THE SUBARNAREKHA ESTUARY – ECOLOGY & FISH BIODIVERSITY

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Riverine Ecology and Fisheries Division

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FOREWORD

One defining feature of estuaries relates to high productivity and diversity of fish communities in these transitional ecosystems well attuned to continual time-space variations in salinity and other physical, chemical and biological properties. The freshwater flow, hydrodynamics and nutrient flux are some of the major drivers of the ecosystem characteristics and estuarine functions. Most of the large estuaries on the east- coast of India are well studied. The Subarnarekha which forms a small estuarine system at its confluence with the Bay of Bengal presents many unique features of ecology and fish diversity, important to local fishers and other stakeholders and yet it has received little research attention to document them till recently. This initiative fills this gap to a large measure.

The qualitative check list of fish species recorded from Subarnarekha estuary, including a range of euryhaline estuarine species as well as freshwater and marine migrants is a testimony to habitat suitability for feeding, breeding and nursery grounds and sustenance of biodiversity conservation. The baseline information on the physical, chemical and hydrobiological aspects are other important elements to further amplify the productivity status and essential fish habitats of Subarnarekha estuary. The suggestions for fisheries management and biodiversity conservation are meaningful. This work could certainly provide a vital link to further studies on fisheries resources of Subarnarekha estuary.

(A. P. SHARMA)
DIRECTOR

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Introduction

The river Subarnarekha, "the streak of gold" as the name connotes, is about 460 km in length, originates in the Chotanagpur plateau near Ranchi and meanders through the states of Jharkhand, West Bengal and Orissa before draining into the Bay of Bengal near Kirtania/Chaumukha in the district Baleswar (Balasore) in Orissa. The estuarine span of the river is about 45-50 km covering a stretch between sea-face (about 1.5 km downstream of Kirtania) and Jaleswar, and is confined within the state of Orissa. Though a feeble impact of tide is sometimes observed in the uppermost part at Jaleswar, in physical dimension, the estuary proper should be considered only up to about 5-7 km downstream of Jaleswar and 5-6 km above Dahamunda. This beautiful estuary dwells through a difficult and almost untrodden terrain, in the state of Orissa and till recently, could attract only a few nature lovers.

For this reason perhaps, it remained little known so far as its ecology, fishery and aquatic bio-diversity are concerned. With this in view, a team of investigators of CIFRI has conducted studies on the ecology, fishery and aquatic biodiversity of the Subarnarekha estuary, including the mangroves at the mouth of the estuary for two years covering 2008-09 and 2009-10.

Study sites

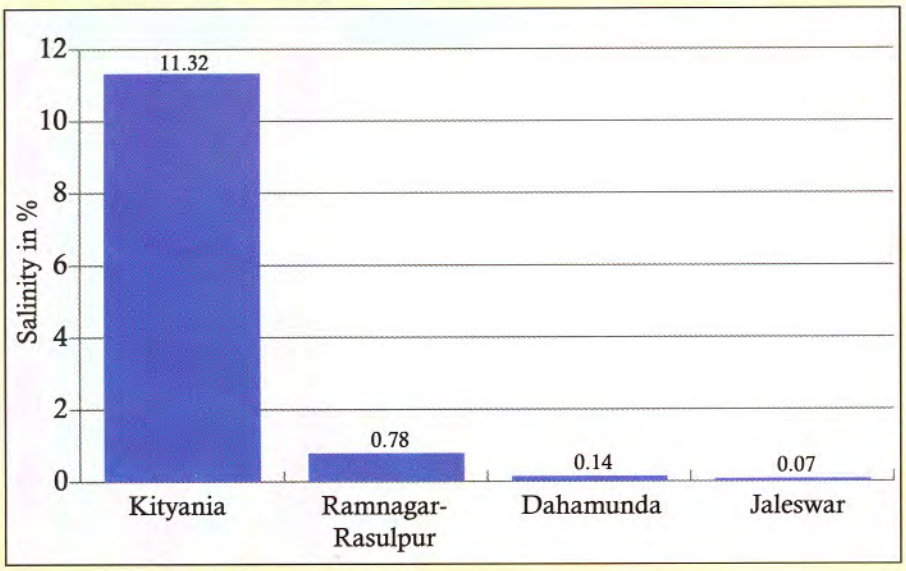
The Subarnarekha estuary which contributes about 10% of the total length of the river, was divided into three main stretches viz., (i) Kirtania-Ramnagar (ii) upstream of Ramnagar to Dahamunda and (iii) upstream of Dahamunda to Jaleswar, based on the primary observation on the salinity regime and extent of tide. The estuary, along its length, has a number of sandflats/ mudflats which are exposed during dry season and get inundated during flood season. These sand flats divide the estuary into 2-3 channels, while the main stream passes by the right bank opposite Jaleswar, Ramnagar and Kirtania. Sand mining is a major activity at Jaleswar during dry season. A deep pool of a few km stretch, located in Dahamunda area, gives the estuarine bed the shape of a large lake. A canal, locally known as 'Hooghly canal' joins the estuary near Ramnagar-Rasulpur some distance below a lock-gate. The head of the estuary in the freshwater zone features a few stagnant pools intermittently during dry season. Locations of different sampling centres are depicted in Fig. 1.

Fig. 1. Study sites on the Subarnarekha estuary

Salinity regime

The salinity regime of the estuary demonstrates almost a freshwater condition throughout its length during monsoon months, save and except in the stretch between Rasulpur-Ramnagar and Kirtania, where a low-saline condition persists. The salinity starts increasing following post-monsoon months. A weak salinity gradient begins to develop in the estuary, which is further intensified from winter to summer months. During the period of observation, the salinity ranged between 0.41 and 27.10 ppt at Kirtania, 0.05 and 2.45 ppt at Ramnagar-Rasulpur; 0.05 and 0.19 ppt at Dahamunda and 0.04 and 0.10 ppt at Sasanbar (Jaleswar). Average values of water salinity at different centres have been presented in Fig.2.

Fig. 2 : Average salinity at sampling sites of Subarnarekha estuary



Other limno-chemical parameters

Dissolved oxygen in Subarnarekha estuary was found to be quite congenial to support fish and other aquatic life. It ranged between 6.2 ppm (Aug.,2008) and 8.8 ppm (Nov. 2008) at Jaleswar; 5.6 ppm (Jun. 2009) and 8.4 ppm (Jan. , 2009) at Dahamunda; 5.7 ppm and 7.2 ppm at Ramnagar-Rasulpur during different months; and 4.8 ppm (Jun., 2009) to 7.4 ppm (Nov., 2008) in the high saline zone at Kirtania. Total alkalinity in the estuary also demonstrated a productive range, though low values were obtained at times (49.0 ppm at Jaleswar, Aug., 2009). The highest value (116.0 ppm) of total alkalinity was obtained at Ramnagar-Rasulpur in the transitional zone during April, 2008. The Gross Primany Production in the estuary ranged between 45.0 and 250.0 mg C m^{-3} h^{-1}. In the high saline zone at Kirtania the GPP

was always found to be lower ranging from 62.5 to 145.83 mg C m^{-3} h^{-1}. In the freshwater zone, save and except in June, 2009 (50 mg C m^{-3} h^{-1}), GPP was little higher. At the transitional zone highest GPP was observed at Ramnagar-Rasulpur with a value of 250 mg C m^{-3} h^{-1} during April, 2009. During August, 2008 also this zone demonstrated a GPP of 218.75 mg C m^{-3} h^{-1} (Dahamunda). pH in the whole estuarine stretch was found to be quite conducive for supporting fish life and ranged between 7.0 and 8.4. Some of the physico-chemical parameters of Subarnarekha estuary are depicted in Table 1.

Table 1. Average values of some liminochemical parameters of Subarnarekha estuary (2008-09 to 2009-10)

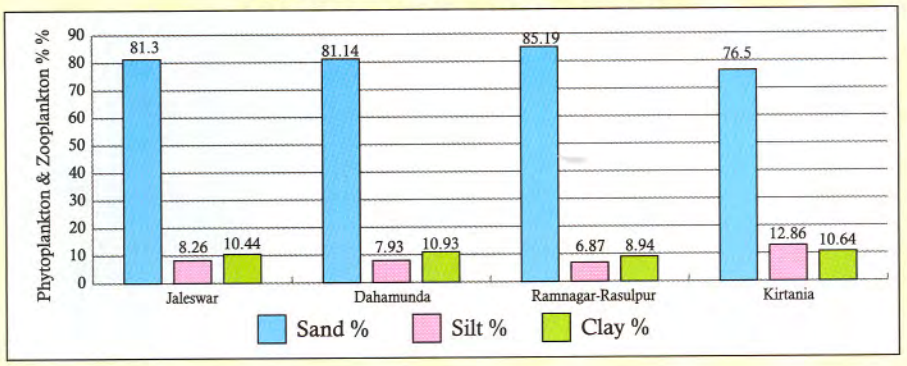
Parameters	Jaleswar	Dahamunda	Ramnagar-Rasulpur	Kirtania
pH	7.75 (7.40-8.28)	7.94 (7.40-8.27)	7.72 (7.00-8.20)	8.77 (6.50-8.20)
Dissolved Oxygen (mg l^{-1})	0.55 (6.20-8.80)	6.80 (5.60-8.40)	6.71 (5.70-7.20)	6.31 (4.80-7.40)
Free CO_2 (mg l^{-1})	0.55 (Nil - 3.2)	0.49 (Nil- 2.0)	1.49 (Nil -3.2)	1.26 (Nil - 4.00)
Total alkalinity (mg l^{-1})	78.25 (49.00-92.00)	84.57 (54.00-110.00)	88.63 (56.0-116.0)	88.86 (60.00-110.00)
NO_3-N (mg l^{-1})	0.106 (0.044-0.208)	0.867 (0.04-0.212)	0.090 (0.028-0.156)	0.077 (0.008-0.140)
PO_4-P (mg l^{-1})	0.045 (0.014-0.096)	0.035 (0.010-0.080)	0.033 (0.01-0.084)	0.044 (0.005-0.108)
Gross Pry. Production (mg C m^{-3} h^{-1})	104.95 (50.00-187.50)	103.28 (45.01-218.75)	119.35 (50.00-250.00)	93.27 (62.50-145.83)

Physico-chemical characteristics of soil

The soil texture of the estuarine bed on the whole was found to be sandy or sandy loam (Fig. 3) Percentage of sand ranged between 66.0 and 90.5 at Jaleswar in the freshwater zone. At Dahamunda it ranged between 72.5 and 90.0, while in the saline zone it ranged between 79.0 and 99.0 at Ramnagar-Rasulpur and 55.0 and 95.0 at Kirtania. The mean percentage of sand at different centres was 81.31, 81.14, 85.19 and 76.5 for Jaleswar, Dahamunda, Ramnagar-Rasulpur and Kirtania respectively. The mean percentage of silt was 8.1, 7.93, 5.88 and 12.87 respectively for these study

cites from freshwater to high saline zone. The percentage of clay was found to be highest at Dahamunda (mean value 10.93) followed by Kirtania (mean value 10.64).

Fig. 3 : Soil texture of estuarine bed



Some of the soil chemical parameters are depicted in Table 2. The conditions of study sites at the estuary at high tide and low tide are depicted pictorially in Fig.4.

Table 2. Mean values of some of the soil chemical parameters of Subarnarekha estuary

Study sites	pH	Available N (mg/100g)	Available P (mg/100g)	Organic C (%)
Jaleswar	7.68 (7.2-8.52)	2.28 (0.56-5.04)	1.96 (0.10-6.04)	0.12 (0.03-0.3)
Dahamunda	7.79 (7.1-8.4)	2.01 (0.28-7.84)	2.86 (0.12-8.86)	0.11 (0.06-0.18)
Ramnagar-Rasulpur	7.66 (7.0-8.2)	2.16 (0.28-5.04)	1.79 (0.12-6.10)	0.15 (0.03-0.42)
Kirtania	7.91 (7.37-8.32)	1.54 (0.28-3.36)	2.48 (0.42-8.74)	0.09 (0.03-0.27)

The range of maximum-minimum values in parenthesis

■ Spot analysis of water quality at the transitional zone

Fig. 4 : Study sites from sea face to the head of Subarnarekha estuary

■ Kirtania at high tide

■ Kirtania at low tide

Fig. 4 *(Contd.)*

Ramnagar-Rasulpur at high tide

Ramnagar-Rasulpur at low tide

Fig. 4 *(Contd.)*

A canal joining the estuary at Ramnagar-Rasulpur

Bhogorai lock-gate on so called Hooghly canal joining Subarnarekha estuary

Fig. 4 *(Contd.)*

■ A view of the large deeper pool at Dahamunda

■ Hook and line fishing in the large deeper pool at Dahamunda

Fig. 4 *(Contd.)*

A view of the head of the estuary at Jaleswar during high flow

A view of the head of the estuary at Jaleswar during dry season

Fish diversity of the estuary

Little attention has been paid to evaluate the status of fish bio-diversity of the Subarnarekha estuary so far. The present investigation, therefore, had the primary objective of enlisting the fish species of the estuary as far as possible, in different salinity zones and to assess the distribution pattern of these species. As per the existing literature 66 species of fishes are on record from the Subarnarekha river on the whole (Karmakar et al. 2008). During the benchmark survey conducted under the present Project a total of 140 species of fish under 55 families and 18 orders have been recorded / documented only from the 50 km estuarine part of the river from Jaleswar to Kirtania (Table 3). Many of the species encountered in Subarnarekha estuary are in common with those of other east-coast estuaries, *e.g.,* Hooghly and Godavari estuaries. Photographs of some species have been presented in Plates 1-11.

Perciformes constituted more than 45% of the total fish species recorded followed by Clupeiformes, Cypriniformes, Siluriformes and Pleuronectiformes (12.86%, 10.71%, 10.00% and 4.29% respectively). The rest of the species were members of the other 13 orders recorded. Marine / estuarine fishes were represented by 83 species constituting 59.29% of the total fish species recorded from the estuary. Fishes restricted to freshwater zone contributed 24.29% to the total number of species encountered. Fishes which are found from the transitional zone to freshwater zone contribute 5.00%, while those distributed from high slaine zone to transitional zone make up only 8.57% of the total number of species. *Tenualosa ilisha, Rhinomugil corsula* and *Xenentodon cancila* have been recorded from all the three zones. *Mystus cavasius* was encountered only in the transitional zone. The present investigation clearly demonstrated that the estuarine environment was fairly congenial to support fish life which has been substantiated by the studies on physic-chemical parameters of water (Table 1). Hilsa has been found to be restricted to high saline - transitional zone, though stray specimens of hilsa are found at Jaleswar following the flood season. *Escualosa thoracata* has been recorded only from the high saline zone and probably is caught from coastal areas. *Gudusia chapra* and *Gonialosa manmina*, the Clupeids fairly common in the freshwater zone of the Hooghly estuary and upper stretches of Ganga river were not encountered in the freshwater zone of Subarnarekha estuary. Of the feather backs *Chitala chitala* has been found to be very rare. Of the polynemids *Polynemus paradiseus* and *Elutheronema tetradactylum* are rarely found in the lowermost part of the transitional zone below Ramnagar-Rasulpur. All the three species, *e.g., P. paradiseus, E. tetradactylum* and *Polydactylus indicus* are restricted mainly

to high saline zone. At Dahamunda, because of the presence of the deeper pool many fish species, *viz., Liza parsia, Liza tade, Pama pama, Sillago sihama, Sillaginopsis panijus* from high saline zone, which migrate into this area, get entrapped. Likewise fishes from upper freshwater zone *viz., Salmostoma bacaila, Wallago attu, Glossogobius giuris,* etc. also get entrapped in this huge deeper area. This fairly long and deeper area supports a commercial fishery substantially all through the year including summer. All the members of Order Cypriformes are restricted to the freshwater stretch from Jaleswar to about 5-7 km down stream, though *S. bacaila* was encountered at Dahamunda also. *Labeo calbasu* has been found to be dominant amongst the carps followed by *Labeo bata* and *Cirrhinus mrigala. Notopterus notopterus, Chitala chitala, Sperata aor, Wallago attu, Ompok pabda, Gagata cenia, Mystus vittatus, Eutropichthys vacha, Pangasius pagasius, Ailia coila* etc. are also found in the freshwater zone. Though *G. giuris* demonstrated a wide range of distribution, *P. lanceolatus* was encountered from low saline to transitional zone. *Pseudapocryptis lanceolatus*, however, has been reported from the freshwater zone of Hooghly estuary (David, 1954; Gopalakrishnan, 1971; Menon at al., 1972 and Ghosh, 2008). At Dahamunda *Rhinomugil corsula* constitute a sizeable fishery. *Mugil cephalus* has been found to be rare and restricted only to high saline zone. *Lates calcarifer* and *Tenualosa ilisha*, though not frequent, are found in the transitional zone. *Ilisha elongata, I. filigera, Escualosa thoracata, Sardinella* spp., *Anodontostoma chacunda, Harpodon nehereus* etc. contribute in high saline zone fishery, besides *Tenualosa ilisha, Lates calcarifer, Lobotes surinamensis, Arius* spp., *Pampus argentius, Trichiurus* spp., Sciaenids and mullets, *Bregmaceros mcclellandi* which was recorded earlier in Hooghly estuary and Sundarbans mangrove area (Ghosh and Satpathy, 2008) and Godavari (Visweswar Rao, 1976; Ghosh and Satpathy, 2009) has also been recorded from Subarnarekha estuary, though the abundance of the species was found to be meagre compared to that from the lower Hooghly and Sundarbans mangrove area. *Elops saurus* was encountered in Subarnarekha, which could not be recorded in Hooghly estuary. The presence of this species in Hooghly has, however been reported by other authors (Talwar et al., 1992). *Sicamugil cascasia*, a small mullet, reported by Ghosh (2009) to be found in the freshwater zone of the Hooghly estuary, was not encountered in the freshwater zone of Subarnarekha estuary. *Catla catla*, locally known as *'Bhakur'* was not encountered in the freshwater zone, though the fishermen and local inhabitants stated the species to be occasionally caught at Jaleswar and Dahamunda, especially in the post flood season. No tilapia (*Oreochromis* spp.) was recorded. Virtually no alien species has been encountered during the present survey in the Subarnarekha estuary.

The only species of Tetradontiformes recorded from Subarnarekha estuary was *Chelondon fluviatilis* which has been found to be restricted only to high saline zone. Though three species of elasmobranchs have been recorded there seems to be no special fishery of these fishes and are probably caught from coastal areas.

Salinity is one of the major factors governing fish distribution. Differences in the salinity regime in different areas influence habitat conditions and therefore, the fish community (Fig. 5). Although salinity is considered a prime factor, there may be other important factors, *viz.*, silt deposition, thermal variation in the estuarine ecosystem, irrational fishing activities, paucity of freshwater discharge, impact of pollutants, accumulated non-biodegradable substances etc. in a given area, which may operate to influence fish biodiversity. All these may affect species composition

Fig. 5 : Hydrobiological sampling in Subarnarekha estuary

Table 3. Fishes recorded from the Subarnarekha Estuary

Class : Chondrichthyes

1. Order: Charcharhiniformes

Family: Carcharhinidae

1. *Scoliodon laticaudus* (Muller and Henle)

2. Order : Rajiformes

Family: Dasyatidae

1. *Himantura bleekeri* (Blyth)
2. *Himantura imbricata* (Bloch & Schneider)

Class: Osteichthys

3. Order Eliopiformes

Family: Eliopidae

1. *Elops saurus* (Forsskal)

4. Order Anguilliformes

Family: Ophichthydae

1. *Pisodonophis boro* (Hamilton-Buchanan)

5. Order: Osteoglossiformes

Family: Notopteridae

1. *Notopterus notopterus* (Pallas)
2. *Chitala chitala* (Hamilton-Buchanan)

6. Order Clupeiformes

Family : Clupeidae

1. *Tenualosa ilisha* (Hamilton-Buchanan)
2. *Escualosa thoracata* (Valenciennes)
3. *Anodontostoma chacunda* (Hamilton– Buchanan)
4. *Sardinella melanura* (Cuvier)
5. *Sardinella* sp.

Family: Chirocentridae

6. *Chirocentrus dorab* (Forsskal)

Family: Pristigasteridae

7. *Raconda russeliana* (Gray)
8. *Ilisha filigera* (Valenciennes)
9. *Ilisha megaloptera* (Swainson)
10. *Ilisha elongata* (Benette)

Family: Engraulidae

11. *Coilia dussumeiri* Valenciennes
12. *Coilia ramcarati* (Hamilton-Buchanan)
13. *Coilia reynaldi* Valenciennes
14. *Setipinna taty* (Valenciennes)
15. *Stolephorus indicus* (van Hasslet)
16. *Stolephorus commersonii* Lacelpede
17 *Thryssa purava* (Hamilton-Buchanan)
18. *Thryssa malabarica* (Bloch)

7. Order: Cypriniformes

Family: Cyprinidae

1. *Labeo calbasu* (Hamilton Buchanan)
2. *Labeo rohita* (Hamilton-Buchanan)
3. *Labeo bata* (Hamilton-Buchanan)
4. *Cirrhinus mrigala* (Hamilton-Buchanan)
5. *Cirrihinus reba* (Hamilton-Buchanan)
6. *Chagunius chagunio* (Hamilton-Buchanan)
7. *Puntius sophore* (Hamilton-Buchanan)
8. *Puntius ticto* (Hamilton-Buchanan)
9. *Salmostoma bacaila* (Hamilton-Buchanan)
10. *Salmostoma phulo* (Hamilton-Buchanan)
11. *Danio devario* (Hamilton-Buchanan)
12. *Parluciosoma daniconius* (Hamilton-Buchanan)
13. *Amblypharyngodon mola* (Hamilton-Buchanan)
14. *Barilius barila* (Hamilton-Buchanan)

Family: Cobitidae

15. *Lepidocephalichthys guntea* (Hamilton-Buchanan)

8. Order: Siluriformes

Family: Bagridae

1. *Sperata aor* (Hamilton-Buchanan)
2. *Mystus cavasius* (Hamilton-Buchanan)
3. *Mystus gulio* (Hamilton-Buchanan)
4. *Mystus vittatus* (Bloch)

Family: Schilbeidae

5. *Eutropichthys vacha* (Hamilton-Buchanan)
6. *Ailia coila* (Hamilton-Buchanan)
7. *Neotropius atherinoides* (Bloch)

Family: Pangasiidae

8. *Pangasius pangasius* (Hamilton-Buchanan)

Family: Siluridae

9. *Wallago attu* (Schneider)
10. *Ompok pabda* (Hamilton-Buchanan)

Family: Sisoridae

11. *Gagata cenia* (Hamilton-Buchanan)

Family: Aridae

12. *Arius jella* Day
13. *Arius sona* (Hamilton-Buchanan)
14. *Osteogeniosus militaris* (Linnaeus)

Table 3. *(Contd.)*

9. Order: Aulopiformes

Family: Harpadontidae

1. *Harpodon nehereus* (Hamilton-Buchanan)

Family: Synodontidae

2. *Saurida tumbil* (Bloch)

10. Order: Gadiformes

Family: Bregmacerotidae

1. *Bregmaceros mcclellandi* Thompson

11. Order: Perciformes

Family: Centropomidae

1. *Lates calcarifer* (Bloch)

Family: Ambassidae

2. *Chanda nama* (Hamilton-Buchanan)
3. *Pseudambasis ranga* (Hamilton-Buchanan)
4. *Ambassis nalua* (Hamilton-Buchanan)

Family: Leognathidae

5. *Secutor ruconis* (Hamilton-Buchanan)
6. *Secutor insidiator* (Bloch)
7. *Gazza minuta* (Bloch)

Family: Gerreidae

8. *Gerres filamentosa* Cuvier
9. *Gerres oyena* (Forsskal)
10. *Gerreomorpha setifer* (Hamilton-Buchanan)

Family: Lutjanidae

11. *Lutjanius johni* (Bloch)

Family: Nandidae

12. *Badis badis* (Hamilton-Buchanan)

Family: Kurtidae

13. *Kusrtus indicus* Bloch

Family: Siganidae

14. *Siganus javus* (Linnaeus)

Family: Scatophagidae

15. *Scatophagus argus* (Linnaeus)

Family: Polynemidae

16. *Polynemus paradiseus* Linnaeus
17. *Elutheranema tetradactylum* (Shaw)
18. *Polydactylus indicus* (Shaw)

Family: Gobidae

19. *Glossogobius giuris* (Hamilton-Buchanan)
20. *Pesudapocryptes lanceolatus* (Bloch & Schneider)
21. *Stigmatogobius sadanundio* (Hamilton-Buchanan)
22. *Stigmatogobius* sp.
23. *Periopthalmus* sp.
24. *Boleopthalmus dussumieri* Valenciennes
25. *Boleopthalmus boddaertii* (Valenciennes)
26. *Gobiopterus chuno* (Hamilton-Buchanan)

Family: Gobioididae

27. *Odontamblyopus rubicundus* (Hamilton-Buchanan)
28. *Taenioides anguillaris* (Linnaeus)
29. *Taeniodes cirratus* (Blyth)

Family: Eleotrididae

30. *Eleotris fusca* (Bloch & Schneider)
31. *Butis butis* (Hamilton-Buchanan)

Family: Sillaginidae

32. *Sillago sihama* (Forsskal)
33. *Sillaginopsis panijus* (Hamilton-Buchanan)

Family: Carangidae

34. *Carangoides malabaricus* (Bloch & Schneider)
35. *Caranx carangus* (Bloch)
36. *Magalaspis cordyla* (Linnaeus)
37. *Scomberoides commersoinnianus* Lacepede
38. *Scomberoides lysan* (Forsskal)
39. *Atropus atropus* (Schneider)
40. *Alectis indicus* (Ruppell)
41. *Gnathanodon speciosus* (Forsskal)

Family: Scombridae

42. *Scomberomorus guttatus* (Bloch & Schneider)
43. *Rastrelliger kanagurta* (Cuvier)

Family: Stromatidae

44. *Pampus argenteus* (Euphrasen)

Family: Parastromatidae

45. *Parastromateus niger* (Bloch)

Family: Ephippididae

46. *Drepene punctata* (Linnaeus)

Family: Mullidae

47. *Upeneus sulphurous* Cuvier

Family: Teraponidae

48. *Terapon jarbua* (Forsskal)

Family: Trichiuridae

49. *Trichiurus savala* (Cuvier)
50. *Trichiurus haumala* Linnaeus

Family: Scianidae

51. *Pama pama* (Hamilton-Buchanan)
52. *Otolithoides biauritus* (Cantor)
53. *Otolithoides ruber* (Schneider)
54. *Macrospinosa cuja* (Hamilton-Buchanan)

Table 3. *(Contd.)*

55. *Daysciaena albida* (Cuvier)
56. *Dendrophysa russelli* (Cuvier)

Family: Lobotidae

57. *Lobotes surinamensis* (Bloch)

Family: Himulidae

58. *Pomadasys argenteus* (Forsskal)

Family: Mugilidae

59. *Liza parsia* (Hamilton-Buchanan)
60. *Liza tade* (Forsskal)
61. *Mugil cephalus* Linnaeus
62. *Valamugil cunnesius* (Valenciennes)
63. *Rhinomugil corsula* (Hamilton- Buchanan)

Family: Sphyraenidae

64. *Sphyraena jello* Cuvier

12. Order : Mastacembeliformes

Family: Mastacembelidae

1. *Mastacembelus armatus* Lacepede
2. *Mastacembelus pancalus* (Hamilton-Buchanan)
3. *Macrognathus aculeatus* (Bloch)
4. *Macrognathus* sp.

13. Order : Channiformes

Family: Channidae

1. *Channa punctatus* (Bloch)
2. *Channa marulius* (Hamilton-Buchanan)
3. *Channa orientalis* (Schneider)

14. Order : Cyprinidontiformes

Family: Hemiramphidae

1. *Hyporhamphus limbatus*(Valenciennes)

Family: Belonidae

2. *Xenentodon cancila* (Hamilton-Buchanan)
3. *Strongylura stronylura*(van Hasselt)

15. Order : Syngnathiformes

Family: Syngnathidae

1. *Ichthyocampus carce* (Hamilton-Buchanan)

16. Order : Scorpaeniformes

Family: Platycephalidae

1. *Platycephalus indicus* (Linnaeus)

17. Order : Tetradontiformes

Family: Tetradontidae

1. *Chelonodon fluviatilis* (Hamilton-Buchanan)

18. Order : Pleuronectiformes

Family: Cynoglossidae

1. *Cynoglossus lingua* (Hamilton-Buchanan)
2. *Cynoglossus arel* (Bloch and Schneider)
3. *Cynoglossus cynoglossus* (Hamilton-Buchanan)
4. *Cynoglossus puncticeps* (Richardson)

Family: Solidae

5. *Eryglossa orientalis* (Bloch & Schneider)
6. *Synaptura commersoniana* (Lacepede)

either directly or indirectly by affecting fish food abundance of a given area in the estuary. Another important aspect affecting fish biodiversity is the indiscriminate release / casual entry of fish species not only by way of ranching, but for other reasons as well. Flooding of some areas during monsoon, when huge areas alongside the estuary get inundated , may also result in entry of fish species including exotic ones, altering biodiversity. In the Subarnarekha, silting of the mouth has resulted in large sand and mudflats and raised estuary bed which virtually restricts tidal ingress long enough landwards. This has led to almost freshwater conditions to prevail up streams of Ramnagar-Rasulpur. In a situation like this, the movement of migratory species further up streams is hindered.

It is also possible that the number of species recorded during this study might have been contaminated by some marine species and also some freshwater species following the flood during August, 2008, which resulted in inundation of huge area on the left bank of the river including Jalewswar. More studies on fish biodiversity and regular monitoring of the ecosystem are required for formulating proper management practices and strategies for biodiversity conservation. The estuary being the lowest

portion of the river with tidal influence, zonation *sensa stricto* with reference to fish distribution may not always be possible. In the absence of chronological records of fish diversity, it has not been possible to assess the time scale changes which might have taken place over the years. Some of the species might have escaped our notice in this study and therefore, continuous effort for updating the fish biodiversity status in the estuary is suggested.

Decapod crustaceans

Fourteen species of prawns and seven species of crabs have been recorded from different zones of the estuary (Plate 7). *Macrobrachium rosenbergii* contribute substantially in the stretch between Jaleswar and Ramnagar-Rasulpur. Of the other members of Palaemonidae *Macrobrachium lamarrei* (from freshwater to transitional zone) and *Macrobrachium rude* (in the transitional zone) has some contribution in the prawn fishery. *P. monodon* and *F. indicus* also were found in low abundance in the high saline zone. *Metapenaeus brevicornis* and *Metapenaeus monoceros* are the principal contributors in the stretch between down stream of Dahamunda (low saline) and Kirtania. Crabs do not have any significant contribution to the decapods crustacean fishery, though *Scylla serrata* and *Portunus pelogicus*. in high saline zone and *Vereena litterata* in the freshwater to transitional zone have minor fishery.

Prawns encountered during the present survey include *Macrobrachium rosenbergii* (de Man), *M. malcolmsonii* (H. Milne-Edwards), *M. sabriculum* (Heller), *M. villosimanus* Tiwari, *M. lammarei* (H. Milne-Edwards), *M. gangeticum*(Bate), *M. dayanum* (Henderson), *M. rude* (Heller), *Penaeus monodon* Fabricius, *Fenneropenaeus indicus* (H. Milne-Edwards), *Metapenaeus monoceros* (Fabricius), *M. brevicornis* (H. Milne-Edwards), *Parapenaeopsis stylifera* (Alcock), *P. sculptilis* (Heller).

Crab species encountered in different zones of the estuary include *Scylla serrata* (Forsskal), *Portunus pelagicus*(Linnaeus), *Veruna litterata* (Fabricius), *Sesarma quadrata* (Fabricius), *Uca lactea* (De Haan), *Uca* sp., *Satorina spinigera* (Wood-Mason).

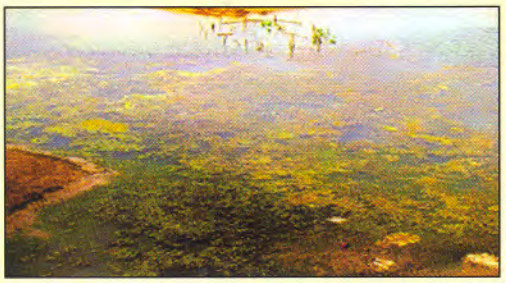
Khadan fishery

An indigenous method of fishing known as Khadan fishing has been observed at Jaleswar and Dahamunda (Fig. 6). At selected vantage points, different aquatic plants are dumped and spread over the area encircled by rope and bamboo frame. This enclosed area may be circular or rectangular (Plate). The fishes assemble below the mass of plant debris for shelter. After 2-3 days the whole area is enclosed by thick meshed nylon net. The aquatic plants are then removed and the entrapped fishes are harvested by dragging or with the help of cast net and finally even by hand picking. The different types of fishing activity is depicted pictorially in Fig.7

Fishing Gear

Different types of gear, notably set barriers, cast net, drift / set gill net, bag net, thick meshed small rectangular net, shore seine, baits, traps etc. have been in use at various centers in the freshwater, transitional and high saline zones. Apart from this trawling is also widely practiced in the mouth of the estuary and inshore regions.

Fig. 6 : Khadan fishery operations at different places in Subarnarekha



Jaleswar

Jaleswar

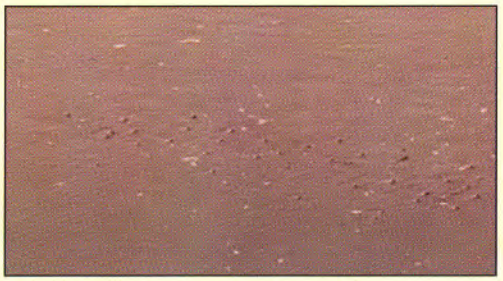
Jaleswar

Dahmunda

Dahmunda

Dahmunda

Dahmunda



A shoal of *R. corsula* surfacing at Dahmunda

Fig. 7 : Fishing activity at different sites in Subarnarekha estuary

Kirtania

Kirtania

Ramnagar-Rasulpur

Dahmunda

Dahmunda

Jaleswar

Jaleswar

Jaleswar

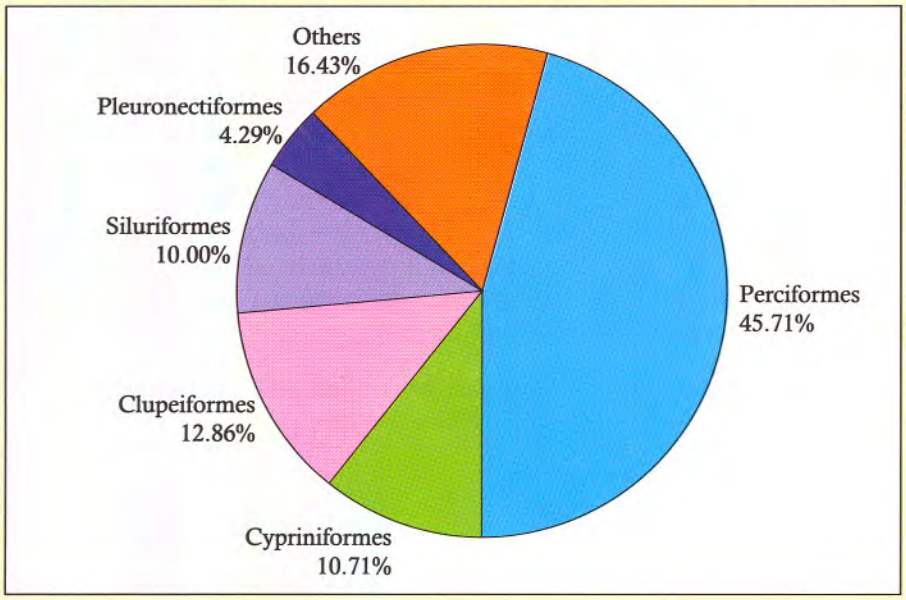
Fish production

An empirical estimate of fish production in Subarnarekha estuary based on survey of landing centres and response of wholesalers indicated a total annual production of about 618 t, in which the saline zone had a major share of around 93% contributed by marine and estuarine fishes (Table 4 and Fig.8). The monsoon season accounted for the highest catch. The least contribution to total fish production was from the freshwater zone, apparently due to sever reduction of freshwater flow for most part of the year beyond a brief period of the wet season.

Table 4. Estimated fish production in Subarnarekha estuary

Zone	Premonsoon	Monsoon	Postmonsson	Annual
Saline Zone	Av. prodn. 180.2 t	Av. prodn. 305.4 t	Av. prodn. 90.4 t	575 t
Transitional zone	Av. prodn. 12.8 t	Av. prodn. 8.5 t	Av. prodn.10.24t	31.5 t
Freshwater Zone	Av. prodn. 3.8 t	Av. prodn. 2.3 t	Av. prodn. 4.23 t	10.3 t
Total	196.6 t	316.5 t	104.67 t	617.77 t

Fig. 8. Group wise composition of fishes in Subarnarekha estuary



Plankton

In the high saline zone at Kirtania where the mean plankton density was found to be 423 u l^{-1}, the phytoplankton had an overall dominance on zooplankton, the mean percentage share being 65.89 for phyto and 34.11 for zooplankters (Fig. 9). The concentration of plankton ranged between 334 u/l (August, 2008) and 500 u/l (April,

2009). The percentage contribution of phytoplankton over the period of observation varied between 50.0 and 77.78. Bacillariophyceans represented principally by *Coscinodiscus granii, Biddulphia* sp., *Asterionella* sp., *Tabellaria* sp., *Gyrosigma* sp., *Nitzschia* sp., *Navicula* sp., *Pleurosigma* sp., *Chaetoceros* sp., *Pinnularia viridis, Fragilaria* sp., *etc.*. dominated the phytoplankton (Table 5.). Blue greens were represented by *Oscillatoria* sp., *Anabaena* sp., *Spirulina* sp., and greens by *Spirogyra* sp., *Oedogonium* sp., *Ulothrix* sp., *Actinestrum* sp., *etc.* during different seasons. In all the seasons Copepods represented by *Heliodiaptomus* sp., *Diaptomus* sp., *Mesocyclops* sp., and the larvae of copepods were the principal constituents of zooplankton. Ramnagar-Rasulpur centre in the transitional zone had a mean plankton concentration of 305 u/l with phyto- and zooplankton contributing on an average 64.75 and 35.25 % respectively. On the whole the plankton demonstrated a similar condition as that of high saline zone, with slight variation like absence of *Biddulphia* sp., and the presence of Chlorophyceans like *Eudorina* sp., *Pediastrum simplex etc.* Zooplankton, besides the copepods, was found to be represented by rotifers, e.g., *Brachionus* spp., *Keratella* sp. and rarely cladocerans – *Moina* sp. At Dahamunda, considered as the upper limit of transitional zone in the present investigation, the average plankton density was to the tune of 409 u /l with phytoplankton contributing 58.81% and zooplankton constituting 41.19% . At this point Chlorophycae represented by *Spirogyra* sp., *Oedogonium* sp., *Coelestrum* sp. had substantial contribution to phytoplankton particularly during April 2008 and August 2009. Diatoms comprising *Fragillaria capusina, Synedra ulna, Melosira granulata, Pinnularia viridis, Pleurosigma* sp., *Gyrosigma* sp., *Navicula* sp. etc. had a share of 38.87 % in total phytoplankton. The percentage of phytoplankton ranged as 38.51% to 76.47% while for zooplankton it was between 61.49 and 23.53 %. High concentration of zooplankton at this centre was recorded during August 2009, which may be attributed to the presence of good number of ichthyoplankton. At Jaleswar (Sasanbar), at the head of the estuary with absolutely freshwater condition, the mean plankton concentration was found to be 336 u/l with an average contribution of phyto and zooplankters of the order of 65.17% and

Fig. 9. Percentage contribution of phytoplankton and zooplankton in Subarnrekha estuary

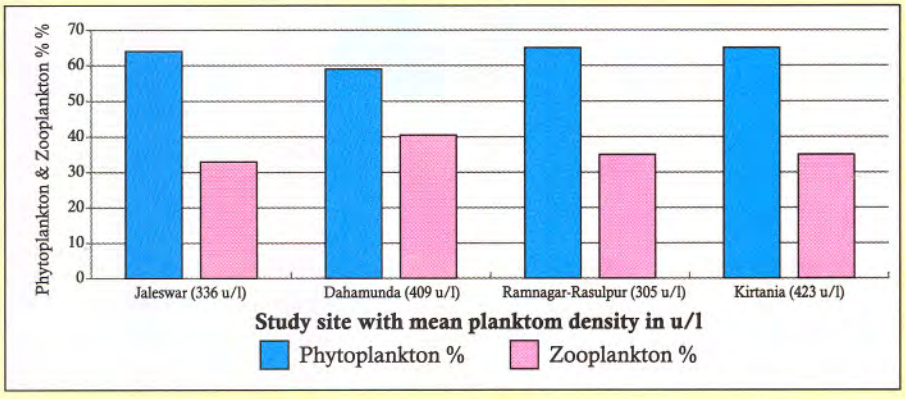


Table 5. : Distribution of plankton in Subarnarekha estuary

Plankers	Freshwater zone (Jaleswar)	Transitional zone (Dahamunda to Ramnagar-Rasulpur)	High saline zone (Kirtania)
Phytoplankters			
Cyanophyceae			
Oscillatoraia sp.	+	+	+
Merismopedia sp.	+	+	+
Anacystis sp.	+	+	+
Anabaena sp.	+	+	+
Spirulina sp.	+	+	+
Chlorophyceae			
Spirogyra sp.	+	+	+
Oedogonium sp.	+	+	+
Ulothrix sp.	+	–	+
Pediastrum sp.	+	+	+
Crucigenia sp.	+	+	–
Actinestrum sp.	+	+	–
Coelestrum sp.	+	+	–
Scenedesmus sp.	+	–	–
Bacillariophyceae			
Gyrosigma sp.	+	+	+
Pleurosigma sp.	+	+	+
Coscinodiscus sp.	+/–	+	+
Navicula sp.	+	+	–
Nitzschia sp.	+	+	+
Diatoma sp.	+	–	–
Tabellaria sp.	+	+	+
Surirella sp.	–	+	+
Synedra ulna.	+	+	+
Anomoeneis sp.	+/–	+	–
Fragilaria sp.	+	+	+
Chaetoceros sp.	–	+	+
Asterionella sp.	+	+	+
Biddulphia sp.	–	–	+
Melosira sp.	+	+	+
Pinnularia sp.	+	+	+
Cymbella sp.	+	+	+
Desmidaceae			
Cosmarium sp.	–	+	+
Euglenophyceae			
Phacus sp.	–	+	–
Dianophyceae			
Ceratium sp.	–	–	+

Table 5. : *(Contd.)*

Plankers	Freshwater zone (Jaleswar)	Transitional zone (Dahamunda to Ramnagar-Rasulpur)	High saline zone (Kirtania)
Zooplanketers			
Copepoda			
Nauplius larvae	+	+	+
Mesocyclops sp.	+	+	+
Diaptomus sp.	+	+	+
Rotifera			
Brachionus sp.	+	+	–
Keratella sp.	+	+	+
Monostyla sp.	–	+	+
Cladocera			
Bosmina sp.	+	+	–
Diaphanosoma sp.	–	+	–
Moina sp.	+	+	–
Others:			
Ichthyoplankton	–	+	–

N.B : + indicates presence, – indicates absence and +/– indicates occasionally present

33.83% respectively. In this part also diatoms were the prime contributor followed by Chlorophycae in the phytoplankton. Diatoms were found to be represented by *Nitzschia* sp., *Synedra ulna, Gyrosigma* sp., *Asterionella* sp., *Anoemoineis* sp., *Melosira granulata, Pinnularia viridis, Fragillaria capusina, Cymbella* sp., etc. and also *Coscinodiscus granii* and *Tabellaria* sp. at times. Chlorophycae, however, was represented by *Spirogyra* sp., *Ulothrix* sp., *Oedogonium* sp., *Pediastrum simplex, Coelestrum* sp., *Actinestrum* sp. etc. Zooplankton comprised copepods and their larvae, rotifers and rarely cladocerans. The contribution of copepods, represented by *Mesocyclops* sp., *Diaptomus* sp. and larvae of copepods, was found to be around 87% of the total zooplankton.

Macrozoobenthos

Macro-zoo-benthic fauna in the Subarnarekha estuary was found to be dominated by molluscs and polychaetes at different places during different seasons. In the freshwater zone (Jaleswar) during 2008-09 the concentration ranged between 176 and 444 nos. m^{-2}. Molluscs dominated by gastropods (*Indoplanorbis exustus, Bellamya bengalensis* and *Thiara lineatus*) contributed 44.22% during summer campaign (Fig. 10). Polychaetes had a share of 22.36% . During August, however, contribution of molluscs to the total macro-zoo-benthos was found to be 75.14% . During post-monsoon the

molluscs continued to dominate in the macro-zoo-benthic population, whereas during winter (January, 2009) polychaetes (*Nephtys polybrancliata)* had an overwhelming dominance contributing 80.18% of the macro-zoo-benthos (444 nos. m^{-2}). During 2009-10 though molluscs had dominance over other groups during summer, bivalves (*Corbicula* sp. and *Parreysia* sp.) had a share of 20% in the total benthic macrofauna and 31.71% of the total molluscan fauna. Towards the end of summer the contribution of polychaetes increased from 20 to 46.63%. During rainy season and so also the post-monsoon months, molluscs were the prime contributor in the macro-benthic fauna contributing 97.18 %(Oct., 2009) to 100% (Aug. 2009). In the transitional zone between Dahamunda and Ramnagar- Rasulpur, molluscs contributed 19.86 to 33.20%, while the contribution of polychaetes (*Nephtys* sp. and *Lumbrinereis* sp.) ranged between 40.18 and 50.19% during April, 2008. At Dahamunda amphipods (*Gammarus* sp.) contributed substantially (30.02%) to the macro-benthic fauna. During rainy season, however, the macro-benthic fauna at Ramnagar-Rasulpur was found to be 441 m^{-2}, where molluscs contributed 39.91%, dipteran larvae 29.93% and polychaetes (*Lumbrineiris* sp.) contributed 20.18%. During post-monsoon the macro-benthic fauna in this stretch was entirely constituted of molluscs. No polychaete or other groups could be encountered. During winter, however, molluscs (both gastropods and bivalves) constituted 33.3%, while polychaetes, 66.67% of the benthic macrofauna at Dahamunda, whereas at Ramanagar-Rasulpur Annelids had low concentration. With the advent of summer the contribution of polychaetes increased (25%) at Ramanagar-Rasulpur. At Dahamunda their contribution was to the tune of 49.81%. In the high saline zone (near the sea face) the contribution of molluscs ranged between 76.26 (January, 2009) and 100% (August, 2008). At Kirtania the contribution of molluscs during January 2009 was found to be 76.26%, while polychaetes had a share of 23.61%. This is in contrast to the observations during August, 2008 and November, 2008, when percentage of molluscs ranged between 85.71 and 100. In 2009 rainy season also the contribution of molluscs was found to be 50% . The percentage contribution of molluscs increased in post-monsoon (October, 2009) and reached to 71.38%. *Neritina smithi, Cerithidea cingulata, C. obtusa, Telescopium telescopium Nectra* sp. etc.Polychaetes had a sizeable contribution during during January, but the rest of the observations did not reveal the presence of polychaetes. During the summer of 2009 (April – June, 2009) the percentage share of polychaetes ranged as 16.70 to 36.21, while the percentage of molluscs ranged between 66.60 and 45.40. Polychaetes were encountered throughout the estuarine stretch from Jaleswar to Kirtania, though the distribution of species at different centres was found to be different. This also holds good for molluscs.

Fig. 10. Some commonly found species of molluscs

Telescopium telescopium

Bellamya bengalensis

Indoplanorbis exustus

Fig.11. Field survey in study site in Subarnarekha estuary

A plaque with details of mangrove plantation by Govt. of Orissa at Kirtania

An active group of fishermen engaged in net mending at Kirtania

Fig. 11 *(Contd.)*

Observing fish arrival at the landing centre at Kirtania

A part of the hilsa landing at Kirtania

Mangroves and other aquatic vegetations

Mangroves are of immense importance from the point of view of fishery. The mangrove region offers suitable feeding ground for many fish larvae/ fry/ juveniles and decapod crustaceans. It also offers protection for the young fishes of many species from predators. Natural but degraded mangrove patches occur at the mouth of the Subararekha estuary (at Kirtania and Chaumukha) in the large mud flats, which get inundated during high tide and also along the shores. The Government of Orissa has initiated a mangrove plantation programme during 2005-2006 (Fig. 11). According to different reports the mangrove area at Subarnarekha mouth is less than 8 m^2. The mangrove and associated flora of the estuary have been found to be constituted of *Exoecaria agallocha, Sonneratia apetala, Avicenia alba, Aegiceros corniculatum, Glycosmis pentaphylem, Indigofera tinctonia, Ipomoea pes-carpae, Withania somnifera, Acanthus ilicifolius* and *Suaeda maritima* etc. The dominant grass species indentified in the tidal inundated flat lands was found to be *Myriostachya whitiana.*

Recommendations

Based on the benchmark survey and field observations on the ecology and fish biodiversity of Subarnarekha estuary some suggestions are recorded for maintaining the estuarine health, conservation of fish biodiversity and sustainable fisheries.

1. Sand and mudflat formations at the mouth and at several other places along the estuary probably is the most important issue of concern, since they prevent landward ingress of tidal water and therefore, limit the scale and magnitude of the mixing zone. This manifests as hindrance for anadromous migratory species of fishes to enter the estuary for the purpose of breeding. Removal of silt from the mouth and other identified places in the estuary is apparently a primary requisite to facilitate upstream migration of fishes, which is likely to improve breeding and recruitment of such fishes.
2. Siltation also affects availability of breeding grounds of many species in the upper part of the estuary. Appropriate measures for desiltation is suggested for improving fish biodiversity conservation.
3. Deepening of river bed is a necessary measure in terms of flood control and other benefits. This is likely to prevent entry of many fish species from culture waters including alien species into estuarine ecosystem causing an adverse impact on the fish biodiversity.
4. A clearly defined regulatory measure like 'fishing ban season' should be strictly in place to prevent catching of hilsa and a few other sensitive fish species prior to or during their early migratory run, in order to facilitate breeding of these species. Mesh size restriction is another important strategy essential for regulating catchable size of important migratory species.

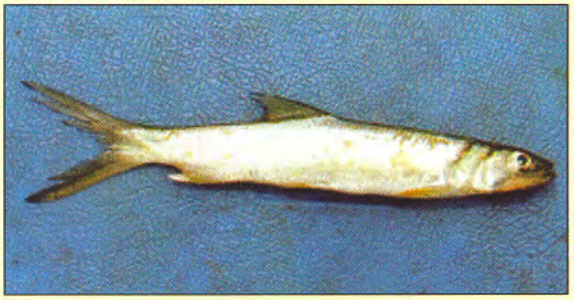
5. Indiscriminate destruction of larvae / juvenile as a direct offshoot of collection of commercial fish and prawn species for aquaculture purpose needs to be stopped. Similar destruction of fisheries resources occurs unnoticed in the form of large quantities of by-catch of little value in commercial fishing activity. Mass awareness campaign in this regard is extremely urgent to be taken up by state / central Govt. agencies in collaboration with gram panchayats and other stakeholder in the estuary.

6. Continuous monitoring of aquatic biodiversity is a vital requirement from the point of view of conservation. Simultaneous to this, there is a need for listing of fish species and their population structure which could be revised and updated periodically.

7. Conservation of fish biodiversity pertains to crisis management. Ranching of the estuary may find an important place in respect of the fish species whose population are found to have been depleted over the years.Ranching of carp species may be taken up in places where a freshwater (or almost freshwater) conditions prevail and water is retained throughout the year.

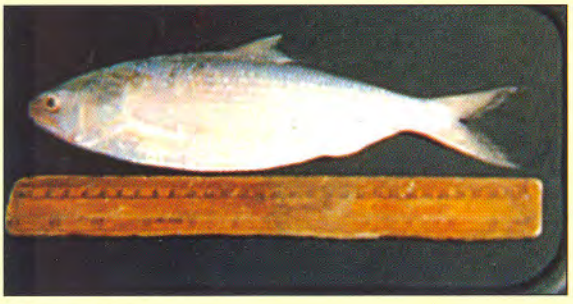
8. Mangrove vegetation being a very significant component of the estuarine aquatic ecosystem it has a major role to support breeding and feeding grounds of several important species of fish and decapod crustaceans. It is highly essential to develop and intensify mangrove plantation along the lower part of the Subarnarekha estuary for sustenance of fishery and fish production.

Plates 1-11. Some fish species from Subarnarekha estuary

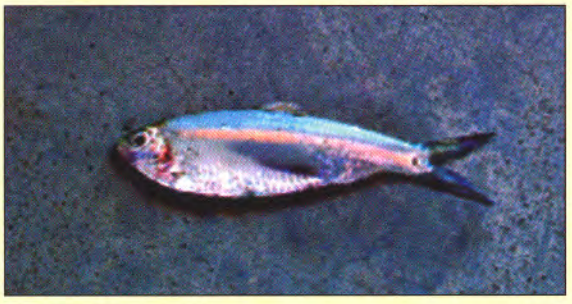


Elops saurus

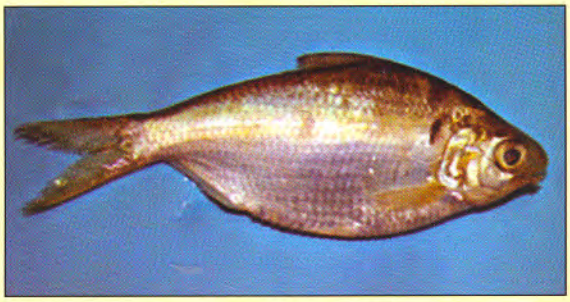
Notopterus notopterus



Tenualosa ilisha



Escualosa thoracata



Anadontosoma chakunda

Coilia dussumieri

Labeo calbasu

Labeo bata

Barilius barila

Puntius sophore

Salmostoma bacaila

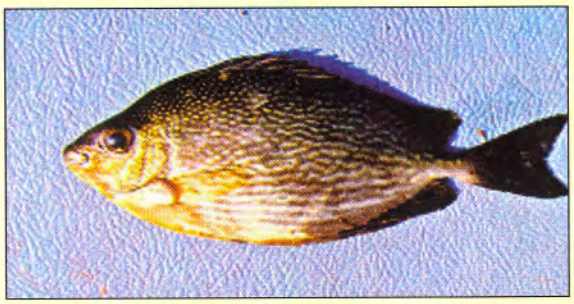
Ailia coila

Sparata aor

Saurida tumbil

Chanda nama

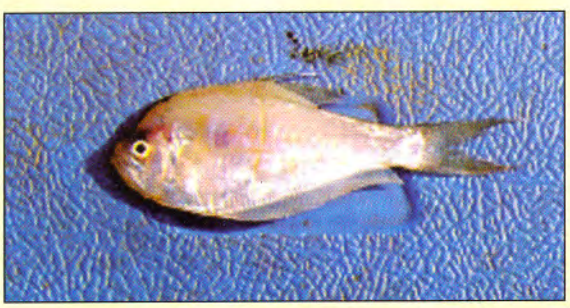
Ambasis nalua



Siganus javus

Gerres filmentosa

Gerres oyena



Kurtus indicus

Dendrophysa russelli

Scatophagus argus

Lobotes surinamensis

Lutjanus johni

Trichiurus savala

Alectis indicus

Elutheronema tetradactylum

Glossogobius giuris

Butis butis

Boleopthalnus bordaertii

Sillago sihama

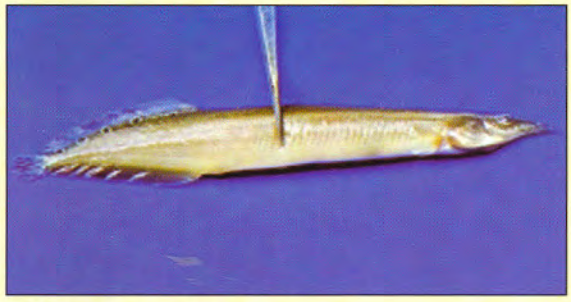
Liza tade

Mugil cephalus

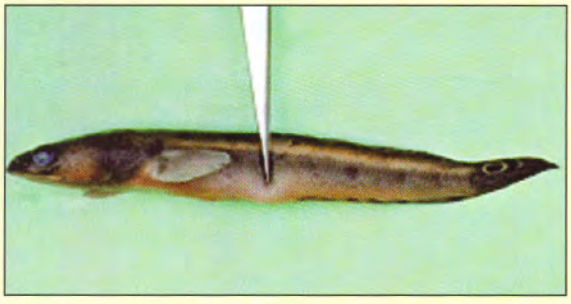
Rhinomugil corsula

Liza parsia

Sphyraena jello



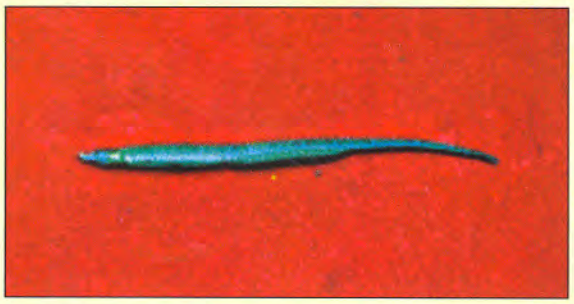
Macrognathus aculeatus



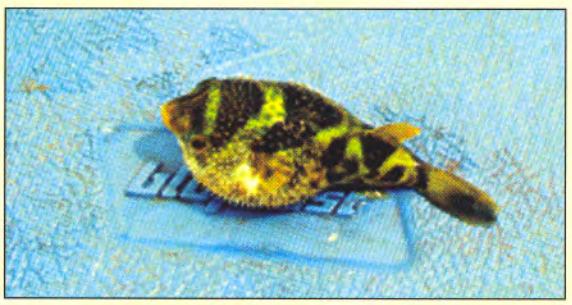
Channa marulius

Channa orientalis

Bregmaceros mcclellandi

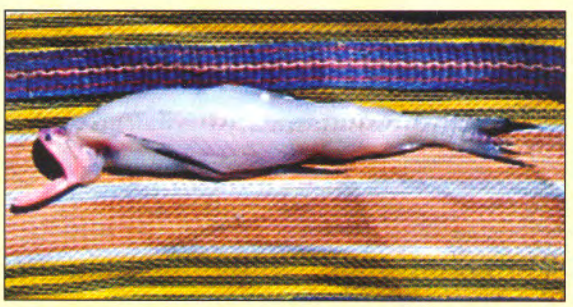


Ichthyocampus carce



Chelonodon fluviatilis

Cynoglossus cynoglossus



Harpodon nehereus

Plate 12. Some species of decapod crustaceans recorded in Subarnarekha estuary

Uca lactea

Scylla serrata

Macrobrachium rosenbergii

Penaeus monodon

Macrobrachium scabriculum

A haul of *Macrobrachium* sp.