

## ESTUARINE FISHERIES RESOURCES OF INDIA IN RELATION TO ADJACENT SEAS \*

V.G. JHINGRAN AND V. GOPALAKRISHNAN

*Central Inland Fisheries Research Institute, Barrackpore, West Bengal, India*

### ABSTRACT

Accurate figures of the total area covered by estuarine waters in India and the yields of fish from them are not available. Some rough estimates indicate that about 2,14,500 ha of estuaries and lagoons and 20,20,000 ha of cultivable coastal areas are available for the development of estuarine fisheries and coastal aquaculture. Among the major estuarine systems, the Hooghly-Matlah in West Bengal, the Mahanadi in Orissa, the Godavari in Andhra Pradesh and the Lakes - Chilka in Orissa, Pulicat in Andhra Pradesh and Tamil Nadu, and Vembanad in Kerala - produce appreciable quantities of fish. In addition to these, the estuaries of other rivers flowing into the Bay of Bengal and Arabian Sea also contribute significantly to the fishery economy of the country. The estimated average production figures are Hooghly - Matlah - 7500 t, Mahanadi (marketable surplus only) - 650 t, Chilka - 3600 t, Pulicat 1000 t and Vembanad backwaters - more than 10,000 t. The species composition, gear employed, salient features of the trends in the fisheries and possibilities of development of culture fisheries in the estuarine waters of the country are discussed bringing out the relationship between the fisheries of the estuaries and the adjacent seas on the east as well as the west coast of the country.

### INTRODUCTION

THE estuarine environment is recognised to be a complex ecosystem, with widely varying physico-chemical influences and characteristic biota. The fauna of a brackishwater system is generally composed of marine and freshwater organisms which can adapt to waters of different and varying salinities and truly resident estuarine species. As far as the fishes are concerned, they are grouped as residents and transients, the former being present in the estuarine waters throughout the year in some or all size groups and the transients entering and remaining in 1 or more zones for short durations. In India, marine fishes predominate in all brackishwaters and the fluctuations in their abundance could be related to movements or migrations of the populations. It has been observed that there is a marked difference in the estuarine fauna of the east and west coasts of India, very dense populations, both with regard to species and individuals, being observed on the eastern side. This is thought to be due to the larger rivers on the east coast pushing the estuarine fauna to the Bay of Bengal (Panikkar, 1970). Another matter of interest in this connection is that all estuaries in India have annual flood cycles and hence the movements of the organisms within and from outside, are governed primarily by the salinity conditions, which in turn influence the nutrients and food organisms. Such characteristic features are common in the major estuarine systems in India and are significant when considering their fisheries resources. In addition to the exploitation of natural resources, the estuarine waters in the country offer considerable scope for development of coastal aquaculture. Since the estuarine fauna, in general,

\*Presented at the 'Symposium on Indian Ocean and Adjacent Seas — Their Origin, Science and Resources' held by the Marine Biological Association of India at Cochin from January 12 to 18, 1971.

is predominantly marine in nature, it is always necessary to study the biology and the fisheries of the commercially important species with reference to the conditions obtaining in the adjoining seas. The present account, therefore, is an attempt to briefly review the estuarine fisheries potential in India and indicate their relationship with the resources of the neighbouring seas.

For the purpose of this paper, the term estuary is meant to include tidal estuaries, brackishwater lagoons and lakes and backwaters. Several definitions have been put forth for describing estuaries, but for all practical purposes the coastal waters which are connected to the sea and have salinities varying between traces to that of the sea water with regular admixture fresh and seawaters, may be considered to be an estuarine system.

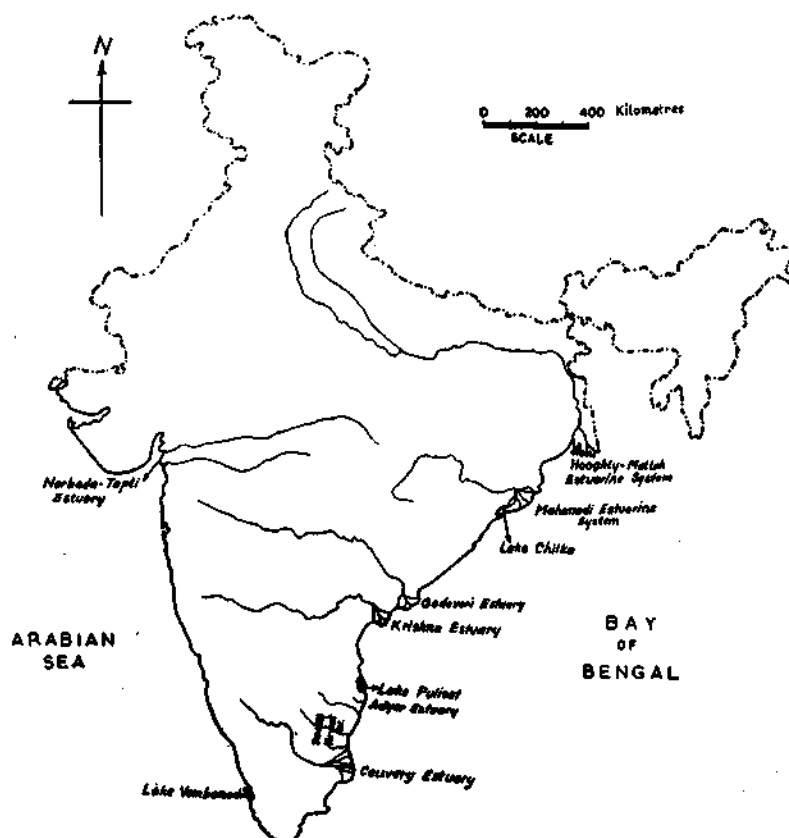


Fig. 1. Map of India showing the important estuarine systems.

#### ESTUARINE AREA AVAILABLE FOR EXPLOITATION AND DEVELOPMENT

Accurate estimates of the total area covered by estuarine waters and the yields from them are not yet available, although such data have been gathered in some of them, mainly through the investigations carried out by the Central Inland Fisheries Research Institute, Barrackpore. Rough calculations indicate that about 2,14,500 ha of deltaic estuaries, lagoons and lakes and 20,20,000 ha of cultivable

brackishwater areas are available in the country for development of estuarine fisheries and coastal aquaculture. The major estuarine systems in the country are: Hooghly-Matlah in West Bengal, Mahanadi and Lake Chilka in Orissa, Godavari and Krishna in Andhra Pradesh, Lake Pulicat and Cauvery in Tamil Nadu, Lake Vembanad in Kerala and Narbada-Tapti in Gujarat (Fig. 1). In addition to these, there are a number of smaller estuaries which are known to have fisheries resources of local importance. The salient features of the fisheries of the more important of these systems, which have been studied so far given below.

#### HOOGHLY-MATLAH ESTUARINE SYSTEM

The fisheries of this estuarine system, as it exists at present, is quite appreciable and provides employment to a large number of fishermen and traders. The investigations made, however, indicate that there is considerable scope for increased exploitation and development of intensive culture in the Lower Sunderbans region. The Hooghly estuary has been found to be a positive one in the myxohaline range. The deltaic area of the entire estuarine system in West Bengal State is estimated to be about 3,100 square miles (Pillay, 1967). The tidal impact is felt up to about 295 km from the mouth and violent tidal turbulations and 'boretides' have been found to be responsible for a complexity of physico-chemical and biological characteristics. Salinity and temperature have been found to be the most significant among hydrological characters, in relation to the fishery resources of this system (Gopalakrishnan, 1968). The annual run off is about 1.118 m and the mean difference between high tide levels in neap and spring tides, about 1.6 and 4.3 m respectively. The water temperature fluctuates between about 19.33 and 32.9°C and there is practically no longitudinal temperature gradient. Vertical homothermy is also exhibited in these waters. Maximum salinity is observed in the lower zone, the values ranging between about 1.56 to 30.39 ppt and almost freshwater conditions occur in the upper reaches. The middle or transient zone presents wide fluctuations in salinity during all seasons (Pantulu and Bhimachar, 1964; Gopalakrishnan, 1969).

TABLE 1. *Estimated annual fish landings from the Hooghly-Matlah Estuarine System*

Year	Total fish landings in tonnes	Landings from the lower zone in tonnes	% of lower zone landings in total
1964-65	10,413	9,492	91
1965-66	6,513	5,290	81
1966-67	6,766	5,308	78
1968	8,054	5,823	72
1969	8,343	6,156	74

The estimated total fish landings from the Hooghly-Matlah Estuarine System for the past 5 years, along with the catches obtained from the lower zone (Sunderbans) alone, are given in Table 1. Generally the capture fisheries in the 'Sunderbans' forms about 70 per cent of the total from the entire system. In 1964 and 1965 the values were exceptionally higher. Of these catches, 75-80 per cent are made during the winter season when a large number of fishermen migrate to the lower zone and engage themselves in the winter fishery operations by setting up temporary camps.

Table 2 gives the estimated landings of selected commercially important fishes of this estuarine system.

TABLE 2. *Species-wise catches in the Hooghly-Matlah Estuarine System (Important species only)*

Species	Estimated catches in tonnes		
	1966-67 (12 months)	1968	1969
<i>Harpodon nehereus</i>	1,328	2,231	1,547
Prawns	1,049	1,194	1,111
<i>Hilsa ilisha</i>	799	589	1,132
<i>Setipinna phasa</i> and <i>S. taty</i>	386	521	611
<i>Tachysurus jella</i>	313	112	420
<i>Pama pama</i>	361	192	392
<i>Trichiurus</i> spp.	156	426	310
<i>Sciaenoides biauritus</i>	156	97	258
<i>Polydactylus indicus</i>	85	244	212
<i>Pangasius pangasius</i>	58	107	120
<i>Ilisa elongata</i>	100	76	116
<i>Coilia ramcarti</i>	86	69	89
<i>Polynemus paradiseus</i>	40	39	64
<i>Mugil parsia</i>	49	58	56
<i>Sillago panijus</i>	26	58	45
<i>Pseudosciaena soldado</i>	31	22	32
<i>Eleutheronema tetradactylum</i>	21	28	27
<i>Lates calcarifer</i>	21	22	25

#### MAHANADI ESTUARINE SYSTEM

The Mahanadi estuarine system is spread out in the districts of Cuttack and Puri (Orissa State) and drain into the Bay of Bengal along a coast line of about 165 km. The annual run off is estimated to be 69.88 cm and the average difference between tides, 0.99 (neap) and 2.76 m (spring) respectively. The tide extends to about 42 km from the mouth. Studies on the hydrology and fisheries of this system have been made by Shetty *et. al.* (1965) and the salient features of their observations are given here. The salinity and temperature range between traces and 35.38 ppt and 19.4 and 34.0°C respectively. A vertical salinity stratification appears to be present in this system (Pantulu and Bhimachar, 1964). The estimated annual fish disposals from the entire system, for the years 1960 to 1964, were:

Year	Fish disposed (in tonnes)		
	Fresh	Dry	Total
1960-61	308.5	493.7	802.2
1961-62	225.0	342.8	567.8
1962-63	131.1	537.9	669.0
1963-64	72.7	491.7	564.4

The above figures, however, are in respect of the marketable surplus only and were based on 2 best possible sampling designs evolved, considering the local conditions. The clupeoids, mainly *Hilsa*, the mullets, polynemids, 'Bhetki', prawns and sciaenids contribute appreciably to the landings. The species-wise marketable surplus are given in Table 3.

TABLE 3. Species-wise marketable fish surplus in Mahanadi estuarine system (1960-64)

Species	Range in quantity (tonnes)	% of total Range	Av. for 4 yrs
<b>Mulletts:</b>			
<i>Mugil cephalus</i>	55.4 - 90.7	6.9 - 14.5	11.0
<i>M. parsia</i>	17.8 - 93.5	7.9 - 14.0	7.9
<i>M. cunnesius</i>	21.7 - 91.1	3.8 - 11.4	7.6
<i>M. macrolepis</i>	6.4 - 22.6	1.0 - 4.0	2.0
<b>Clupeoids:</b>			
<i>Hilsa ilisha</i>	13.7 - 309.7	2.6 - 38.6	-
<i>Sardinella</i> spp.	16.6 - 44.4	-	3.7
<i>Thrissocles</i> spp.	9.5 - 18.6	-	-
<i>Nematalosa nasus</i>	7.2 - 21.6	1.3 - 2.7	2
<i>Ilisha</i> spp.	4.9 - 6.5	-	0.9
<i>Anchoviella</i> spp.	0.1 - 5.0	-	-
<b>Prawns:</b>			
( <i>Leander stylifreus</i> <i>Penaeus indicus</i> , <i>P. carinatus</i> , <i>Metapenaeus brevicornis</i> , <i>Acetes</i> spp.)	73.7 - 113.9	-	12.5
<b>Polynemids:</b>			
<i>Eleutheronema tetradactylum</i>	6.5 - 40.89	1.1 - 6.1	3.4
<i>Polydactylus indicus</i>	2.1 - 25.2	0.4 - 4.4	2
<b>Perches:</b>			
<i>Lates calcarifer</i>	14.5 - 30.2	-	3.7
<b>Catfishes:</b>			
( <i>Pangasius pangasius</i> , <i>Tachysurus</i> spp., <i>Mystus</i> spp., <i>Osteogobius militaris</i> )	2.5 - 18.8	-	1.9
<b>Sciaenids:</b>			
( <i>Otolithoides biauritus</i> , <i>O. brunneus</i> , <i>Sciaena cuja</i> , ( <i>S. miles</i> ) ]	14.8 - 49.5	2.6 - 7.4	-

#### LAKE CHILKA

The Lake Chilka, located in the districts of Puri and Ganjam (Orissa State) on the east coast of India, has a water spread of 902 sq. miles in summer and 1,165 sq. miles in the flood season. Detailed studies on the hydrology and fisheries of

[5]

the lake have been made by the Central Inland Fisheries Research Institute (Jhingran and Natarajan, 1966; 1969). The salinity of the lake water is influenced by the flood discharges from the branches of the Mahanadi system, and shows cyclic changes in the range of 0.13 to 34.28 ppt. The fishery and biology of 16 commercially important species of fish have been studied and a summary of the data on species-wise landings, for the period 1957-66, is given in Table 4. The overall average annual yield has been estimated to be 3,663 tonnes, the group-wise distribution being:

Prawns	-	28.08	Per cent
Mulletts	-	19.07	"
Catfishes	-	12.40	"
Clupeids	-	12.14	"
Perches	-	11.03	"
Threadfins	-	6.44	"
Scianids	-	5.90	"

TABLE 4. Species-wise fish landings in Lake Chilka (1957 - 1966)

Species	Quantity in tonnes	
	Range	Average
<i>Mugil cephalus</i>	180 - 894	478
<i>M. macrolepis</i>	27 - 299	114
<i>Eleutheronema tetradactylum</i>	122 - 364	236
<i>Hilsa ilisha</i>	34 - 293	142
<i>Nematalosa nasus</i>	55 - 199	141
<i>Mystus gulio</i>	189 - 485	311
<i>Tachysurus arius</i>	13 - 66	44
<i>Osteogobius militaris</i>	12 - 73	42
<i>Plotosus canius</i>	22 - 59	34
<i>Pseudosciaena coibor</i>	103 - 294	199
<i>Lates calcarifet</i>	55 - 749	215
<i>Gerres setifer</i>	16 - 82	45
<i>Etroplus suratensis</i>	32 - 222	108
<i>Sparus sarba</i>	2 - 165	91
Prawns:		
<i>Penaeus indicus</i>	335 - 978	661
<i>P. monodon</i>	84 - 485	246
<i>Metapenaeus monoceros</i>	17 - 237	84
<i>M. dobsoni</i>	3 - 158	38

only 3 years' data  
available

only 4 years' data  
available

only 6 years' data  
available

#### LAKE PULICAT

The Lake Pulicat, which spreads over an area of about 1,120 sq.km, in the State of Andhra Pradesh and Tamil Nadu, has been known to be the source of a variety of aquatic organisms. Detailed studies on the fisheries of this lake have been undertaken by the Central Inland Fisheries Research Institute. The salinity

TABLE 5. *Species-wise landings in the Lake Pulicat*

Species	Estimated Landing (tonnes)		
	1967	1968	1969
Prawns	635	379	564
Important species :			
<i>Penaes indicus</i>	388	155	349
<i>P. monodon</i>	65	30	51
<i>P. semisulcatus</i>	31	32	9
<i>Metapenaeus monoceras</i>	80	78	61
<i>M. dobsonii</i>	55	72	88
Mulletts	202	193	216
Important species :			
<i>Mugil cephalus</i>	141	130	123
<i>M. macrolepis</i>	23	23	26
<i>M. cunnesius</i>	23	18	31
<i>M. tade</i>	13	21	34
Perches	84	121	97
Important species :			
<i>Sillago sihama</i>	34	36	33
<i>Sparus</i> sp.	18	12	9
<i>Lates calcarifer</i>	17	25	18
<i>Gerres oyena</i>	6	13	8
<i>G. limbatus</i>	3	7	2
<i>G. filamentosus</i>	4	6	6
Clupeids	64	59	105
Important species :			
<i>Nematolosanassus</i>	42	36	60
<i>Chanos chanos</i>	7	8	20
<i>Thrissocles</i> spp.	7	8	16
<i>Elops saurus</i>	3	5	6
Catfishes	57	47	59
Important species :			
<i>Tachysurus</i> spp.	52	40	53
<i>Plotus canius</i>	5	7	6
Sciaenids	21	20	29
Beloniforms	14	19	28
<i>Polydactylus indicus</i>	14	14	5
Crabs	23	52	25
<i>Scylla serrata</i>	16	35	10
<i>Neptunus pelagicus</i>	7	17	14

in the different sectors of the lake ranges between 1.0 and 41.3 ppt and the temperature, between 23.0 to 33.75°C (Michael, 1969). The total annual estimated landings for the past 3 years are:

1967	-	1,134 tonnes
1968	-	927 "
1969	-	1,141 "

The % composition of the major groups for the 1967 and 1968 were:

	1967	1968
Prawns	55.9	40.9
Mulletts	17.8	20.9
Perches	7.4	13.1
Clupeids	5.6	6.4
Crabs	1.8	5.6
Catfishes	5.0	5.1

The species-wise details of the catches are given in Table 5.

#### KERALA BACKWATERS

Rough estimates show that the fish landings from Kerala backwaters is about 14 to 17 thousand tonnes per annum, from an area of about 50,000 ha (George and Sebastian, 1970). In addition to this about 88,000 tonnes of live clams and 1.7 lakh tonnes of dead shells are collected annually. The composition of the catches is generally as follows (George and Sebastian, 1970) :

Prawns - 60-70%	Mulletts - 11%
<i>Metapenaeus dobsoni</i>	<i>Mugil cephalus</i>
<i>M. monoceros</i>	<i>M. macrolepis</i>
<i>M. affinis</i>	<i>M. cunnesius</i>
<i>Penaeus indicus</i>	<i>M. parsia</i>
<i>Macrobrachium rosenbergii</i>	<i>M. sehli</i>
Pearlspots - 10%	Catfishes - 9%
<i>Etroplus suratensis</i>	Others - 1%
<i>E. maculatus</i>	

The so-called 'Prawn filtration' method of farming is carried out in about 4,300 ha paddy fields (George *et. al.*, 1968; Jones, 1968; George and Sebastian, 1970). The estimated annual prawn catches from this source is more than 10,000 tonnes.

The Lake Vembanad, which is the largest portion of the Kerala backwaters, has an area of 256 sq. miles and the waters exhibit wide fluctuations in salinity, being almost fresh during the South West monsoon season and the values varying from 10.49 at the southern end and 23.31 to 33.55 ppt at the northern regions near the mouth of the lake during other seasons (Shetty, 1963). A preliminary survey of the Lake indicated that the major commercially important fishes are (Shetty, 1973):



Prawns: *Metapenaeus dobsoni*, *M. monoceros* and *Penaeus indicus*.  
Mulletts: *Mugil cephalus*, *M. connesius*, *M. parsia*, *M. troschelii* and *M. waigiensis*.

*Lates calcarifer*, *Chanos chanos*, *Etroplus suratensis*, *Sciaena coiter*, *Lutianus argentimaculatus* *Tachysurus* spp., *Hilsa hilsa* is reported to occur occasionally in shoals (Pillay, 1960).

The annual estimated catches from the lake during 1965-66 were 1,251.8 tonnes of which 518 tonnes were got from 'Chinese dip net', 695 tonnes by stake nets and 38 tonnes by boat seines (Samuel, 1969).

#### OTHER ESTUARINE SYSTEMS

Besides the above mentioned estuaries, a few other smaller ones have been studied by workers in different institutions and on the basis of information readily available, some idea of their fisheries potential could be gathered. Salient features of the data available are given below:

##### Godavari estuarine system in Andhra Pradesh

The area of this estuarine system is about 180 sq. km and the annual run off is estimated to be 39 cm. The mean differences between high and low tide levels are 53 and 134 cm during neap and spring tides, respectively. In the Goutami, which is the main branch of the system, the tidal influence is felt up to about 45 km from the mouth and the salinity and temperature fluctuate between traces and 34 ppt, and 29 and 35°C respectively (Pantulu and Bhimachar, 1964). As regards the fish landings, it is understood that mullets form one third of the total catches, the important species being *Mugil cephalus*, *M. spleigleri*, *M. dussumieri*, *Liza troschelii*, *L. oligolepis* and *L. seheli*. The total prawn catches are estimated to be about 5,000 tonnes per year, the species composition being (Ganapati, 1969) :

<i>Metapenaeus monoceros</i>	- 42.6%	<i>M. dobsoni</i>	- 3.9%
<i>P. indicus</i>	- 24.5%	<i>M. mutatus</i>	- 3.6%
<i>P. monodon</i>	- 10.9%	<i>M. brevicornis</i>	- 2.0%

##### Estuaries in Tamil Nadu

The total area of all brackish-waters in the State of Tamil Nadu has been estimated to be about 0.15 million ha, the important ones being Lake Pulicat, Ennore estuary and backwaters, Cooum estuary, Kovalam backwaters, Chunampet backwaters, Markanam backwaters, Vellar estuary, Killai backwaters, Coleroon estuary Muthuppet lagoon, Tambaraparni estuary and Manakudi backwaters (Chacko, 1969). The total annual fish landings from these waters is estimated to be about 10,000 tonnes, the bulk being contributed by mullets.

The fisheries potential of the estuaries in the South Arcot District (Tamil Nadu) has recently been studied by Venkatesan (1969) and some of his important findings are enumerated below.

Name of estuary	Area	Fish production in 1967-68
Kazhuveli	782 ha	72 tonnes
Ponnaiyar	43 ha	13 "
Gadilam-Paravanar	346 ha	28 "
Vellar	262 ha	29 "
Killai	1685 ha	139 "
Coleroon	809 ha	90 "

[9]

The overall species composition has been found to be: Mulletts - 24.5 per cent, prawns - 24.2 per cent, clupeids - 8.4 per cent, Lates - 3.9 per cent, Polynemus - 28. per cent, eels - 2.4 per cent, crabs - 4.0 per cent and other miscellaneous species.

The fisheries of the Vellar estuary had been studied in detail by Chacko *et. al.* (1954) and the catch composition for 1952-53 was:

<i>Mugil</i> spp.	-	76,993	lbs.
Prawns	-	48,342	"
<i>Leiognathus</i> sp.	-	18,850	"
<i>Sardinella gibbosa</i>	-	7,962	"
<i>Johnius</i> spp.	-	7,861	"
<i>Eleutheronema tetradactylum</i>	-	4,871	"
<i>Engraulis malabaricus</i>	-	4,743	"
Catfishes	-	1,935	"

The fisheries of Vamsadra estuary were also studied by Chacko *et. al.* (1954), but the catches were not appreciable, there being only about 12 lb fish in a day's effort. The mullets formed the dominant element in this estuary also, followed by prawns.

#### The Adyar estuary

The fisheries of the Adyar estuary, located on the southern part of Madras City, has been described by Evangeline (1967). The general trends in the fish catches are:

	1963-64	1964-65
Total catches	21. 6 tonnes	7.2 tonnes
Mulletts	14.86 %	19.02 %
Prawns	23. 2 %	6.78 %
<i>Sillago sihama</i>	4.23 %	2.67 %
<i>Tilapia mossambica</i>	9.67 %	25.17 %
Catfishes	8.55 %	11.33 %
Others	39.59 %	35.03 %

#### GENERAL CONSIDERATIONS

The species composition of the fish catches from different estuarine systems in the country clearly indicates that both on the West and East coasts, many commercially important species of fin-fish and shell-fish penetrate into brackish waters to form important local fisheries. Since most of them are known to perform either short or long term movements or migrations, it become necessary for fishery biologists to consider the distribution of populations in the estuaries and adjoining seas simultaneously. In tidal estuaries, as for example, in the Hooghly-Matlah Estuarine System, the major portion of the fish catches are obtained from the mouth region and are composed of species common to the coastal seas. These marine fishes get into the estuarine waters when favourable conditions of salinity, temperature, water currents, abundance of food items, etc. are prevalent. Further, the marine zone of the estuaries are known to be very productive and this is generally reflected in the higher fish catches from the region. In the Hooghly estuary, the important fishes that move up for spawning purposes are : *Hilsa ilisha*, *Polynemus paradiseus*, *Sillago panijus*, *Pama pama*, *Polydactylus indicus* and *Eleutheronema tetradactylum*. The mullets, penaeid prawns, *Harpodon nehereus* and *Trichiurus*

spp. migrate to the sea for breeding. Major portion of the stocks of mullets like *Mugil parsia* and *M. tade* are supposed to remain in the inshore areas and the rest only migrate into estuarine waters (Sarojini, 1957). As regards the penaeid prawns, the interdependence of the seas and estuaries for completion of their life cycles, is well known.

In Lake Chilka, almost half of the fish catches are formed of catadromous species which depend on the sea for completion of their life cycles. The concerned species are : *Mugil cephalus*, *Liza troschelli*, *Penaeus indicus*, *Penaeus monodon*, *Sparus sarba* and *Lates calcarifer*. The anadromous species include *Hilsa ilisha*, *Nematolosa nasus*, *Tachysurus arius*, *Eleutheronema tetradactylum*, and *Pseudosciaena coibor*, which together form about 19-25 per cent of the catches. More or less similar conditions occur in the other brackishwater lakes also, although the commercially important species may vary.

Panikkar (1969) has recently stated that a possible explanation to the marked difference in the estuarine fauna of the East and West Coasts of India is that the populations on the West Coast suffer from partial or complete destruction during the South West Monsoon period, followed by re-population by marine species in the post-monsoon seasons. He has also pointed out that the oceanographic conditions in the Arabian Sea and Bay of Bengal have important roles to play in the formation of the coastal fauna. This naturally applies to the animals which enter the estuaries also. All these factors emphasize that, for the development of the capture fisheries in estuaries, the problem has always to be tackled on an inter-estuary and adjacent sea basis. To cite an example, about 63 to 75 per cent of the production of Lake Chilka has to depend on recruitment from the sea and the ingress of the marine fishes depends on certain species preference. It is therefore essential that the parameters concerning such ingresses should be comprehensively studied when the overall development of the fisheries of coastal eco-systems has to be achieved. It would also be necessary to establish correlations with the inward fish migrations and productivity of the same species within the brackishwaters systems, in order to increase the quantum of sea-estuary migrations.

#### REFERENCES

- CHACKO, P.I. 1969. Estuarine fisheries resources of Tamil Nadu, First all-India symposium on estuarine biology, Tambaram, Madras.
- , et al. 1954. A study of the fisheries of the Vellar estuary with special reference to their conservation. *Contr. Freshw. Fish. biol. Sta. Madras*, 1 : 1-31.
- EVANGELINE, T. G. 1967. Trend in the fisheries of the Adyar estuary, April 1963 to March 1965. *Madras J. (Fish.)*, 4 : 1-20.
- GANAPATI P.N. 1969. Prawn fishery in Godavari Estuarine System. *Sea food export Journal* 1 (9) : 11.
- GEORGE, A.I. AND M.J. SEBASTIAN 1970. Review of the backwater fisheries and Brackishwater fish culture in Kerala State. *Symposium on coastal aquaculture, Indo-Pacific Fisheries Council, IPFC/C70/SYM 19* (Mimeo).
- GEORGE, M. J., K. H. MOHAMED AND N.N. PILLAI 1968. Observations on the paddy-field prawn filtration of Kerala, India. *FAO Fish. Rep.*, (57) 2 : 427-442.
- GOPALAKRISHNAN, V. 1968. Fishery resources of the Hooghly-Matlah estuarine system and its relation to fisheries of Bay of Bengal. *Symposium on the living resources of the seas around India*, Central Marine Fisheries Research Institute, India, pp. 373-386.
- , 1969. The biology of the Hooghly-Matlah estuarine system (West Bengal, India) with special reference to its fisheries. *J. mar. biol. Ass. India*, 13 : 182-194.

- JHINGRAN, V.G. AND A.V. NATARAJAN 1966. Final report on the fisheries of the Chilka lake (1957-65). *Bull. cent. Int. Fish. Res. Inst., Barrackpore*, (8) : pag.var.
- , 1969. A study of the fisheries and fish populations of the Chilka lake during the period 1957-65. *J. Inland Fish. Soc. India*, 1 : 49-126.
- JONES, S. 1968. The prawn fishery resources of India. *FAO Fish. Rep.*, (57) 3 : 725-747.
- MICHAEL, R.G. 1969. Hydrobiology of the Pulicat Lake. First all-India symposium on estuarine biology, Tambaram, Madras.
- PANIKKAR, N.K. 1969. New Perspectives in estuarine biology. Inaugural Address, First all-India symposium on estuarine biology, Tambaram, Madras.
- PANTULU, V.R. AND B.S. BHIMACHAR 1964. Observations on the hydrology and biology of some Indian estuaries. Paper presented at the Marine Science Seminar, Calcutta.
- PILLAY, T.V.R. 1960. The occurrence of the *Hilsa*, *Hilsa ilisha* Hamilton in the Vembanad backwaters (Kerala). *Sci & Cult.*, 26 (1) : 48.
- , 1967. Estuarine fisheries of the Indian Ocean Coastal Zone. In : Estuaries, Washington, American Association for the Advancement of Science, 647-657.
- SAMUEL, C.T. 1969. Problems and prospects of the estuarine fisheries of Kerala. First all-India symposium on estuarine biology, Tambaram, Madras.
- SAROJINI, K.K. 1957. Biology and fisheries of the gray mullets of Bengal. I Biology of *Mugil parsia* Hamilton with notes on its fishery in Bengal. *Indian J. Fish.*, 4 (1) : 160-207.
- SHETTY, H.P.C. 1963. A preliminary fishery survey of the Vembanad Backwaters, Kerala *Survey report, Cent. Int. Fish. Res. Inst., Barrackpore*, (2) : 25 pp.
- SHETTY, H.P.C., R.D. CHAKRABARTY AND C.G. BHATTACHARYA 1965. A report on the fisheries of the Mahanadi Estuarine System. *Bull. cent. Int. Fish. Res. Inst., Barrackpore*, (5) : 81 pp.
- VENKATESAN, V. 1969. A preliminary study on the estuaries and backwaters in South Arcot District, Tamil Nadu (South India). Part II : Fisheries. First all-India symposium on estuarine biology, Tambaram, Madras.