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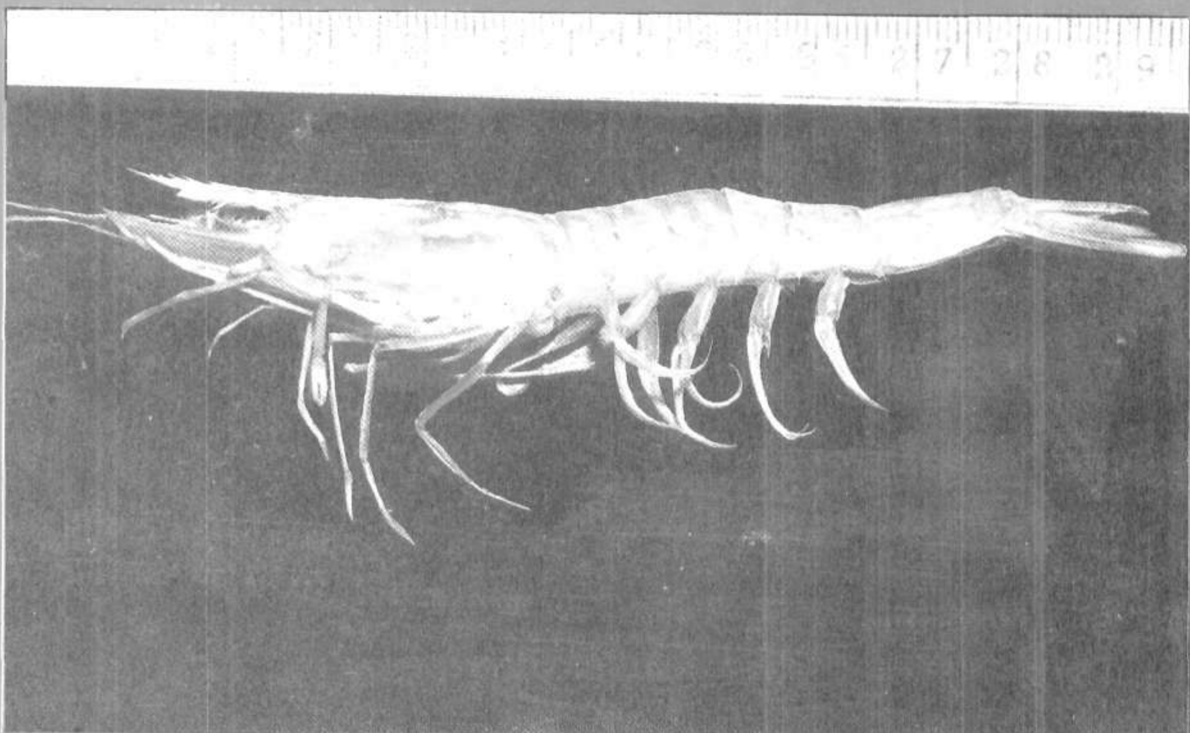

तकनीकी एवं विस्तार अंकावली TECHNICAL AND EXTENSION SERIES

केन्द्रीय समुद्री मात्स्यिकी अनुसंधान संस्थान कोचिन, भारत CENTRAL MARINE FISHERIES RESEARCH INSTITUTE COCHIN, INDIA

भारतीय कृषि अनुसंधान परिषद
INDIAN COUNCIL OF AGRICULTURAL RESEARCH

GILLNET FISHERIES OF INDIA

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Introduction

Gillnetting, an age-old fishing practice in the world has shown a spectacular increase in operation in recent years. A recent article (Anon., 1992) makes the following observations on the world gill net fishing: "The drift gill net fleet of the world act as curtains of death, land huge quantities of non-targeted species, prevent the salmon from reaching their native spawning sites, and also entangle, mutilate and drown thousands of marine mammals. The situation is alarming that more than 1,000 fishing vessels operate large sized nets hanging as much as 11 metres deep and spanning about 50 km, the combined length of the fleet's nets operating in the Pacific, Atlantic and Indian Oceans amounting to about 50,000 km, more than the distance around the earth". It further states that "the International Institute for Environment and Development of London describes gill net fishing as a major threat to sea-life and adds that the World Watch Institute observed that without curtailment of drift gill net fishing humanity will have little scope to protect its seas for future generations".

The United Nations General Assembly Resolution 44/225 adopted on 22 December 1989 (UN Bulletin Vol. 3, No.1, p.12), expressed serious concern that over-exploitation of living marine resources in the high seas adjacent to the EEZ of coastal states is likely to have adverse impact and called for progressive reduction as well as ceasing further expansion of large-scale pelagic drift net fishing.

Oceanic drift gillnetting as a commercial enterprise is not in vogue in the Indian EEZ. But in the traditional sector a variety of large mesh drift gillnets are being operated by mechanised and non-mechanised crafts, aiming mainly to catch larger pelagics in the offshore waters upto 50-80 m. These gear have become more popular in view of easy maintenance and economy in operation. As the number of these units has been increasing in recent years, a detailed study of the resources exploited by the large and small meshed gillnets was taken up to assess their present trend and pattern of exploitation to provide information for a rational exploitation.

Data base

Date on statewise fish landings by gillnets provided by the Fishery Resources Assessment Division (FRAD) of the CMFRI for the years 1989-'92 were analysed to study production trends, statewise contribution, catch, catch per effort and species composition. Based on the fish samples examined, results of study on the fishery and biological characteristics of some of the important fishery resources of the large meshed gillnet obtained at various observation centres of the Institute have been summarised. Results of the study carried out from July 1991 to June 1992 on the economics of operation of gillnets at Madras and Tuticorin are also outlined.

The gillnets are broadly grouped into :

1. Mechanised drift gillnets (MDGN)
2. Mechanised bottom set gillnets (MBSGN)
3. Inboard mechanised gillnets (IBMGN)
4. Outboard gillnets (OBGN)

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5. Non-mechanised bottom set gillnets (NMBSGN)
6. Non-mechanised gillnets (NMGN)
7. Others

These various groups of gillnets have been assorted further into the following two major categories :

1. Large meshed gillnet (LMG) with mesh size more than 45 mm (MDGN, OBGN, etc);
2. Small meshed gillnets (SMG) with mesh size less than 45 mm.

An important gillnet unit in each state was identified based on the total yield and regularity of operation to estimate the standard effort. was found to be the standard gillnet unit for Gujarat, Maharashtra, Pondicherry, Tamil Nadu and Andhra Pradesh; MDGN for Orissa and West Bengal; and OBGN for Kerala, Karnataka and Goa. Based on this standard effort in units (SE) the catch per standard effort (C/SE) was calculated for each state. In the case of small meshed gillnets their effort has been pooled to get total effort.

Crafts and gear

The crafts employed for gillnet operation include catamarans, plank-built boats, dugout canoes and fibreglass coated plywood boats. Motorisation of the gillnet crafts, by fitting inboard or outboard engine in traditional small fishing boats, enjoyed a great vogue in the north-west region since early 1940s. But only from early 1980s the motorization of fishing crafts was initiated in other sections of the Indian coast. This has resulted in gaining greater manoeuvrability and increased access to more deeper areas for fishing, realising higher catches in general with noticeable changes in catch composition of the target groups.

Further, in making the gear, the natural fibres have been replaced by synthetic fibres. Large and thick meshed nets have been evolved to suit target fishing. Specialised nets are designed within the large and small mesh gillnets to capture effectively the large sized clupeoid fishes, seerfishes, mackerel, pomfrets, tunas, elasmobranchs, other sardines (lesser sardines), whitebaits, half-beaks, flying fishes, crabs and prawns.

The mesh size for the large mesh gillnet goes upto 500 mm, the mesh size upto 160 mm being common. The overall length of net in operation may range between 500 m and 2,500 m and depth between 3 m and 15 m; those with 1,000 m length and 10 m depth being common. Fishing is generally done within 20-45 m, but often extend upto 50-80 m depth. In the case of the small mesh gillnets the smallest mesh size is about 14 mm with a length of 100-300 m and depth of 2-7 m; their operations being confined to nearshore waters.

In Gujarat, operation of small meshed gillnet was quite insignificant in the regular fishing activity, whereas in the other states both the major categories of gillnets were operated in fishing.

In Gujarat, an important state for gillnet fishing, the traditional crafts (plank built boat) with IBM and OBM were replaced by FRP dugout canoes (with out-board motor) of the same size of the traditional crafts. In recent years, the extension of the operational range of gillnet to 35-75 m depth has resulted in drastic changes in catch and species composition. Surface drift gillnets *(Jadajal)* of mesh size 65-85 mm and 170-215 mm are in use in addition to surface/bottom drift gillnets of 140-160mm mesh used exclusively for pomfret fishing during monsoon. In a single operation of a boat any of the 3 types of gear is used either individually or in combination. Usually 30 and 60 nets are employed by OBM and IBM crafts respectively. These are usually operated at 20-45 m depth. Mostly daily fishing was made, but in a few cases the fishing extended to 2-3 days. In Karnataka drift gillnets of mesh size 50-135 mm are employed and operational depth varies between 25 and 60 m. At Calicut (Kerala) nets of mesh size 55-60 mm and 110-130 mm are employed, the former aimed mainly to catch mackerel. At Cochin the mesh size of gillnets varies from 70-130 mm and the operation is in the 20-70 m depth zone. Mesh size of 50-80 mm are encountered in Vizhinjam.

At Tuticorin the *Paruvalai* (mesh size 80 - 120 mm) *Podivalai* (60-70 mm) and bottom set gillnet (250-500 mm) are operated from Tuticorin-type country craft called *vallom.* The operation of the *Podivalai* is in the 12-60 m depth and *Paruvalai* in the 60-110 m depth zones. In the Mandapam-Rameswaram area, plank built boats with inboard engines operate gillnets of mesh size 45-70 mm, 80-90 mm and 90-160 mm. Here, periodical change in the fishing ground takes place : to Palk Bay with the onset of the southwest monsoon and to the Gulf of Mannar area during the northeast monsoon. At Chennai mostly non-motorised country crafts operate large mesh gillnets in the 20-50 m depth zone. At Visakhapatnam the drift gillnets with 55 mm mesh size are operated entirely from non-mechanised plank-built boats at 20-50 m depth.

The strength of the crew varied between 2 and 9 persons depending upon the size of the gear and the craft. Usually 1-2 hauls are made per day's fishing trip. Use of navigational aids like compass though used only by a few has increased their efficiency.

Fish production by gillnet

The gillnets landed 2.9-3.5 lakh tonnes of marine fish accounting for 15 % of the total marine fish landings in India during 1989-'92. The large mesh gillnets contributing to about 11 % of the total marine fish landings accounted for 65-79 % (Av. 71 %) of the total gillnet landings with annual catch rate (CPUE) ranging between 109 and 220 kg (Av. 113 kg). The small mesh gillnets contributed 21-35 % (Av. 29 %) with an annual CPUE of 26-41 kg (Av.33 kg).(Figs.1 & 2). The average annual contributions by the large and small mesh gillnets for the east and west coasts are given in Fig. 3 and the all-India annual catch, standard effort and catch rate by these two major categories of gillnets for the different years of study (1989 to 1992) are given in Figs. 4 & 5.

Statewise contribution to the fishery by gillnets

Statewise relative contributions by large and small mesh fillnets over the period of

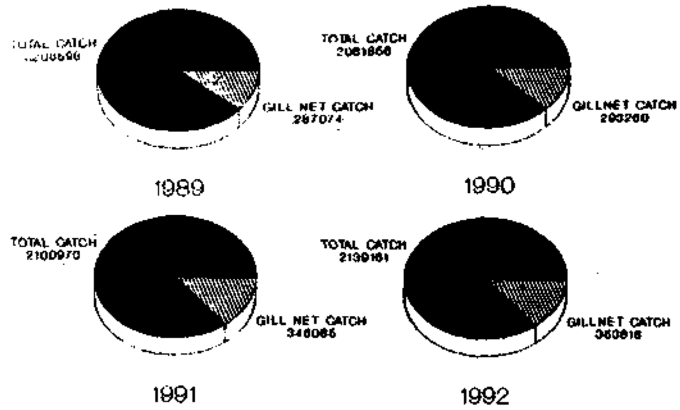

Fig. 1. Contribution of gillnet catch to all-India total fish landings (tonnes) during 1989-'92.

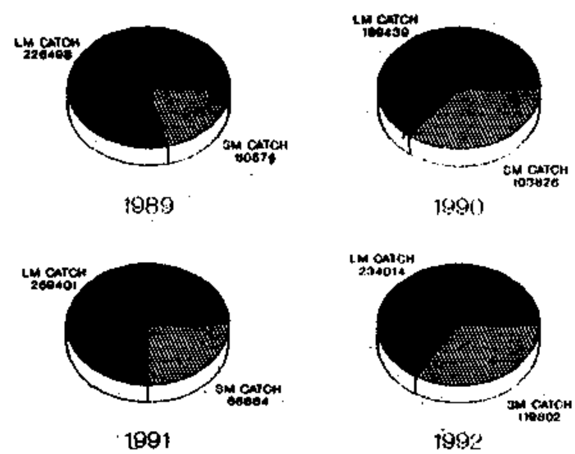

Fig. 2. Contribution of large and small meshed gillnets to total gillnet catch (tonnes) during 1989-'92.

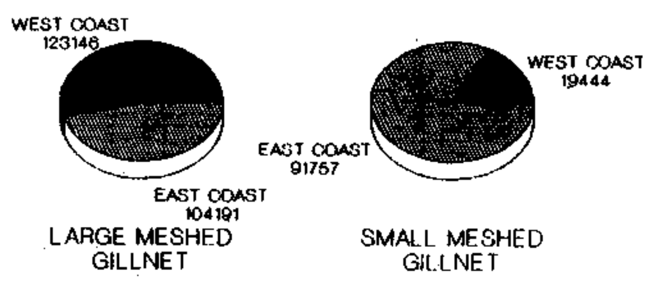

Fig. 3. Contribution by large and small meshed gillnets (tonnes) on the east and west coasts of India during 1989-'92.

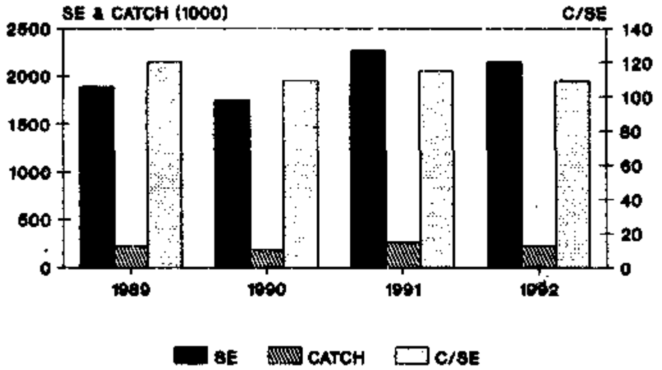

Fig. 4. All-India annual catch (tonnes), standard effort (SE) and catch/SE (kg) by large meshed gillnet during 1989-'92.

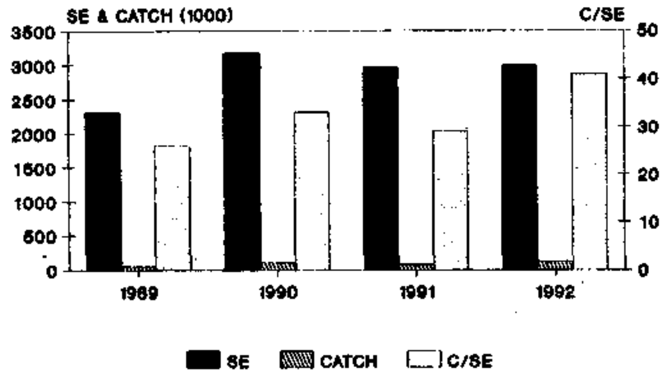

Fig. 5. All-India annual catch (tonnes), standard effort (SE) and catch/SE (kg) by small meshed gillnet during 1989-'92.

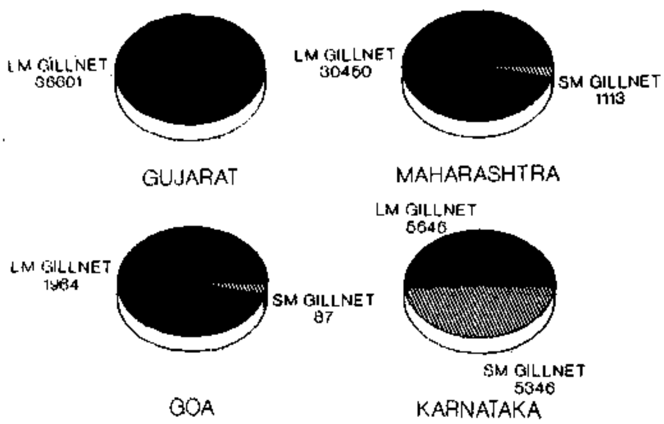

Fig. 6. Statewise contribution by large and small meshed gillnets (tonnes) during 1989-'92.

study are depicted in Figs. 6 & 7. Kerala landed the bulk (21 %) of the large meshgillnet catch

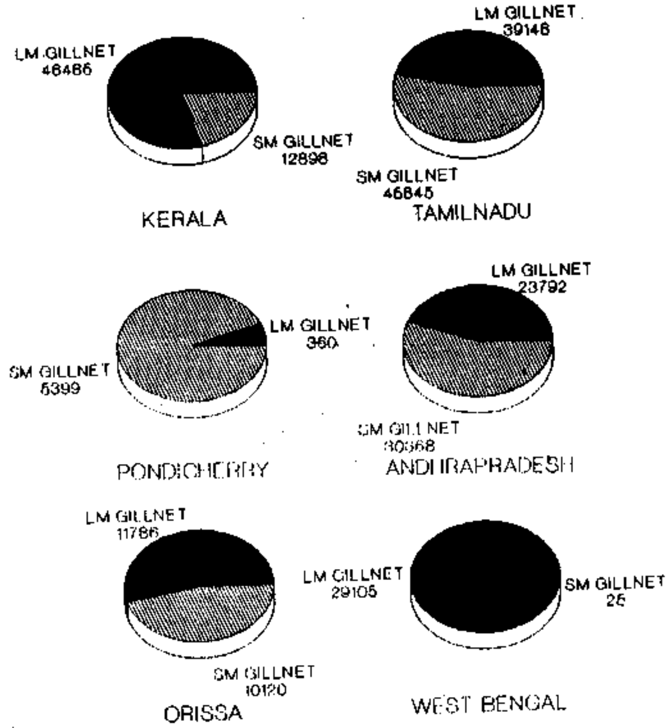

Fig. 7. Statewise contribution by large and small meshed gillnets (tonnes) during 1989-'92 (contd.)

of the country followed by Tamilnadu (17 %), Gujarat (16 %), Maharashtra (13 %), West Bengal (13 %), Andhra Pradesh (11 %), Orissa (5 %), Karnataka (3%), Goa (1 %) and Pondicherry (0.1 %). From Fig. 8 it may be noted that the level of the catch compared to the effort input was quite high in West Bengal followed by Maharashtra and Gujarat. The difference between these two levels namely, catch and effort as also the catch rates (C/SE) show the same order in these states. Fishing effort has exceeded the level of the catch in Kerala and Tamil Nadu resulting in poor catch rates. But in West Bengal followed by Karnataka, Pondicherry, Goa and Orissa the catch rates exceeded the level of catch and effort. Thus the highest catch rate was obtained in West Bengal (454 kg) and was followed by Maharashtra (156 kg), Gujarat (141 kg), Karnataka (125 kg), Orissa (114 kg), Andhra Pradesh (101 kg), Kerala (83 kg), Tamil Nadu (80 kg), Goa (69 kg) and Pondicherry (62 kg).

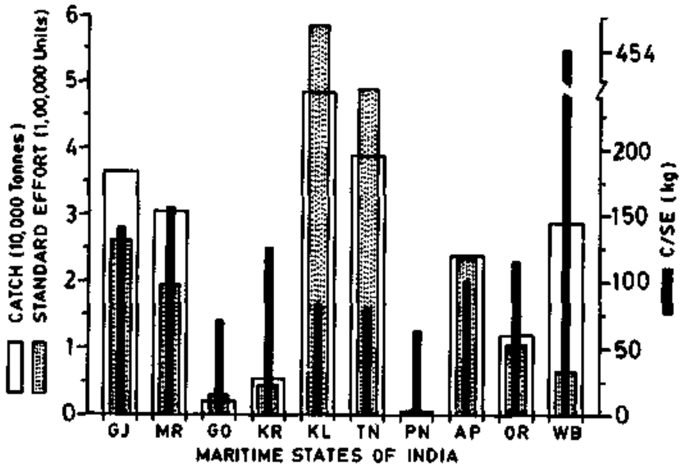

Fig. 8. A comparative picture of the levels of catch, effort and catch per standard effort by large meshed gillnet in the maritime states of the mainland of India during 1989-'92. GU: Gujarat; MR: Maharashtra; GO: Goa; KR : Karnataka; KL: Kerala; TN: Tamil Nadu; PN: Pondicherry; AP: Andhra Pradesh; OR: Orissa; WB : West Bengal.

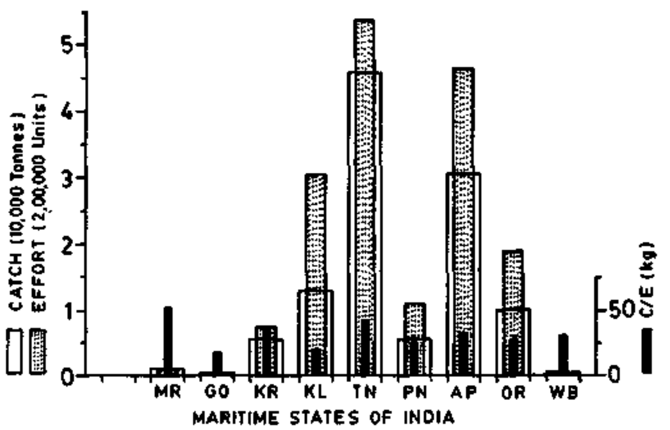

Fig. 9. A comparative picture of the levels of catch, effort and catch per unit effort by small mesh gillnet in the maritime states of the mainland of India during 1989-'92. (Explanation to notations as for Fig. 8).

Statewise levels in catch, effort and catch per unit effort (C/E) for small mesh gillnet are given in Fig. 9. Tamil Nadu landed the bulk (41 %) of the catch by small mesh gillnets followed by Andhra Pradesh (27 %), Kerala (12 %), Orissa (9 %), Karnataka and Pondicherry (5% each). Effort as well as catch were meagre to low in Gujarat, Maharashtra, Goa and West Bengal. In spite of high fishing effort expended in the other states, the catch rates were poor varying from 20 kg in Goa to 52 kg in Maharashtra.

Seasonal variation in the gillnet fishery

On the west coast, except at Cochin and Vizhinjam intensive gillnet fishing commences by the close of southwest monsoon, around

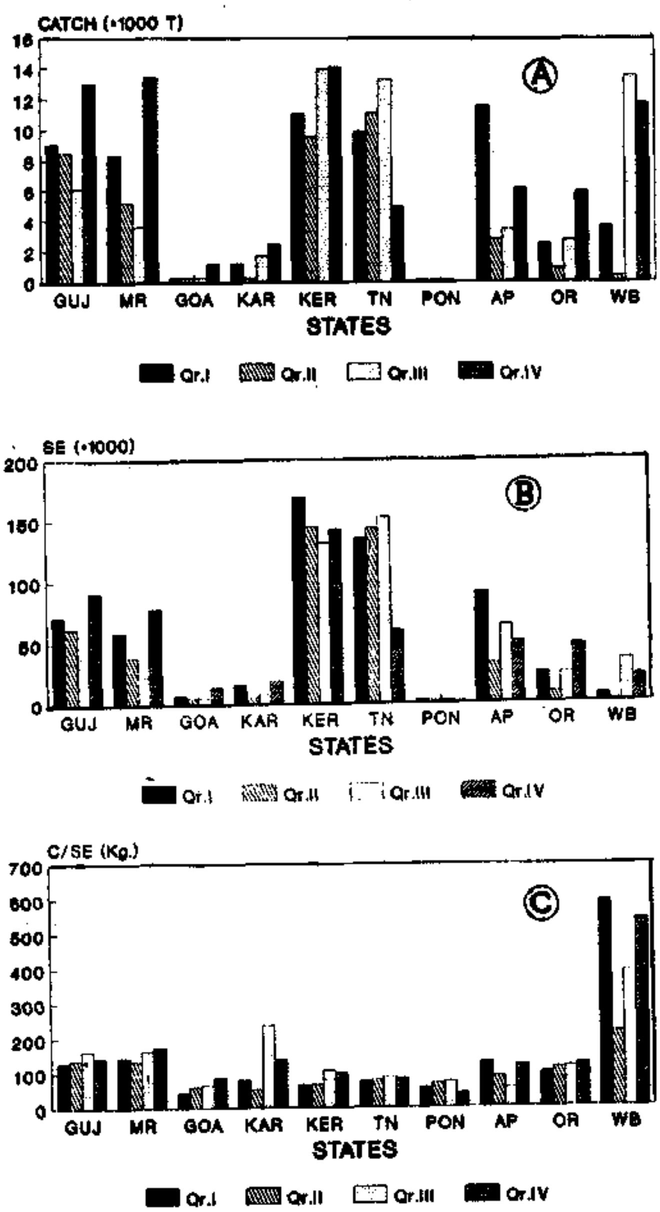

Fig. 10. Statewise average quarterly catch (A), standard fishing effort (B) and catch per standard effort (C) for large meshed gillnet in the maritime states of India during 1989-'92. GU : Gujarat; MR: Maharashtra; GO: Goa; KR: Karnataka; KL: Kerala; TN: Tamil Nadu; PN: Pondicherry; AP: Andhra Pradesh; OR: Orissa; WB: West Bengal.

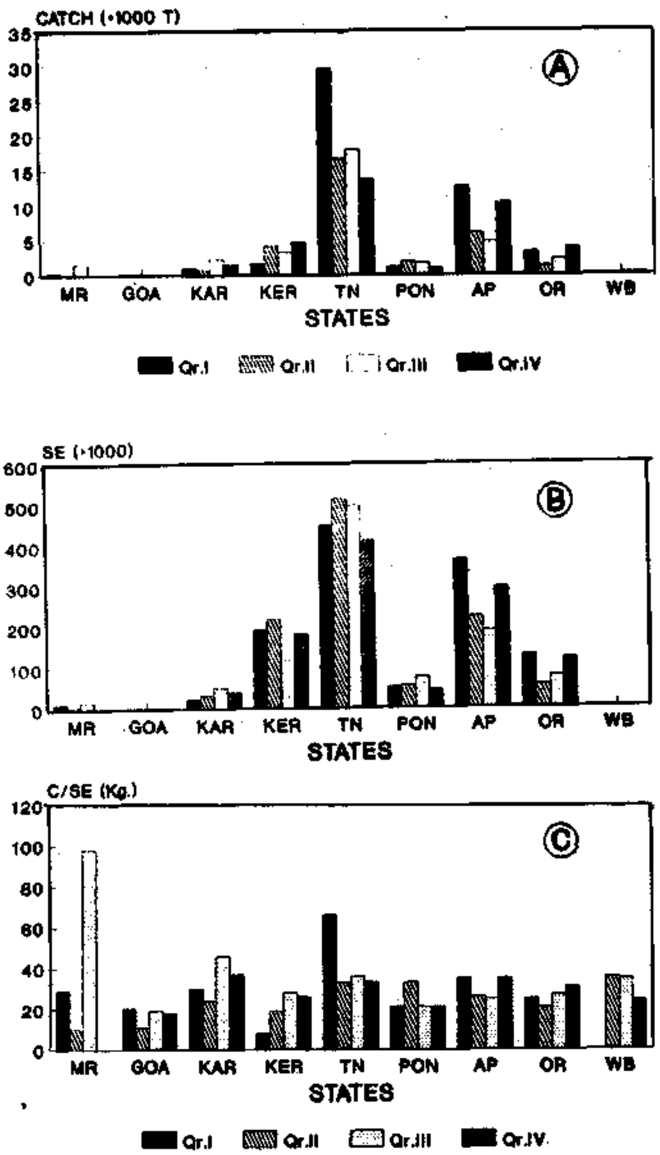

Fig. 11. Statewise average quarterly catch (A), fishing effort (B) and catch per unit fishing effort (C) for small meshed gillnet in the different maritime states of India during 1989-'92. (Explanation to notations as for Fig. 10).

September and continues till January-February. Thereafter fishing shows a declining trend till the onset of the SW monsoon. The same trend is noticed in the Gulf of Mannar also. From Palk Bay to Kakinada the gillnet fishing period is mainly during January-September. Off Visakhapatnam it is during October-June, as along the west coast. Further north, drift gillnetting is done mainly during September-December off Orissa while it is done during July-March off West Bengal.

Statewise quarterly average fishing effort, fish landings and catch rate for large meshed and small meshed gillnets during 1989-'92 are furnished in Figs. 10 & 11. Occasionally, periods of high catch and high catch rate did not coincide because of the variations in the effort in-put in the different periods. Therefore each quarter was ranked for its catch and catch rate separately and assigned points: the first rank receiving 5 points, second 4 points, third 3 points and fourth 2 points. These points received by catch and catch rate for a quarter were multiplied and the product, which varied between 4 and 25, has been considered to represent the overall rank of the fishery for that quarter and the line connecting these quarterly points gave the trend of the fishery (Fig. 12).

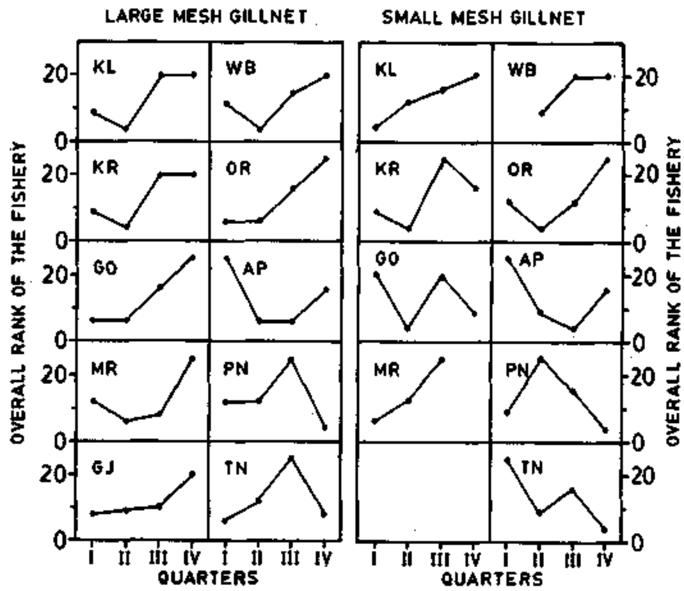

Fig. 12. Quarterly fishery trends for large and small meshed gillnets in the different maritime states of the mainland of India during 1989-'92. (Explanation to notations as for Fig. 8).

From these trends the peak/main fishery season for the large mesh gillnet is considered to be the I quarter (January-March) in Andhra Pradesh, III quarter in Tamil Nadu and Pondicherry, III & IV quarter for Kerala and Karnataka and IV quarter in Gujarat, Maharashtra, Goa, Orissa and West Bengal. For small mesh gillnets the picture is somewhat different. The I quarter represents the good fishery season for Andhra Pradesh, Tamil Nadu and Goa; II quarter for Pondicherry; III quarter for Tamil Nadu (second peak), Karnataka, Goa, Maharashtra; III and IV quarter for West Bengal; and IV quarter for Kerala and Orissa. These statewise, quarterly fishery trends are in general agreement with the observed regional fishery trends mentioned earlier.

Statewise major gillnet fisheries and bionomics of some important species

Annual ranges in catch per unit effort (kg) for the different groups in the LMG and SMG for the different states during the four year period (1989-'92) are given in Tables 1 & 2 respectively. The overall percentage composition of the different groups of fish landed, together with their respective composition and rank in the total marine fish landings is given in Table 3. Some aspects of the bionomics such as size range, dominant size, fishery season and spawning period studied for some species landed by the large mesh gillnet at the different observation centres of the CMFR Institute have been tabulated (Table 4).

TABLE 1. *Range in catch per standard effort (C/SE-kg) of different groups in the large meshed gillnets in different states during 1989-'92*

	GU	MR	GO	KN	KR	TN	PO	AP	OR	WB
Clupeoid fishes	22-24	20-30	7-19	2-27	7-30	28-29	7-30	8-65	15-27	220-352
Indian mackerel	-	2-15	1-9	10-90	14-16	3-12	3-4	5-17	-	-
Tunas	4-15	2-9	2-4	2-16	8-18	3-7	12-30	1-2	-	-
Billfishes	-	1-2	-	-	-	-	2-12	-	-	-
Seerfishes	11-21	17-24	18-43	22-56	5-13	2-6	4-15	6-21	13-17	10-27
Ribbonfishes	4-8	7-16	1-3	-	-	-	-	3-4	-	2-13
Carangids	5-10	1-4	2-6	2-6	3-12	3-6	*-2	3-13	1-2	-
Catfishes	9-13	8-12	1-2	-	*-3	1-3	-	2-4	12-24	36-49
Croakers	9-13	-	1-2	1-5	1-3	1-2	-	4-7	2-10	1-19
Elasmobranchs	11-18	6-16	2-5	3-8	1-3	3-4	6-8	9-20	6-14	1-13
Pomfrets	10-18	27-41	1-11	1-6	1-2	-	-	5-10	27-48	29-74
Lactarius	-	-	-	-	1-2	-	-	-	-	-
Barracuda	-	-	-	-	-	1-2	*-10	-	-	-
Leather-jackets	1-3	-	-	-	-	-	-	-	-	-
Silverbellies	-	-	-	-	-	9-2	-	-	-	-
Flyingfishes	-	-	-	-	-	-	*-17	-	-	-
Goatfishes	-	-	-	-	-	-	*-10	-	-	-
Threadfins	4-5	-	-	-	-	-	-	2-3	-	7-12
Perches	-	-	-	-	-	-	-	-	1-3	-
Bombay duck	-	-	-	-	-	-	-	*-4	-	*-11
Mullets	-	-	-	-	-	-	-	*-2	-	-
Soles	-	-	-	-	*-1	-	-	-	-	-
Penaeid prawns	-	-	-	-	*-1	*-1	-	5-9	-	-
Others	6-20	9-36	7-13	11-20	7-24	9-29	*-12	12-18	4-17	19-31

* less than 0.5 kg. GU = Gujarat; MR = Maharashtra; GO = Goa; KR = Karnataka; KL = Kerala; TN = Tamil Nadu; PO = Pondicherry; AP = Andhra Pradesh; OR = Orissa; WB = West Bengal.

TABLE 2. *Range in catch per standard effort (C/SE-kg) of different groups in the small meshed gillnets in different states during 1989-'92*

Fish Groups	GU	MR	GO	KR	KL	TN	PN	AP	OR	WB
Clupeoid fishes	-	4-18	2-7	10-18	10-16	16-26	10-20	10-17	6-9	15-19
Croakers	-	*-36	1-3	2-8	<1	1-2	< 1	1-3	1-3	*-1
Indian mackerel	-	*-2	1-2	2-9	1-3	2-19	3-6	1-11	*-2	-
Carangids	-	*-1	1-3	1-7	1-2	1-2	1-2	*-1	1-2	-
Ribbonfishes	-	<1	<1	-	-	-	<1	*-2	1-3	-
Pomfrets	-	-	<1	*-1	-	-	-	*-1	1-2	1-3
Tunas	-	-	-	-	<1	-	-	-	-	-
Seerfishes	-	-	-	*-2	-	-	-	1-2	1-2	*-1
Barracuda	-	-	-	-	-	*-1	-	-	-	-
Leather jackets	-	<1	-	-	-	-	-	-	-	-
Flying fishes	-	-	-	-	-	-	*-1	-	-	-
Bombay duck	-	-	-	-	-	-	-	-	-	1-2
Catfishes	-	<1	-	-	<1	-	-	*-1	1-3	2-4
Lactarius	-	-	*-1	1-5	<1	-	-	-	-	-
Goatfishes	-	-	-	-	-	*-1	-	-	-	-
Perches	-	-	<1	*-1	-	-	<1	*-1	-	-
Silverbellies	-	-	*-1	1-3	<1	*-1	*-1	-	-	-
Soles	-	-	<1	-	-	-	-	-	-	-
Elasmobranchs	-	1-2	<1	1-3	*-1	-	-	*-2	*-1	-
Penaeid prawns	-	2-23	*-1	*-7	<1	*-2	-	*-1	-	-
Lobsters	-	-	*-1	-	-	-	-	-	-	-
Crabs	-	-	*-2	-	-	1-2	-	-	<1	-
Others	-	4-6	2-7	3-7	3-4	5-7	3-6	6-7	2-3	5-7

* Less than 0.5 kg. GU = Gujarat; MR = Maharashtra; GO = Goa; KR = Karnataka; KL = Kerala; TN = Tamil Nadu; PN = Pondicherry; AP = Andhra Pradesh; OR = Orissa; WB = West Bengal.

TABLE 3. *A comparative statement on the all India percentage composition of the different groups of fishes caught in large mesh gillnet (LMG) and small mesh gillnet (SMG) as well as in the total marine fish landings TMFL together with their ranks*

Rank	Fish group	% composition in			Rank in
		LMG	SMG	TMFL	TMFL
1.	Clupeoid fishes	25	45	24	1
2.	Seerfishes	14	2	2	15
3.	Pomfrets	10	2	2	14
4.	Indian mackerel	9	10	8	3
5.	Tunas	8	<0.5	2	13
6.	Elasmobranchs	7	2	3	10
7.	Catfishes	5	3	2	12
8.	Carangids	4	5	7	4
9.	Croakers	3	8	6	5
10.	Ribbonfishes	2	2	4	8
11.	Billfishes	1	-	<0.5	26
12.	Barracudas	1	<0.5	1	19
13.	Crustaceans	1	6	16	2
14.	Flying fishes	1	<0.5	<0.5	23
15.	Threadfins	1	<0.5	<0.5	22
16.	Bombay duck	<0.5	1	5	6
17.	Perches	<0.5	1	5	7
18.	Silver bellies	<0.5	2	3	11
19.	*Lactarius*	<0.5	1	<0.5	20
20.	Queenfishes	<0.5	<0.5	<0.5	Negligible

Large mesh gillnet catch composition Large sized clupeoid fishes (Wolf-herrings, hilsa shad, other shads and other clupeoids), seerfishes, pomfrets, Indian mackerel (Rastrelliger kanagurta), tunas, elasmobranchs and catfishes are the important groups contributing to the bulk (about 75 %) of the LMG landings. Their relative composition in the gear, however, varied in the different states. Clupeoid group which appears to hold the first rank in the all-India level, however, keeps the first rank in the LMG landings only in Gujarat, Kerala, Tamil Nadu, Andhra Pradesh and West Bengal. It takes second rank in Maharashtra, Goa, Pondicherry and Orissa; and third rank in Karnataka. Seerfish which is the second important group in LMG landings takes the first rank in Goa and Karnataka; second rank in Gujarat; third rank in Maharashtra, Pondicherry and Andhra Pradesh; fourth rank in Kerala, Orissa and West Bengal, and fifth rank in Tamil Nadu. Pomfrets contribute to the LMG landings most significantly only along the northeast and northwest coasts of the country occupying the first rank

Table 4. *Summary of results of studies on the fishery and biological characteristics of some important gillnet (large mesh) fishery resources made at the various centres of the CMFRI*

Fish group	Dominant species/species studied	Other important species	Size range in the fishery (cm)	Dominant size (cm)	Fishery season	Spawning season	Other information
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Veraval							
Pomfrets	*P. argenteus*	-	10.0-29.0	19.0-29.0	May-Sep. (Veraval) Sep.- Mar. (Kotada Madhawad)	Jun.-Sep.	*P. argenteus* accounts for 65-70 % of the pomfret catch; juveniles occur mainly during May-Sep; fecundity 600,000,-2,540,000 eggs; a serial spawner.
	-	*P. niger*	25.0-35.0	-	Apr.-Jun.	-	
Seerfishes	*S. guttatus*	-	12.0-82.0	30.0-45.0	Sep.-Mar.	Apr.-Jun.	*S. commerson* is sporadic in its occurrence. *S. lineolatus* and *Acanthocybium solandri* also occur occasionally.
	-	*S. commerson*	28.0-138.0	50.0-90.0	-		
Tunas	*T. tonggol*	-	28.0-106.0	56.0-80.0	Sep.-May	-	Sep.-Dec. and Apr.-May form the main season for tuna. Juveniles of *E. affinis* (18-20 cm), *A. thazard* (16-18 cm) occur during Oct.-Nov., Feb.-Mar. and May.
	-	*T. albacares*	50.0-148.0	88.0-106.0	Oct.-Mar.		
	-	*A. thazard*	22.0-48.0	30.0-36.0	Oct.-Mar.		
	-	*E. affinis*	12.0-78.0	40.0-60.0	Oct.-Mar.		
	-	*K. pelamis*	51.0-73.0	-	Oct.-Mar		
Sharks	*C. melanopterus*	-	50.0-150.0	-	May-Dec. & Feb.-Mar.	-	*S. melanopterus* forms 42% and *S. laticaudus* 27% of the elasmobranch catches.
	-	*S. laticaudus*	24.0-60.0	42.0-48.0	Apr.-Sep.	Around December	*S. laticaudus* was estimated to grow to a length of 317 mm, 453 mm, 548 mm, 614 and 660 mm at the end of 1-5 years of life. Female attains maturity at 350 mm length (Age 1.2 years). Female carried 6-12 young ones in a litter.
Catfishes	*T. thalassinus*	-	-	25.0-35.0	Jun.-Sep. & Nov.-Feb.		
	-	*O. militaris*	24.0-49.0	33.0-37.0	Jan.-May	-	Juveniles are met with during May-Jun. and Oct.-Mar.
Bombay							
Pomfrets	*P.argenteus*	-	-	19.0-29.0	Aug.-May	Aug.-Sep. Jan.& Mar.	Size at first maturity 22.0-24.0 cm.
	-	*P. niger*	-	15.0-50.0	Aug.-May		
Sharks	*C. melanopterus*	-	-	46.0-48.0	Sep.-Mar.		
	-	*S. laticaudus*		46.0-48.0	Sep.-Dec.		
Catfishes	*T. serratus*	-	-	89.0-100.0	Sep.-Mar.		Juvenile catfish are dominant during May-Jun. and Oct.-Mar.
Mangalore							
Seerfishes	*S. commerson*	-	7.5-130.0	50.0-90.0	Sep.-Mar.	Jan.-Sep.	*S. commerson* accounts for 94% of seerfish landings. Population parameters : L_∞ = 169 cm; K=0.22 (annual); t_0 = 0.16 years; Z=1.31;

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
							F=0.91; exploitation ratio 0.50. Average annual standing stock in the presently exploited area 351 t. Size at first maturity 74 cm.
	-	*S. guttatus*	22.5-90.0	30.0-45.0	Oct.-Dec.	Apr.-Jul.	Size at first maturity 36.5 cm.
Tunas	*E. affinis*	-	15.0-76.0	36.0-64.0	Aug./Sep.-Nov.	Sep.-Oct.	Size at first maturity 43.0 cm. Population parameters of *E. affinis* L_∞= 77.5 cm K=0.859 (annual): t_0 = -0.171 years Z=2.475 : F=1.278; exploitation ratio 0.46. Average annual standing stock in the presently exploited grounds 96 t. Sizes estimated at ages 1-5 are 44.11 cm, 63.35 cm, 71.51 cm, 74.96 cm and 76.42 cm respectively. *T.albacares* and *S. orientalis* were the other species of tunas met with in the catches.
	-	*T. tonggol*	34.0-78.0	36.0-68.0	-	-	
	-	*A. thazard*	24.0-49.0	-	Sep.-Dec.	Oct.-Nov.	
Mackerel	*R. kanagurta*	-	17.5-28.0	18.5-27.0	Sep.-Jan.	Jun.-Aug.	Pre-adults and adults constitute the fishery. Juveniles occur during Nov.-Dec. Size at first maturity: 21.70 cm.
Pomfrets	*P. niger*	-	14.0-32.0	19.0-20.0	Sep.-Apr.	Oct.-Dec.	Size at first maturity 29.0 cm
	-	*P. argenteus*	5.0-24.0	-	Oct.-Apr.	Apr.-Jun.	Size at first maturity 18.0 cm.
Catfishes	*T. serratus*	-	46.0-109.00	68.0-106.0	Sep.-Mar.	-	*T. dussumieri* was met with at Malpe.
	-	*T. thalassinus*	32.0-92.0	48.0-56.0	Sep.-Mar.	-	
	-	*T. tenuispinis*	44.0-54.0	48.0-53.0	Sep.-Mar.	Sep.-Oct. & Dec.	Size at first maturity of *T. tenuispinis* 27.5 cm.
Sharks	*C. limbatus*	-	38.0-122.0	77.0-85.0	Sep.-Mar.	-	Size at first maturity of *C. limbatus* 61 cm.
	-	*C. melanopterus*	-	69.0-81.0	Sep.-Mar.	-	
	-	*S. laticaudus*	36.0-76.0	53.0-59.0	Throughout the year		
	-	*S. lewini*	46.0-108.0	51.0-91.0	-		
Calicut							
Tunas	*E. affinis*	-	28.0-68.0	42.0-54.0	May & Aug.-Jan.	Sep.-Oct.	Size at first maturity of *E. affinis* 43.0 cm.
	-	*A. thazard*	-	-	Aug.-Oct.	-	*S. orientalis* also occur in this area.
Seerfishes	*S. commerson* -	-	40.0-126.0	50.0-88.0	May & Aug.-Jan.	Apr.-May	Size at first maturity 75.0 cm
		S. guttatus	30.0-60.0	-	Oct.-Nov.	Apr.-May	Size at first maturity 41.0 cm.
Mackerel	*R. kanagurta*	-	18.0-26.0	25.0-26.0	Aug.-Oct. & Jan.-Apr.	May-Aug.	Size at first maturity 20.0 cm. Juvenile mackerel occur during Aug.-Nov.
Cochin							
Tunas	*E. affinis*	-	36.0-68.0	44.0-50.0	May-Sep.	Oct.-Mar.	Juveniles of *E. affinis* occur during Jul.-Sep. Size at first maturity 42.0-43.0 cm.
	-	*A. thazard*	22.0-46.0	30.0-36.0	Apr.-Nov.	Oct.-Dec.	Size at first maturity 30.0 cm (*A. thazard*).
	-	*T. tonggol*	20.0-56.0	around 42.0	-	-	*S. orientalis* also occur in this area.
Seerfishes	*S. commerson*	-	50.0-125.0	60.0-85.0	Jul.-Nov.	Jan.-Sep.	Size at first maturity 75.0 cm.
	-	*S. guttatus*	30.0-50.0	-	Sep.-Nov.	-	-

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pomfrets	*P. niger*	-	18.0-52.0	36.0-39.0	Aug.-Jan. & May	Sep.-Dec. & Feb.-Nov.	Size at first maturity 28.0 cm.
Carangids	*A. djedaba*	-	18.0-36.0	19.0-27.0	May-Oct.	Apr./Jul.-Nov.	Size at first maturity 18.0-18.9 cm.
	-	*M. cordyla*	16.0-82.0	27.0-33.0	Nov.-Dec.	Apr./Jul.-Nov.	Size at first maturity 27.0 cm.
	-	*D. russelli*	13.0-22.0	18.0-20.0	Jan.-Feb. & Jul.-Aug.	Apr./Jul.-Nov.	Size at first maturity 13.0 cm.
Mackerel	*R. kanagurta*	-	16.0-26.0	25.0-26.0	May-Feb.	Jun.-Aug.	Main fishery season coincides with monsoon months. Size at first maturity 22.0 cm. Juvenile mackerel common during Aug.-Nov.
Catfishes	*T. serratus*	-	74.0-110.0	84.0-108.0	Jun.-Oct.	Sep.-Oct.	Size at first maturity 60.0 cm.
	-	*T. thalassinus*	24.0-84.0	47.0-77.0	May-Oct.	Aug.-Oct.	Size at first maturity 37.0 cm.
	-	*T. tenuispinis*	30.0-52.0	42.0-46.0	May-Oct.	Apr.-Sep.	Size at first maturity 32.0 cm. During Jul.-Sep. females of *T. serratus* and *T. thalassinus* dominate the catfish catch.
Sharks	*R. acutus*	-	41.0-93.0	45.0-85.0	Apr.-Oct. & Dec.- Feb.	-	
	-	*C. melanopterus*	53.0-212.0	60.0-85.0	-do-	-	
	-	*R. oligolynx*	37.0-80.0	around 60.0	-do-	-	
	-	*C. limbatus*	62.0-108.0	-	Oct.-Nov.	-	
	-	*S. laticaudus*	29.0-56.5	-	Nov.-Dec.	-	
	-	*S. lewini*	48.0-102.0	50.0-95.0	Jun.-Sep.	-	
Vizhinjam							
Tunas	*E. affinis*	-	20.0-72.0	42.0-50.0	Sep.-Jun.	-	*S. orientalis* (12-52 cm), *T. albacares* (38-156 cm) and *K. pelamis* also occur in the catches.
	-	*A. thazard*	18.0-50.0	26.0-40.0	Feb.-Jun. & Sep.- Dec.	- -	
	-	*A. rochei*	16.0-30.0	-	Jul.-Dec.		
Mackerel	*R. kanagurta*	-	11.5-29.0	25.0-26.0	Variable	Mar.-Jun. & Sep.-Oct.	Fishery season variable : Aug.-Mar. ('89-'90); Mar.-Jul. ('90-'91); monsoon months ('91-'92). Juveniles occur during Aug.-Nov.
Seerfishes	*S. commerson*	-	-	-	Jun.-Oct. (mechanised units) Apr.-Jun. & Sep.-Nov. (Non mechanised units)		
Carangids	*S. crumenophthalmus*	-	-	-	Oct.-Mar.		D. macarellus a deep water carangid was caught by motorized units operated off Vizhinjam during Nov.-Mar.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	-	*D. russelli*	-	-	Oct.-Mar.	-	
	-	*A. mate*	-	-	Oct.-Mar.	-	
Catfishes	*T. thalassinus*	-	30.0-89.0	-	Jul.-Oct.	Jul.	Bulk of the catfish catch (94%) was obtained by bottom set gillnet and the rest by drift gillnet at Manakudi.
Tuticorin							
Tunas	*E. affinis*	-	28.0-76.0	-	Apr./May-Sep./Oct.		*S.orientalis* and *K. pelamis* also occur in the area.
	-	*A. thazard*	30.0-48.0	-	-	-	
Seerfishes	*S. commerson*	-	13.0-135.0	35.0-120.0	Nov.-Apr.		Smaller fish of 20-30 cm length are exploited off Tuticorin during Apr.-Sep. Young ones of *S. guttatus* are caught throughout the year. Growth parameters of *S. commerson* : L_∞= 192.8 cm, K = 0.2006 (annual) t_0= -0.0635 (annual). *S. lineolatus* was regularly caught off Tuticorin.
	-	S. guttatus	22.5-90.0	32.5-40.0	Jun.-Aug.		
Sharks	*L. macrorhinus*	-		60.0-90.0	-	Jan.-Apr.	Mainly caught in *Paruvalai*.
	-	C. sorrah		52.0-120.0	-	Jan.-Apr.	
Rays	*D. bleekeri*	-	60.0-78.0	-	May-Oct.	-	Caught in bottomset gillnet.
	-	*A. kuhlii*	12.0-37.0	-	-		Mainly caught in *Podivalai*. *A. kuhlii* of 25.0.-26.0 cm length onwards carried young ones in uterus measuring 62-100 mm disc length.
	-	*D. bleekeri*	19.0-46.0	-	-		
Catfishes	*T. dussumieri*	-	40.0-92.0	58.0-84.0	-	May-Jul. & Nov.-Mar.	Stomach contents were mainly holothurians.
	-	*T.thalassinus*	20.0-86.0	22.0-36.00 & 56.0-64.00 & 72.0-82.0	-	-	
	-	*T. serratus*	68.0-114.0	92.0-104.0	-		
	-	*T. caelatus*	16.0-40.0	21.0-34.0	-		
Mandapam							
Seerfishes	*S. commerson*	-	13.0-134.0	30.0-95.0(PB) 65.0-110.0 (GM)	Sep.-Mar./Apr.	-	Juveniles of 15-45 cm length occur in good abundance in Palk Bay during Jun.-Sept.
Tunas	*E. affinis*	-	22.0-66.0	28.0-54.0	Variable Jan.-Mar. or May-Oct.	-	*A. thazard* also occur in the area.
Mackerel	*R. kanagurta*	-	17.0-27.0	20.0-23.0	Sep.-Mar.	Aug. & Feb.-Mar.	Juvenile mackerel are abundant during Aug.-Nov.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Catfishes	*T. thalassinus*	-	32.5-77.5	60.0-77.0	Mar.-May & Sep.- Nov.	-	Females with ripe gonads were observed in March, August, Sept. and May.
	-	*T. serratus*	50.0-98.5	-	-do-	-	
	-	*T. dussumieri*	70.0-130.0	76.0-86.0	-do-	-	
	-	*T. caelatus*	34.0-52.0	-	-do-	-	
	-	*T. maculatus*	30.0-40.0	-	-do-		
Sharks	*S. pelasurrah*	-	10.0-109.0	40.0-69.0	Feb.& May-Dec.	May-June	Two young ones were noted per litter.
	-	*L. macrorhinus*	-	around 62.0	-do-	-	*C. molluccensis* was also recorded in this area.
	-	*C. sorrah*	-	around 70.0	-do-	-	
Madras							
Seerfishes	*S. commerson*	-	30.0-125.0	45.0-90.0	Jan.-Jul.	-	
	-	*S. guttatus*	30.0-80.0	30.0-55.0	Jan.-Sep.	-	
Tunas	*E. affinis*	-	20.0-65.0	30.0-60.0	Jan.-Sep.	-	Stray catches of *K. pelamis*.
Catfishes	T. dussumieri	-	-	-	Around Apr.	-	
Sharks					Jan.-Sep.	-	
Visakhapatnam							
Mackerel	*R. kanagurta*	-	10.5-30.0	18.5-22.5	Oct.-Mar.	Feb.-Jan. & Aug.-Sep.	Juvenile mackeral occur mainly during Aug.-Feb. *R. kanagurta* beyond 19.4 cm length accounted for 96-99% of gillnet catch. Growth parameters : L_∞ = 29. 194 cm; K=1.3824 (annual) ; t_o =0.0152 years; L_{max} = 27.74 cm. Life span of 5 years; effective life span 2.5 years. Length-weight relationship log W=-5.0817 + 3.3066 Log L (r = 0.998). Food consists, mainly of phytoplankton.
	-	*R. faughni*	10.5-30.0	18.5-28.0	Mar.-Jun. & Sep.-Nov.	Around Mar.	
Carangids	*Alepes djedaba*	-	-	-	-	-	Growth parameters of *M. cordyla* L_∞ = 41.9 cm. K = 0.9475 yrs. t_o = -02148 years.
	-	*M. cordyla*	-	-	Aug.-Dec.	-	
		D. russelli	-	15.0-19.0	Jan.-Feb. & May	-	
Seerfishes	-	-	-	-	Sep./Oct.-Jan./Feb.	-	
Catfishes	*T. thalassinus*	-	24.0-45.0	-	May-Jun.	-	

in Maharashtra and Orissa; second rank in West Bengal and third rank in Gujarat. Their contribution is somewhat significant in Goa and Andhra Pradesh also.

The *Indian mackerel* takes second rank in LMG landings in Karnataka, Kerala and Tamil-Nadu; fourth rank in Goa and Andhra Pradesh. Appreciable amounts of mackerel are also landed in Maharashtra and Pondicherry.The contribution of tunas is significant only in a few states. It takes first rank in Pondicherry though LMG landings themselves are quite moderate here compared with the other larger states; third rank in Kerala and Tamil Nadu and fourth rank in Karnataka. Its contribution is quite significant in Gujarat. Appreciable amounts are landed in Maharashtra and Goa also. Elasmobranches contribute significantly to the state's LMG landings in Andhra Pradesh, Gujarat, Maharashtra, Orissa and Pondicherry.In Tamil Nadu, Karnataka and Goa also this group accounts for fairly good landings. Catfishes, like the pomfrets, contribute quite significantly along the coasts of West Bengal-Orissa and Gujarat-Maharashtra. The other important groups met with in this gear are the carangids, croakers, ribbonfishes and others. These and other groups though not significant in their overall composition, contribute in considerable amounts in certain regions. Thus carangids in Gujarat, Kerala, Tamil Nadu and Andhra Pradesh; croakers in Gujarat, Andhra Pradesh and Orissa; ribbonfishes in Gujarat and Maharashtra; billfishes, barracudasand flying fishes in Pondicherry; and penaeid prawns in Andhra Pradesh form the other important groups landed by the large mesh gillnet.

From Table 3 it may be noted that seerfishes, pomfrets, tunas, elasmobranchs and catfishes which occupy a lower rank in their contribution to the total marine fish landings of the country come to occupy seventh rank in the LMG landings. The same situation applies to wolf herrings, hilsa shad, other shads and other clupeiods, which form the dominant clupeoid fish catch in the LMG landings, though they together account for less than 5 % of the total marine fish landings. This situation is noticeable in different states. In the overall composition of the marine fish landings in Orissa, for example, croakers take the first rank followed by clupeoids, catfishes, pomfrets, elasmobranchs and prawns, seerfish taking the ninth rank. In the LMG landings of this state, however, as mentioned earlier, pomfrets take the first rank followed by clupeoid fishes, catfishes, seerfishes and elasmobranchs. Similarly in the total marine fish landings of Karnataka the clupeoid fishes take the first rank followed by mackerel, carangids, prawns, perches, ribbonfishes and catfishes while tunas, seerfishes and elasmobranchs take about the 10th, 12th and 13th ranks respectively. However, seerfishes take the first rank in the LMG landings followed by mackerel, clupeoid fishes, tunas and elasmobranchs. Thus the large mesh gillnet with appropriate size of mesh can be an effective gear to exploit the large sized clupeoids, seerfishes, mackerel, pomfrets, tunas, elasmobranchs and catfishes.

Species of constituent groups

The species constituting the different groups varied in the different states. Thus the notable constituents of the clupeoid group, mentioned in decreasing order of importance, were the other shads, wolf herrings and other clupeoids in Gujarat; other clupeoids and wolf herrings in Maharashtra; wolf herrings and other clupeoids in Goa; oil sardine, other sardines and wolf herrings in Karnataka and Kerala; other sardines, oil sardine, anchovies, wolf herrings and other clupeoids in Tamil Nadu and Pondicherry; other sardines, other shads, other clupeoids, oil sardine and wolf herrings, in Andhra Pradesh; hilsa shads, wolf herrings, other clupeoids and other shads along the Orissa and West Bengal coast.

Scomberomorus guttatus takes precedence over *S. commerson* in Gujarat, Maharashtra, Goa, West Bengal, Orissa and Andhra Pradesh while the latter is dominant over the others in the other states. Similarly, the silver pomfret, *Pampus argenteus*, dominates over the black pomfret, *Parastromateus niger* along the West Bengal-Orissa and Maharashtra-Gujarat coasts and the latter species along the rest of the Indian coasts.

The little tunny, *Euthynnus affinis* is the common and dominant species of tuna in most of the maritime states of the main land of India. While the long-tail tuna, *Thunnus tonggol* forms the second important species along the stretch of the Gujarat-Karnataka coast, *Auxis* spp. take their place in Kerala, and *Kastuwonus pelamis* in Pondicherry. *Thunnus albacares, T. obesus* and *Sarda orientalis* are the other tunas met with in the LMG landings.

Sharks dominated the LMG elasmobranch landings. *Rhizoprionodon acutus, R. oligolynx, Carcharhinus melanopterus, C. limbatus, C. sorrah, Scoliodon laticaudus, Loxodon macrorhinus, Sphyrna lewini* are the important species of sharks met with along the Indian coast. Seven species of catfishes are on record from gillnet landings. *Tachysurus tenuispinis, T. thalassinus (T. bilineatus), T. dussumieri* are almost continuous in their distribution along the Indian coasts, their relative composition varying from year to year in the same locality. Other species are patchy in some areas. Thus *T. serratus* occurs mostly along the southwest coast while *T. caelatus* and *Osteoganeosus militaris* occur along the N.E. and *N.W. coasts; and T. sona* along the Mumbai coast.

Small mesh gillnet

Clupeoid fish group not only occupies the first rank in the SMG landings in all the states but its overall composition (45 %) far exceeds that in the LMG landings resulting in decreased contribution by the other groups. Thus three other groups namely, the Indian mackerel, croakers and carangids only contribute significantly to the SMG landings of the country besides penaeid prawns, catfishes, elasmobranchs, seerfishes, pomfrets, ribbonfishes, silver bellies, crabs and *Lactarius* which occur in some areas in smaller quantities.

The small sized clupeoids that occur in the small mesh gillnets namely, the other sardines (lesser sardines), oil sardine, anchovies and smaller clupeoids, together from about 20 % in the total marine fish landings. They make up 50-60% in the SMG landings in Kerala, West Bengal and Pondicherry; 45-50 % in Tamil Nadu, Andhra Pradesh and Orissa and 25-40% in the other states. The contribution of this group far exceeds the group that stands next to it in the SMG landings in most states except in Maharashtra where the difference is only about 5 %. As stated earlier, the SMG is not in common use in commercial fishing in Gujarat.

Mackerel, catfishes and croakers also come to occupy higher ranks in this gear compared to their respective ranks in the total marine fish landings. The Indian mackerel stands next to the clupeoid group in all the southern states with its maximum contribution in Tamil Nadu followed by Pondicherry, Andhra Pradesh, Karnataka and Kerala forming 8-25 % of the SMG landings. The contribution of croakers is fairly high in Maharashtra followed by Goa, Karnataka, Andhra Pradesh and Orissa accounting for 5-25 % of the SMG catch. Carangids' contribution is significant in Goa followed by Orissa, Karnataka, Kerala and Pondicherry forming 5-10 % of the SMG landings.

Though several other groups are present in this gear they individually do not contribute significantly to the country's SMG landings on the whole; only one or two groups contribute appreciably in some states. Thus contributions by penaeid prawns in Maharashtra and Karnataka; catfishes in West Bengal and Orissa; elasmobranchs in Andhra Pradesh and Maharashtra; young seerfishes in Orissa, Andhra Pradesh, Karnataka and West Bengal; pomfrets in West Bengal and Orissa; ribbonfishes in Orissa and Andhra Pradesh; silver bellies in Goa and Karnataka; crabs in Goa and Tamil Nadu; *Lactarius* in Karnataka and Goa are noteworthy.

From Table 3 it may be noted that the clupeoid fish group which takes the first rank in its percentage contribution in the SMG landings far exceeds its composition in the total marine fish landings. Though the Indian mackerel and croakers come to enjoy higher percentage composition and thus higher ranks in this gear (SMG), their percentage composition is only slightly higher than in the total marine fish landings. Carangids retain their rank but fall short in percentage composition. Catfishes come to occupy a higher rank with higher percentage composition than in the total marine fish landidngs. Crustaceans with their significant contribution to the SMG landings fall short in their rank and percentage composition compared to those in the total marine fish landings. These comparisons make clear that the small mesh gillnet, using appropriate size of mesh could be an effective gear to catch mainly the small sized clupeoid fishes besides the Indian mackerel, croakers and catfish.

Marine mammals encountered

It is not surprising to fishermen in certain sections of the Indian coast to encounter marine mammals as well as the whale shark, *Rhynchodon typus* in some seasons. Records of their landings and strandings along the Indian coast are too numerous to mention in detail except to list here the species of the whales, dolphins, porpoises and sea cow met with in recent years.

Whales

Physeter catodon (Syn. *P. macrocephalus*), *Pseudorca crassidens Balaenoptera borealis*, *B. musculus*, *B. physalus*, *B. acutorostrata*, *Globicephala macrorhynchus*.

Dolphins

Delphinus delphis, *Sousa chinensis* and *Tursiops aduncus*, (Syn. *T. truncatus*).

Porpoises

Neophocaena phocaenoides.

Sea cow

Dugong dugong

(The first three species of whales and the first two species of dolphins were more frequently recorded than the other mammals. The records relate to strandings in living or recently dead condition or to those that got washed ashore. Instances of getting entangled in drift gillnets/fishing nets were met with only in the case of sea cow and dolphins which were incidental. Thus fishing by drift gillnet or other units in the Indian coastal waters poses no threat to the larger marine mammals as in the Pacific, Atlantic and Indian Oceans).

Economics of drift-net fisheries

The salient findings of a study carried out from July 1991 to June 1992 on the costs and earnings of mechanised gillnetters operating in Chennai area and motorised plank built boats operating gillnets in Tuticorin area are outlined here. Crafts employed in Chennai area have 10 and 12 m OAL and are engaged in one-day and two-day fishing respectively. Those in Tuticorin area range between 10 and 13 m fitted with 20 HP engine. Mesh size of net is 10-14 cm. Each gillnet unit at both the centres are manned by 5-6 crew. 50 % of the net returns at Tuticorin and 40 % at Chennai are given as labour share.

The average capital investment of gillnet units operating at Chennai and Tuticorin is given in Table 5. The average initial investment is about Rs. 3.1 lakh for 10 m size boats engaged in single day fishing and Rs. 4.0 lakhs for 12 m size boat engaged in two day fishing in Chennai; and Rs.1.58 lakh for a Tuticorin type boat fitted with 20 HP engine.

The annual expenditure comprising fixed costs (depreciation of the fishing unit) and variable costs (operational expenses) were estimated (Table 6). The average fixed costs came to about Rs. 82,750/- for 10 m unit; Rs.104,666/- for 12 m unit and Rs. 48,366/- for Tuticorin type unit. The average annual variable costs came to about Rs. 5.03 lakh, Rs. 4.68 lakh and Rs. 66.6 thousand respectively for the above three types of fishing units. Labour costs to crew came to about 64, 55 and 50, and fuel expenses about 22, 27 and 19 % of the operational costs for the three types of units respectively.

The percentage contributions to the gross earnings (revenue) from the different varieties of fishes landed by gillnet for the three categories of fishing units are given in Table 7. Seerfishes contributed to 60-65 % of the gross earnings in Chennai area. But at Tuticorin, tunas contributed to about 40 % followed by seerfishes 21 % and carangids 20 % of the gross earnings of the gillnet units.

Table 5. *Average capital investment (Rs.) of a gillnet unit at Madras and Tuticorin regions of Tamil Nadu (1991-'92)*

Item	Initial investment		
	Madras		Tuticorin
	Single day fishing units (10 m)	Two day fishing units (12 m)	Tuticorin type boats
Craft	1,20,000	1,60,000	43,000
Engine	82,500	1,20,000	8,875
Gear	1,00,000	1,10,000	1,04,375
Other accessories	7,500	10,000	2,000
Total	3,10,000	4,00,000	1,58,250

Table 6. *Annual income and expenditure statement of gillnet units at selected centres of Tamil Nadu (1991-'92)*

Item	Madras		Tuticorin
	10 m OAL	12 m OAL	Tuticorin type boat
1. Annual fixed cost			
Interest (15%)	46,500	60,000	23,738
depreciation			
Craft (6.6%)	8,000	10,666	2,866
Gear (20%)	20,000	22,000	20,875
Engine (10%)	8,250	12,000	887
Sub total	36,250	44,666	24,626
Total	82,750	1,04,666	48,366
2. Annual operating expeditre			
i. Wages	3,01,334	2,38,497	29,512
ii. Loading, unloading & transportation	46,272	31,848	-
iii. Fuel	18,441	21,411	1,798
(Q (litre) V (Rs.)	1,08,411	1,25,837	12,584
iv. Auctioning	4,635	2,446	6,139
v. Bata	18,444	20,392	3,810
vi. Ice	-	31,568	-
vii. Repairing & maintenance	20,000	15,000	10,000
viii. Others	3,445	2,362	4,595
Total	5,02,541	4,67,950	66,640
3. Catch (kg)	53,732	40,043	11,620
4. Revenue (Rs)	9,34,542	8,10,697	1,06,960
5. Net operating income (Rs)	4,32,001	3,42,747	40,320
Actual fishing trips	190	115	140

Table 7. *Revenue composition by different varieties of fish in gillnet units, (1991-'92)*

Fish groups	Madras		Tuticorin
	10 m	12 m	Tuticorin type boats
Elasmobranchs	15	12	13
Seerfish	60	65	21
Tuna	15	12	40
Carangids	5	6	20
Perches	2	1	2
Others	3	4	4
Total	100	100	100

Table 8. *Key economic indicators for gillnet units*

Particulars	Madras		Tuticorin
	10 m	12 m	Tuticorin type boats
Average number of fishing trips in a year	190	115	140
Average catch per trip (kg)	283	348	83
Average revenue per trip (Rs)	4,919	1,050	764
Average value received per kg of fish (Rs)	17.38	20.26	9.2
Quantity of fish produced per man per trip (kg)	47	58	14
Value of production per man-trip (Rs)	817	1.175	76
Average remuneration received by a labourer per trip (Rs)	281	375	40
Quantity of fish produced per litre of fuel (kg)	2.91	1.87	6.46
Average fuel cost per trip (Rs)	571	1,094	90
Fuel cost per kg of fish (Rs)	2.02	3.14	1.08
Average operating cost per trip (Rs)	2,645	4,069	476
Operating cost per kg of fish (Rs)	9.35	11.69	5.73
Average total cost per trip (Rs)	3,080	4,979	821
Total cost per kg of fish (Rs)	10.88	14.30	9.89
Capital turnover ratio	3.01	2.03	0.68
Rate of return to capital (%) (Net profit + interest) / Average capital investment	126	93	10
Pay back period (years)	0.8	1.1	9.5

Some of the key economic indicators for gillnet units operating at Chennai and Tuticorin worked out on the basis of costs and earnings are given in Table 8. Since the acquisition of cost of capital was about 15 %, investment on gillnet units in Chennai area appears to be profitable. But the Tuticorin type of boat operating gillnets required further improvement and diversification for its sustainability and also increase in their fishing trips to become economically viable. The study further indicates that the mechanised gillnetters are efficient in terms of their productivity and profitability.

Estimation of resource potential and fishing effort

An attempt was made to study the stock by using the catch and standardised effort of gillnets for the period 1985-'92. These data were pooled over the period of study and the catch per standard effort (C/SE) was computed for each year and plotted against standard effort. When the scatter of the plot showed a clear trend, an attempt was made to fit the surplus production models of Schaefer and Fox and to estimate the coefficients by linear least square and estimates of MSY and corresponding f(MSY) were obtained for each state separately as given below:

State	Estimates of	
	MSY	f(MSY)
West Bengal	30,016	35,274
Orissa	Estimation was not feasible	
Andhra Pradesh	4,950	44,439
Tamil Nadu	28,651	845,952
Pondicherry	Estimation was not feasible	
Kerala	-do-	
Karnataka	4,454	59,588
Goa	Estimation was not feasible	
Maharashtra	- do -	
Gujarat	95,810	20,92,094

The salient features of the results of analysis are as follows :

For West Bengal, the level of exploitation by gillnet has crossed the MSY level during 1985-'88 and in 1992. For Andhra Pradesh the gillnet effort has crossed MSY level during 1990 - '92. In Tamil Nadu the level of exploitation by gillnet has exceeded the MSY in 1988. In Karnataka the standard effort (SE) exceeded the f(MSY) level in 1989 but in all the other years the exploitation was below the f(MSY) level. In Gujarat the standard effort crossed the f(MSY) level in 1992.

Environmental factors in relation to fish catches

Environmental factors like temperature, salinity and dissolved oxygen content of surface waters, rainfall and zooplankton volume were examined for their relation with large mesh gillnet fish landings in general and with particular reference to scombroid fishes namely, mackerel, tunas and seerfishes. Though this study was not a comprehensive one, a few associations between good landings of the above groups of fishes and the environmental features have been pointed out to serve as a basis for further studies. These results presented relate to six observation centres of the CMFRI.

Visakhapatnam

Good catches of mackerel were caught when water temperature suddenly decreased by 2°C as during October 1991 although the lowest value of temperature was noted in January 1992. Similarly during the post northeast monsoon period of 1992 (January-February) also coincided with the starting of the upwelling and better catches of mackerel.

Mandapam

On the Palk Bay side the unusually low temperature, high salinity and low dissolved oxygen content that occurred during the northest monsoon of 1991-'92 coincided with the unusually high catch of mackerel and tuna as well as other fishes. Similarly, during March '91 when surface temperature showed a sudden increase by 2°C good catches of tuna were encountered.

On the Gulf of Mannar side upwelling as observed during November 1991, was associated with highest catches of mackerel, seerfishes and total gillnet catch. The upwelling in turn was associated with lower temperature, higher salinity and lower dissolved oxygen content. Subsequently, just after peak NE monsoon (January-February '91) an increase in the catch of tuna was more pronounced when there was a sudden increase in salinity from 30 ppt in December 1990 to 30.5 ppt in January 1991.

Tuticorin

Sudden fluctuations in temperature and salinity that occurred during the moderate upwelling period of June-August 1989 were associated with very good landings of seerfish and tuna.

Vizhinjam

An abrupt increase in temperature in July '91 during the course of its usual gradual declining trend from May to August /September was associated with very good catches of seerfish and tuna. Good catches of seerfish were associated with monsoon and this was evident from the fact that the season of good catches of seerfish got advanced when occurrence of monsoon was advanced in the area. However, when the temperature declined unusually (as during August 1990) to 23°C there was marked decrease in the availability of seerfish as also of other fish in the fishing ground.

Cochin

Fish abundance appears to be related more to rainfall than to upwelling. A positive cross correlation has been found to exist between catch and higher salinity due to upwelling from lag 3 to lag 5 (i.e., the correlation between salinity and total catch was positive from lag 3 to lag 5). Higher catches were associated with lower salinity in the monsoon period. But during the premonsoon period higher catches were associated with higher salinity. Higher catches of fish were obtained in the monsoon during upwelling when temperature was low. Low catches occurred when temperature was high during premonsoon period. High catches were associated with dissolved high oxygen content. But during upwelling when O_2 was low the catches were high. Higher positive relationship was seen between monsoon and total catch than with upwelling and total catch. Rainfall and total catch was positively correlated, though weak, for lag 1. Rainfall and upwelling had the same relation with mackerel catch as well as with total catch. But with rainfall mackerel showed a higher correlation than total catch, seerfish or tuna. However, early start of monsoon say in May had a positive effect on the landings of mackerel than the magnitude of rainfall. Between seerfish and tuna the catches of the latter were more closely related to rainfall. Mackerel had higher negative correlation with salinity than seerfish and tuna for lag 1. The relation between zooplankton volume and tuna catch was high. Zooplankton volume was positively related to total catch for lag 1. In the case of seerfish good catches were related more to high zooplankton volume for lag 1 than to rainfall and upwelling.

Mangalore

In the post-monsoon months higher catches of tuna, seerfish and mackerel as well as total gillnet catch were obtained after a lag period of one or two months of upwelling associated with good rainfall. However, it appears that in predicting the mackerel fishery the rainfall during May also needs to be taken into account. Correlation between rainfall and fish catch was more with mackerel than with seerfish and other catches by gillnet. This fact gains support from the high negative correlation obtained between salinity and mackerel catch. A sharp rise in temperature after a steep fall appears to trigger increase in the catches of seerfish and tuna in inshore waters. Postive correlation was noticed between monsoon and tuna catch than with seerfish. Similarly, zooplankton volume was positively correlated to total gillnet catch for lag 1.

Not withstanding the foregoing relations between individual factors, the overall net effect of all the several aspects together on the catches of mackerel, tuna or seerfish either singly or combined remains to be investigated for a fishery zone.

General remarks

The gillnet fishery of India in the commer cial sense comprises small scale localised operations as no modern technology and large scale capital expenditure are applied to catch, store and process the fish on board the fishing boat or at the landing centres (Nielsen and Lackey, 1980). Fishing by small mesh gillnet with its catch contributing to a mere 4 % of the total marine fish landings or about 27 % of the total gillnet catches of the country remained essentially a subsistence fishery (Nielsen and Lackey 1980). Only manual labour being employed in this type of fishing; the craft as well as methods of capture by this gear remained unchanged over the years. On the other hand, some innovations are being made by the large mesh gillnetters as they get good results in productivity and profitability accompanied by some favourable changes in the pattern of the fish landed. For example, Gopakumar and Sarma (1989) have reported that motorization of the country crafts - traditionally operating drift gillnets - at Vizhinjam (Trivandrum) has increased tuna production in relation to the other groups besides bringing about a change in the pattern of species abundance of tuna catches in that area. At Calicut (Kerala) motorization of country crafts has increased the landings of the tunas and seerfishes though landings of the other groups like catfishes, pomfrets and sharks have been affected (Sivadas, 1994). During the course of the present study it was observed that while at Veraval (Gujarat) catches of large sized sharks and scombroids such as *T. tonggol, T. albacares, S. commerson* and *Istiophorus* spp. as well as their landing trends have indicated the availability of vast potential of these resources in deeper waters, the picture obtained at Vizhinjam (Trivandrum) is somewhat disquieting. Here, as the effort of the motorised drift gillnet units gradually increased, the catch rates gradually declined from 63 to 46 kg. The impact of motorization on non-motorised units also has been rather appalling. Eventhough effort by the non-mechanised drift gillnets gradually decreased during this period it resulted only in corresponding decrease in its catch rate from 50 to 32 kg, thus signalling the inadvisability of increasing the effort by motorised drift net units in the presently exploited areas.

Taking into consideration the investment requirements of the gillnet fishing unit, the ownership pattern being practised at present, and the key economic indicators, the large mesh gillnet (motorised or non-motorised has proved to be efficient in the exploitation of the known off shore large pelagic fishery resources off the Tamil-Nadu coast. However, the need for innovations in the design and operation of these nets with specific mesh size each to exploit a different kind of the offshore fishery resource needs no special emphasis.

Occurrence of dolphins and other marine mammals in the large mesh gillnet is quite insignificant in the Indian seas. There is also no evidence that large mesh gillnet operations exert any adverse effect on the stocks of either anadromous fishes such as *Hilsa*, or the spawning stocks of other groups of marine fishes.

Fig. 8 presents an intriguing result obtained for West Bengal. Although the catch rate obtained by the large mesh gillnet in the other states generally corresponds to their relative total fish production by all the gear, in West Bengal it is far beyond reasonable expectations. This would cause one to seriously reflect whether a review of the present method of estimating fishing effort is needed for the State, taking into consideration the peculiar nature of transporting the catches made at sea to the final landing centre often involving intermediate fish assemblage centres and carrier boats. Fig. 8 further suggests scope to increase fish production by large mesh gillnet in most states where the level of the catch or the catch rate has exceeded that of the fishing effort, except in Kerala, Tamil Nadu and Andhra Pradesh. If this view could be tenable, then, there is little scope to increase fish production by increasing fishing effort by small mesh gillnet in most states except in Maharashtra, Goa and perhaps in Gujarat and West Bengal (Fig. 9). In spite of the higher fishing effort by the small mesh gillnets (Figs. 4, 5, 8 & 9) in other States, their relative contribution to the fish landings was not so significant. This is attributable to the low catch rates obtained by this gear. However, the small mesh gillnets undoubtedly play their role in the exploitation of the smaller clupeoid fishes such as the lesser sardines and anchovies, and also in sustaining the lower rung small scale fisherman in eking out his living.

A variety of small mesh gillnets and large mesh gillnets are employed in each State and throughout the country. They are to be standardised as to their relative fishing efficiency to obtain reliable estimates of resource potential and fishing effort needed for gillnetting. Refinement of this aspect demands the primary attention of all concerned.

Post-monsoon period (September-January) accounts for about 56 % of the annual fish landings along the west coast of India followed by pre-monsoon (February-May) 33 % and monsoon (June-August) 11 % although the different sections of the west coast showed variations in this regard. This impressive increase in the landings being witnessed during the post-monsoon period is on account of the maximum catch rates obtained by drift gillnets which in turn indicates availability of the resources especially of the pelagic groups (Alagaraja *et al,* 1992). These authors have also indicated the possibility of increasing marine fish landings by increasing gillnet operations in Gujarat during the monsoon period. The section of the southeast coast extending from Palk Bay to Kakinada and also northern section of the northeast coast of West Bengal afford drift gillnetting during the southwest monsoon period, unlike the other parts of the Indian coast.

In this connection mention may be made of the abundance of mackerel and other columnar fishes in the offshore waters of Andhra - Pradesh Orissa coast as reported by Sivaprakasam (1987). According to Reuben *et al.* (1989) mackerel and jacks make regular and constant contribution to the fish trawl landings in depths upto 180 m along the Andhra-Orissa coast. They also state that the landings of the above two groups fall much short of the potential yields. These results suggest scope to expand the fisheries of these two pelagic groups considerably through gillnetting along this section of the northeast coast.

Comparison of the catch composition of the two types of gillnets (LMG & SMG) shows that though the clupeoid group of fishes occupy the first rank in both, the ranks of the other catch components vary much. Even with the clupeoid group its relative composition in the LMG is barely twice that of the next group, while it amounts to four and a half times to the next group in the SMG. This contrast is on account of the relative abundance in nature of the particular clupeoid subgroups occurring in the two types of nets as revealed from the total marine fish landings from all the gear. Further, the clupeoid subgroups occurring in the LMG comprise species that grow to relatively large size as sub adults and adults compared to those that occur in the SMG, whose maximum size as adults does not usually exceed 20 cm. Bulk of the other species of fish caught in this gear are also small to medium size, largely planktivorous and of low average age compared to the fish caught in the LMG. These latter groups besides being longer in size are piscivorous (with the exception of clupeoids other than wolf herrings) and of higher average age. Hempell (1973) who found food-chain efficiency to decrease in increasing average age of fish population opines that the highest overall fish production could be achieved by keeping the stock in a high density and at low average age.

Although the trophic dynamic theory predicts that terminal production will decrease substantially with increasing length of food chain, according to Keer and Martin (1973) the ultimate yield of fish may be greater on a longer food chain due to lower metabolic expenditure when animals are preying on a longer food chain, as they have found production efficiency of piscivorous trout to exceed that of 56 % of planktivorous trout by a factor of two or more. They further add that food-chain shortening, atleast in oligotrophic environment, does not necessarly imply an increase in terminal production. However, Gulland (1973) has drawn attention to the fact that catches of several of the larger and more valuable species (as in the case of those caught by LMG) are approaching their upper limit and stated that potential for greater expansion of catches is among species lower in ecological pyramid, as in the case of fish caught by SMG. Therefore, the SMG may have a role to play in increasing fish landings and to maintain sustained fisheries development taking into consideration the apprehensions expressed by Luther *et al.* (1994) on the likely adverse effect of gillnet with less than 28 mm mesh size in the exploitation of lesser sardine fishery resources which form the bulk of the clupeoid fish landings. The point which may be emphasised here is that when fisheries based mostly on juvenile fishes are properly monitored throughout the geographical ranges of the species with a view to evolve suitable management measures, then employment of both the small and large mesh gillnet would be complementary to each other in the exploitation of the pelagic fishery resources. It may be noted from Fig. 3 that the contribution of the west coast to the country's small mesh gillnet landings is only 18 % compared to 54 % by the large mesh gillnet indicating some scope for increasing the effort by small mesh gillnet. However, this need is presumably being met through the extensive operations of purse seine, ring seine, dol net, boat seine, etc along this coast.

Though gillnet landings account for only about 15 % of the total marine fish landings their seasonal trend bears close similarity to that of the latter. This could be attributable to seasonal variations in their environment. Influence of weather on fish populations and their behaviour in general and of the southwest monsoon as well as the upwelling occurring around that period on the distribution pattern and movement of pelagic fish such as oil sardine and mackerel, as well as demersal fishes and prawns has been recognised (James, 1992). Recently, Longhurst and Wooster (1990) have correlated the abundance of oil sardine with upwelling on the southwest coast of India and sea level as an indicator of intensity of the upwelling and consequently on the oil sardine catch.

The present study which attempted to relate fish catches to prevailing environmental situation has also indicated some associations. Higher catches of mackerel, tuna and seerfish as well as total gillnet catches were noticed during the post-monsoon months after lag 1 or 2 months of upwelling associated with good rainfall. Total gillnet catches were associated more to rainfall during monsoon than to upwelling at Cochin showing positive correlation to rainfall for lag 1. Total catch as also landings of tuna and seerfish showed good relation to high zooplankton volume and seerfish indicated closer relation with zooplankton than with rainfall and upwelling after lag 1.

A sudden decrease in temperature was associated with a decline in the catches of seerfish and total gillnet catches but this seems to favour good catches of mackerel and tuna provided salinity was high. However, a sharp rise in temperature during the course of its rapid decline brought good catches of seerfish and tuna. Mackerel showed higher negative correlation with salinity than seerfish and tuna for lag 1 along the northern section of the southwest coast. However, total gillnet catches showed positive cross correlation with higher salinity due to upwelling from lag 3 to 5.

The above mentioned simple relations between the various environmental features and the availability of some of the important pelagic fishes do not, however, help in developing any prediction system as no attempts were made to seek for the cause and effect in these relations.

It may be relevant here to point to the observations of Murty and Vishnudatta (1976) that the fisheries of the oil sardine and mackerel along the southwest coast are associated with high salinity and moderate temperature and deeper thermocline. They further state that the dissolved oxygen content of the mixed layer having identical distributions over the seasons, as obtained along the southwest coast, may be regarded as ineffective in understanding the fluctuations in the catches of pelagic fishes. Murty (1965), however, has drawn attention to the fact that mackerel and other pelagic fish along the southwest coast have definite regional and seasonal trends in their distribution, due partly if not wholly, to the variations in the pattern of the coastal currents, the catches being maximum during winter season when the northerly drift gets established. Expressing the possibility of the pelagic fisheries of the Indian west coast being intimately related to the coastal drifts, Murty (1965) suggests that any effort to evolve a prediction system for pelagic fisheries along the west coast should take this factor into consideration. Broadhead and Barret (1964) have shown that currents and temperature effect the distribution and apparent abundance of yellowfin and skipjack tuna in the Eastern Pacific Ocean. Similar pattern of migration in relation to temperature dovetailing into the migratory movements of *S. guttatus* under the influence of currents in the Bay of Bengal has been pointed out by Srinivasa Rao (1985). Recently Luther (1994) has drawn attention to the possible relation between the pattern of sea surface circulation in the Bay of Bengal and its influence on the seasonal abundance of lesser sardines in the inshore waters of the north Andhra coast.

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