FISHERIES OF THE HOOGHLY - MATLAH ESTUARINE SYSTEM
AN APPRAISAL

CENTRAL INLAND CAPTURE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
Barrackpore 743 101 West Bengal

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PREFACE

The Hooghly-Matlah estuarine system, located within the State of West Bengal, India span into 0.8 million ha is forming one of the largest estuarine systems in the world. The system lies with the geographical coordinates, 20°35' to 23°20' N and 87°45' to 89° E, covering a network of many estuarine distributaries and creeks apart from the principal river, the Hooghly and its tribuitary, the Rupnarayan. The Hooghly-Matlah estuarine system, known for its high faunistic richness, forms the mainstay of the capture fisheries of West Bengal. It sustains a major multi-species commercial fishery providing a source of livelihood to several lakhs of fishermen and supporting a flourishing trade.

A survey for estimation of fish catch from this estuarine system was conducted during 1961-62 to 1977-78 by the Central Inland Fisheries Research Institute, Barrackpore. Since then, Commissioning of the Farakka barrage took place which resulted in major ecological changes and other associated factors. A sharp decline in the salinity pattern, greater extension of freshwater zone and changes in the species spectrum of the estuarine catch were evident. Therefore, a need was keenly felt to undertake a fresh survey to ascertain the changed catch and effort structure, catch per unit effort (CPUE) and major shifts in gear selection during 1983-84 to 1993-94. A major objective of the present investigation is to assess the effect of Farakka barrage on the fish production and fish catch structure with a view to evolving scientific management policies to ensure a high rate of fish yield. Attempts have been made by statistically analysing the earlier and recent data, to bring out the significant changes in the fishery resources of the estuary.

Authors

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CONTENTS

1. INTRODUCTION

The river Ganges has an extensive estuarine system covering the southern part of West Bengal and Bangladesh. The portion within the Indian territory in southern West Bengal comprises the Hooghly-Matlah estuarine complex. The principal component of it, *viz.*, the river Hooghly runs a winding course from its point of divergence from the parent river till it merges with the sea. On its way it receives river Rupnarayan, a major tributory alongwith the rivers Saptamukhi, Thakuran, Matlah, Gosaba, Bidya, Harinbhanga, Ichamati and Raimangal forming an estuarine complex. The lower portion of this estuarine system, a network formed by the main channel, its distributaries and anastomosary creeks, is known as the Sunderban delta. The rivers Saptamukhi, Thakuran, Matlah are now just inlets of tidal water with their upper connections lost due to siltation and neo-tectonic activities of 12th century. The Hooghly is a positive estuary in the mixo-haline range (Pantulu, 1966). This estuarine system supports commercial fisheries of considerable value.

The Hoghly-Matlah estuarine system with its deltaic region is one of the biggest estuarine systems of the world spanning across about 0.8 million ha in area. This region is rich in faunistic resources and forms the mainstay of the capture fisheries of India. The system lies approximately between 20° 35' and 23° 20' N and 87° 45' and 89°E (Mitra *et al.*, 1977). The tidal influence in the estuary is felt upto a distance of about 290 km from the sea face. This estuarine system, particularly its lower zone, sustains important multi-species commercial fisheries exploited by multi-gears.

A survey for estimation of fish catch from this estuarine complex was conducted by the Estuarine Division of Central Inland Fisheries Research Institute (CIFRI), Barrackpore during 1960-61 to 1977-78 and reported earlier (Dutta *et al.*, 1973 and Anon, 1972-78). Since then two major factors have significantly changed the fishery resources and the exploitation pattern of this estuary. These may be enumerated as :

i) The commissioning of Farakka barrage in April, 1975 has resulted in a major change in estuarine ecology and the associated environment. A sharp decline in salinity patterns, greater extension of freshwater zone, by squeezing telescopically the corresponding intermingling and marine zones, changes in the species spectrum of the estuarine catches, greater abundance of the freshwater species and decline or total absence of many of the neritic species from the upper estuary, are some of the resultant changes.

ii) The income from fishing *vis-a-vis* other sectroral engagements, in the fast developing urban complex of Calcutta, has undergone a change in depending operational costs and returns of gear and their catch structure.

In context of the above, a survey afresh was undertaken to ascertain the changed catch and efforts structure, catch per unit effort (CPUE), catch size patterns and major shifts of exploitation gear during 1983-84 to 1993-94. Aprat from assessment of fishery resources, fish population study were also undertaken. The objectives of the present investigations were to :

i) assess the effect of Farakka barrage on the structural changes in the fishery of the system, specially of the Indian shad, *Tenualosa ilisha*.

ii) evolve scientific management policies to ensure a high rate of fish yield specially of *T. ilisha* from the system,

iii) assess the extent to which there have been shifts in fishing efforts in recent years, and

iv) monitor the impact of ecological modifications on structure and abundance of commercial species.

Attempts have been made by statistically analysing the earlier and the recent data, to bring out the significant changes in the catch structures and other related details of the past and present.

2. METHODOLOGY

2.1 Stratification of the estuary

During the pre-Farakka period the tidal effect in the Hooghly estuary was felt upto Nabadwip. For the purpose of estimation of catch and considering variation in salinity, fishing effort and landing pattern, the Hooghly-Matlah estuarine system had been divided into

i) upper zone having salinity between 0.011‰ to 0.036‰ extending from Nabadwip to Baranagar on main channel,

ii) a middle zone between Baranagar and Diamond-Harbour on the main channel where salinity ranged from 0.020‰ to about 0.596‰,

iii) a lower zone including the entire estuarine area of the Sunderbans and the tract below Diamond Harbour on the main channel where salinity varied from 0.020‰ to nearly neritic values, and

iv) another zone containing the Rupnarayan tributary, joining the main channel about 19 km above Diamond Harbour and had salinity range of 0.043‰ to 1.025‰. Zones I, II and IV together constituted the upper estuary (Fig. 1).

These salinity regimes are no longer there in these areas after commissioning of Farakka barrage. Sinha *et al.* (1996) proposed new zonations of Hooghly estuary based on presently observed salinity regimes. However, for the sake of comparison old zonations were continued to be followed for this study too (Fig. 1).

2.2 Landing pattern of the catch

In the Hooghly estuarine system the fishing and landing patterns have the following characteristics. There is an extensive lower zone, having the most productive fishing grounds of the lower Sunderbans, and the less productive upper zone of lesser area. The main landings from this estuarine system are from the lower Sunderbans. The remote fishing grounds extend from the lowest part of the Hooghly, the main channel, on the west to Harinbhanga river on the east. The catches from such remote areas arrive mostly by country or mechanised boats to few assembly points situated upstream, well connected to Calcutta by road/rail. Namkhana, Diamond Harbour, Digha, Raidighi and Canning are such important assembly centres and their destination markets are in the city of Calcutta or suburbs. Almost the entire landings from the lower zone have been covered at the assembly centres, recording the data on a suitably designed and classified proforma (Schedule A) with a view to obtain the estimates of the landings, species-wise and gear-wise. The catch is landed at Namkhana, in ice-packed boxes, and is despatched to Sealdah and Behala markets in Calcutta due to which its species composition could not be recorded there. Hence, the markets at Sealdah and Behala were covered to gather the necessary data. Previously, the daily landings at each of the landing centre were enumerated for all the days of the month, involving a high number of standard man-days. At present systematic sampling has been introduced in such landing centres regarding days of observation with a view to reduce the number of man-days. The data on quantity of fish catch (species and gear-wise) were gathered from the records maintained by owners of fish assembly centres. Since the catch is generally landed in standard size baskets or packing boxes of specific capacities, the quantitative estimation is sufficiently accurate. Large specimens and economic species are usually sorted out before ice packing. Twenty-six fish species alongwith prawns and mackerel have been listed, considering their economic importance and contribution to total fish catch. Few other species contributing individually less than 1% of the total catch have been clubbed as 'miscellaneous'.

During winter season the fishing activity in the lower zone of the estuary increases and many temporary landing centres get established at Frasergunj, Jamboodwip, Bakkhali, Sagar, Lot no. 8, Falta etc. Therefore, the survey programme was correspondingly intensified at that time to cope up with the increased landings.

2.3 Sampling procedure

For the upper region of Hooghly estuary, which generally lies within the consuming region, such simplification as for the lower zone is not applicable. In the upper stretches both banks of the estuary have numerous fishing villages with some concentration of gears. Since the consuming area is situated very near to the capture, every village usually has a landing point where the fishes arrive. It was not possible to cover all these landing points at a time in any enumeration programme. Hence, a sampling approach had necessarily to be adopted, in which stratification has been effected, considering the fishing patterns. The upper stretches of Hooghly were divided into three strata with a view to achieve greater homogenity with respect to salinity and fishing pattern. Within each stratum, a number of fishing villages were selected on the following basis :

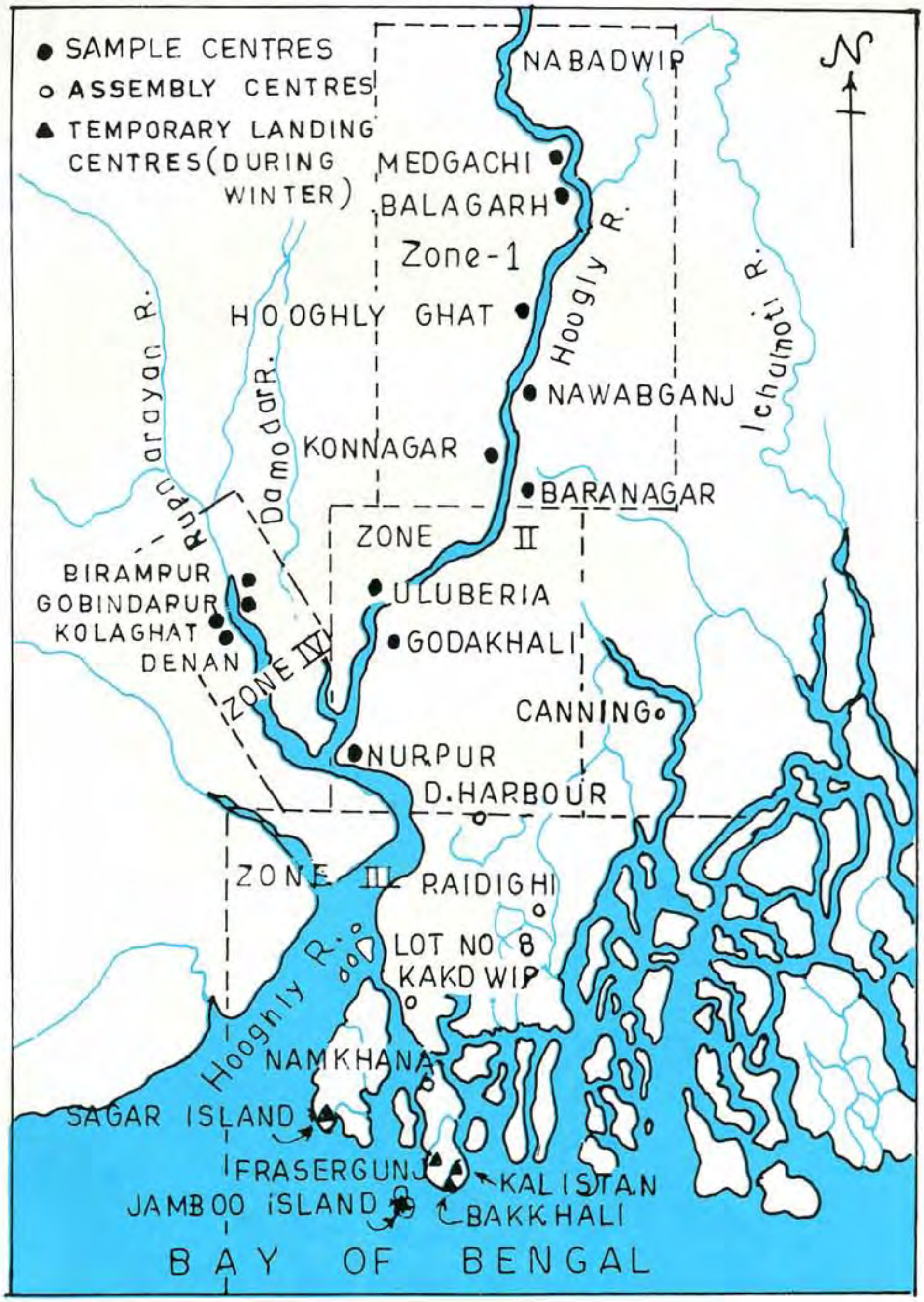
i) The villages were roughly classified as 'prosperous', 'medium' and 'poor' on the basis of concentration of fishing units. As far as possible, all these groups were represented in the sample.

ii) The villages were more or less distributed within the entire strata.

iii) All types of gears available in the stratum as a whole, was available in the selected village.

Prior to introduction of this programme, a complete inventory of craft, tackle and fisherman population in the villages on both the banks of the river in the different strata were prepared by actual enumeration. The sampling plan adopted utilized this inventory as a frame and also for final estimation. The method of sampling adopted for the upper stretch was a stratified multi-stage sampling, ultimate sampling units being the fishing units of different type of gear, selecting the villages within each stratum

FIG. 1 - HOOGHLY ESTUARY AND ITS VARIOUS FISHING ZONES



and then selecting the fishing units to be observed within each selected village. The fishing units which were ultimately brought under the purview of the sample may be considered to constitute a random sample of the total number of fishing units in the stratum. This was combined with a cluster sampling regarding days of observation. Each sample centre (i.e., village) was observed on two consecutive days per fortnight. A cluster of two days was randomly selected within each fortnight except that cluster of a gap of 15 days were not used (to eliminate the effect of tidal periodicity related to lunar phase). On a sampling day a surveyor recorded the number of each type of unit operating at the centre, catch and effort of all or a sample of them depending on the number of operating units, species-composition etc. on a suitably designed proformae (schedule B and B(1).

2.4 Estimation procedure

The estimated total catch of the lower zone (assembly centres) in a month is :

$$\hat{Y}_1 = \frac{N}{n} \sum_j \sum_{i=1}^{n} y_{ij}$$

where N = Total number of days in a month.

n = Number of sampling days selected by systematic sampling procedure,

y_{ij} = Total catch of the i^{th} day of j^{th} landing centre

Since the sampling methodology used to estimate the catch was a systematic sample of one cluster, no estimate of the variance can be formed from the sample. As suggested by Sukhatme *et al.*, (1984) considering the systematic sampling of one cluster as simple random sampling, the following formula was used to estimate the variance :-

$$[\frac{1}{n} - \frac{1}{nk}]S^2$$

where $S^2 = \frac{1}{n-1} \sum_{j=1}^{n} (y_{ij} - \bar{y}_i)^2$

is the mean square between units within the selected systematic sample, where Y_{ij} is the catch of jth sampling day of i th cluster, and y_i is the mean of i th cluster.

Total of variances of all assembly centres gives the estimated variance of the total catch of the lower estuary.

For the upper stretch, the estimation of catch at a sample centre (selected village) was made gear-wise.

Let U_{ijk} be the number of fishing units of i^{th} type of gear operating all the j^{th} sample village on k^{th} sample day,

C_{ijkl} be the catch taken by the i^{th} unit of j^{th} type of gear on k^{th} sample day at j^{th} village,

O_{ij} be the number of operating days of i^{th} type of gear at j^{th} village in a month.

Further, let $\bar{C}_{ij}$ be the average catch per fishing unit of effort of i^{th} type of gear at j^{th} village,

and $\bar{U}_{ij}$ be the corresponding average number of fishing units operating per day.

The $\bar{C}_{ij} \times \bar{U}_{ij} \times O_{ij}$ gives an estimate of the monthly total catch at the j^{th} village from i^{th} type of gear.

Hence $\Sigma_j C_{ij} U_{ij} O_{ij}$, the sums taken over the set of sample villages, gives the total catch from gear type 'i' in the set of sample villages.

If n_i and N_i represent the total number of units of i^{th} type of gear in the set of sampled villages and entire stratum respectively, then the zonal monthly catch from the i^{th} type of gear was estimated as :

$$\frac{N_i}{n_i} \sum_j \bar{C}_{ij} \bar{U}_{ij} O_{ij}$$

Combination of all the gears, *i.e.*,

$$S_m = \sum_i \frac{N_i}{n_i} \sum_j (\bar{C}_{ij} U_{ij} O_{ij})$$

gave the estimated monthly total catch of a stratum. Adding total monthly catch of three strata gave the estimate of total monthly catch of the upper estuary, *i.e.*,

$$\hat{Y}_2 = \sum_{m=1}^{3} S_m$$

Total monthly catch (Y) of the estuary was thus arrived at by adding total monthly catch of the lower zone and the upper zone, *i.e.*,

$Y = \hat{Y}_1 + \hat{Y}_2$.

3. FISHERY RESOURCES

3.1 Total fish yield

The Hooghly-Matlah estuarine complex is highly productive. The total estimated annual catch (Fig. 2) from the system fluctuated within 22, 143 to 41,569 m tons per year during the period 1984-85 to 1993-94, showing an increasing trend over the years. The decline in total yield during 1986-87 was mainly due to drastic fall in winter migratory bagnet fishery in lower estuarine zone. The year in question has been assigned the period covered between March to February which enables to account for the seasonal winter migratory bagnet catches during the month mid-October to early February. There has been significant sign of increase in catches over the years. Species-group yield also indicated increasing trend over the years (Table 1).

3.2 Month-wise catch structure

Although fishing in the estuary continues all through the year, the catches begin to increase from July with the onset of monsoon and reach a peak during the winter months of November to January (Fig. 3). Maximum catches (81.9%) were accounted during winter months of November, December and January, while the minimum catch (3.6%) were during the summer months of March to June.

Table 1 : Group-wise yield (in t) from the Hooghly-Matlah Estuarine system

Species group	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94
Clupieds	4492.1	3984.6	4948.4	7581.6	9454.8	6791.9	11958.1	10325.7	9621.1	10181.5
Catfishes	550.9	718.4	425.4	1021.2	895.3	477.1	1811.7	2148.2	1304.1	975.1
Polynemids	152.7	248.1	262.0	463.5	486.3	266.5	323.2	517.4	100.8	276.2
Sciaenids	3503.0	4484.9	1264.9	4091.0	6956.8	4058.3	5520.1	5207.8	4351.7	4291.6
Mullets	10.7	36.4	25.8	25.7	21.0	12.3	18.2	11.9	9.6	16.0
Ribbon fishes	4812.2	1471.8	1449.0	2487.3	3784.7	3974.5	1858.1	2151.8	4461.4	2798.6
Bombay duck	4143.5	5179.0	2548.9	4994.7	7998.9	4731.9	7069.4	4860.7	6247.0	5276.0
Prawns	2135.0	2050.1	2303.3	1996.6	3344.2	2686.5	2618.7	4366.2	2761.8	3973.7
Others	6244.8	5768.4	8915.5	8930.2	8580.0	10042.7	10391.9	7815.5	8042.5	6789.8
Total	***26044.9***	***23941.7***	***22143.2***	***31591.8***	***41522.0***	***33077.8***	***41569.4***	***37405.2***	***36900.0***	***34578.5***

FIG.2 TOTAL CATCH (t) FROM THE HOOGHLY-MATLAH ESTUARINE SYSTEM DURING 1984-85 TO 1993-94

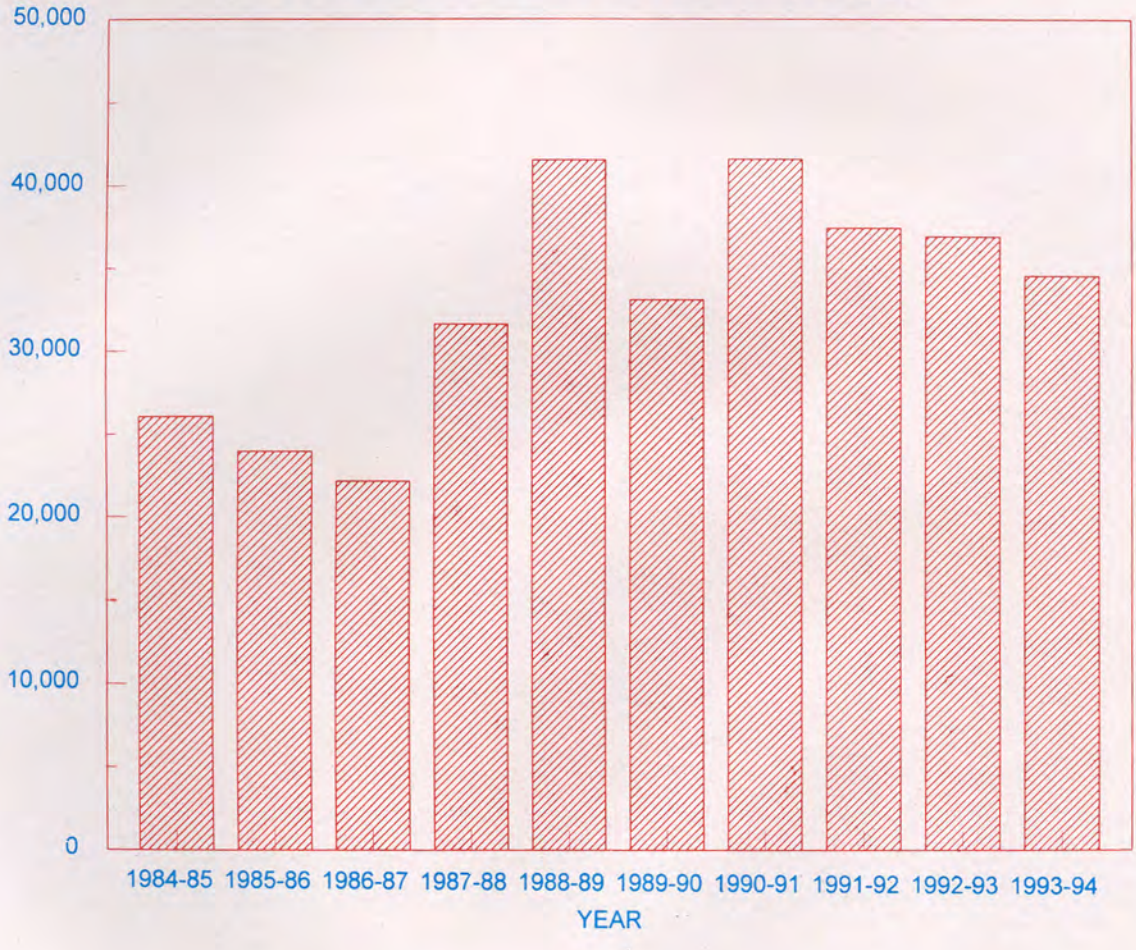


FIG. 3 AVERAGE MONTHLY LANDINGS IN TONNES FROM THE HOOGHLY- MATLAH ESTUARY

3.3 Species composition

Pantulu (1966) classified the Hooghly-Matlah estuarine fish fauna into residents and transients or migrants. Generally speaking the fish fauna can be broadly divided into three categories :

i) Marine species migrating upstream and spawning in freshwater areas of the estuary like *Tenualosa ilisha, Polynemus paradiseus, Sillago panijus* and *Pama pama.*

ii) Freshwater species which spawn in saline areas *viz., Pangasius pangasius* and the prawn, *Macrobrachium rosenbergii.*

iii) Marine forms coming into saline zone of the estuary for breeding, like *Tachysurus jella, Osteogeniosus militaris, Polynemus indicus* and *Eleutheronema tetradactylum.*

Besides prawn and mackerel, 26 species are mainly represented in the commercial catches of this estuary. A few species contributing less than 1% of the total catch individually in most of the years were clubbed as 'miscellaneous'. The important species are listed alongwith their percentage contribution to the annual landings during 1984-85 to 1993-94 in Table 2. Generally the dominant species were the Bombay duck *(Harpodon nehereus)* - 11.5 to 21.6%. ribbon fishes *(Trichiurus spp.)* - 4.5 to 18.5%, *Pama pama* - 5.2 to 16.2%, anchovies *(Setipinna spp.)* - 5.5 to 14.6%, Indian shad *(Tenualosa ilisha)* - 3.9 to 16%, prawns - 6.3 to 11.7%, *Coilia* spp., *Tachysurus jella* and *Sciaenea biauritus.*

3.4 Zone-wise catch structure

The three salinity zones (Fig. 1) demarcated on the basis of chloride concentration as Zone I (freshwater), Zone II and IV (negligibly saline) and Zone III (high saline), yield significantly different fish catches. Zones I, II and IV contribute together 6 to 10% of the total annual catch while the rest 90 to 94% comes from the lower estuarine zone (Zone III) with 2.52 to 6.20% and 3.1 to 3.94% coefficient of variation at the assembly centres and winter migratory bagnet fish catch respectively. Marine and neritic species like *Harpodon nehereus, Tachysurus jella, Osteogeniosus militaries, Polynemus indicus, Eleutheronema tetradactylum, Coilia spp., Sciaenea biauritus, Tenualosa ilisha, Lates calcarifer* and mullets, form the bulk of the lower zone catches. The hilsa *(T. ilisha)*, an active migrant, breeding in upper freshwater region of the Hooghly estuary, and some other active/passive migrants, like *Polynemus*

Table 2 : Percentage composition of different species in the total catches during different years

Species	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94
Tenualosa ilisha	4.98	4.54	12.89	3.88	4.30	4.50	16.01	11.43	8.85	9.99
Liza tade	*	0.01	0.01	0.01	*-	*-	*-	*-	*-	0.01
Liza parsia	0.04	0.15	0.10	0.07	0.05	0.04	0.04	0.03	0.03	0.04
Lates calcarifer	0.03	0.03	0.03	0.02	0.02	0.01	0.03	0.59	0.05	0.23
Sillago pajinus	0.06	0.14	0.08	0.14	0.04	0.04	0.10	0.24	0.05	0.23
Polynemus paradiseus	0.55	0.96	0.48	0.77	0.76	0.30	0.42	0.74	0.23	0.35
Polynemus indicus	0.02	0.04	0.58	0.61	0.39	0.47	0.18	0.57	0.03	0.41
Eleutheronema tetradactylum	0.01	0.03	0.12	0.09	0.02	0.04	0.17	0.08	0.01	0.04
Sciaena biauritus	0.27	2.53	0.50	1.87	0.87	0.25	0.60	0.51	0.38	3.59
Colia spp.	2.31	1.82	2.37	5.01	2.73	1.60	1.16	2.15	1.56	3.21
Pama pama	13.18	16.20	5.21	11.08	15.88	12.02	12.68	13.41	11.41	8.82
Tenualosa toli	0.02	0.39	0.28	0.26	0.09	0.04	0.18	*-	*-	0.01
Ilisha elongata	1.30	1.27	1.29	2.67	1.18	1.27	2.07	2.12	1.33	1.59
Chataeseus spp.	0.01	0.06	0.16	0.06	0.06	0.02	0.02	0.02	0.02	0.05
Mystus gulio	*-	0.01	0.02	*-	0.01	0.01	*-	0.04	0.04	0.03
Setipinna spp.	8.63	8.62	5.52	12.18	14.47	13.22	9.35	11.90	14.33	14.64
Chirocentrus dorab	0.02	0.17	0.65	0.30	0.19	0.31	0.68	0.49	0.20	0.18
Pangasius pangasius	0.04	0.08	0.01	0.03	0.05	0.01	*-	0.02	0.08	0.01
Tachysurus jella	2.07	2.85	1.77	2.43	1.87	1.29	4.11	5.02	3.24	2.42
Osteogeniosus militaris	*-	0.06	0.12	0.77	0.22	0.13	0.25	0.67	0.18	0.36
Lutzaneous spp.	0.02	0.01	0.05	0.07	0.05	0.03	0.03	0.01	0.02	0.02
Trichiurus spp.	18.48	6.15	6.54	7.87	9.12	12.02	4.47	5.75	12.09	8.09
Harpodon nehereus	15.91	21.63	11.51	15.81	19.26	14.30	17.01	13.00	16.93	15.26
Stomateus cinereus	1.04	1.05	2.11	2.13	2.15	0.49	4.66	2.25	2.70	2.96
Prawns	8.20	8.56	10.40	6.31	8.05	8.12	6.30	11.67	7.48	11.49
Mackerel	0.02	0.20	3.12	0.41	0.20	0.58	0.29	1.08	1.46	0.99
Miscellaneous	22.77	22.23	33.74	24.86	17.85	28.79	19.15	16.18	17.17	14.57
Freshwater fishes	*-	0.20	0.33	0.29	0.11	0.10	0.04	0.03	0.12	0.31
Total	***99.98***	***99.99***	***99.99***	***100.00***	***99.99***	***100.00***	***100.00***	***100.00***	***99.99***	***99.98***

paradiseus, Pama pama, Sillago panijius, migrating within the gradient and low saline zone, contribute to the middle zone fisheries of the system while in the upper zone the catch comprises of 'miscellaneous fishes' and prawns of both estuarine and freshwater origin. Zone-wise catch is depicted by the divided bar diagram (Fig. 4).

3.5 Fishery of important species

The most prized species of this estuary are *T. ilisha* amongst clupeids, *Liza parsia* and *L. tade* amongst mullets, *Penaeus monodon, P. indicus, Metapenaeus monoceros, M. brevicornis, Leander styliferus, Acetes indicus* etc. amongst prawns, *Eleutheronema tetradactylum* amongst polynemids and *Lates calcarifer* amongst perches. Size range and mean size range of some of these species are presented in Table 3.

3.5.1 Fishery of Tenualosa ilisha

T. ilisha forms the commercially most important fishery of the estuary and is seasonal in nature. The two main seasons of this fishery are monsoon (July/August to mid-October) and winter (mid November to January) when the fish ascends up the river. A sizeable quantity of persisting hilsa is also captured during spring months (February to March). The annual yields of this fish from this estuary are highly fluctuating and generally varied between 1,087 and 2,854 m tons forming 3.9 to 16% of the total catch.

Hilsa catches from Hooghly during 1990-91 was the highest (6655.9 m tons) recorded in the last decade and constituted 16% of the total fish yield from the estuary. The enormous catch of hilsa during 1990-91 is indicative of the fact that the Hooghly estuary shows a bumper catch of hilsa almost every ten year interval as is evidenced by the catch figures given below :

Year	Hilsa catch in m tons
1971-72	6573.3
1981-82	6886.0
1991-92	6256.5

For comparative study of hilsa catch a bar diagram which depicts catch from 1961-62 to 1993-94 (except 1978-79 to 1980-81, the figures for which are not available) is presented (Fig. 5). The landing data from 1961-62 to 1977-78 are taken from annual reports of CIFRI and Dutta *et al.*(1973).

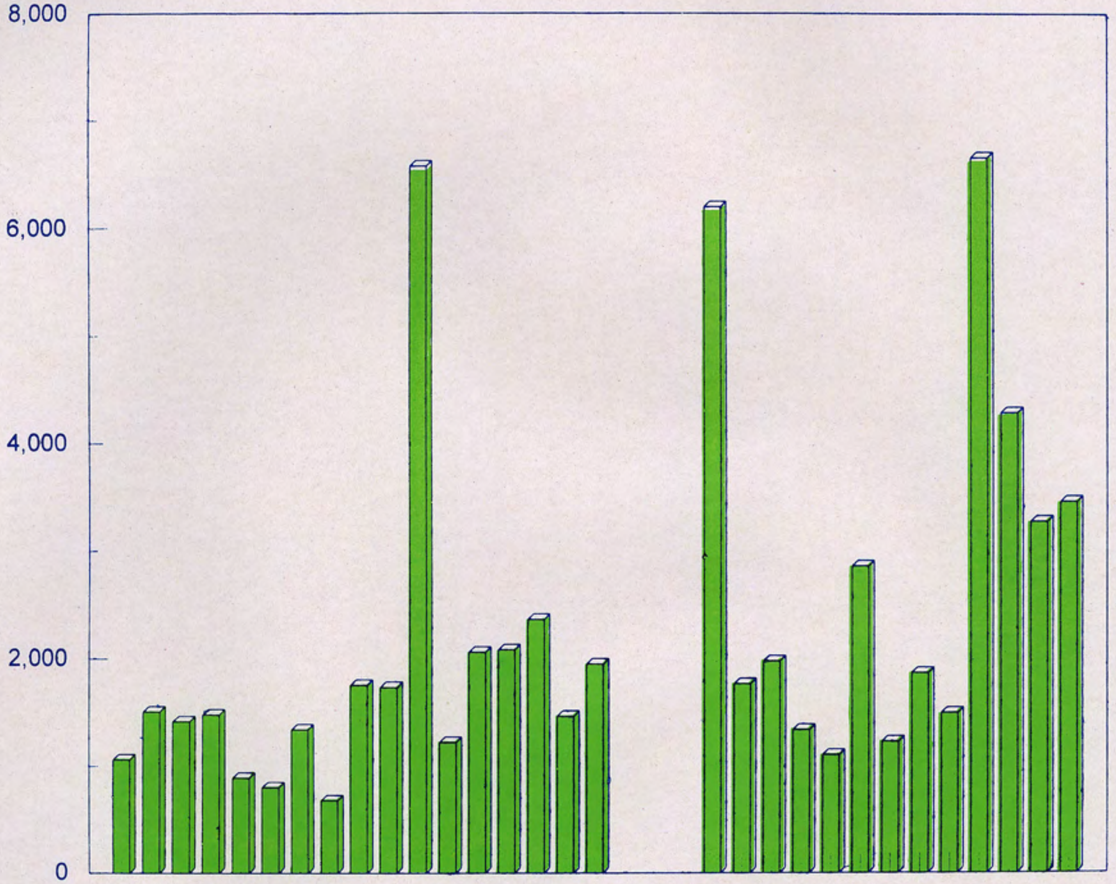
Table 3 : Size range and mean size of some important species

Sl. No.	Species	Size range (mm)	Mean size (mm)
1.	*T. ilisha**	210-550	356
2.	*P. paradiseus*	63 - 248	160
3.	*L. parsia*	48 - 193	106
4.	*P. pama*	20-230	115
5.	*L. calcarifer*	213-451	293
6.	*P. indicus*	183-401	263
7.	*H. nehereus*	51 - 290	174
8.	*Setipinna* spp.	40 - 180	121
9.	*Trichiurus* spp.	180-700	415
10.	*S. biauritus*	20 - 270	147
11.	*Coilia* spp.	30 - 230	123
12.	*T. jella*	60 - 210	122
13.	*S. cinereus*	90 - 290	187
14.	*I. elongata*	60 - 270	166

* Excluding juveniles

Excluding the catches from the winter migratory bagnet fishery, hilsa forms the mainstay of the estuarine fish catch, contributing 16 to 25% to total annual fish landing. In the monsoon months, the catches are obtained mostly through drift gill nets (locally called *chandi jal, nangar jal, kona, dholi* etc.) and during winter, the catches from the inshore areas of the lower estuary are available mostly through large seines (locally called *kochal jal, jangla jal*) as well as drift gill nets. Drift gill net, particularly *chandi jal* and purse net (locally called *sanglo jal*) are selective gears exclusively used for catching hilsa. In the upper estuary, particularly in Zone I, besides gill nets, small purse nets are also operated in both the hilsa seasons. CPUE (catch per unit of effort) of different hilsa gears is presented in Table 4. It can be seen therein that more the fish migrates towards upstream CPUE gradually decreases indicating that the uppermost point of the estuary is the breeding ground of hilsa. De (1986) also observed the same regarding its breeding ground.

FIG.5 HILSA CATCH OF HOOGHLY ESTUARY



1961-62 TO 1993-94

1978-79 TO 1980-81 PROJECT SUSPENDED

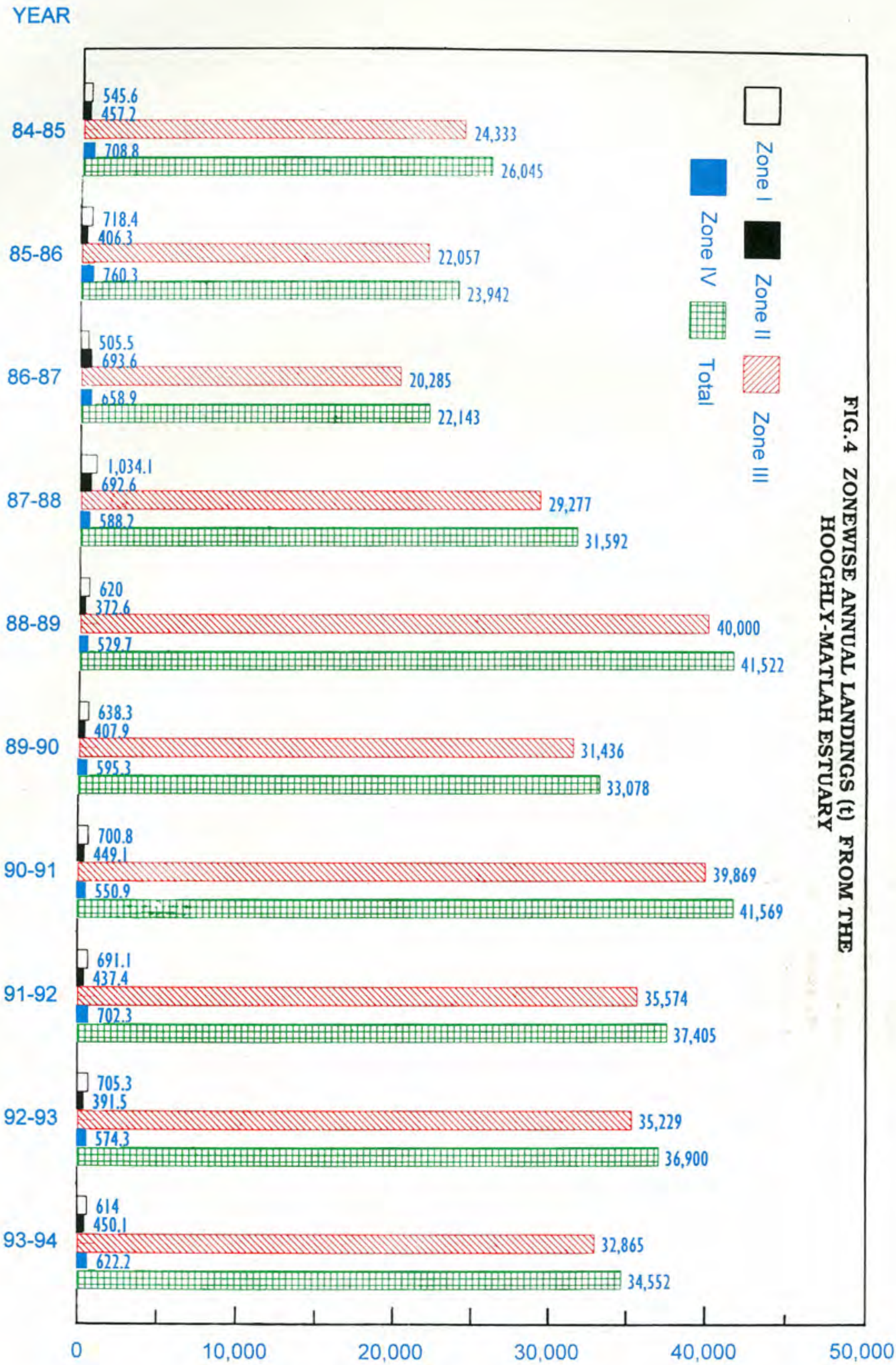


FIG.4 ZONEWISE ANNUAL LANDINGS (t) FROM THE HOOGHLY-MATLAH ESTUARY

Table 4 : Gear-wise CPUE of Hilsa in upper estuary during 1984-85 to 1993-94

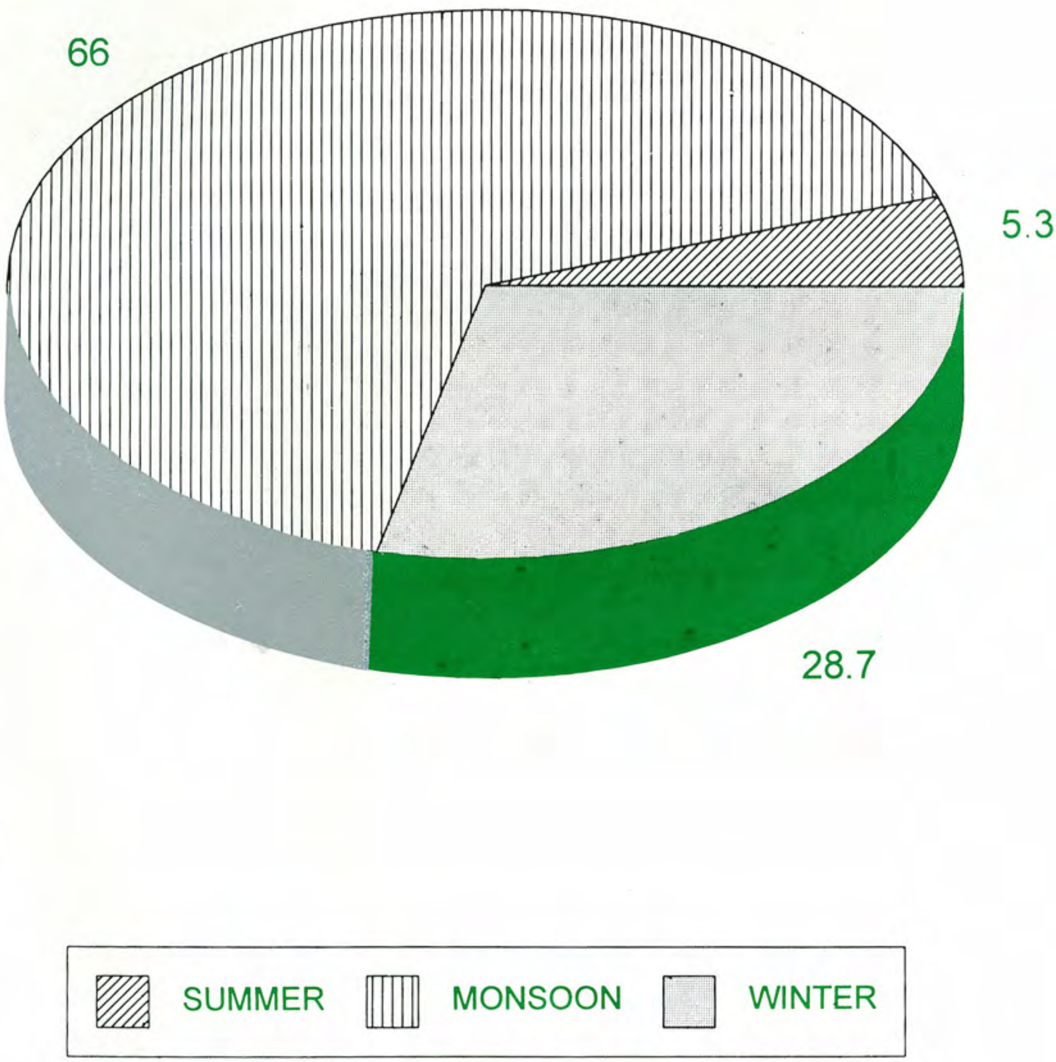
	ZONE I			*ZONE II*	*ZONE IV*
Year	Purse CPUE (Kg.)	Drift gill CPUE (Kg.)	Set gill CPUE (Kg.)	Drift gill CPUE (Kg.)	Drift gill CPUE (Kg.)
1984-85	0.22	0.32	0.74	1.57	0.92
1985-86	0.22	0.25	1.39	0.75	0.37
1986-87	0.36	0.32	1.36	1.16	1.13
1987-88	0.49	0.64	1.08	1.60	0.96
1988-89	0.61	0.42	1.65	1.06	0.97
1989-90	0.33	0.56	1.12	1.63	0.79
1990-91	0.47	0.68	0.89	1.82	0.69
1991-92	0.76	0.71	1.17	1.47	0.93
1992-93	0.67	0.88	1.11	0.59	0.88
1993-94	0.48	0.66	0.75	1.42	0.71

The monsoon (July to October) hilsa catch contributes 49 to 76% of the total annual landings of the species from the estuary. Dominance of large sized fishes in the length range of 23 to 52 cm, representing third, fourth and fifth year age groups, is the striking feature of the monsoon hilsa fishery. The fishery in winter is of a smaller magnitude. Generally winter catch of hilsa contributes 19 to 33% of the total annual catch of the species. The 47% hilsa catch during winter of 1988-89 was due to bumper yield (528 m tons) at Digha. The length range of hilsa during winter was observed to be between 24.0 to 39.7 cm (mean length 31.9 cm). Season-wise hilsa catch is depicted by the pie-chart (Fig. 6).

With the advent of the monsoon, hilsa ascends upstream, the freshwater stretches of the estuary, from the inshore areas of the sea, mainly for spawning purposes (Hora, 1940). Post-larvae, fry, early juveniles and advanced fingerlings of the species are available in varying quantities in the freshwater stretches of the river Hooghly during November to May, and even upto July, with peak availabilities during November and December (De, 1980). Juveniles (fry and fingerlings) constitute a substantial part of hilsa catch from the estuary. Indiscriminate fishing with very small meshed nets, *viz.*, the bagnets and small seine nets, is mainly responsible for the large juvenile catches, when these young ones start their downstream migration. While the bagnets are operated throughout the freshwater stretch of the estuary right from Nabadwip to Geokhali during November to June/ early July, the seine net operations are restricted to some pockets in the upper area. These nets undoubtedly take a heavy toll of the juveniles and the young ones of hilsa. An estimated yield of 115.5 m tons through these small meshed nets during 1984-85, numerically works out to 26.2 millions of young fish (Mitra *et al.*, 1988). The average weight and size of the juvenile fish caught ranged from 2.2 to 27.0 g and 6.4 to 15.3 cm respectively. The magnitude of young hilsa being caught by small meshed nets is considerably high in the freshwater stretch of the estuary alongwith juveniles of other commercially important species, such as *P. paradiseus, P. pama, S. phasa* and *P. pangasius*.

The abundance of hilsa during monsoon is largely linked with the volume of freshwater discharge down the river, and the influence of previous exploitation on the stock is of lesser importance for the hilsa fisheries of the subsequent years. Although the main determining influence for the magnitude of the winter run is yet to be known, it appears that the characteristics of the environment has an important role to play.

FIG. 6 SEASONWISE HILSA CATCH FROM THE HOOGHLY- MATLAH ESTUARY



In view of the high economic value of the species, hilsa fishery in the season of availability replaces the fishery of the other species. A fall in intensity of operation of other gears occurs while hilsa gears increasingly appear in the field, particularly in the upper areas of the estuary. Hilsa fisheries continues as long as ascending or descending hilsa are available in the estuary. Exploitation of hilsa in fact continues almost throughout the year with very low intensity during summer months. The abundance of the monsoon, and winter runs can to a fair extent be judged from the catches of hilsa during these seasons. Total catch can also be utilised as a indicator of population size, particularly when it is justified by other background knowledge (Rounsefell and Everhart, 1962). However, for hilsa the strength of runs may not reflect the abundance of the stock. The upstream migration, particularly during monsoon, appears to be determined to a large extent by the volume of freshwater discharge. But the behavioural clues to migration of winter run is not exactly known. However, physico-chemical conditions, like temperature, salinity etc., have been suggested (Jones and Sujansinghani, 1951) as plausible governing factors.

It is generally believed that the hilsa ascending the different Indian estuaries are distinct stocks (Pillay, 1958). It is also suggested that the Hooghly hilsa may not be exactly anadromous in that prior to the ascent it normally resides in the inshore areas and is not a truely marine species. The lower estuaries and inshore areas of the sea form their natural home, from where they migrate up the rivers for spawning (Pillay, 1958). Hence, corresponding to an estuarine stock of hilsa, there may be an inshore area close to the confluence which is the abode of the species and the catch from this area should be taken into account so far as the study of exploitation of the stock is concerned. Hence, the inclusion of the catch at inshore areas, close to the confluence of the estuary with the sea, is meaningful for hilsa, as fish from the same stock is caught in the river while ascending.

The main key to the improvement of the hilsa fishery is to be sought not in regulation of present exploitation but in other measures like improvement of habitat and ensuring sufficient water discharge. Modification of exploitation might be necessary in so far as it relates to indiscriminate killing of the young ones. This may be done by declaring the peak periods of abundance of young hilsa as closed season for small meshed nets by fishermen, providing alternative source of fishery based employment elsewhere or any other suitable alternatives.

3.5.2 *Fishery of Polynemus paradiseus*

The annual contribution of *P. paradiseus*, one of the prized estuarine species, ranged from 105.6 to 314.1 m tons, with an average of 187 m tons. Although its contribution was less that 1% of the total catch, the importance of the species lies in its high economic value. From Rupnarayan tributory (Zone IV) and mid estuary (Zone II) the species contributed substantially (50 to 76%) to the total annual catch of these two zones except during the year 1988-89. The contribution of the species in the lower estuary depends largely on its availability from winter migratory fishery. In 1988-89, winter fishery alone contributed 79% of its annual catch. In the upper freshwater stretch of the estuary (Zone I), the availability of the species is negligible. Most of its catches (90%) are from bagnet alone. In Zones II and IV, over 95% of its landings are from the bagnet while in the lower estuary (Zone III), small seines share the catch (about 10%) with bagnet (90%). The main seasons of availability of this species are April to July in mid estuary, April to July and October to November in the Rupnarayan tributory and April to July and November to December in the lower estuary. The size of the species ranges from 8.7 to 24.0 cm with a mean length of 16.8 cm.

3.5.3 *Fishery of Setipinna spp.*

The annual contribution by *Setipinna* spp. ranged from 1221.3 to 6,007.4 m tons, accounting for 5.5 to 14.6% of the total catch. The bulk catch of the species (69 to 95%) comes from winter migratory bagnet fishery alone. Excluding the landings from the winter fishery, 75 to 88% of the catch is obtained from the lower estuary. However, *Setipinna* spp. is available in all the zones of the estuary to some extent. Bagnet alone contributes about 96% of the total catch. Other gears, like seine, drift gill net, set barriers, also contribute to a small extent towards the catch of this species. While *Setipinna* spp. are available throughout the year in lower estuary, in other zones they are caught in summer and winter months only.

3.5.4 *Prawn and shrimp fishery*

The prawn fishery of this estuary is very important in view of volume of landings as well as good market value. The annual yield of prawns ranged from 1996.6 to 3344.2 m tons, contributing 6.3 to 8.6% of the total catch from this estuary. The bulk catch of prawn (38 to 73%) comes from winter fishery alone. Excluding the landings from the winter fishery, the lower estuary, the upper estuary and the Rupnarayan tributory also contribute substantially (168 to 614 m tons), forming 8 to

26% of the remaining total prawn catch. Most (90%) of the capture of prawns is by bagnets of small or large size (the later in the winter fishery). The rest (10%) is captured by trawl nets, cast nets, lift nets, seines and set barriers. Although the catch includes a wide variety of about 19 species, only 6 species are of commercial importance by virtue of their landings (Rao, 1967). In order of predominance they are *Metapenaeus brevicornis* (in all zones), *Parapenaeopsis sculptilis, Leander tenuipes and L. styliferus* (in lower stretches) and *Macrobrachium rosenbergii, M. malcolmsonii* in the upper stretches. The larger penaeids, *viz., Penaeus monodon* and *P. inducus* are rarely found in the commercial catches although their post-larvae occur in large quantities (as compared to their abundance in other parts of the country) in the lower estuarine stretches. Rajyalakshmi (1980) suggested that the fast flowing waters and the wide tidal amplitude with their disturbing influence deter the larger penaeids from forming a fishery of a good magnitude in the system itself.

3.5.5 *Fishery of Pama pama*

P. pama accounted for 1,154.1 to 6,593.9 m tons, forming 5.2 to 15.9% of the total annual estuarine catch. Winter fishery contributed the bulk catch (3,189.7 to 6,201.8 m tons; 91 to 94%) of this species, exception being the year 1986-87, a lean year for the winter fishery. Without taking into account the landings from the winter fishery, 74 to 91% catch of *P. pama* comes from the lower estuary estuary alone, the contributions from other zones being of very low magnitude. Over 95% of the landings of the species were by bagnets only.

3.5.6 *Fishery of Harpodon nehereus*

The annual landings of Bombay duck, *H. nehereus*, was of the order of 2,549 to 1,999 m tons, constituting about 11.5 to 19.3% of the total catch of the estuary. Most (89-95%) of the yield came from winter fishery. The lower estuary accounted for rest of the catches (243 to 461 m tons). *H. nehereus*, being basically a marine and typically neritic species, was totally absent in the upper freshwater stretches of the estuary. Over 98% of the species was caught by bagnets only.

3.5.7 *Fishery of Trichiurus spp.*

The annual catch of *Trichiurus* spp. ranged from 1,449 to 4.812 m tons accounting for 6.5 to 18.5% of the total annual catch of the estuary. Like *H. nehereus* and *P. pama*, winter fishery constituted the bulk catch (91 to 99%) of this species also. The lower estuary accounted for the rest. Like *H. nehereus* the species was absent in the upper freshwater stretch of the estuary and over 98% of the catch was by bagnets only.

3.5.8 Fishery of Coilia spp.

The annual contribution of *Coilia* spp. varied between 436.5 to 1,582.8 m tons accounting for 1.8 to 5.0% of the total landings of the estuary. Like other typically neritic species, bulk of the catches (187.3 to 906.9 m tons : 1.8 to 5%) of the species come from winter fishery. The lower estuary contributed the rest. The species was absent in the upper freshwater stretches of the estuary and about 99% was caught by bagnet only.

Likewise, in case of *Tachysurus* jella, *Sciaenea biauritus* and *Stromateus cinereus*, the basically other marine and typically neritic species, the winter fishery constituted the bulk catches and the lower estuary the rest. Here also most (90 to 95%) of the catches were by bagnets only.

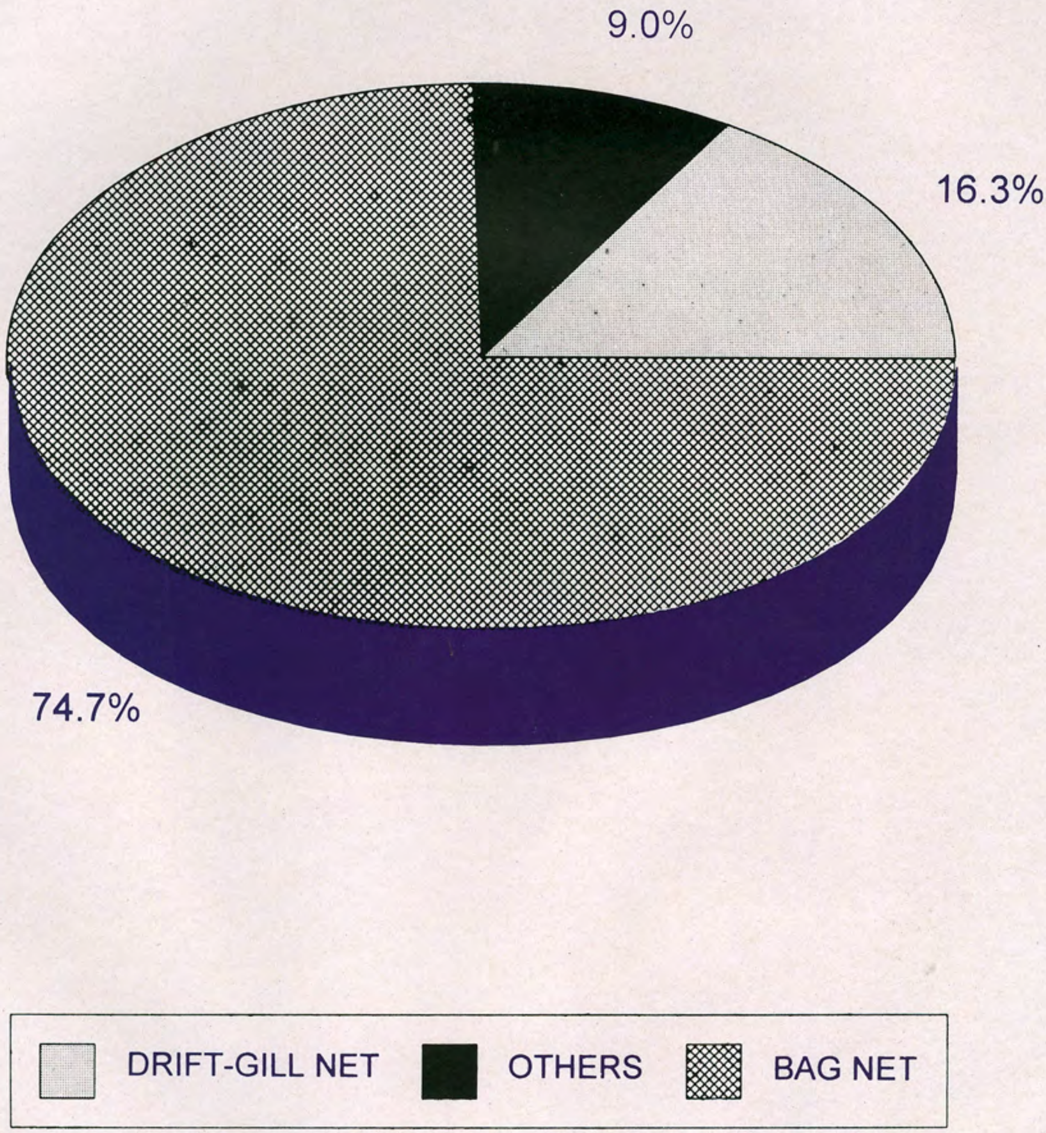
3.6 Gear-wise composition of catch

A wide variety of gear are operated round the year in the estuary for commercial fishing. Some are selective for a particular species, but most of them are for multi-species exploitation. Based on the mode of operation, the gears encountered in the estuary have been classified into the following major groups :

i) trawl nets
ii) seine nets (large and small)
iii) purse or clap nets
iv) drift gill nets
v) lift nets
vi) cast nets
vii) bagnets (stationary)
viii) set gill nets
ix) set barrier nets
x) hooks and lines, and
xi) traps

The different types of gear, their local names, areas, seasons of operation and main species caught etc. in the upper and middle estuary have been described in detail by Mitra et al. (1987). The gear-wise contribution in the annual catch of these zones of the estuary is depicted by pie-chart (Fig. 7). Bagnets and drift gill nets constituted the most dominant gears in the entire estuary, accounting for 42.3 to 86.7% (av. 74.7%) and 11.6 to 35.7% (av. 16.3%) of the total catch of these zones respectively with the rest contributing 9% on an average.

FIG. 7 GEARWISE AVERAGE LANDINGS FROM THE HOOGHLY-MATLAH ESTUARY



3.7 Migratory bagnet fishery during winter

A unique feature of the Hooghly estuary is the migratory fishery of winter season consisting of stationary bagnets, locally known as *'been jals'*. A large number of fishermen in groups of fishing parties migrate mainly from different areas of the estuary during winter season to suitable spots near the sea in the lower zone. These fishing parties establish fishing camps and remain engaged in bagnet fishing from the end of October to early February. This fishery has come to be known as winter migratory bagnet fishery. Two major concentrations of such parties are commonly seen, one on Sagar island at the mouth of Hooghly estuary and the other cluster around Frasergunj, Bakkhali, Kalisthan, Upper and Lower Jamboodwip complex. The temporary fishing camps so established are commonly called 'khutis'. Each fishing camp consists of a fair amount of enclosed space on the beach with a small hutment portion within it which is utilised for shelter and stocking the dried fish. The open space in the enclosure are utilised for drying the catch. The importance of this fishery lies in its high total yield from the lower zone as well as from the whole estuary.

The fishermen population migrating to different centres, the number of bagnets possessed by them and the number of mechanised and non-mechanised boats put into operation during the year 1984-85 to 1993-94 are presented in Table 5, 6, 7, 8. Over the years the number of fishing camps, nets, boats and fishermen has generally increased.

An inventory of the number of migratory fishermen, their holdings in terms of bagnets and boats was undertaken prior to the commencement of witnter bagnet fishing operations by visiting individual camps (schedule C(1). Adopting a three day sampling procedure in a month, based on direct observations, informations pertaining to total fish catch and CPUE, was recorded. The days of observation were selected following a systematic sampling plan. Total catch and the effort input for the days of observation were noted for all the camps at a site (Schedule C-2). For ascertaining species composition, a few random samples from the catches from the fishing camps were examined.

The fishermen have to incur relatively heavy expenditure for sustaining themselves in these remote places. However, there are several factors which make this migratory bagnet fishery an economical venture. Prevailing calm weather during winter in the extreme lower stretches of the estuary near the seaface are favourable for operating stationary bagnets. These conditions prevail till the onset of south winds by the middle of February, making the sea rough and operation of these nets difficult and unsafe. Then this fishery comes to an end. Secondly the abundance of

Table 5 : Centre-wise concentration of bagnets in winter migratory bagnet fishery in lower estuary during 1984-85 to 1993-94

Centres	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Frasergunj	68	87	66	53	57	83	61	61	57	68
Bokkhali	110	76	66	*	46	75	70	64	59	78
Upper Jamboo	137	131	156	180	208	222	140	149	220	332
Lower Jamboo	189	142	118	122	123	65	60	39	556	84
Kalisthan	*	121	97	161	160	137	147	156	215	169
Sagar Island	243	267	329	411	453	580	359	359	370	465
Total	***747***	***824***	***832***	***927***	***1047***	***1162***	***837***	***824***	***988***	***1214***

* No fishing camps was set up

Table 6 : Centre-wise concentration of boats in winter migratory bagnet fishery in lower estuary during 1984-85 to 1993-94

Centres	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Frasergunj	37 (8)	46 (10)	38 (10)	28 (11)	28 (9)	43 (11)	27 (5)	21 (5)	29 (9)	21 (17)
Bokkhali	59 (19)	35 (10)	33 (11)	*	17 (1)	32 (1)	23 (4)	24 (-)	21 (2)	28 (3)
Upper Jamboo	62 (17)	61 (16)	65 (16)	69 (24)	86 (29)	91 (30)	55 (18)	58 (17)	87 (33)	67 (47)
Lower Jamboo	86 (26)	63 (20)	51 (15)	53 (16)	55 (19)	27 (10)	24 (11)	14 (5)	17 (6)	16 (8)
Kalisthan	*	60 (19)	48 (17)	67 (24)	75 (27)	51 (17)	52 (17)	63 (21)	49 (18)	63 (31)
Sagar Island	103 (2)	112 (3)	128 (4)	165 (3)	168 (13)	200 (22)	132 (14)	132 (14)	152 (33)	128 (32)
Total	**347 (72)**	**377 (78)**	**363 (73)**	**382 (78)**	**429 (98)**	**444 (91)**	**313 (69)**	**312 (62)**	**355 (101)**	**296 (138)**

* No fishing camps was set up.
Figures in parenthesis indicate the number of mechanised boats.

Table 7 : Centre-wise concentration of migrant fishermen in winter migratory bagnet fishery in lower estuary during 1984-85 to 1993-94

Centres	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Frasergunj	246	394	256	216	208	307	164	121	168	211
Bokkhali	599	367	328	*	73	158	118	103	94	149
Upper Jamboo	741	898	988	1068	1193	1299	790	854	1132	1896
Lower Jamboo	1366	889	760	875	832	347	286	255	320	505
Kalisthan	*	597	564	854	816	703	766	875	717	811
Sagar Island	777	812	961	1095	1025	1157	878	878	904	1012
Total	***3729***	***3957***	***3857***	***4108***	***4147***	***3971***	***3002***	***3086***	***3335***	***4584***

* No fishing camps was set up.

Table 8 : Centre-wise catch (in t) of winter migratory bagnet fishery in lower estuary during 1984-85 to 1993-94

Centres	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Frasergunj	748.6	988.9	401.5	1420.7	1029.4	1552.7	1143.6	514.7	697.2	847.1
Bokkhali	4050.4	1963.4	795.3	*	200.3	319.5	424.2	170.8	110.6	276.2
Upper Jamboo	4305.4	4772.4	3013.2	8961.7	13607.2	11993.5	7554.0	8227.9	11442.7	8291.7
Lower Jamboo	10077.5	5413.7	1683.4	5488.1	7761.6	3569.7	2787.9	2196.4	2995.7	2852.4
Kalisthan	*	3423.5	1532.8	6819.1	10146.9	6539.6	12918.0	8562.7	9312.0	4140.9
Sagar Island	457.6	1019.5	699.6	1086.0	1512.6	1713.7	1841.3	1788.3	1448.1	1284.9
Total	***19639.5***	***17581.4***	***8125.3***	***23775.6***	***34258.0***	***25688.7***	***26669.0***	***21460.8***	***26006.3***	***17693.2***

*No fishing camps was set up

fish vulnerable to bagnets during winter in the lower estuary is much higher (18 to 36 times) than the average abundance of fish in the upper estuary throughout the year. CPUE at the winter fishing centres ranged between 11 to 285 kg as against the average of about 2 to 7 kg in the upper estuary. The increased abundance of fish mainly results from the winter blooms of plankton causing a feeding and breeding migration of fishes and prawns in the estuary. This induces migration of their predators as well. Large amounts of organic matters, detritus and other washed off materials which are rich in nutrients are deposited below the mouth of the estuary during monsoon by the heavy inflow in the streams (Datta *et al.*, 1975). This brings about major changes in the food chains by inducing a rich growth of phytoplankton which reaches a peak in winter months (Shetty *et al.*, 1961; Saha *et al.*, 1975). Such conditions are highly prevalent in the shallow seaface regions of the bay where the winter migratory bagnet fishery operates.

The total estimated bagnet fish landings fluctuated within 8,125.3 to 34,258 m tons per season with an average CPUE of 78.19 to 189.7 kg (Table 9) during the period 1984-85 to 1993-94 showing an increasing trend both in catch and CPUE over the year except for the year 1993-94.

The capture by the migratory bagnet fishery during three and half months usually accounts for 40.7 to 86% of the total yield from Zone III and 37 to 82% of the total yield of the whole estuary (Fig. 8). The drastic fall in catch during 1986-87 was mainly due to unprecedented cyclonic storm, heavy rainfall and flood in early winter of 1986, causing closure of a number of fishing camps, loss of nets, boats and even fishermen and resultant lesser effort input compared to other years. Due to oceanic surges, the coastal salinity increased and subsequent appearance of jelly fish shoals in the water also hampered the availability of commercially important fishes in the region and, thus, made the operation of bagnets uneconomical.

The catch abundance at different centres was fairly consistent with the effort pattern. The available effort potential in the form of concentration of nets at a centre, had contributed to yield pattern to a large extent. However, the difference in concentration of nets also depended on the differential catches per unit effort at the centres. This becomes clear from a comparison of yield at Bakkhali and Frasergunj centres in 1985-86, the former contributing almost twice the yield with a smaller number of operating units. The low yield and CPUE at Sagar island in comparison to other centres may be attributed mainly to deployment of nonmechanised boats and smaller sized bagnets. Besides, the operational place of nets by the fishermen at Sagar island was one of

Table 9 : Centre-wise CPUE of winter migratory bagnet fishery in lower estuary during 1984-85 to 1993-94

Centres	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Frasergunj	58.34	84.21	45.04	140.26	84.31	77.54	85.10	34.84	47.82	42.06
Bokkhali	188.57	191.94	95.97	*	25.01	19.54	25.45	20.51	10.74	20.63
Upper Jamboo	139.89	246.67	135.32	254.98	258.26	215.95	265.82	205.83	177.82	101.07
Lower Jamboo	234.93	252.53	103.58	208.63	270.12	218.46	231.90	203.71	158.50	139.57
Kalisthan	*	195.66	123.31	227.85	285.41	184.62	449.23	205.18	195.03	108.07
Sagar Island	10.75	28.66	23.87	21.53	18.81	17.95	44.60	29.08	28.25	24.72
Total	***130.44#***	***151.79#***	***83.37#***	***156.47#***	***157.43#***	***107.41#***	***189.69#***	***121.19#***	***125.55#***	***78.19#***

* No fishing camps was set up
# Average CPUE for all centres combined together

the major factor for low yield and low CPUE. The fishermen at Sagar island operate nets in shallow coastal water and do not go deep for fishing. Thus, with heavier concentration of operating units, the total yield as well as CPUE at Sagar island is the least among all the centres. Moreover, oil spill and hydrocarbon wastes from sea going vessels in Sagar region restrict the abundance of fish.

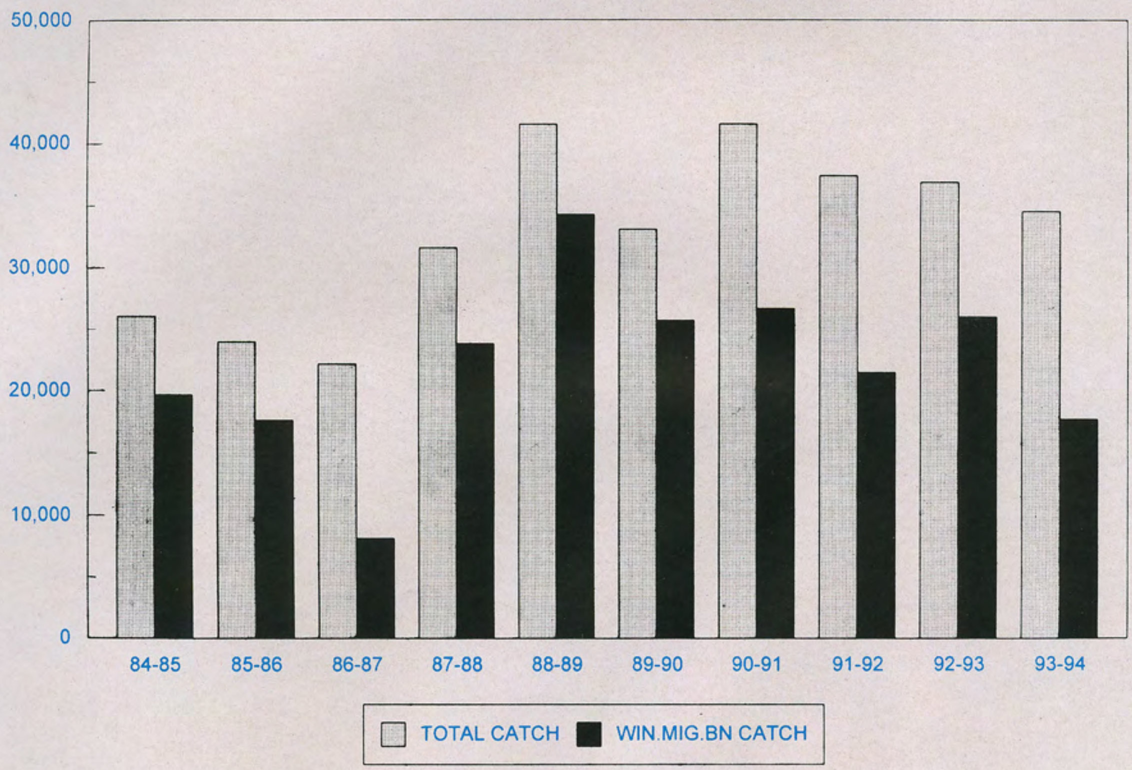
Table 10 : Average species-wise composition of catches (in tonnes) in winter migratory bagnet fishery in lower estuary

Species		Catch	Percentage(%)
1.	*S. panijus*	16.7	0.0
2.	*P. paradiseus*	72.6	0.33
3.	*P. indicus*	2.0	0.01
4.	*E. tetradactylum*	3.4	0.01
5.	*S. biauritus*	209.0	0.94
6.	*Coilia* spp.	505.5	2.28
7.	*P. pama*	3647.1	16.47
8.	*T. ilisha*	5.5	0.02
9.	*T. toli*	12.3	0.06
10.	*I. elongata*	377.0	1.70
11.	*Chataseus* spp.	2.1	0.01
12.	*Setipinna* spp.	3237.0	14.61
13.	*C. dorab*	7.8	0.04
14.	*P. pangasius*	1.6	0.01
15.	*T. jella*	255.8	1.16
16.	*O. militaris*	65.3	0.29
17.	*Trichiurus* spp.	2606.7	11.77
18.	*H. nehereus*	4716.1	21.29
19.	*S. cenereus*	241.1	1.09
20.	Prawns	1653.4	7.46
21.	Mackerel	0.4	*
22.	Miscellaneous	4511.4	20.37
	Total :	***22149.8***	***100.00***

Less than 0.01%

In terms of availability as measured by CPUE, Kalisthan was the centre with highest average CPUE value of 285.4 kg followed closely by lower Jamboodwip (270.1 kg) and upper Jamboodwip (258.3 kg). Over the years the concentration of nets has steadily increased in upper Jamboodwip and fallen in Bokkhali and lower Jamboodwip. Preference for spot appears to be based on several considerations like higher availability of fish, facility of landing close to the camping spot, adequate space for camping and drying, general safety and anchorage of boats well inside the

FIG.8 TOTAL CATCH (t) AND WINTER MIGRATORY BAGNET CATCH FROM THE HOOGHLY MATLAH ESTURINE SYSTEM DURING 1984-85 TO 1993-94



creeks and nallahs. The general loss of depth due to siltation at the mouth of the canal close to the landing spot near Bokkhali causes hapazard fluctuation of water waves making it difficult for landing close to camping spot. An accident occurring three years back during landing of fish, resulting in loss of several human lives, was also responsible for decreasing trend of concentration of nets at Bokkhali.

Winter fishery bagnet catches mainly comprise of small sized fishes. The average species-wise landings of winter migratory bagnet fishery during 1984-85 to 1993-94 are presented in Table 10. The dominant groups of species contributing to the fishery are : Bombay duck *(H. nehereus)*, anchovies *(Setipinna* spp.), ribbon fishes *(Trichiurus spp.)*, sciaenids *(P. pama)*, clupeids *(I. elongata)*, *Coilia* spp. and different prawn species. These species alone accounted for about 66 to 83% of the landings. These species during winter fishery constituted over 90% of the total removals from the estuary.

The different centres exhibit some variations in the size composition of the nets also. The nets are classified as 'medium', 'large' and 'very large' groups characterised by 800 to 1000, 1000 to 1200 and above 1200 meshes respectively at the net mouth. Nets of very large category are usually more frequent at Jamboodwip (upper and lower) and Kalisthan. Nets of medium and large groups are prevalent at Bokkhali and Sagar island fishing camps.

The catches landed during the season are mostly sun dried except the highly economic species like *T. ilisha*, *P. paradiseus* and *S. cinereus* landed in smaller quantity, are sold out locally to fish merchants in the area. The dried fishes stocked in the fishing camps are periodically sent by boats to the marketing centres, mainly to Uluberia, from where further distribution to other markets takes place through dry fish traders.

An important question is whether the high rate of yield may continue if the fishing is done in this region even after February. So far as these fishing grounds are concerned the high rate of yield is not likely because of a number of considerations. CPUE pattern indicates appreciable fall in mid February in respect of all the species and a similar situation is noticed in respect of total catches, indicating that the margin of profit will fall appreciably in the following months. With the onset of south winds in the middle of February, resulting in the roughness of the sea, the operation of these nets becomes difficult. Besides, the abundance of fish and prawns, on account of plankton blooms, setting in feeding migrations of fish and prawns, is also likely to decrease in the coming months, thus bringing about an end to the migratory bagnet fishery in the lower deltaic region of the Hooghly estuary.

4. CHANGES IN TRENDS OF FISH LANDINGS AND FISHERY

The commissioning of Farakka barrage, to augment freshwater discharge into Hooghly estuary, has resulted in major change in the ecology of Hooghly-Matlah estuary. Large scale change in salinity structure has resulted in extension of freshwater stretch towards downstream (Sinha et al., 1996). The earlier recognised gradient-transit zone has shifted from Uluberia to Nurpur by about 40 km downstream in the estuary (Fig. 1). Significant structural changes in the fishery resources as well as fishing patterns have been observed in the upper zones (I, II & IV) and the lower estuary (Zone III) in recent years. Total average yield from the estuary has increased from 9,481.5 m tons during 1966-67 to 1974-75 to 28805.7 m tons during 1984-85 to 1993-94.

Some of the marine and typically neritic species, *viz., L. parsia* among mullets, *E. tetradactylum* among polynemids, *Coilia* spp. among anchovies, *T. toli* and *I. elongata* among clupeids and *H. nehereus* and *Trichiurus* spp. among others have shown a sharp declining trend or total absence in the upper estuary. Total landing in Zone I showed a declining trend over the years whereas the total catches in Zones II and IV do not have any significant difference during the three periods (pre-Farakka, post-Farakka and recent years). A comparative study of the average species composition during the three periods, is presented in Table 11. A few of the freshwater fish species *(Rita rita, Wallago attu, Mystus aor, Ailia coila, Catla catla, Labeo rohita, L. calbasu, L. bata)* and freshwater prawn *(Macrobrachium rosenbergii)* contributing 50 m tons on average and not reported earlier from the estuary have started appearing in the catches from the upper estuarine waters where the salinity has almost become nil due to increased freshwater incursion.

Hilsa catches have gone up in upper estuary during the recent period (1984-85 to 1993-94) compared to the two earlier periods. During 1984-85 to 1993-94 hilsa formed about 25.6% of the total catch in the upper estuary against 19% and 17% recorded during 1966-67 to 1974-75 and 1975-76 to 1977-78 respectively. Commissioning of Farakka barrage has affected the migration of the species to upstream of the barrage and with freshwater zone in the estuary extended, the abundance of hilsa in the upper zones of the estuary has considerably increased.

The comparatively high catch of hilsa and low catch of *P. pangasius, S. panijus* and *S. phasa* are perhaps not due to ecological changes only but also due to changed fishing pattern or effort exerted for different species in recent years. This will be evident from Table 12 (Mitra *et al.,* 1987) which presents comparative figures of total number of different gear that have been enumerated through the village to village

Table 11 : Average species-wise landings (in t) from Hooghly-Matlah estuary during three periods.

Speocies	Pre-Farakka Average (1966-67 to 1974-75)					Post-Farakka Average (1975-76 to 1977-78)					Recent Years Average (1984-85 to 1993-94)				
	Zone-I	Zone-II	Zone-III	Zone-IV	Total	Zone-I	Zone-II	Zone-III	Zone-IV	Total	Zone-I	Zone-II	Zone-III	Zone-IV	Total
T. ilisha	127.9	132.9	1077.1	119.2	1457.1 (15.4)	101.8	35.8	1813.1	175.5	2126.2 (11.5)	191.4	223.6	1587.7	132.7	2135.4 (7.4)
Setipinna spp.	33.5	3.5	651.1	20.9	709.0 (7.5)	29.9	1.8	1015.9	17.7	1065.3 (5.8)	8.6	37.0	3130.0	11.5	3187.0 (11.1)
Trichiurus spp.	-	0.8	452.0	1.2	454.0 (4.8)	-	0.2	1340.0	0.2	1340.4 (7.2)	-	0.1	2683.5		2683.6 (9.2)
H.nehereus	1.7	47.0	1929.1	90.1	2067.9 (21.9)	-	15.5	4249.0	80.6	4345.1 (23.5)	-	0.3	4570.7	-	4571.0 (15.9)
P. pama	8.6	9.2	172.7	26.7	217.2 (2.3)	7.1	12.7	3088.9	42.0	3150.7 (17.0)	2.2	35.3	3298.6	19.4	3355.4 (11.7)
S.panijus	2.9	2.5	17.4	9.1	31.9 (0.3)	3.1	15.2	26.4	17.8	62.5 (0.3)	3.4	3.3	24.1	0.5	31.3 (0.1)
T.jella	-	-	176.0	0.2	176.2 (1.8)	-	-	162.7	-	162.7 (0.9)	-	-	744.7	-	744.7 (2.6)
P. paradiseus	5.7	2.6	18.6	30.3	57.2 (0.6)	3.1	37.5	27.7	68.1	136.4 (0.7)	2.7	33.5	82.0	58.2	176.4 (0.6)
Coila spp.	2.3	1.5	70.9	47.6	122.3 (1.3)	0.2	-	97.2	13.0	110.4 (0.6)	-	1.0	783.2	-	784.2 (2.7)
H. toli	0.1	-	16.9	0.2	17.2 (0.2)	0.1	-	94.6	-	94.7 (0.5)	-	-	38.1	-	38.1 (0.1)

Table 11 Contd.......

Speccies	Pre-Farakka Average (1966-67 to 1974-75)					Post-Farakka Average (1975-76 to 1977-78)					Recent Years Average (1984-85 to 1993-94)				
	Zone-I	Zone-II	Zone-III	Zone-IV	Total	Zone-I	Zone-II	Zone-III	Zone-IV	Total	Zone-I	Zone-II	Zone-III	Zone-IV	Total
I. elongata	0.2	0.9	164.2	1.4	166.7 (1.8)	-	-	654.6	0.1	654.7 (3.5)	-	0.1	478.2	-	478.3 (1.7)
E. tetradactylum	-	0.3	24.8	1.7	26.8 (0.3)	-	-	24.7	-	24.7 (0.1)	-	-	16.2	-	16.2 (0.1)
S. biauritus	0.1	0.9	188.8	0.4	190.2 (2.0)	-	-	310.0	0.7	310.7 (1.7)	-	0.2	407.5	-	407.7 (1.4)
P. pangasius	8.9	5.7	76.1	40.1	130.8 (1.4)	10.4	10.1	86.2	20.5	127.2 (0.7)	3.9	2.1	3.1	0.3	9.4 (*)
L. parsia	-	3.2	42.9	3.5	49.6 (0.5)	-	2.5	39.1	8.8	50.4 (0.3)	-	1.6	16.6	-	18.2 (0.1)
L. calcarifer	-	0.1	24.1	0.3	24.5 (0.02)	-	-	28.8	-	28.8 (0.2)	-	-	42.6	-	42.6 (0.2)
S.cinereus	*	1.1	63.4	4.4	68.9 (0.7)	0.5	-	224.9	-	225.4 (1.2)	-	-	549.9	-	549.9 (1.9)
Prawns	367.6	51.8	751.1	167.8	1338.3 (14.1)	233.0	49.3	1145.8	320.8	1748.9 (9.4)	287.0	74.7	1969.7	224.7	2556.1 (8.9)

Table 11 Contd........

Speccies	Pre-Farakka Average (1966-67 to 1974-75)					Post-Farakka Average (1975-76 to 1977-78)					Recent Years Average (1984-85 to 1993-94)				
	Zone-I	Zone-II	Zone-III	Zone-IV	Total	Zone-I	Zone-II	Zone-III	Zone-IV	Total	Zone-I	Zone-II	Zone-III	Zone-IV	Total
Others	404.8	48.1	1545.9	176.9	2175.7 (23.0)	304.5	55.2	2215.4	170.2	2745.3 (14.8)	136.5	64.6	6588.2	179.3	6968.6 (24.1)
Freshwater fishes	-	-	-	-	-	-	-	-	-	-	38.8	2.4	-	10.3	51.5 (0.2)
Total	964.3	312.1	7463.1	742.0	9481.5 (100.0)	693.7	235.8	16645.0	936.0	18510.5 (99.9)	*674.5	479.8	27014.5	636.9	28805.7 (100.1)

Figures in parenthesis relate to percentage to total catch.

* < 0.01

Table 12 : Census figures of different gears in Zones I,II & IV

Zones	Gears	Trawl		Large seine		Small seine		Purse		Drift		Lift	
		82-83	56-58	82-83	56-58	82-83	56-58	82-83	56-58	82-83	56-58	82-83	56-58
I		439	1067	1413	9204	6595	9375	4335	12329	67976	49435	1483	3648
II		-	-	551	3554	837	2717	52	2262	56892	42563	23	395
IV		-	-	77	726	2864	3914	38	651	98083	36966	56	126
Total		***439***	***1067***	***2041***	***13484***	***10296***	***16006***	***4425***	***15242***	***222951***	***128964***	***1562***	***4169***

Zones	Gears	Cast		Bag		Set gill		Set barrier		Hooks		Traps	
		82-83	56-58	82-83	56-58	82-83	56-58	82-83	56-58	82-83	56-58	82-83	56-58
I		2434	4635	584	887	1196	680	2138	1311	136	186	4490	6386
II		681	396	1071	866	26	784	226	71	24	234	-	-
IV		41	302	682	532	-	792	2476	-	-	27	-	-
Total		***3156***	***5333***	***2337***	***2285***	***1222***	***2256***	***4840***	***1382***	***160***	***447***	***4490***	***6386***

survey during 1982-83 in different zones of the upper estuary and the level of earlier inventory of gear made during 1956-58. The data presented indicate structural changes in the gear inventory. A marked decline in trawls, seines, purse (or clap) and lift nets, traps and long lines has been observed in all the zones. The gears operated for catching hilsa indicate a significant increase in numbers except for purse net. The maximum increase (165%) is observed in case of drift gill nets in Zone IV. In Zones I and II also, a significant increase (38 and 33% respectively) of drift gill nets are recorded. Operation of cast nets also declined in Zone I and IV as is indicated by their low numbers. Bagnets have shown increase in Zones II and IV but in Zone I it has gone down, the total number of bagnets remaining same in the zones covered. Set-barrier nets also showed marked increase in all the zones over 1956-58 level of inventory.

Going by effort pattern, it is observed that in earlier years bagnets dominated the gears in operation in all the zones of the upper estuary. However, in recent years the pattern has changed. Drift gill nets (for hilsa) are equally dominant as bagnets in zones I and II. This is well reflected by the average catch by these two gears in Zones I and II as well as the much higher effort put in by drift gill nets specially during monsoon and winter months in recent years.

Thus, the comparatively higher catch of hilsa in recent years in the upper stretch may be attributed to more effort put in by hilsa gears as well as the higher abundance of the species. Since the grown up potential brooders are seldom captured, there is no likelihood of recruitment failure due to higher fishing mortality.

The catch by other gears, *viz.*, bag, trawl, lift, seine, cast, hooks and line and traps comprise mostly of small sized prawns and other smaller varieties of fishes, mostly *S. phasa, S. panijus and P. pangasius.* The operation of such gear fetches low return. The economic factor of income from fishing may be the main cause of decline in number of these gears in the upper stretch, resulting in low catch of the aforesaid species. Although the catches by set-barrier nets do not differ much in qualitative compsoition as compared to those of the aforesaid gears, the higher magnitude of yield by this gear, as reflected by its CPUE, might have resulted in increase in the number of this gear in the upper stretch.

Thus, it emerges that the structural changes in the species composition in the upper stretch of the Hooghly estuary in recent years is due to ecological changes consequent to Farakka barrage as well as due to changes in the fishing pattern and effort. Changes in the species composition in the lower deltaic region are not much pronounced but with the pushing back of salinity seawards the catches have improved difficult to apply in case of migratory fish stocks (Sparre *et al.*, 1989). Moreover, due to diversity of exploitative gears evaluation of effective effort poses problems. As a result, the model based on catch and effort only (Schaeffer, 1954) for the assessment of maximum sustainable yield (MSY) cannot effectively be used.

However, stock assessment and population dynamics of prime fish, hilsa, was attempted and the results and other details are as follows :

Month-wise length frequency data alongwith catch data of hilsa for 1987 and 1988 were collected from the sampling stations of different stretches of Hooghly-Matlah estuary. These monthly length frequency data were put to LFSA (Sparre *et al.*, 1989) and ELEFAN (Gayanilo *et al.*, 1988) computer packages for finding growth parameters, mortality, MSY, MSE etc. and to assess the stock of hilsa in Hooghly-Matlah estuary. The Bhattacharya (1967) plot for different size groups did not indicate any interprettable pattern. Failure of this method indicates that the growth is attributable to migration within the estuary. Therefore, Petersen method was applied assuring that the peaks in the periodic samples correspond to successive year classes. Estimation of K by regression analysis of Gulland and Holt plot was not good enough. So forced Gulland and Holt was done using the relation :

$$K=\frac{\bar{Y}_i}{(L_\infty-\bar{X})}$$ where X_i is the mean length of the fish and $$\bar{Y}_i=\frac{(X_i-X_{i+1})}{1year}$$

The growth coefficient, K, thus obtained was 0.5/yr. Asymptotic length, $L\infty$, was obtained as 55 cm.

To perform the length converted catch curve analysis, the annual catch was obtained by raising the samples and taking the mean catch of two years as input and using a = 0.0000306 and b = 2.72 (parameters of length-weight relationship of hilsa). The catch curve plot indicated recruitment starting from the class interval 37 to 38 cm. Total mortality rate, Z, was obtained as 1.1513.

Length base cohort analysis was performed using the parameters $L\infty$ = 55 cm, K = 0.5/yr. and exploitation rate, F/Z = 0.5 for obtaining the number of survivors, exploitation rate, fishing mortality (F), total mortality etc. for each group. Higher mortality (0.806) was observed for the group 37 to 38 cm.

tremendously from this zone. The increase is by 262% and 62% in comparison to pre-Farakka and post-Farakka periods respectively. The tremendous increase in the winter migratory bagnet catches in recent years is the prime factor for the overall heavy increase in catch from the lower estuary. Three and a half month's seasonal fishery accounts for an average estimated catch of 22,090 m tons forming about 67.2% of the total annual fish yield from the whole estuary, compared to only 29 to 33% of about one and half decade ago. The current winter bagnet fishery (1984-85 to 1993-94) is about nine times and five times more than that of the period 1964-65 to 1968-69 and 1970-71 to 1974-75 respectively. The increased fish abundance in recent years in winter bagnet fishery is also reflected by higher CPUE. An average CPUE of about 130 kg during 1984-85 to 1993-94 is about two to three times more than that of one and half decade ago in the lower estuary. This rise in winter fishery catch may be attributed mainly to the deployment of mechanised boats, larger number of bagnets and higher number of involved fishermen in this operation during recent years specially in Kalisthan and Jamboodwip (upper and lower) areas (Table-13). Without taking into account the winter migratory bagnet fishery, the catch from lower estuary has also increased considerably. Greater abundance of the fish stocks, particularly clupeids, sciaenids, anchovies, ribbon fishes, Bombay duck, prawn and other miscellaneous species, coupled with deployment of mechanised boats and larger fishing effort has resulted in increased landings during the post-Farakka period.

5. STOCK ASSESSMENT, FISH POPULATION DYNAMICS AND OTHER STATISTICAL ANALYSIS

5.1 Stock assessment

Hooghly-Matlah estuarine system has multi-species fisheries exploited by multigears. Analysis by individual species is an unwidely task and estimation of species-specific effort is rather difficult. Majority of the fish species available in the estuary are either marine or euryhaline or migratory forms. Distribution of stocks involved extend beyond the exploited limits of the estuary. Most of these areas are not exploited at present with the result that local abundance in these areas and consequently overall stock abundance in the entire area cannot be evaluated. Under such circumstances, representative random samples of the stock cannot be taken as example for whole range of length frequency. When stocks are not vulnerable to fishing due to migrations to areas not covered by the normal fishing gears during part of their life span, it is usually not possible to sample such stock durisng these periods. Thus, the length based methods, such as modal progression analysis, catch curve analysis, yield per recruit model of Beverton and Holt etc., are

Table 13 : Comparative table of average nets, catch and CPUE in winter migratory bagnet fishery during the periods 1964-65 to 1968-69, 1970-71 to 1974-75 and 1984-85 to 1993-94

Period	Nets (no.)	Migrant fishermen (no.)	Catch(t)	CPUE (kg)	Average % contribution to total annual catch of the estuary
1964-65 to 1968-69	299	1120	2316.1	52.30	28.6
1970-71 to 1974-75	289	1078	4152.8	71.26	32.7
*1984-85 to 1993-94	940	3774	22089.8	130.21	67.2

* Excluding the centre, Sagar Island as it was not covered in earlier periods.

Thompson and Bell analysis was performed for long term prediction of catch. MSY was estimated as 1435 m tons/yr and MSE was estimated as Rs. 3.6 x 1000000. But this MSY concept is not well defined, as the range of annual catch varying between 1087.1 m tons to 6655.9 m tons indicated wide fluctuations. This is probably due to following inadequacies :

a) gill net selectivity,
b) inherent problems in obtaining random samples from migratory stocks,
c) migration route not well defined, and
d) variation in mesh-size of gill net in different fishing grounds and season

In addition to these inadequacies, another difficulty for hilsa stock assessment is due to common stock sharing between Bangladesh and India. The estuaries in the deltaic West Bengal are not discrete from their counterparts in the Bangladesh. Most of these estuaries in the two countries are well inter-connected through creeks, channels and canals. Hence, no fish stock can be claimed as Indian stock in the absolute sense and no estuarine population is likely to spend their complete life cycle within the boundaries of one country only. The complexity of problems involved in shared stocks contains the problem of stock identification and migration routes. Hence, a joint venture between India and Bangladesh needs be undertaken to arrive at any fruitful result for shared stocks and their management.

5.2 Other Statistical analyses

5.2.1 Comparison between pre-Farakka and recent years' catch

Comparison of fish yield from different stretches of estuary over two periods, *viz.*, pre-Farakka (1968-69 to 1974-75) and recent years (1984-85 to 1993-94) revealed significant differences as found by Sinha *et al.*, (1996). The total estimated catch during the aforesaid two periods (excluding bumper year of hilsa catch, *i.e.*, 1971-72) was taken up for analysis of variance after introducting log transformation. ANOVA (Table 14) reveals significant differences between stretches. The catch from the lower and middle estuary which contribute about 85 to 95% is significantly higher in recent years than the pre-Farakka period. The catch from the upper freshwater tidal stretch is significantly lower in the recent years compared to those of pre-Farakka years. However, no significant change is observed in the catch of the Rupnarayan tributary (Zone IV) over the two periods.

Table 14 : Analysis of variance of total fish yield from different zones of Hooghly-Matlah Estuary

Sources of variation	Degrees of freedom	Sums of squares	Mean square	F
Period	1	0.16676	0.16676	14.882*
Zones	3	18.02339	6.00780	536.124*
Period x Zones	3	0.88052	0.29351	26.192*
Error	41	0.45945	0.01121	
Total	*48*	*19.53012*		

* P < 0.0

5.2.2 Comparison between year-wise and zone-wise catches of the recent years.

Analysis of variance for percentage contribution of catch from different zones over the years was taken up after introducing sine transformation. Although ANOVA has indicated highly significant differences between zones, no significant differences were observed between zones I,II, and IV. The variations so far encountered in the total landing over the years, excluding winter fishery catch, do not show significant differences.

5.2.3 Sex-ratio of hilsa

Sex-ratios in the catches during monsoon (August to October) were significantly different (X^2 = 38.6, P < 0.005) from rest of the period indicating more dominance of female hilsa over the male during monsoon. The average male-female ratio during monsoon and winter were 1:1.6 and 1:1:1 respectively, the overall ratio being 1:1.5.

5.2.4 Determination of body weight of hilsa

Determination of body weight of mature hilsa using several morphometric characters have been studied to find out their relevance as indicators of body weight. The total length, the body height and the body thickness have been found to be jointly the best estimators of the body weight in case of mature females while total length and body thickness in case of male. The estimating equations were worked out as :

$$Y = -2270.2453 + 4.0291\ X_1 + 7.5280\ X_2 + 8.8468\ X_3 \text{ for female}$$

and $$Y = -897.2636 + 2.5615\ X_1 + 9.9404\ X_3 \text{ for male}$$

where Y = body weight in g, X_1 is the total length in mm, X_2 is the body height in mm and X_3 is the body thickness in mm (Mitra and Karmakar, 1988).

5.2.5 Multivariate analysis of CPUE in relation to physico-chemical and biotic parameters

Data collected during 1985-87 on nine physico-chemical and biotic parameters, *viz.*, water temperature, total alkalinity, nitrate, phosphate, silicate, salinity, specific conductivity, total plankton and primary productivity as independent variables and CPUE of bagnets as dependent variable were subjected to multiple regression analysis. Only two parameters, *viz.*, phosphate of water and primary productivity were found to be significant ($P < 0.05$). The multiple regression model was worked out as :

$$Y = 0.2539 + 5.9309\, X_1 + 0.0379\, X_2$$

where Y = CPUE of bagnet in kg, X_1 = phosphate of water in ppm, X_2 = net primary productivity in mgC/m^3/hr.

The b_1 and b_2 of the model were significant ($R^2 = 0.2998$) and indicated that 30% of the variability in CPUE of bagnet is explained by the model.

5.2.6 Predicting estimates of expected fish catch

Trend analysis of time series data on the total yield for the period 1984-85 to 1993-94 has been carried out to predict estimates of expected catches in the coming years. Linear Autoregression of first order has been found to be the best fit with three years moving average as the best period for cyclical component analysis. The trend equation is estimated as : $Y = 12460.93 + 0.676528\, X$, where Y is the expected total yield in tonnes and X is the moving average of estimated catch of preceeding three years. Error was estimated as 4368 t.

Forecast values

Year	Predicted catch (in t)
1994-95	37,780
1995-96	38,020
1996-97	38,183

The reliability of the analysis may be considered fairly high when we compare the estimated total catch for the year 1994-95 which is 37981 t against a predicted catch of 37780 t. The above analysis may be valid under the following assumptions :

i) the exploitation gears do not undergo major changes.
ii) major shifts in effort in the near future are not brought about.

7. CONCLUSION

The total estimated annual catch from the system shows significant sign of increase over the years with increasing effort. The fishing effort exerted is increasing every year. This may ultimately lead to depletion of stock. Thus, assessment of mixed fishery using length/age based cohort analysis should be studied to evaluate stock size, exploitation ratios, MSY and corresponding optimum fishing effort level.

At present, the fishermen are operating selective or multi-species gear with a wide range of mesh size to capture a particular size range of species. Analysis of length frequency data of various species from commercial catches poses a problem due to selectivity of gear as a result of deployment of various mesh size.

Moreover, fishermen are very reluctant to allow measurement of priced fishes like *T. ilisha, P. paradiseus* at the landing site and this perhpas can be overcome by undertaking experimental fishing in the selected zone of the estuary.

Exploitation by very small meshed nets like bagnet, small seine net etc. can affect the stocks of those species whose young ones and juveniles are located within the exploited region and are subjected to wanton destruction. A better yield can be obtained by raising the minimum size limits to some reasonable values preferably about 20 mm mesh size. The operation of these nets may be prohibited in the upper estuary where young fry of many species *(T. ilisha, P. pama, P. paradiseus, M. rosenbergii, S. phasa* etc.) are found to inhabit. Another satisfactory solution is that peak periods of abundance of young fry may be declared as closed seasons for opertion of small meshed nets in the upper estuary and the fishermen may be motivated to operate during this period in the lower estuary.

References :

Anonymous, 1972-78. *Annual Report 1972-78,* Central Inland Fisheries Research Institute, Barrackpore.

Bhattacharya, C.G., 1967. A simple method of resolution of a distribution into Guasian Components. *Biometrics* **23** : 115-35.

De, D.K., 1980. Maturity, fecundity and spawning of post monsoon run of Hilsa, *Hilsa ilisha* (Ham.) in the upper stretches of the Hooghly estuarine system. *J. Inland Fish. Soc. India,* **12** : 54-63.

De, D.K., 1986. Studies on the food and feeding habit of *Hilsa ilisha* (Ham.) of the Hooghly Estuarine System and some aspects of its biology. *Ph.D. Thesis,* Calcutta University, Calcutta.

Dutta, P., G.C. Laha, P.M. Mitra, D.K. De, A Chowdhury, P.K. Pandit, A.R. Chowdhury, R.N. Dey, B.K. Saha, H.S., Majumder, N.D. Sarkar, N.C. Mandal, G.P. Bhattacharya, A.K. Namasudra, S.P. Ghosh and A.R. Paul, 1973. Fishery Resources of the Hooghly-Matlah Estuarine System, *Bull. Cent. Inl. Fish. Inst.* No. 19, P. 24.

Dutta, P., G.C. Laha and P.M. Mitra, 1975. Exploitation of the lower zone of the Hooghly by migratory fishing units. *J. Mar. biol. Ass. India, 1975,* **17**(3) : 580-599.

Ganilo, F.C., Jr., M. Soriano and D. Pauly, 1988. A draft guide to the *COMPLEAT ELEFAN. ICLARM Software Project* 2.65 p and 10 diskettes (5.25 inches, 360 K).

Hora, S.L., 1940. Life History and wonderings of Hilsa in Bengal Waters. *J. Roy Asiatic Soc. Bengal (Sci.),* **6**(2) : 93-112.

Jones, S. and K.H. Sujan Singhani, 1951. The Hilsa fishery of the Chilka lake. *J. Bombay nat. Hist. Soc.,* **50**(2) : 264-280.

Mitra, P.M., G.C. Laha and K.K. Ghosh, 1977. Projections of expected fish catches from Hooghly-Matla Estuarine System during 1976-80. *J. Inland Fish. soc. India,* **9** : 131-37.

Mitra, P.M., K.K. Ghosh, B.N. Saigal, N.D. Sarkar, A.K. Roy, N.C. Mondal and A.R. Paul, 1987. Fishing Gears of the upper and the middle Hooghly estuary. *Bull. Cent. Inl. Fish. Res. Inst.,* No. 49, p. 22.

Mitra, P.M. and H.C. Karmakar, 1988. A multiple regression model for estimating body weight of mature *Hilsa ilisha* (Ham.). *J. Inland Fish. Soc. India,* **17**(1&2) : 62-65 (1985).

Mitra, P.M., B.N. Saigal and H.C. Karmakar 1988. Indiscriminate exploitation of young *Hilsa ilisha* (Ham.) from the upper freshwater stretches of the Hooghly estuary. *Proc. Nat. Acad. Sci. India,* **58**(B) : 349-358.

Pantulu, V.R., 1966. Contribution to the study of the biology and fishery of some estuarine fishes.' *D.Phil. Thesis, Calcutta University.*

Pillay, T.V.R., 1958. Biology of *Hilsa ilisha* (Ham.) of the river Hooghly. *Indian J. Fish.,* **5**(2) : 201-257.

Rao, R.M., 1967. Studies on the biology of *Macrobrachium rosenbergii* (de Man) of the Hooghly estuary with notes on its fishery. *Proc. Nat. Acad. Sci. India,* (B) **33**(5&6) : 252-279.

Rajyalakshmi, T., 1980. Comparative study of biology of the freshwater prawn, *Macrobrachium malcolmsonii* of Godavari and Hooghly river system. *Proc. Nat. Acad. Sci. India,* **(B) 46**(1) : 72-89.nsefell, G.A. and W.H. Everhart, 1962. Fishery Science, its methods and applications, John Wiley & Sons Inc., New York : 444 p.

Saha, S.H., B.B. Ghosh and V. Gopalakrishanan, 1975. Plankton of the Hooghly estuary with special references to salinity and temperature. *J. mar. biol. Ass. India,* 1975, **17**(3) :

Schaefer, M., 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. *Bull. I-ATTC/Bol. CIAT* **1**(2) : 27-56.

Shetty, H.P.C., S.B. Saha and B.B. Ghosh. 1961. Observations on the distribution and fluctuations of plankton in the Hooghly-Matlah estuarine system with notes on their relation to commercial fish landings. *Indian J. Fish.,* **8**(2) : 326-365.

Sinha, M., M.K. Mukhopadhyay, P.M. Mitra, M.M. Bagchi and H.C. Karmakar, 1996. Impact of Farakka Barrage on Hydrology and Fishery of Hooghly Estuaries, Extuary, **19**(3),1996.

Sparre, P., E. Ursin and S.C. Venema, 1989. Introduction to tropical fish stock assessment. *FAO Fish. Tech.b Paper 306/1, Rome, FAO 1989* : 337 p.

Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S., and Ashok C., 1984. Sampling theory of Surveys with applications. *Indian Society of Agricultural Statistics, New Delhi,* 556 pp.

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ASSESSMENT OF FISHERY RESOURCES OF HOOGHLY MATLAH ESTUARINE SYSTEM

Schedule A : DETAILS OF CATCHES BROUGHT AT MARKETS

Centre : ***Month :***

1. Date of landing Total

2. Date of fishing

3. Fishing ground

4. Tides operated (No.)

5. A. Name of gear
   B. No. of gears
   C. Pieces/mesh No.
   D. Piece size
   E. Mesh size

6. Species-wise catches (kg)

   1. *T. ilisha*
   2. *L. tade*
   3. *L. parsia*
   4. *L. calcarifer*
   5. *S. panijus*
   6. *P. paradiseus*
   7. *P. indicus*
   8. *E. tetradactylum*
   9. *S. biauritus*
   10. *Coilia* spp.
   11. *P. pama*
   12. *T. toli*

13. *I. elongata*

14. *Chataeseus* spp.

15. *M. gulio*

16. *Setipinna* spp.

17. *C. dorab*

18. *P. pangasius*

19. *T. jella*

20. *O. militaris*

21. *P. canius*

22. *Lutjeneous* spp.

23. *Trichiurus* spp.

24. *H. nehereus*

25. *S. cinereus*

26. Prawns

27. Mackerel

Miscellaneous

Total

7. Investigator's name :

8. Date sent :

ASSESSMENT OF FISHERY RESOURCES OF HOOGHLY-MATLAH ESTUARINE SYSTEM

Schedule B : Details of catches landed at the sample centre

1. Centre :

2. Month :

3. Fishing gear :

    a) Local name

    b) Type

4. a) Date of observation

    b) Date of last observation

    c) No. of fishing days between the two days

    i) During previous month :

    ii) During current month :

    Gear-wise observation ** :

i)	Sl. No. of observed gear	Total
ii)	Tides of observation LT/HT/LT/HT	
iii)	Catch of tide nos.	
iv)	No. of pieces	
v)	Piece-size	
vi)	Species-wise catches	

5. No. of fishing nets/gears operated :

6. No. of fishing nets/gears observed :

7. Fishing by local or migratory fisherman*

8. Investigator's name :

9. Date sent :

10. Gear-wise observation **

vii)+ No. of fishes in case of Hilsa catch

Remarks :

* If by migratory fisherman, give detail in the remarks space

** Fishing details of a particular net is to be mentioned in adjecent columns under one head.

First low tide (LT) - 1 First high tide (HT) - 2 2nd low tide (LT) - 3 2nd high tide (HT) - 4	Within 24 hours from 1800 hrs.of previous day to 1800 hrs. on the date of observation

+ In case of large number of smaller hilsa av. no./kg may be indicated within brackets

ASSESSMENT OF FISHERY OF HOOGHLY MATLAH ESTUARINE SYSTEM

Schedule B(1) : Number of operating days and related details

Month and year : **Zone :**

Name of centre	Name of fishing gear Local name	 Classification	No. of operating days	Periods of non-operation	Av. no. of net tides operating	Av.catch (kg) per net-tide
(1)	(2)	(3)	(4)	(5)	(6)*	(7)*

Remarks :

Investigator's name & date sent :

* This information are required only for those gears which did not operate in any of the observation days.

ASSESSMENT OF FISHERY RESOURCES OF HOOGHLY MATLAH ESTUARINE SYSTEM

Schedule C(1) : **Inventory of Fishing Camps (Khuties) of winter migratory bagnet fishery in the lower Hooghly estuary**

Name of centre : **Date of inventory :**

Name of fishing camp (khuti) owner	Date of migration		Place from which migrated	Dt. of starting fishing	No. of bagnets possessed	No. of mesh	No. of boats possessed*	No. of men engaged in fishing	No. of fishing before the dt. of inventory	Av. net tide operated for that period	Av. catch per net tide for that period	Remarks
	Bengali calender	English calender										

* Mechanised and non-mechanised boats may be given separately.
If any other type of nets are possessed, give the details in Remarks column.

ASSESSMENT OF FISHERY RESOURCES OF HOOGHLY MATLAH ESTUARINE SYSTEM

Schedule C(2) : Details of Winter Migratory Bagnet Catches in the lower Hooghly Estuary

Centre .... Month .... Year .... Name of Khuti owner ....

Details corresponding to the catch observed										For use at Headquarters	
Dt. of observation	Time of landing	No. of nets operated	No. of tides operated	No. of net tides operated	Catch in no. * of baskets	Catch in kgs.	Time of previous landing	No. of net tides operated on the previous day	No. of days operated after last dt. of observation (inclusive)	Estimate for the day's catch colmn.(6) x col (9) Colmn.(5) whichever is appropraprìate	Estimate of total catch for the period in col. 10 x Col. 11
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)