment of Rs. 8 lakhs for a 32 footer is a hypothetical figure obtained from local boat building yards, as no new boats of this size are presently being made. The operational cost of MDF unit is about 3.5 times higher than SDF and the income earned is also proportionately higher by three times. Concurrently, the catch realized/boat for an MDF is almost double that of an SDF. The net income was remarkably high for MDF, while it was about 5.5 times less for an SDF. The high profitability of an MDF is primarily due to its higher catch/boat and higher price relized per kg of catch (Table 9). Interestingly, although the MDF venture into deeper and farther grounds, their expenditure on fuel as percentage of operational cost is not significantly higher than that of SDF (39% compared with 23% for SDF). By tradition, SDF workers get 30% of the catch as their share, while MDF workers get 25% only. Even so, this represents only 37% of the operational cost for MDF, while it is a high 57% of the same for SDF.

Table 9. *Key economic efficiency indicators for the two trawl fleets at Mangalore*

Indicators	Multi-day unit	Single day unit
Annual revenue/unit	Rs.12,32,000	Rs. 4,25,933
Annual net profit/unit	Rs. 1,21,314	Rs. 17,401
Profit over operational cost	Rs. 4,70,904	Rs. 2,10,428
Rate of return (%)	24.56	18.07
Per cent return to capital	8.67	2.18
Production cost/kg	Rs. 15.83	9.90
Avg. price earned/kg	Rs. 17.56	Rs. 10.07
Profit/kg	Rs. 1.73	Rs. 0.17
Monthly income/worker	Rs. 5,161	Rs. 3,417

The comparative economic efficiency indicators for the two trawl fleets are listed in Table 9. The MDF outperforms the SDF in all spheres of economic returns. The rate of return, a key efficiency indicator, of MDF is 1.5 times more than that of SDF. Moreover the rate of return of SDF is more or less equal to the rate of interest facing the venture, and therefore, clearly suggests no profitability in investing in SDF trawl fishing at current prices. However, since almost all the units in SDF are relatively old (at least five years and

more) they have little or no repayments on loan and interest, and therefore at present, the SDF's net profit would be entirely the profit over operational cost (Table 9). In spite of this, the SDF operations are a far less profitable venture than MDF operations.

Because of the higher profit/kg of catch realized by MDF, the monthly income of a MDF crew is 1.5 times more than that of a SDF crew, although the SDF crew get 30% of the catch as their share against 25% for MDF crew.

Conclusions

This study reveals that the multi-day trawl fishery that has existed since the past one and a half decades has developed into a separate and strikingly different form of trawl fishery from the conventional single day fleet operating in the nearshore grounds. The success of this fishery can be gauged from the fact that during 1982/'83, single day fishing contributed as much as 64% of the total trawl landings at Mangalore (Sukumaran, 1985) while presently their average contribution amounts to only 32%. During the 15-year period (1980/'81-1994/'95) the trawl catch from Mangalore centre has increased by 8.7 times and what is more important, the value has increased by 43.5 times (Table 10). The steep increase in value is not only because of the steep increase in prices of exportable prawns, but also due to the increasing percentage of cephalopods and quality finfishes in MDF catches. While crustaceans contributed as much as 57% of the value realized by SDF, its contribution was only 31% in MDF. Finfishes contributed the highest 43% and cephalopods as much as 26% of the value of MDF catch (Fig.15).

Table 10. *Trend in total catch landed and value earned by trawlers at Mangalore for a period of 15 years*

Year	Quantity landed (tonnes)	Index of quantity (Base 1980/'81 =100)	Index of value (Rs. million)	Index of value (Base 1980-'81 =100)
1980/'81*	5,221.7	100.0	12.5	100.0
1981/'82*	7,804.0	149.5	21.3	170.4
1982/'83**	9,295.9	178.0	30.0	240.0
|	|	|	|	|
|	|	|	|	|
|	|	|	|	|
1994/'95	45,580.0	872.9	544.1	4,352.8

* Sukumaran *et al.* (1982).

** Sukumaran (1985).

This increase in monetary value of the trawl fishery is reflected in the economic efficiency of MDF boats. All economic indicators studied presently manifest the high profitability of MDF vis-a-vis the SDF. Earlier, a comparative economic efficiency study by Iyer *et al.* (1968) between 30, 32 and 36 foot trawlers designed by CIFT and operated along Kerala coast also indicated that the larger 36 foot vessels were better performers. An economic evaluation of the medium trawlers (=MDF trawlers) along the mid-shelf off Mangalore by Rao *et al.* (1993) showed increased profits and rate of return as high as 21%. The rapid increase in the number of MDF boats introduced into the fishery at Mangalore and Malpe bases (Fig. 16) over the years is a reflection of the success of MDF operations. In the past few years a few purse seiners have also been converted to trawl units and added to the multi-day trawl fleet. Conversely, no new

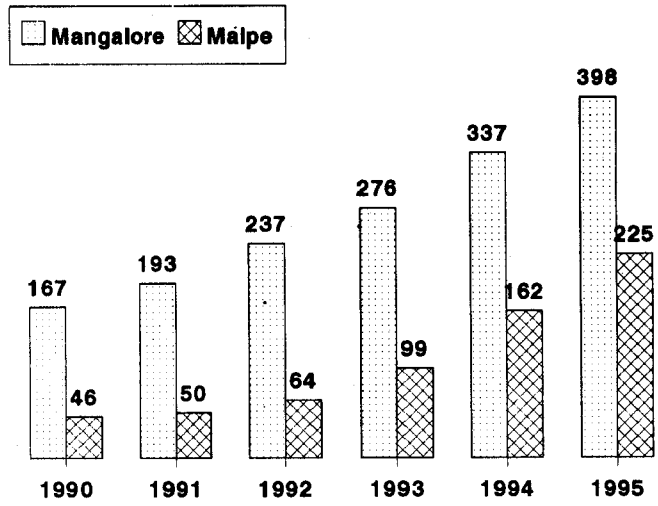

Fig.16. Graph showing the cumulative increase in multi-day boats at Mangalore and Malpe bases. (For 1995, only data upto 20-11-'95 is used).

SDF boats are being made presently in any of the boat building yards in this area. Further, a good number of SDF boats are non-operational for a large part of the season (functioning as carrier boats for the purse seine fleet etc.). An examination of the catch rate of the SDF boats shows wide fluctuations but in general, a recovery from a declining phase can be made out. It would appear that this fishery is slowly recovering from overcapitalization and with the gradual decrease in number of units (due to age and emigration), it should remain moderately profitable.

On the other hand, the catch rate in respect of MDF boats are clearly declining although catches are improving, particularly at Mangalore. A

reduction in mesh sizes of the trawl nets by 10 mm (38%) for shrimp nets and 12 mm (34%) for fish nets is observed from that reported in a previous study (Rao *et al.* 1993). The steep spurt in fleet strength at both Mangalore and Malpe bases is the primary reason for the decline in catch rates in spite of a reduction in cod end mesh size of both shrimp and fish nets operated by MDF. Further, the grounds exploited by this fleet are shared by similar trawlers operating from other bases in Karnataka. Notwithstanding this, it is conceivable that in the future, this fleet will further expand its grounds to include the 100-200 m depth zone. Although this would not result in much addition in the area of the ground (by virtue of the nature of continental slope), it would result in exploitation of virgin grounds for cephalopods and fish. Already the Indo-Danish Fisheries Project (IDFP) at Tadri in their project findings (IDFP, 1995) have reported on the feasibility of operating 48-50 footers with 102 HP engine upto 200 m depth with a few additions like modern fish finding equipments. The latest addition of few steel trawlers with GPS and video fish sounders to the MDF fleet at Mangalore are aimed in this direction. The IDFP (1995) have also mapped the resources existing in the area along the Karnataka coast for the benefit of trawl operators.

Effort limitation is an important means by which a fishery can be regulated to maintain it at biologically and economically sustainable levels. In the absence of such controls by the governments, fleet owners innovate and incorporate technological advances to keep their operations profitable. Evidently this has happened with the trawl fishery along this coast. Further innovations may be possible especially by expansion of grounds as mentioned earlier. However, effort limitation (by limiting new entries) is suggested as a more rational recourse for the scientific management of the trawl fishery of this coast.

Acknowledgement

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