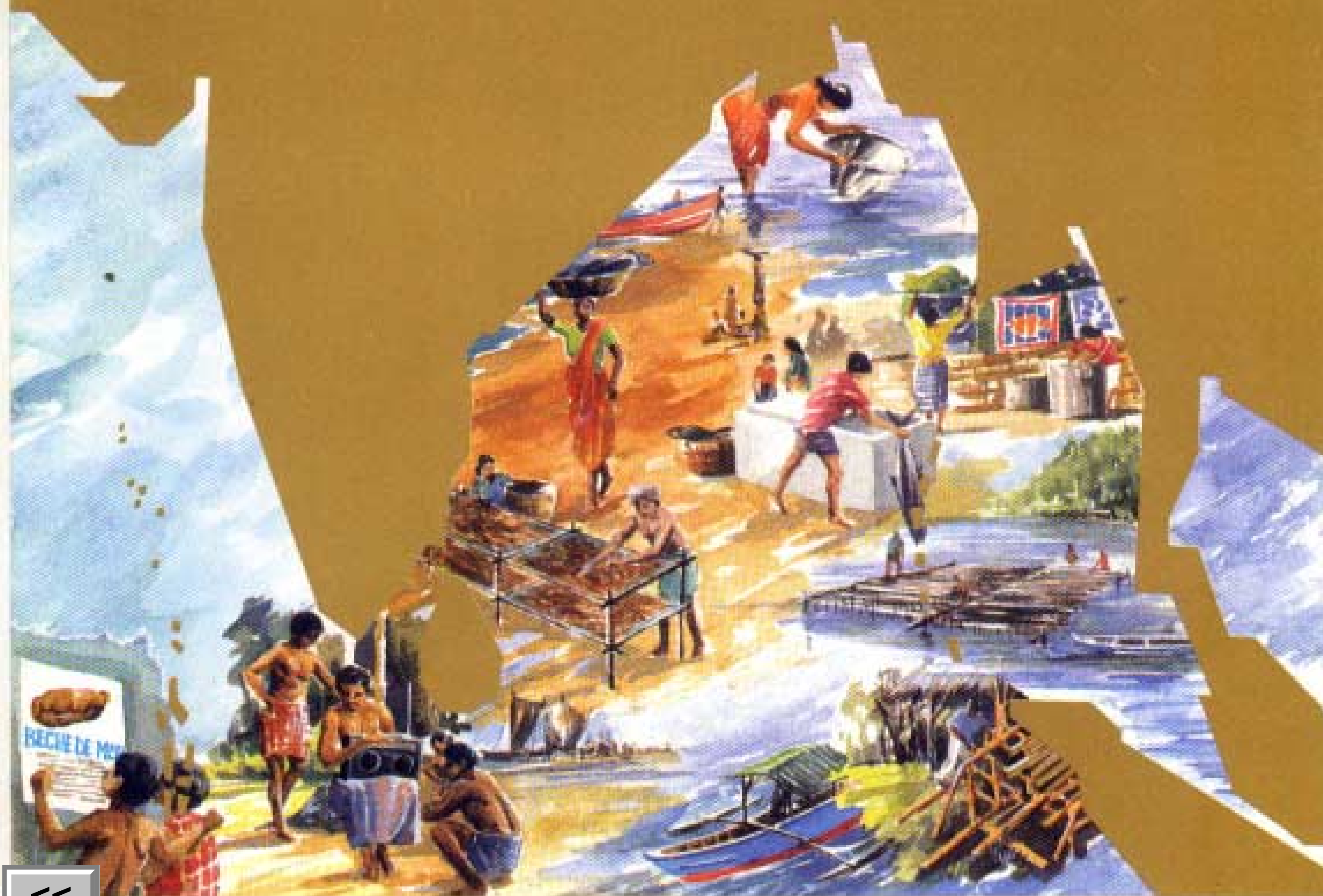
BOBP/WP/94

Biosocioeconomic Assessment of the Effect of the Estuarine Set Bagnet on the Marine Fisheries of Bangladesh



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BAY OF BENGAL PROGRAMME

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Small-scale Fisherfolk Communities
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Biosocioeconomic Assessment of the Effect of the Estuarine Set Bagnet on the Marine Fisheries of Bangladesh

by

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The estuarine set bagnet (ESBN) fishery of Bangladesh is one of the country's niost important traditional fisheries and a large population of small-scale fisherfolk have been dependent on it for a long time. In the last two decades, the introduction and rapid expansion of the bottom trawl fishery and of shrimp culture have contributed to problems of interaction and competition among the fisheries which exploit the same penaeid shrimp and demersal finfish stocks. The traditional, but less efficient, ESBN fishery has not only become vulnerable, being likely to be affected by other fisheries, but may also be destructive to small penaeid shrimp and some of the finfish resources that these other fisheries exploit. The Department of Fisheries, Bangladesh, decided to investigate this issue and the Bay of Bengal Programme (BOBP) was requested to assist. The study was funded by the United Nations Development Programme (UNDP). Bioeconomic and socioeconomic surveys were undertaken in 1989/90 and a National Seminar was held in January 1992 to discuss the results.

Because of the interactive nature of many of the marine fisheries, it was necessary, for the assessment and management of any one fishery, to consider the other fisheries exploiting the same resources. Therefore, in addition to the estuarine set bagnet fishery, the fisheries employing marine set bagnets (MSBN), trammelnets (TRN), beach seines (BS), bottom longlines (BLL) and trawlnets (TWL), as well as shrimp fry-collection using pushnets (PN) and dragnets (DN), were investigated. These studies have been documented separately in BOBP working papers BOBP/WP/89 *Studies of Interactive Marine Fisheries of Bangladesh* and BOBP/WP/90 — *The Socioeconomic Condition of the Estuarine Set Bagnet Fisherfolk in Bangladesh.* The present paper is based on the results and findings of these publications and assesses the biosocioeconomic impact of the ESBN fishery on the other marine fisheries of Bangladesh. The working papers mentioned provide additional information on the respective fisheries.

The Bay of Bengal Programme (BOBP) is a multiagency regional fisheries programme which covers seven countries around the Bay of Bengal — Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka and Thailand. The Programme plays a catalytic and consultative role: it develops, demonstrates and promotes new technologies, methodologies and ideas to help improve the conditions of small-scale fisherfolk communities in member countries. The BOBP is sponsored by the governments of Denmark, Sweden and the United Kingdom, and also by UNDP (United Nations Development Programme). The main executing agency is the FAO (Food and Agriculture Organization of the United Nations).

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1. *SUMMARY*

The estuarine set bagnet fishery (ESBN) of Bangladesh is one of the country's most important traditional fisheries, a large population of small-scale fisherfolk having been dependent on it for a long time. But in the last two decades, shrimp trawl operators and shrimp culturists have been complaining of damage caused, by the ESBN fishery, to resources exploited by their fisheries and to the supply of fry for culture activity. Hence, the Department of Fisheries, Bangladesh, decided to carry out an investigation of the ESBN fishery to determine whether it is a destructive fishery and, if so, what kind, and degree, of damage it caused to the resources and other fisheries. Training of scientific officers was also another objective. A biosocioeconomic assessment was undertaken with the assistance of the Bay of Bengal Programme (BOBP), under a United Nations Development Programme project, RAS/9l/006, and surveys were conducted from December 1989 to November 1990, with the analysis being carried out in 1991.

Since the ESBN fishery interacts with other fisheries, such as the pushnet (PN), dragnet (DN) and fixed bagnet (FBN) for shrimp fry-collection, beach seine (BS) and marine set bagnet (MSBN) for finfish and some shrimp, bottom longline (BLL) for croaker, and trawlnet (TWL) and trammelnet (TRN) for a number of high-valued penaeid shrimp and finfish species, these fisheries were also investigated, to some degree, for better assessment of the impact of the ESBN fishery.

It was found that the ESI3N fishery catches over 100 commercial species of shrimp and finfish, but only three penaeid shrimp *(P. monodon, P. indicus* and *M. monoceros)* and three finfish *(L. savala, H. nehereus* and *Johnius* spp.) are of importance in terms of value and abundance. These were, therefore, studied in detail to assess the impact of the ESBN fishery.

The fishing grounds of the different gear are more or less distinct and cover an area from the very shallow (Im) waters of the estuaries to the deep waters of the sea (80m). Consequently, the different fisheries act sequentially on the different st/ages in the lives of the animals selected for the study, which means that the mean sizes of the animals differ, even though the size ranges overlap to some extent.

In the marine sector, the ESBN fishery has 12,561 gear units and the highest production, though the shrimp fry-collection fishery has a much greater number of gear units (693,000). The trawl fishery, with the least number of units (54), ranks second in production, because of its high productive capacity.

The relationship between catch number, catch weight and catch value of each species differs significantly with the fishery, because of the differences in thT mean size of the animals caught by each fishery and differences in prices for different sizes. The tiger shrimp fry-collection fishery removes billions of other penaeid shrimp and valuable finfish fry and juveniles, apart from tiger shrimp fry, and, thus, destroys a great number of these other species. Such a large number of fry should not be destroyed and appropriate management measures need to be introduced.

The catch rates of not only the PN fishery but also of the ESBN in the Maiskhali area are the highest for the estuarine waters of Bangladesh (see BOBP/WP/89). The lowest ESBN catch rate is in the Kaliganj area. The largest number of species are taken by ESBN, but most of the valuable species caught by this gear are immature or juveniles.

The general trend appears to be that many of the selected species are at present being exploited beyond the maximum sustainable yield (MSY) levels by most of the fisheries, except for tiger shrimp and brown shrimp in the TWL and TRN fisheries, white shrimp in the ESBN fishery and Bombay duck in the MSBN fishery.

Analysis of each fishery with all selected species combined also reveals that the MSY and maximum sustainable economic yield (MEY) are realized below the present levels of effort and are attained at a relatively much lower level of fishing mortality in the ESBN, BS and MSBN than in the TRN and TWL fisheries.

Analysis also indicates that if the TWL fishery alone is allowed and all other interactive fisheries are suppressed, there would be a 300 per cent gain in yield and value of the catch, while if only the ESBN fishery is suppressed, the gain would be about 250 per cent in these values. On the other hand, the TRN fishery shows an extremely high gain of about ten times the yield and value if all other interactive gear are suppressed, but a smaller gain in yield and a large gain in value (300 per cent) if only the ESBN fishery is suppressed. There is no evidence that technological improvements to the ESBN gear will bring about significant improvements to the yield or the income.

The ESBN fishery engages about 55,000 fishermen, and around 85-100,000 fisherfolk are dependent on it for their livelihood. The majority of these fisherfolk, particularly the women, are illiterate, live under temporary roofs because of the destructive effects of frequent cyclones and have poor amenities except for, perhaps, primary schools. The fishing grounds, however, are adjacent to their homes and this reduces travelling and the risk of losing their gear — loss of which would result in increase in debt or loss of livelihood altogether.

Fishing is the primary source of income and about a third of the households are solely dependent on the ESBN fishery, while about two-thirds combine ESBN fishing with other fishery-related and nonfishery activities. Only 11 per cent of the households work as labour in the fishery or in nonfishery activities.

ESBN-owning households are 82 per cent of the total number of households in the study area, but only 25 per cent of ESBN owners have other fishing gear also. ESBN fishing is a family-oriented enterprise, with a high degree of participation by family members and negligible use of hired labour and motorized craft, thereby making operational costs negligible. Consequently, even with extremely poor catches during lean seasons, the ESBN fishery serves as a means of survival without actual income. Seasonality in the fishery and in income is significant.

Except in the Maiskhali area, more than 40 per cent of the ESBN fisherfolk are below the poverty line. The income disparity is not due to differences in skills, but more due to uneven distribution of fish resources in the six different geographical areas (strata) of the estuaries that were studied. Those in areas of low abundance do not earn enough surplus income during the peak seasons to compensate for the poor income during the lean seasons, unless a household owned more than two units of the gear.

The major fishery-related activity is drying of fish. There is very little scope for improving income through any improvements in this activity. Nonfishery income activities in the ESBN villages are also very limited. There is some livestock-rearing, manual labour etc, but lack of land for productive activities is a serious constraint. Only about 21 per cent of ESBN households are able to keep themselves above the poverty line with supplementary income from other fisheries and fishery-related and nonfishery activities. Some possibilities of alternative or additional income from other fisheries have been discussed, but there is very little scope for such opportunities in nonfishery activities.

Extremely low income from the ESBN fishery, repeated destruction by cyclones and high illiteracy contribute to these fisherfolk living without much hope for betterment of their livelihood, unless it be through the mercy of God. Credit facilities, if made available, may encourage some of them to shift to more lucrative fisheries. Alternatives for the ESBN fisherfolk appear to be in the fisheries sector and **not** in the nonfishery sector. In the high catch rate and high income areas (Maiskhali), ESBN fisherfolk are investing their surplus income in more ESBN, whereas, in the moderate income areas, their surplus income is being invested in other gear.

For proper management of many of the marine resources in Bangladesh, management of the ESBN fishery alone will be insufficient; the interactive fisheries also need to be regulated. The highest total catch rate and the largest percentage of penaeid shrimp, ribbonfish and croakers caught are in the Maiskhali area. Regulation of this fishery, in this area alone, preferably during the peak seasons (July-September and, to a lesser extent, February-April) could have a favourable impact on the resources of major valuable species.

The ESBN fishery involues the largest number of fisherfolk, excluding shrimp fry-collection which mainly utilizes women and children. With 37 per cent of the population under 10 years of age, 22 per cent between 10 and 20 years and only 21 per cent between 30 and 60 years, there will be a very significant increase in ESBN fisherfolk in the productive age classes by the year 2000 and they will require additional employment opportunities.

Reduction of ESBN effort or introduction of closed seasonal/area measures will not increase the income of ESBN fisherfolk, but could enhance the recruitment, catch rates and income for interactive fisheries outside the ESBN area and into which some of the ESBN fisherfolk should be encouraged to enter.

2. *APPROACH AND METHOD*

The penaeid shrimp and finfish caught by the estuarine set bagnet and interactive gear appear in different areas and depths, depending on their age and size (see Figure 1).

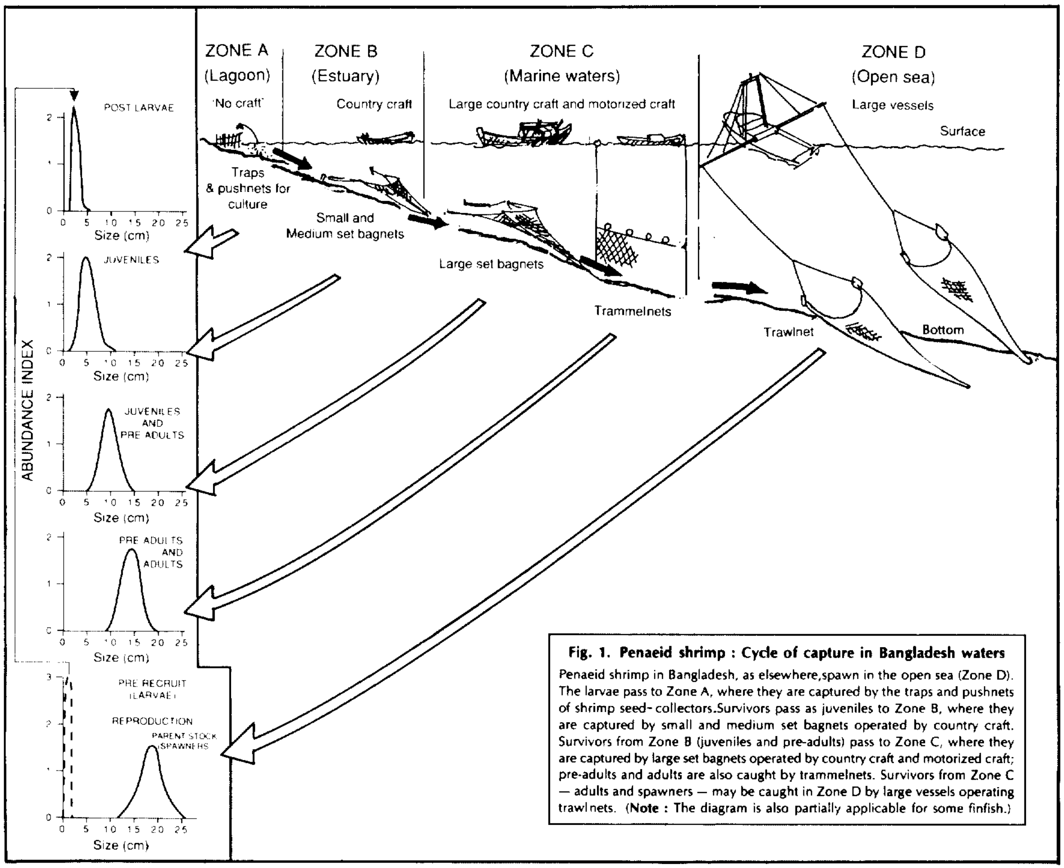

Fig. 1. Penaeid shrimp : Cycle of capture in Bangladesh waters
Penaeid shrimp in Bangladesh, as elsewhere,spawn in the open sea (Zone D). The larvae pass to Zone A, where they are captured by the traps and pushnets of shrimp seed- collectors.Survivors pass as juveniles to Zone B, where they are captured by small and medium set bagnets operated by country craft. Survivors from Zone B (juveniles and pre-adults) pass to Zone C, where they are captured by large set bagnets operated by country craft and motorized craft; pre-adults and adults are also caught by trammelnets. Survivors from Zone C — adults and spawners — may be caught in Zone D by large vessels operating trawl nets. (**Note :** The diagram is also partially applicable for some finfish.)

During their lifetime, fish and shrimp pass through different fisheries, each of which contributes to the total fishing mortality. Hence, the size of a cohort (a particular group of a species spawned during a particular season and in a particular spawning area) entering a fishery depends on the accumulated fishing mortality from all the preceding fisheries. The change in biomass of a cohort through decrease in number of animals is, to some extent, compensated by the gain in weight of the survivors.

The monthly length-frequency samples of each species from each fishery were used to obtain the total number of individuals in the catch of each length class. This was done by raising the number, in the monthly samples, in the following manner:

a) The number of individuals of a particular species of a particular length were multiplied by the first raising factor. This factor was the ratio of the total weight of the species caught by the sampled boats in a month to the weight of the actual sample taken from the boats during the same month.

b) The number of individuals calculated in (a) was raised a second time. The second raising factor, by which (a) was multiplied, was the ratio of the total production in all the boats of the fleet during the month to the weight of the total catch of the sampled boats that month.

The total number of individuals of a particular size and species caught during the month was, thus, estimated. These monthly production frequencies for all fisheries were pooled for each month to obtain better estimates of growth parameters.

The monthly frequencies were pooled to obtain the annual catch-at-length for each species, for length-based cohort and for virtual population analysis (VPA). These values were obtained for the ESBN catch and shrimp fry-collection using standard procedures, but those for the interactive fisheries were estimated with less accuracy due to limitations of manpower, facilities and time to undertake comprehensive data-collection programmes. In the case of the trawl fishery, the existing monthly length-frequency data were utilized. These frequencies were used to estimate growth parameters and fishing mortalities caused by each gear type during successive stages of the animal's life. The population sizes of selected species were obtained using the catch-at-length data for each species from the ESBN and the interactive fisheries and the virtual population analysis method of ELEFAN III (VPA-II).

The natural mortality (M), probability of capture by each gear, exploitation rates (E) and terminal fishing mortality (Fr) values were obtained using ELEFAN 11 (Gayanilo, Soriano and Pauly, 1989). Length Cohort Analysis (Sparre, 1987) was used to obtain Fnax (highest fishing mortality of the age or size classes exploited) values for each species in each fishery. A constant value of M was used for all fish sizes. Since very large numbers of the shrimp were removed at the post-larval stage for aquaculture, the available estimate of M is considered wrong for these stages as M is extremely high during the post-larvae stage, but for which no reliable estimate of M was available. Hence, when carrying out the analysis for species removed by various fisheries from the larval stage to the full-grown stage, the estimate of the population size prior to the exploitation of post-larvae (PL) is considered underestimated.

The number of shrimp removed at the post-larval size, the number surviving from shrimp fry-collection and the number removed successively in the ESBN and other capture fisheries have been estimated (see BOBP/WP/89) and these numbers used to assess the impact of the ESBN, and other gear, on the population of selected species. Each cohort and its passage through various fisheries in different areas was identified and used to plot the life cycles. A yield-recruit analysis was carried out with ELEFAN **II** for each fishery to determine the maximum yield for each species in the fishery. Growth parameters, natural and fishing mortality rates and mean length at first capture in each fishery were used for this analysis.

The economic yields and benefits were compared with the catches by the ESBN and other gear interactive with it to determine the impact of the ESBN fishery on the other fisheries and the fisherfolk involved, both from a biological and economic point of view. The results of the yield per recruit analysis are not presented, as the Thompson and Bell method of Sparre (1987) was preferred to determine the trends in yield and revenue for the selected species from each of the fisheries and to examine the impact of each fishery on each resource.

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The technical characteristics of the ESBN were examined to evaluate their performance and to determine if their design could be improved, both from an economic and biological perspective, and to guide possible management-oriented decisions on their use.

The small-scale fisherfolk in Bangladesh are mostly poor. It was felt that if any regulatory measures, or changes in the fisheries, were to be introduced, their likely impact on these fisherfolk would have to be assessed in advance. Rehabilitation programmes would also have to be identified and implemented in good time to compensate affected fisherfolk. The number of households that may be affected by management measures and other existing, or potential, income-generating activities (both fishery and nonfishery) were, therefore, identified.

Further, it was felt that the success of development and management would depend on the fisherfolk's understanding of, and willing participation in, these processes. Therefore, an attempt was made to ensure that appropriate information was collected to develop material to educate fisherfolk on fisheries-oriented issues, problems and solutions and to gain their understanding and cooperation in the development and management programmes. Without this, these programmes may be unsuccessful, it was thought.

3. *FISHERIES AND SPECIES UNDER CONSIDERATION*

Except for the *Hilsa* gillnet fishery, all major fisheries in the marine sector of Bangladesh may be considered to be interactive with the ESBN fishery because they target penaeid shrimp and finfish. Penaeid shrimp, croaker and ribbonfish are the most important species in the ESBN catches. They are relatively abundant and have a high commercial value. Fisheries employing pushnet (PN) /dragnet (DN)/fixed bagnet (FBN) (for shrimp fry-collection), beach seine (BS), marine set bagnet (MSBN), trammelnet (TRN), bottom longline (BLL) and shrimp/fish trawl (TWL) have been identified as being significantly interactive with the ESBN fishery for these and other species.

The ESBN fishery catches more than 180 species of shrimp, shellfish and finfish, while the other gear mentioned above catch around 80 species, except for the BLL and TRN, which, generally, catch only about 15-20 species. The numbers of species or species groups identified in the catches of different gear are given in Table I and the relative vulnerability of common species to the interactive gear is shown in Appendix I.

Table 1. Number of species **of major varieties of finfish and shellfish caught by different gear**

Variety	*ESBN*	*PN/FBN*	*MSBN*	*BS*	*BLL*	*TRN*	*TWL*
Penaeid shrimp	15	6	5	7	0	11	3
Nonpenaeid shrimp	3	1	1	1	0	0	0
Freshwater prawn	9	4	1	4	0	0	0
Crab and mollusc	6	4	6	4	0	5	
Finfish	152	50	30	38	15	57	14
Others	0	20	2	2	0	3	0

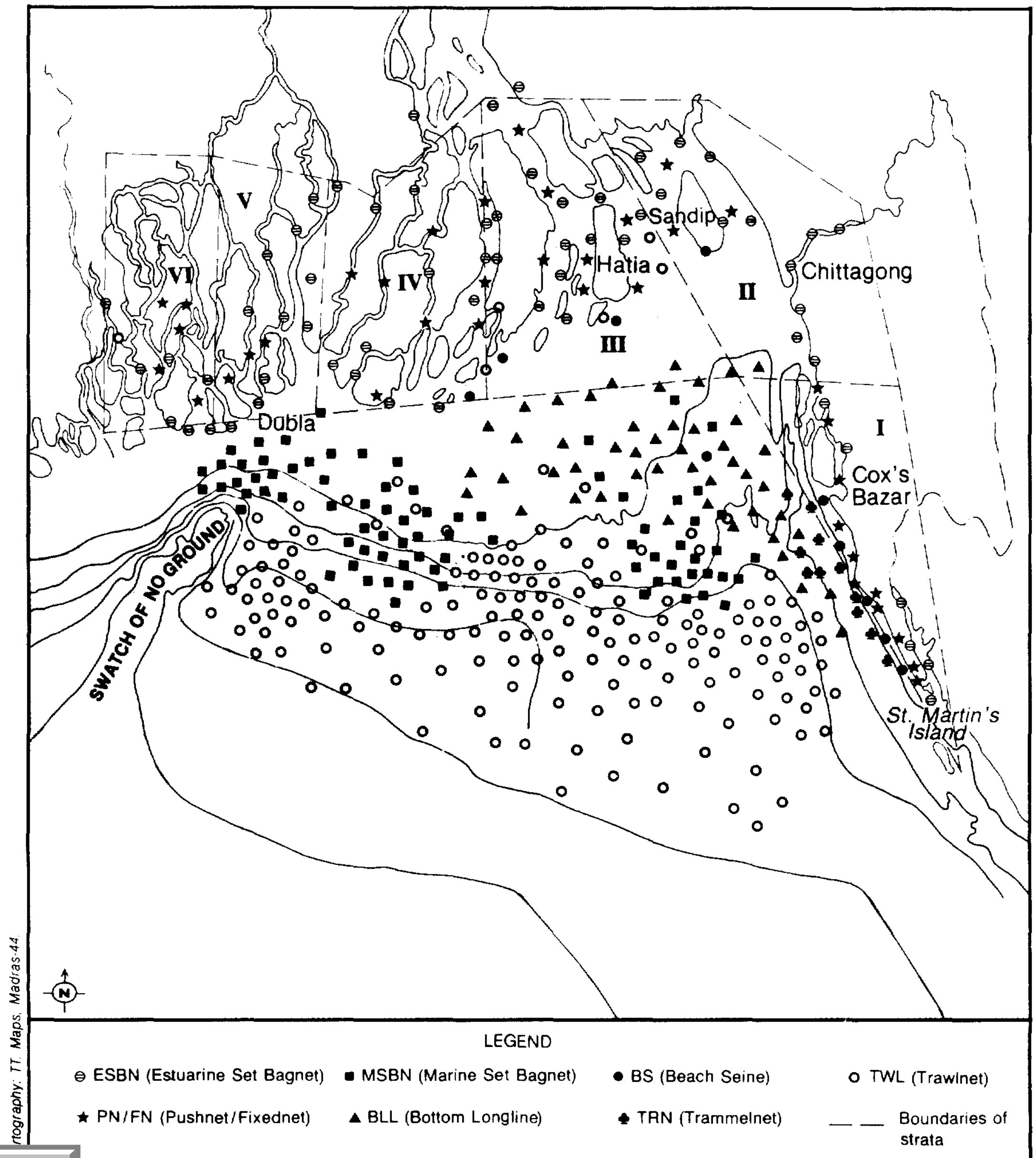
Due to limited manpower, facilities and time available, biological studies of only a few species, common to most of the interactive gear, were undertaken . These included tiger shrimp *(P. monodon),* brown shrimp *(M. monoceros),* white shrimp *(P. indicus),* ribbonfish *(L. savala),* Bombay duck *(H. nehereus)* and large croaker *(Johnius* spp.) — Belanger's croaker *(J. belangeri),* Tigertooth croaker *(J. argenteus)* and Blotched croaker *(J. maculatus).* **In the** absence of literature for identification of the juveniles of croakers and due to the difficulties in differentiating them in the early stages of their lives, the three large-sized species of this family have been recorded under *Johnius* spp.

4. FISHING AREAS

The ESBN fishery is spread throughout the channels, canals, tributaries and the estuaries of Bangladesh, wherever a brackishwater environment prevails. The gear is operated in less than 5 m depth, more or less throughout the year. The MSBN is generally larger than the ESBN and is operated at around 20 m depths, at three locations, Sonadia, Mohipur and Dubla, from October to March. Some of the large MSBN are used as ESBN during the other months.

Trammelnets are operated off the Teknaf-Cox's Bazar coast, at 5-10 m depths. The trawl fishery operates in the 30-80 m depth range. Beach seines are operated from the shoreline and cover depths of upto 8-10 in. This gear is operated in the Cox's Bazar, Chittagong, Noakhali, Barisal, Patuakhali and Khulna areas, but 62 per cent of the units are located in the Cox's Bazar area alone. Shrimp fry-collection gear are widely used in the estuaries and river mouths along the coastline, except in the Noakhali area. The fishing areas of the gear and the geographical strata studied are shown in Figure 2.

Fig 2. Area of operation of different fisheries in Bangladesh



5. *FISHING EFFORT AND PRODUCTiON*

The PN/FBN fishery has the largest number of gear units and the TWL the least. The former is a very simple and inexpensive gear with low productivity, while the latter is very complex and expensive and has a very high production capacity (see Table 2). The gear units in the ESBN fishery are the second largest in number and their production is almost equal to that of the TWL fleet. The number of units in the other interactive fisheries are much less than that in the ESBN fishery.

Though PN/FBN and MSBN production are less than that of the ESBN fishery, the values of their catch are much higher than that of the ESBN fishery and are second only to the TWL fishery. BS, TRN and BLL have low production levels, but BLL catches have relatively better value because its target species are exported (see Table 2).

Table 2. Fishing effort (CPUE), production and value of the catch of selected species in different fisheries (1990/91)

				Gear			
Items	*PN/FBN*	*BS*	*ESBN*	*TRN*	*MSBN*	*TWL*	*BLL*
Catching units (No.)	193,000	558	12,561	400	3852	54 (43+11)	280
Mesh size (mm)	2	sides: 18-24 mid.: 12-14	mm. 8-12 max. 12-22	40-45 150.265	12-25	45m+60m	—
Total effort	28950,000 man-days	51,787 net-days	14,703,998 hauls	34,288 net-days	580,916 hauls	7119 boat-days	25,480 hoat.days
CPUE	608 Nos/day	156 kg/day	5.1 kg/haul	48.2 kg/day	45 kg/haul	381 kg/day*	104 kg/boat/day
Total production (t)	187,386 **	8080	54,000	1754	26,111	56,217	2650
Prod. value (Tk. million•)	*406*	*89*	*286*	*43*	*391*	*600*	*147*
Penaeid shrimp production (t)	21,000 million	739	7746	41	2373	2713	—
Avg. crew/unit	2	15	3	6	3	15	9
Fisheifolk engaged in fishery	200,000	8370	37,683	2400	11,556	810	2520
Periods operated in a year (months)	5-8 (varies with location)	12 (Nov-Feb seasonal; May-Nov estuary)	10-12 (Depending on sea condition)	7 (Depending on sea condition)	6 (Oct-Nay)	10-12 (Depending on sea condition)	7 (Aug-Feb)

* For shrimp only, as most of the others are discarded. Million Nos.fday.

From an employment point of view, the PN/FBN fishery engages the largest number of individuals, but they are generally children and women; the income per individual is very low and incidental. The ESBN employs the second largest number of fisherfolk, the MSBN, PN/FBN, TRN and BLL are highly seasonal fisheries, unlike the ESBN, BS and TWL. A small percentage of the penaeid shrimp caught by the ESBN fishery is suitable for export, but the main exports are from the TWL, TRN and BLL fisheries which target exportable shrimp and croakers. The high values of shrimp and finfish for export and the low values of juveniles, small shrimp and finfish caught for the local market contribute to the large variation in the values of the catches in the various fisheries (see Table 2).

• US $I = 35 Taka (appx)

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6. *PRODUCTION TRENDS OF SELECTED SPECIES*

Among the selected species/species group, tiger shrimp constituted only 2 per cent of the catch — 827 **t (see Table** 3). The post-larvae collection was negligible (11 **t), but the cultured tiger** shrimp harvested from the stocking of these larvae was in the region of five to six thousand tonnes annually, or about six times the production of this species by all capture fisheries. In the capture fisheries, ESBN and TWL account for 97 per cent of the total production of tiger shrimp. Production of brown shrimp also follows a similar pattern, though the larvae caught are not utilized for culture and are discarded. In the case of white shrimp, production by ESBN (a 78 per cent contribution) outweighs all other capture fisheries. In fry-collection, white shrimp are five times more in terms of number than tiger shrimp and exceed in weight the production of the TRN, which is highly selective in respect of white shrimp because of the depth range in which the gear is operated. White shrimp, obviously, have a greater abundance (as indicated by the proportion in the fry-collection), but because this species concentrates in relatively shallow waters, it is not fully available to the trawinets, which operate mainly at 30 m and more. The relatively low proportion of brown shrimp to tiger shrimp in fry-collection may be due to concentration of the effort in water conditions favourable to the occurrence of the latter.

Table 3. Estimated catch by weight (t) and number (NxlO’) of selected species caught by different gear

Name of species		*ESBN*	PN/FBN *(N=10^3)*	*MSBN*	*BS*	*TRN*	*BLL*	*TWL*	*Total*
Tiger shrimp	(W)	356.86*	11.00	Neg.	Neg.	6.66		452.67	827.19
	(N)	13.22	2035.00		Neg.	0.07		9.29	2.29%
Brown shrimp	(W)	735.27	1.21	Neg.	5.97	3.86	—	1567.04	2313.35
	(N)	432.51	346.00	Neg.	2.39	0.35	—	124.39	6.39%
White shrimp	(W)	271.74	34.26	2.35	8.58	28.58	—	4.02	349.53
	(N)	17.99	10706.00	0.15	1.65	1.50	—	0.16	0.96%
Ribbonfish	(W)	675.11	Neg.	8353.19	544.65	67.16	—	520.95	10161.06
	(N)	140.65	Neg.	287.05	22.19	0.76	—	5.17	28.06%
Bombay duck	(W)	2615.88	Neg.	8233.00	1.83	333.00	—	1034.99	12216.87
	(N)	670.74		55.26	0.46	1.96	ND.	8.73	33.76%
Croaker	(W)	3343.04	—	451.26	2368.56	391.00	2810.00	968.87	10332.73
	(N)	835.76	300.63	20.61	108.15	2.64	6.31	6,67	28.54%
Total catch of selected species	(W)								36200.73 100%
Total (w) for all species caught and percentage of catch by all gear		**54000.00** **36.2%**	**176864** **(Numbers)**	**26111.00** **17.5%**	**8080.00** 5.4%	**1754.50** 1.2%	**2810.00** 1.9%	**56217.00** 37.8%	**148972** 100%

W = Weight N = Number *ND*= **Not** detected Neg Negligible All spccics:.Selected species listed plus other species

* This includes **about** 127 t of cultured ***P. monodon*** which were caught **in ESBN at** Maiskhali due to pond overflooding by tidal bore in July ‘90.

Over 80 per cent of the ribbonfish production comes from the MSBN fishery and only about 7 per cent from ESBN; the rest come from the beach seine and trawl fisheries. Croaker production is more evenly distributed, with 33 per cent from ESBN, 27 per cent from BLL and 23 per cent from BS. Bombay duck production is mainly contributed by MSBN (67%) and ESBN (21%).

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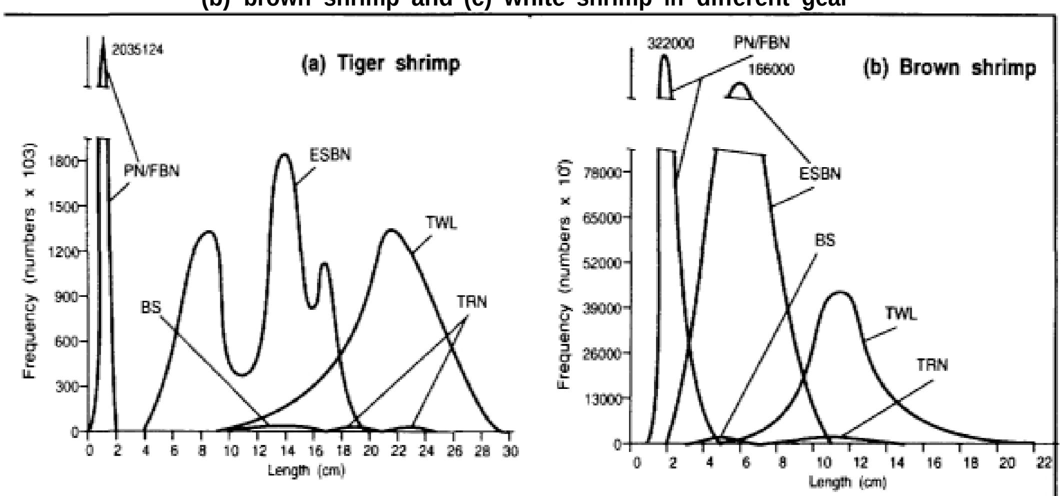
In the overall production by each fishery, TWL stands out by contributing 38 per cent, followed by ESBN (36%) and MSBN (17%). In terms of catch numbers, shrimp fry-collecting gear contribute 83 per cent of the selected species, followed by ESBN with 13 per cent, while the other fisheries contribute less than 2 per cent each. The numbers of brown shrimp, croaker and Bombay duck are highest in the ESBN fishery and those of ribbonfish highest in the MSBN fishery. Mean weight of individuals of each of the selected species is shown in Table 4.

Table 4. Average weight (g) **of individuals of selected species caught by different gear**

Name of species	*ESBN*	*PN/FBN*	*MSBN*	*BS*	*TRN*	*BLL*	*TWL*
Tiger shrimp	27.1	0.0052	–	–	92	–	48.2
Brown shrimp	1.7	0.0035	–	2.5	II	–	12.6
White shrimp	15.1	0.0032	16	5.2	19	–	24.7
Ribbonfish	4.8	–	29.1	7 for E 27 for M	88	–	100.7
Bombay duck	3.9	–	149	4	169.6	–	118.5
Croaker	4	–	21.9	21.9	148	445	145.3

E = Estuary M = **Marine**

Fig 3 a,b,c. Catch-at-length of (a) tiger shrimp, (b) brown shrimp and (c) white shrimp in different gear



7. *SIZE SELECTIVITY*

The modal size of penaeid shrimp caught by the fry-collectors is of the order 1-2 cm, by ESBN 7-9 cm and by TWL 12-16 cm and 20-24 cm, depending on the species (see Figures 3 a-c). There is some, but not very much, overlap in size caught by these three gear. Some distortion of the frequency distribution for tiger shrimp in the ESBN fishery is likely because of the destruction of most of the culture ponds during the 1991 cyclone, when large quantities of tiger shrimp fry may have been released into the open waters and may have been caught by ESBN when fishing operations resumed. The production by BS and TRN are not only low, but the size ranges of the shrimp are also narrow.

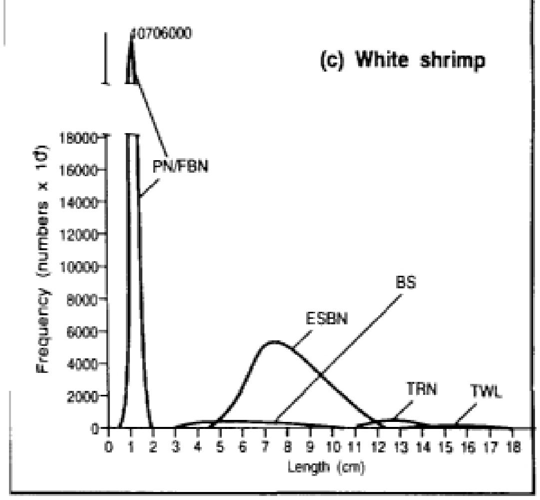


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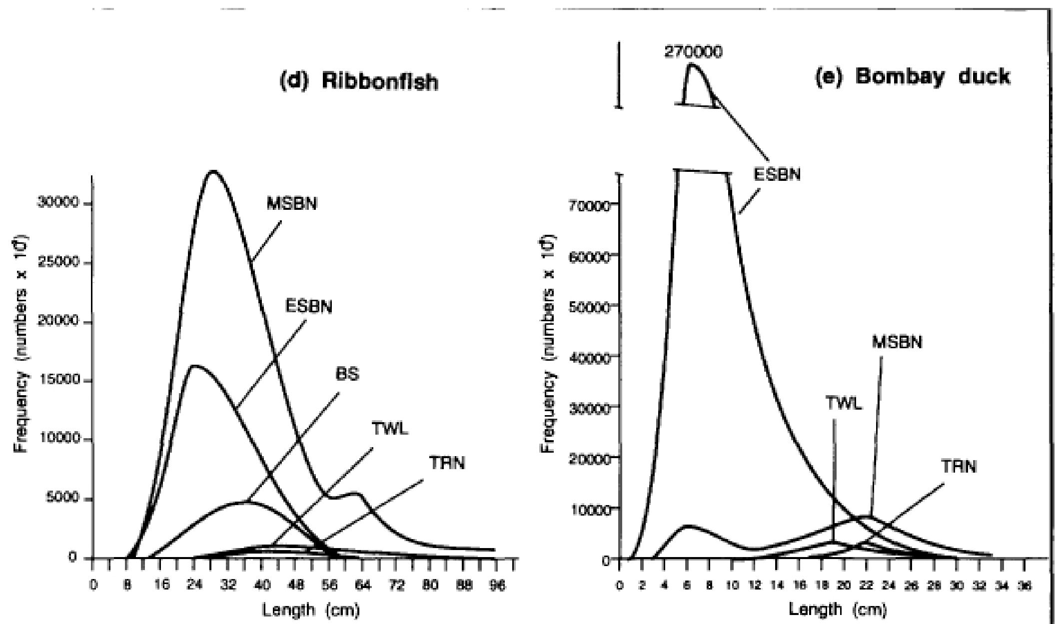
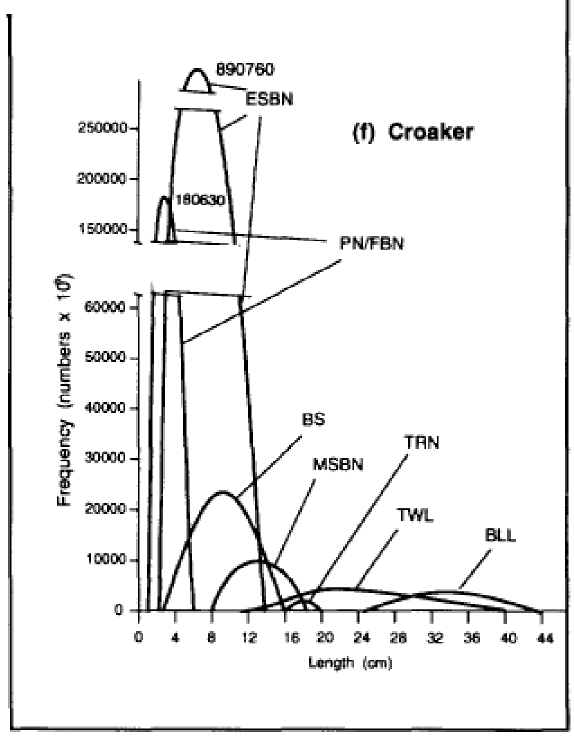
Fig 3 d,e,f. Catch-at-length of (d) Ribbonfish,
(e) Bombay duck and (f) Croaker in different gear



With regard to finfish, there is considerable overlap in sizes between different gear (see Figures 3 d-f). The size ranges for ribbonfish, for instance, are similar for all gear, while there are some differences in the modal sizes.



The values of mean length at first capture for selected species, as estimated by the ELEFAN method, are presented in **Table** *5* **on the facing page. As the shrimp or fish grows, its percentage** gain in weight is much more than the percentage gain in length. This will significantly influence the increase in yield in terms of weight, even with small changes in the mean length at first capture.

8. *GROWTH PARAMETERS*

Table *5* summarizes, for four of the selected species, the growth parameters obtained from length-frequency data in individual fisheries and those based on pooled catch-at-length data. Unlike the estimate made with length-frequency from a single fishery — the ESBN catching primarily smaller specimens or the trawl fishery yielding primarily larger ones — the pooling of

Table 5. Growth parameters (Lα, K), natural mortality (M), fIshing mortality (F), mean length at first capture (L_c) and exploitation rate (E) by ELEFAN method, for selected species and different gear

Gear	*Lα*	*K*	*M*	*F*	L_c	*E*	*C*	*M/k*	*Month of origin*
Tiger shrimp									
ESBN	31.3	0.72	1.42	8.37	13.8	0.85	0.418	1.89	
TRN	31.3	0.72	1.4	2.8	18.1	0.66	0.548	1.89	
TWL : Male	28.8	1.2	2.03	5.86	17.5	0.74	0.53	1.69	
Female	30.5	1.7	2.5	3.28	15.7	0.57	0.566	1.17	
Pooled data (Summer Cohort)	33.2	0.89	1.61	2.3	—	0.58	—	1.81	August
Pooled data (Winter Cohort)	32.8	0.92	1.6	2.2	—	0.57	—	1.74	February
Brown shrimp									
ESBN	19.77	0.43	1.16	3.65	5.86	0.75	0.28	2.68	
TRN	19.3	0.58	1.41	1.16	10.1	0.55	0.52	2.43	
TWL Male	18.0	1.4	2.8	2.41	8.9	0.54	0.4	2.0	
Female	18.6	1.6	2.7	3.58	9.5	055	0.51	1.52	
Pooled data (Summer Cohort)	20.73	0.69	1.6	2.1	—	0.55	—	1.68	June
Pooled data (Winter Cohort)	21.27	0.73	1.6	2.00	—	**0.55**	—	2.19	February
White shrimp									
ESBN	22.83	0.55	1.3	3.7	6.8	0.74	0.29	2.3	
Ribbonfish									
ESBN	**93**	0.29	0.58	2.62	5.79	0.81	0.505	1.44	
MSBN	**108.6**	0.72	*1*	2.62	13.9	0.72	0.121	1.44	
BS	**93**	**0.29**	**0.58**	**1.1**	**18.1**	**0.65**	**0.158**	**1.44**	
TRN	108.6	0.72	1	0.33	73.65	0.25	0.64	1.44	
TWL	105.0	0.85	1.33	0.73	40.05	0.65	0.347	1.44	
Pooled data (Summer Cohort)	115.9	0.63	0.91	2.46	—	0.72		1.44	July
Pooled data (Winter Cohort)	113.2	0.61	0.89	2.34	—	0.75	—	1.45	February
Bombay duck									
ESBN	34.9	0.38	0.91	3.7	6.27	0.35			
TWL	**38.3**	0.42	0.94	0.6	9.88	0.38			

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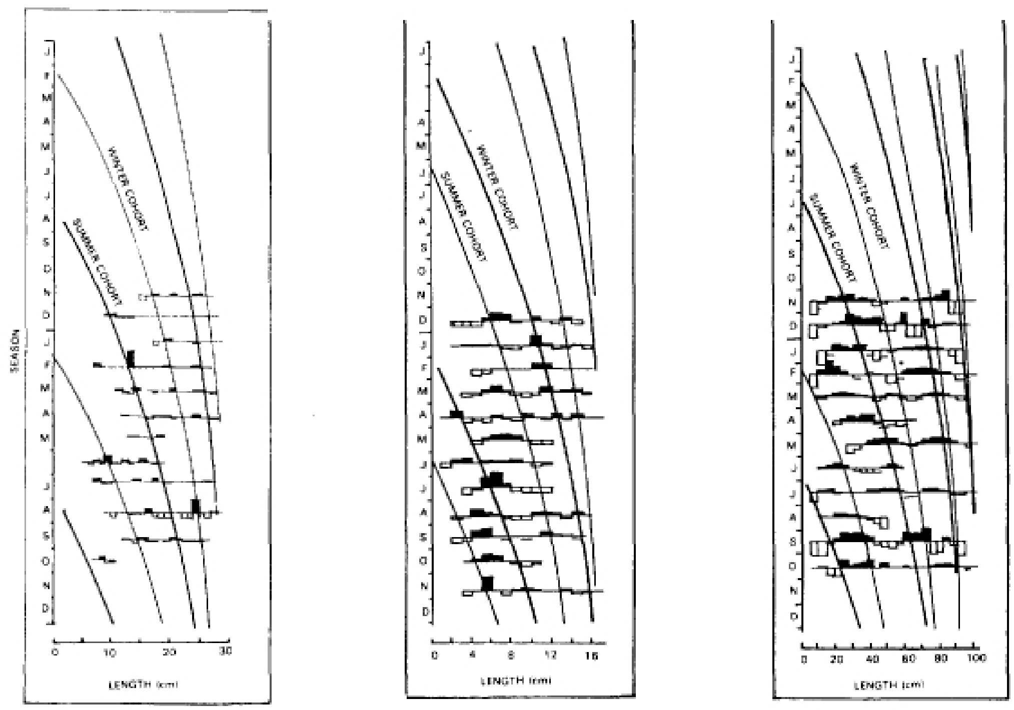
catch-at-length data of a species from several fisheries gives a wide range of sizes and an increased number of modal groups to fit the growth curves (see Figures 4 a-c).

Fig 4. Monthly length-frequency distribution for

Tiger shrimp, Brown shrimp and Ribbonfish

Tiger shrimp | Brown shrimp | **Ribbonfish**



9. RECRUITMENT PATTERN AND SPAWNING SEASONS

The ELEFAN analysis of growth parameters and recruitment pattern clearly exhibits the existence of two recruitments each year (see Figure 4) or two peak spawnings a year, which are common for most of the shrimp and finfish in tropical waters. However, the two spawnings are not of equal strength. The number of young ones produced in each is significantly different. Whether the difference is consistent over the years cannot be ascertained from one year's data. Extrapolation of the two growth curves to zero length would indicate the appropriate spawning seasons for the two recruitments — one being spawned during the winter season, *i.e* the winter cohort, and the other spawned in summer, *i.e* the summer cohort. The stronger of the two cohorts will determine the peak fishing months. Examination of the maturity state of tiger shrimp, brown shrimp and ribbonfish, during the trawl surveys, also showed the presence of relatively more ripe females during the spawning periods obtained by extrapolating the growth curves in Figure 4.

10. *LIFE CYCLE OF SELECTED SPECIES*

All the selected species are exploited at different stages of their life cycles (refer Figure 1) by the ESBN and other gear which interact with it. Sometimes, at certain stages of their lives, they may encounter exploitation by more than one type of gear. Based on the seasonal catch rates and size ranges of the species caught by all major interactive fisheries operating in different ecosystems or depth ranges and at different seasons, and in the light of the spawning seasons estimated by extrapolating the growth curves, as well as from the recruitment pattern derived, the life cycles with two cohorts a year have been fitted for tiger shrimp, brown shrimp and ribbonfish (see Figures 5 a-c on facing page).

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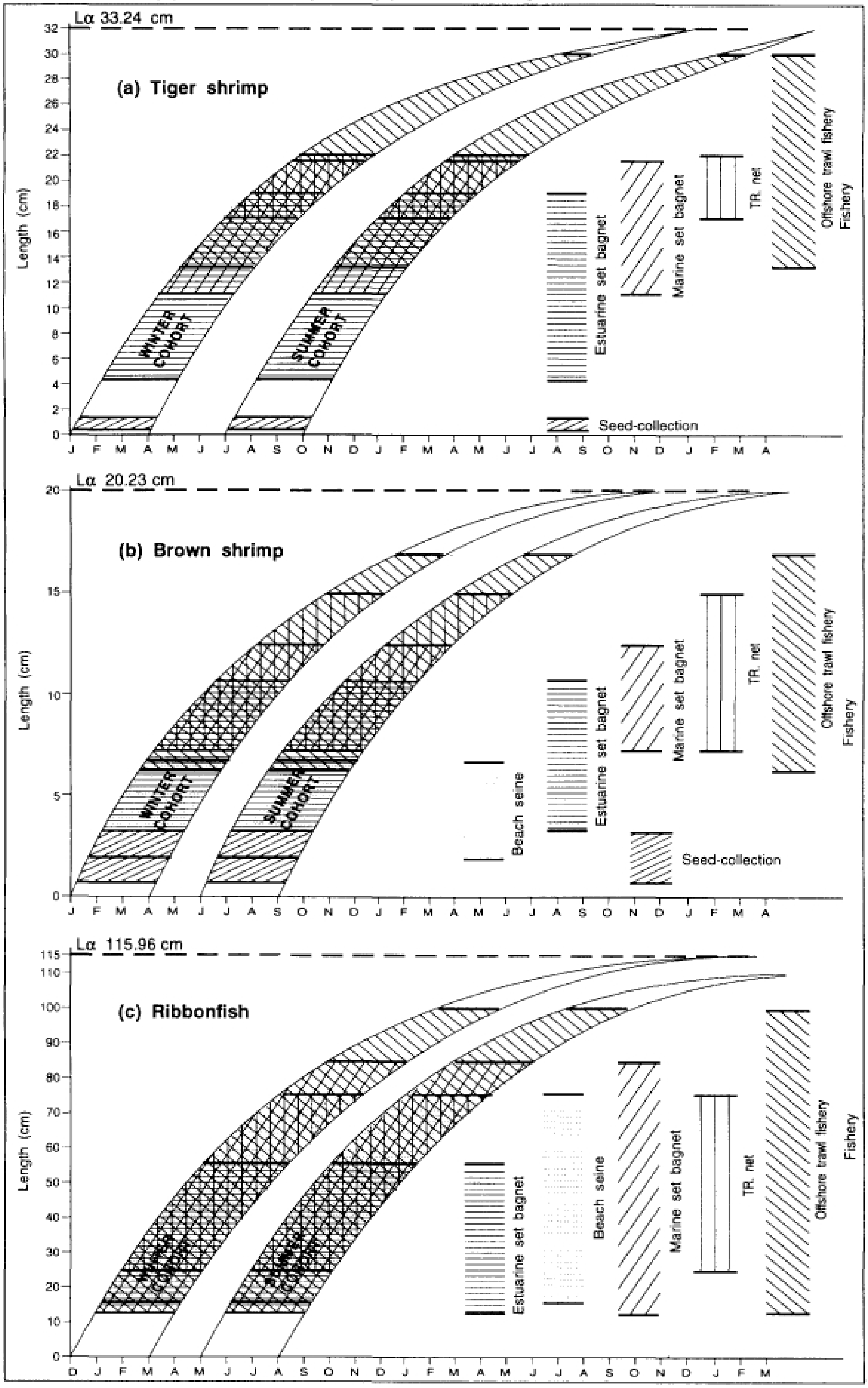
Fig 5. Life cycle-based exploitation of (a) Tiger shrimp, (b) Brown shrimp and (c) Ribbonfish by different fisheries



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It appears that all selected species enter one fishery or the other at each stage in their lives, starting with the PN and FBN fishery for shrimp post-larvae. However, tiger shrimp and white shrimp of 2-4 cm, Bombay duck of 0.1-4 cm and ribbonfish of 0.1-10 cm size ranges seem to escape from all major fisheries (see Figures 3 and *5).* The overlapping nature of fisheries is either due to different fisheries occurring in the same fishing ground or the same size of shrimp and fish occurring in a wide range of depths. In the case of most bottom-dwelling shellfish and finfish,the depth of the habitat increases with the size of the animal. Consequently, the illustrations of life cycle also indicate the migratory pattern of the animal from the shallow brackishwaters to the deep open seawaters of the continental shelf. The depth and time (season/month) scales, in relation to length or size of animals as indicated by Figure 5a, for tiger shrimp, gives the migratory pattern in relation to time and, consequently, the seasonality pattern in various fisheries exploiting the two cohorts of the resource annually.

11. *POPULATION SIZE AND FISHING MORTALITY OF SELECTED SPECIES*

11.1 *Tiger shrimp*

It is estimated that 2035 x 10^6 number of PL 1 - 2 cm length are removed annually in the shrimp fry-collection fishery (BOBP/WP/89). VPA at a constant mortality rate (M) of 1.6 (see Table 5) for all ages shows a population of >33,755 x 10^6 (see Table 6), which may be an underestimate as the mortality rate at the larval stage would be higher than that assumed. From this total population, shrimp fry collected account for 6-6.5 per cent. The population available for the ESBN and other interactive fisheries is estimated at 934 x 10^6 (see Table 6). The major harvesters are ESBN and TWL, accounting for 13.22 x 10^6 and 9.29 x 10^6 animals respectively (see Table 3).

Table 6. Indices of recruitment and exploitation by ESBN **and other fisheries (in numbers), of selected species**

Species	*Population size close to larval stage/stze*	*Total catch (all fisheries)*	*% of N_c in N_{P1}*	*Catch of fry*	*% of N_{fy} in N_{P1}*	*Population size at the time of entry*	*Catch excluding fry*	*% of N_{P2} caught*
	(N_{P1})	*(N_c)*	*(N_c/N_{P1})*	*(N_{fy})*	*(N_{fy}/N_{P1})*	*(N_{P2})*	*(N_c-N_{fy})*	*(N_c-N_{fy}) /N_{P2}*
Tiger shrimp	*> 33755 x 10^6*	*2058 x 10^6*	*< 6.1*	*2035 x 10^6*	*< 6*	*934 x 10^6*	*23 x 10^6*	*2.4*
Brown shrimp	*>3353 x 10^6*	*906 x 10^6*	*<27*	*346 x 10^6*	*< 10*	*2189 x 10^6*	*560 x 10^6*	*25.5*
White shrimp	*>12395 x 10^6*	*10727 x 10^6*	*<86*	*10706 x 10^6*	*<86*	*1689 x 10^6*	*21 x 10^6*	*1.3*
Bombay duck.	*1100 x 10^6*	*737 x 10^6*	*< 67*	*Negligible*	*0*	–	–	–
Ribbonfish	*787 x 10^6*	*456 x 10^6*	*< 58*	*Negligible*	*0*	–	–	–

The length-cohort analysis and VPA (see Table 7 on facing page) indicate a significant decline in population of animals of length exceeding 20 cms. This length range is predominantly caught by TWL. With increasing fishing effort, it is not surprising that trawl catch rates have shown a declining trend in recent years. It may be possible to strengthen recruitment of larger sizes to the trawl fishery if tiger shrimp fry-collection and juvenile catches in the ESBN fishery are reduced (see Figure 3a).

11.2 *Brown shrimp*

The estimate of brown shrimp fry caught accidentally by tiger shrimp fry-collectors (as this is not a target species) is 346 x 10^6 (see Table 6), giving a virtual population of >3353 x 10^6 of PLs, on the same assumptions made for estimates of tiger shrimp. The population available for ESBN and other interactive fisheries is estimated at 2189 x 10^6 (see Table 6), of which ESBN catches are 432 x 10^6(20%) and TWL catches 124 x 10^6 (5-6%) (see Table 3). Comparatively smaller catches are also made by BS: 2.39 x 10^6.

It is interesting to note that the total number of brown shrimp fry caught by PN/FBN and juveniles by ESBN are, together, much lower than tiger shrimp fry. This means that there is a larger recruitment to the trawl fishery of brown shrimp compared to tiger shrimp. This is also confirmed by the fact that catch rates of brown shrimp in the trawl fishery are high (see Figure 3b) and production of these shrimp is three-and-a-half times the amount of tiger shrimp by weight.

11.3 *White shrimp*

The by-catch of white shrimp in the tiger shrimp fry fishery is estimated at 10,700 x 10^6 **PL (see** Table 6), almost five times the amount of tiger shrimp fry caught. This may also include another species *(P. merguiensis)* which is similar in appearance, biology, ecology and distribution. The virtual population is estimated at >12,400 x 10^6 PL, indicating that over 80 per cent are removed as fry.

The population available for ESBN and other interactive fisheries is estimated at 1689 x 10^6 animals (see Table 6) entering the ESBN fishery at about 4 cm in length. It is also estimated that 17.99 x 10^6 PL are caught by ESBN and much less by MSBN and TWL (see Table 3). There is a small but significant amount taken by TRN *(1.5* **x** 10^6). The higher production in shallow waters may be due to the restricted migratory habit of adult shrimp and its habitat preference for shallow coastal waters close to estuaries. Catches of white shrimp of larger size could be higher using TRN if the fishing effort is increased (see Figure 3c). Poor availability of white shrimp in deeper waters is one of the reasons for low trawl catches. Other reasons could be the reduction of fishing effort by trawlers in shallow waters and the large amounts lost for recruitment at the fry stage.

Table 7. 'Mean F' from length-based VPA analysis and F_{max} from Jones' length-cohort analysis, for the selected species, by fishery

Gear	F_{max} *(Length. cohort analysis)*	'MeanF' *(VPA analysis)*
Tiger shrimp		
ESBN	10.41	1.60
TRN	3.82	1,76
TWL: Male		
Female	3.10	0.54
Pooled data (Summer Cohort)		37.9 *
Pooled data (Winter Cohort)		
(*including PN)		
Brown shrimp		
ESBN	10.87	0.85
TRN	5.30	1.05
TWL: Male		
Female	6.26	0.30
Pooled data (Summer Cohort)		1.57 *
Pooled data (Winter Cohort)		
(*inclnding PN)		
White shrimp		
ESBN	8.63	1.72
Ribbonfish		
ESBN	15.03	1.06
MSBN	7.64	2.62
BS	6.28	0.87
TRN	2.08	0.81
TWL	3.09	0.92
Pooled data (Summer Cohort)		
Pooled data (Winter Cohort)		0.92
Bombay duck		
ESBN	6.0	1.12
MSBN	1.85	0.19
TWL	2.33	0.36
Pooled data		1.76

11.4 *Ribbonfish*

This is another commercially valuable finfish with negligible catches during shrimp fry-collection, probably for reasons similar to those for Bombay duck. The MSBN appears to be the most productive gear, accounting for 8353 t out of a total catch of 10161 t (see Table 3). Catches by weight from ESBN, BS and TWL are similar and are *5-6* per cent each of the total catch (see Table 3). The harvested total catch in numbers is estimated at 50 per cent of the virtual population prior to recruitment to the ESBN fishery. The exploitation rate obtained for catch at length for all fisheries combined is 0.7 (see Table 5), which suggests caution in any further expansion of the fishery.

Nearly 93 per cent of the total catch in number is caught by ESBN and MSBN when the animals are small (see Figure 3d). Reduction in fishing effort in these two fisheries would permit harvesting of fish of larger size in the TWL fishery, resulting in an overall increase in yield. Unfortunately, even the trawlers periodically operate in shallow waters and harvest small fish.

11.5 *Bombay duck*

This commercially valuable finfish species does not appear to be caught during shrimp fry-collection in lagoons. However, a large number of juveniles are caught by ESBN. The surviving population is progressively harvested by MSBN, TRN and TWL. In terms of weight, the bulk of the harvest is by MSBN, accounting for 8233 t or nearly 70 per cent of the total catch (see Table 3). Sufficient data is not available, however, to assess the trends in production, effort and catch rate for this species in ESBN and MSBN — the two major fisheries — to determine the potential for this fishery.

The exploitation rate obtained for catch at length for ESBN and TWL fisheries were below 0.40 (see Table 5), indicating that the overall effort is not too high. But the high fishing mortality rate in the ESBN fishery of animals 7-10 cm in length suggests that if fishing effort is reduced in this fishery there will be an increase in recruitment for the TWL fishery of animals 22-28 cm long (see Figure 3e).

11.6 *Croaker*

Three major species of croaker had to be grouped together since data were not available separately for the larval and juvenile stages of each. No VPA or mortality computations could be attempted due to lack of sufficient length-frequency data. Catch details for the various fisheries (see Figure 30 show that the BLL fishery catching the larger size (or older) fish, could benefit by reducing the fishing effort by ESBN and BS on the smaller size, or younger, fish.

12. *YIELD AND REVENUE PREDICTIONS*

Annual value and catch in the different fisheries are given in Table 8 (below).

Table 8. Annual value (million Taka) of selected species caught in different fisheries

Name of Species	*ESBN*	*PN/FN*	*MSBN*	*BS*	*TRN*	*BLL*	*TWL*	*Total*
Tigei shrimp	**76.16**	**283.29**	—	—	**1.91**	—	322.90	684.26
Brown shrimp	27.15	—	—	0.11	0.24	—	364.34	391.84
White shrimp	8.25	—	0.14	0.14	3.24	—	1.80	13.57
Ribbonfish	17.00	—	140.34	6.43	1.13	—	15.63	180.53
Bombay duck	67.34	—	98.32	0.01	4.66	—	20.70	191.03
Croaker	75.97	—	4.54	25.54	7.08	144.46	24.22	281.81
Total Tk	271.87	283.29	243.34	32.23	18.26	144.46	749.59	1743.04
Total t	54,000	****11**	**26,111**	**8080**	**1764.50**	**2810**	**56,217**	148,972
Avg. Tk/kg	**5,0**	****25,753**	**9.3**	**3.9**	**10.3**	**51,4**	**13.3**	***11.70**

Note: This **table is related to Table 3.**
* Excluding catch and revenue of PN/FN;**Tk 25,7531/kg of seed or Tk 14/100 Tiger shrimp seed

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The Beverton and Holt method of yield per recruit analysis of selected species for ESBN and other interactive fisheries did not give satisfactory results with reference to revenue predictions. As a result, the Thompson and Bell prediction model was adopted, using catch at length, price and F_{max} obtained from Jones' Length-Cohort Analysis, to predict yields and revenues for varying fishing effort. The main findings* are:

- Most species are being currently exploited beyond MSY with the exception of
  - tiger shrimp and brown shrimp in the TWL fishery,
  - white shrimp in the ESBN fishery, and
  - Bombay duck in the MSBN fishery.
- MSY and MEY for all species are reached at relatively low fishing mortalities (or fishing effort) for ESBN, **BS and** MSBN fisheries compared to TRN and TWL fisheries.
- The effect on the TWL fishery, by banning all other interactive fisheries, shows a possible gain of 300 per cent in yield and value. When only the ESBN is banned, the gain is 250 per cent.
- The effect on the TRN fishery is more dramatic, with a tenfold increase in yield and value when all other interactive fisheries are banned but only a small gain in yield and 300 per cent gain in value when only the ESBN is banned.

13. *SOCIOLOGICAL CHARACTERISTICS OF ESBN FISHERFOLK*

On the basis of the estimated number of ESBN units in Bangladesh and the average number of crew engaged in the operation per unit of each size of ESBN, it would appear there are about 55,000 fishermen engaged in this fishery. Considering the average number of family members in the ESBN household in each of the six strata (see Figure 2) covering the estuarine waters of Bangladesh, at least 85-100,000 fisherfolk are dependent on this fishery for their livelihood (BOBP/ WP/90). The sampled households indicated that the male to female ratio was 1:1.1 or about equal numbers of both sexes. Only 4 per cent of the ESBN fisherfolk population were over 60 years, but 37 per cent are children under 10 years. Excluding these and the 35 per cent engaged in productive activities, around 24 per cent are considered to be unemployed females and males in the ESBN fishing villages surveyed. The proportion of unemployed is relatively higher (>35%) in the two strata (I and VI) at the western and eastern extremities of the country.

Sixtynine per cent of the ESBN fisherfolk are illiterate (females 81% and males 57%). The literate generally have only primary schooling. A higher literacy level was noticed in areas on the eastern side of the coastline. Both Hindus and Muslims are engaged in this fishery, varying in proportion in each strata.

Frequent cyclones have caused repealed losses of human life and damage to houses, livestock and property belonging to the estuarine fisherfolk. Being vulnerable to adverse weather conditions has influenced these fisherfolk in making low investments in housing. The majority of the houses are temporary huts and have few such amenities as toilets and clean water supply. Most villages have primary schoofs. Secondary schools are available within commutable distance from many of the estuarine fishing villages.

The fishing grounds of the ESBN fishermen are generally close to their fishing villages, thereby reducing the travelling time and the risk of losing nets through theft or other causes.

* Any discrepancies obsers ed between the estmated level of yietd and value front the Thompson and Bell analysis and the estimated production and value for the same fishery and species may be attributed to possible errors in the estimations of tiatuial and fishing moitalities ot the species concerned. Or due to the Ittusitation in the estimation of production and value front the saitiph in p carried out

14. *ECONOMIC ACTIVITIES IN THE ESBN FISHING VILLAGES*

Fishing is the primary income-generating activity in the villages surveyed and, of the households in these villages, 34 per cent are solely dependent on the ESBN fishery. About 62 per cent combine ESBN fishing with other fishing, fishery-related activities and/or nonfishery activities. Around 11 per cent are labour households (7 per cent fishing labour and 4 per cent nonfishing labour).

14.1 *Fishing activities*

The average number of working members in a family is two. Considering all the estuarine strata, an average of 82 per cent of the households own fishing craft and gear for the ESBN fishery, but only about 25 per cent of the households have other fishing gear, such as *Hilsa* gillnets, mixed fish gillnets, hooks-and-lines etc.

Fishing with the ESBN is a family-oriented enterprise, with a high degree of participation by the family members in fishing operations, repairing craft and gear, and processing and marketing of the catch. As a result, the operational costs are negligible. Consequently, even during lean seasons, the operation seldom exhibits a loss and, thus, serves as a means of subsistence.

The productivity in the ESBN fishery is generally very low, with catch rates averaging 2-4 kg/operation in most areas (Strata II to VI) and about 15 kg/operation in one area (Stratum I). This meagre catch of juveniles and small fish, which fetch very low prices, gives a small income. Investments on craft and gear, costs, benefits and the benefit-cost ratio, for ESBN and other interactive fisheries are summarized in Table 9. More details on these are presented in the working papers on the respective fisheries (BOBP/WP/89 and 90). Excluding shrimp fry-collection, which is an activity linked with aquaculture, the ESBN fishery has the least capital investment among the major marine fisheries. In terms of benefit, the ESBN in Stratum I has extremely high income compared to other fisheries that have an equal or higher investment, hut in all other strata the income is much less than that from other fisheries. The benefit-cost ratio exhibits the relative ranking of these fisheries.

Table 9. Capital investment, annual total cost and benefit in the ESBN and other interactive fisheries in Bangladesh

Gear	*Investment (Tk)*		*Costs (annual) (C)*	*Benefit (B) (Tk)*	*B/C*	*Total investment on fleet (Tk)*	*%*
PN	500		200	7,600	38.0	96,500,000	6.8
FBN	900		450	6,200	13.7		
ESBN	22,000	St.I	12,866	137,449	10.6	276,342,000	20.0
		St.II	12,866	33,000	2.5		
		StIll	12,866	33,000	2.5		
		St.IV	14,866	41,702	2.8		
		St.V	25,866	54,723	2.1		
		St.VI	12,395	23,550	1.9		
MSBN	850,000		16,436	112,000	6.8	218,450,000	15.5
BS	170,000		28,800	103,360	3.5	94 8 0000	6 7
			24,400	158,696	6.5	· 6 .	
TRN	24,000		84,227	59,437	0.7	9,600,000	0.6
BLL	24,000		337,157	80,335	0.2	6,720,000	0.4
TWL (Shrimp)	13,000,000		7,360,000	1,715,000	0.2	702,000,000	50.0
Total						1,404,472,000	**100.0**

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Seasonality in income from the ESBN fishery is also significant. This is only to be expected, for most traditional fisheries have to depend on the limited area covered by the traditional craft and the seasonal movement of fish into that area. There is some attempt by ESBN fishermen to compensate their highly variable seasonal income by shifting to other fisheries. *Hilsa* gillnetting is the most lucrative of the other fisheries, but the gear and craft for this require heavy additional investment and this results in it being practised only by a few fishermen in Strata II and III. Other gear are less productive and less remunerative, but large numbers in each household take up these methods and contribute collectively to a significant addition to the overall income of the village (BOBP/WP/89 and 90).

The income disparity observed is not because of the capabilities of the households, but more due to the uneven distribution of the resources in the different estuarine areas. Many ESBN households earn surplus income during the good fishing season, which is sufficient to compensate for the poor income during the lean fishing season, but those in areas that are relatively low in fish resources are unable to generate sufficiently large surpluses to compensate for the lean season unless they have at least two ESBN units. Apart from the nonfishing labour, those fishermen without enough alternative fishing gear units or without at least two ESBN units, generally tend to fall below the poverty line in strata low in resources.

14.2 *Fishery-related activities in ESBN fishing villages*

Fishery-related activities are fish-processing — mainly drying of unsold finfish — deheadingl cleaning of shrimp for export and local marketing of small quantities of fish. In some villages, where *Hilsa* gillnetting is seasonally carried out, more active involvement in cleaning, icing, salting and packing of this high-value fish contributes an additional income to the ESBN fishing households from fishery-related labour.

The processing, marketing, utilization and consumption of ESBN catches was studied by a consultant from the Natural Resources Institute (NRI), U.K., and the findings (Bennett and Alam, 1992) were that there is very little evidence of processing ESBN catches and, therefore, all added value comes from exploiting markets further away from fishing villages. There are three marketing chains:

- For large, exportable quality, partially processed (deheadedliced) shrimp, agents are paid bi-monthly and they, in turn, provide long-term credit to fisherfolk — loans for guaranteed supply.
- Juveniles and small fish are sold mostly through hawkers who sell door-to-door or at market places. Small quantities are purchased at the shore and large quantities directly from boats at the fishing grounds.
- High-value fish, such as Bombay duck and ribbonfish, are collected from boats at the fishing grounds by agents for the wholesale market.

Fish consumed by fisherfolk households, the study found, are generally of low value.

14.3 *Nonfishing activities*

There is very limited scope for nonfishery activities in the ESBN villages. Livestock-rearing, manual labour for construction and agricultural activities, trade and salaried jobs were observed. Agricultural activity is relatively more in Strata IV, V and VI, than in I and II. Livestock-rearing is more predominant in Strata III and VI.

14.4 *Income distribution*

Considering income from all sources, a survey of ESBN households in the six strata showed that except for Stratum I, where the annual income per household is more than Taka 90,000, 20 per cent of households in Stratum II, 36 per cent in Stratum III, 20 per cent in Stratum IV, 27 per cent in Stratum V and 47 per cent in Stratum VI are below the poverty line of 40,000 Tk/year (BOBP/WP/90).

Relative proportions of the income from SBN, other fisheries, fishery-related and nonfishery activities in the six strata are presented in Table 10 for identification of inter-relationship among them. Three categories were evident.

Table 10. Income source (on the basis of per cent participation)

Activity	STRATA					
	I	II	III	*IV*	*V*	*VI*
ESBN fishery	85	51	29	24	87	67
'Other fisheries'	6	29	43	54	3	1
Fishery-related activities	7	6	22	15	8	14
Nonfishery activities	2	14	6	7	2	18
Category	A	B	C	C	A	B

A. In Strata I and V, with high ESBN incomes (>80%), involvement in other fisheries, fishery-related or nonfishery activities is relatively less.

B. Strata II and VI have moderate incomes (50-70%) from ESBN. The nonfishery activities and even some fishery-related activities gain significance. But other fisheries have a relatively higher role with declining ESBN income in Stratum II.

C. **Strata III and IV have low earnings from ESBN** (<30%). Income from other fisheries gains greater significance than from ESBN. Fishery-related activities also show high relative contribution in this category, but nonfishery activities have less significance than the second category.

15. *PERCEPTIONS OF ESBN FISHERFOLK*

A one-month minor field study was conducted under the supervision of BOBP in 1992 (Skagesstrom and Brattstrom, 1991), to assess the understanding of fishery resources and fisheries management and the perceptions of ESBN fisherfolk in Bangladesh. The results indicated that the ESBN fisherfolk know the fishing areas and seasonality of the fishery for various major species, but their understanding of the nature and dynamics of the resources and their concept of fisheries management were poor. Many of them felt strongly that the annual catch was determined by God and, hence, the need to understand or regulate the fishery did not arise. However, quite a few of them felt that if they could get credit facilities to shift into some other fishery, they could improve income and live better. Lack of credit, and limitations in opportunities for income from other activities, besides the agonizing consequences of repeated cyclones, have created a sense of pessimism in these fisherfolk, when it comes to aiming and working for a better life. Considerable effort may be required to change their attitudes.

16. *DISCUSSION*

Valuable species of shrimp and finfish in Bangladesh are exploited by different fishing gear at different stages in their life cycle. It is also established that the recruitment into a particular fishery is dependent on the fishing effort (fishing mortality) in the preceding zone (fishery). Yield and value are invariably linked to the size at capture and it follows, therefore, that recruitment of larger sizes for exploitation in deeper waters will result in higher yields and values with lower fishing efforts. In actual fact, however, exploitation depends on several factors, such as investment capacity, technical knowhow, social habits and market demands. For instance, the rapid growth in shrimp culture and the insufficient supply of fry from hatcheries have resulted in increased efforts to capture wild shrimp fry.

Low investment capacity, poor access to credit and traditional convictions have, on the other hand, limited the opportunity of ESBN operators to diversify into other, more profitable fishing methods. New and lucrative export markets have, for instance, resulted in the development of a BLL fishery for croaker. In such a scenario, with the existence of the many interactive fisheries, management measures, to achieve sustainable and profitable exploitation of the marine resources, should consider

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not only hioeconomic aspects hut also the socioeconomic implications for the fisherfolk involved in each fishery. particularly shrimp fry-collection and the ESBN fishery, as they are considered to be the most destructive.

Shrimp fry—collection (PN, FBN): fry-collectors are mostly women and children. It is estimated that nearly 200.000 persons are involved in fry-collection during the peak season. Only tiger shrimp fry have a market, but, it is estimated, they constitute only 10 per cent of the total collection. Of the 0 per cent that are discarded, more than half are white shrimp fry. This phenomenal loss of white shrimp and finfish larvae could, in the long run, lead to severe depletion of stocks affecting all other capture fisheries.

Increasing hatchery capacity, improving survival rates and exploring alternate means of income-generation for fry-catchers are possibilities that need to be pursued. However, the fact that capital costs are low and the benefit-to-cost ratio in this fishery is high compared to other fisheries makes this task difficult.

ESBN: Among the interactive fisheries discussed, the ESBN fishery involves the largest number of fisherfolk, excluding shrimp fry-collectors. Surveys of the six strata show that this fishing community is generally poor, with nearly 39 per cent below the poverty line, except in Stratum I where the ESBN fishery is highly profitable. There seem to be very few alternatives available to F.SBN fisherfolk to increase their income from nonfishery activities. But the fact remains that the ESBN fishery accounts for nearly half the production of high-value marine species, though at a juvenile stage. The residual level of biornass. as predicted by the Thomson and Bell method, is well below 10 per cent of the entry level, clearly indicating overfishing and exploitation beyond MSY.

Reduction in the exploitation of juvenile shrimp and firifish will no doubt result in an increase in recruitment to fisheries like the TRN, BLL and TWL, which catch the species at larger sizes and contribute to a higher yield and value. It has been estimated that banning ESBN would result in an increase of 250 per cent in yield and value in the TWL fishery and 300 per cent in the TRN fishery. But such drastic measures would have very high social costs and would endanger the survival of the poor fisherfolk.

The better option, then, is to strive for regulation of the fishery by encouraging changes in the gear design, to reduce the catches of very small species and by, perhaps, even enforcing a closed season. Providing access to credit for diversifying into MSBN and TRN to compensate for loss of income by regulatory methods would also need to be considered.

Rather than any across-the-hoard measures, it may be expedient to regulate this fishery in Stratum I. which accounts for nearly 46 per cent of the production by ESBN in the country and where household earnings are over 90,000 Tk/year. This is easier said than done and, unless a serious attempt at awareness-building of new opportunities is made, together with training and credit to promote fishery diversification, it may be rejected outright.

Perhaps the only positive toehold is that nearly 60 per cent of the ESBN fisherfolk population are under twenty years of age and may he more amenable to a change in perception.

17. *SUGGESTIONS AND RECOMMENDATIONS*

The results of this case study were presented at a National Seminar on the Estuarine Set Bagnet Fishery in January 1992, at Cox’s Bazar, Bangladesh. Representatives from the Department of Fisheries, Bangladesh, Agricultural Research Council, Fisheries Research Institute, Universities in Bangladesh and observers from Indonesia, Malaysia, Myanmar and Thailand participated. For management of the resources discussed in this paper, and in BOBP/WP/89, it is necessary to manage not only the ESBN fishery but also other fisheries exploiting the same resources. Suggestions and recommendations are given below

17.1 *Marine fisheries resources management mid development*

- Surveys should be conducted systematically for assessment and monitoring of the shrimp and finfish stocks.

- Closed season for shrimp trawlers to be confirmed after specific analysis of available information and data from the trawl fishery.

- For the expansion of the small-scale/artisanal fisheries, such as tramnielnetting and bottom drift gillnetting and bottom longlining, the trawl fishery may have to be restricted to areas deeper than 30m and also expanded into depths greater than 80 m, to exploit other bottom and close-to-bottom resources which are presently unutilized — mackerel, scad, deepwater lobster etc.

- If any of the existing shrimp-trawlers go out of commission, they should be replaced with finfish trawlers only.

- Prospects for expanding trammelnetting for shrimp in waters greater than 30 m should be investigated and economic feasibility established.

- A comprehensive marine fisheries census, including craft, gear and their specifications, as well as the fisherfolk population in the respective fisheries, should be conducted to improve marine fisheries planning and effective management of the marine fisheries.

- All types of gear used in the artisanal fisheries should also be incorporated into the Fisheries Ordinance and should be licensed, so that some control on their fishing effort would be made possible.

17.2 *Estuarine set bagnet fisheries*

Estuarine set bagnet operations, in estuarine as well as marine environments less than 10 m deep, should not be permitted. Considering the tidal variation, the isobath line at 10 m depth, during the mean-tide level, could be used for such a purpose. Any reduction in this depth limit, under specific conditions such as seasonality in tidal variations, bottom configuration of certain locations, mesh size etc, should be specified.

Seasonal reduction of the fishing effort of estuarine set bagnets, in selected locations that are to be identified more clearly from high percentages of juveniles of highly valued species and the areas and seasons of their occurrence, as reflected by the data on the estuarine set bagnet catches.

- Test fishing should be conducted, with the participation of set bagnet fisherfolk, to establish suitable, economically viable alternative fishing methods to replace estuarine set bagnets, *e.g.* mud crab catching, crab-fattening, hook-and-line fishing, trammelnetting, bottom drift gillnetting etc.

- Scope for further expansion of gillnetting and hook-and-line fishing, in the light of the reduction in the fishing effort by estuarine set bagnets, should be determined.

- A special programme should be undertaken by DOF to replace estuarine set bagnets with alternative income-generating fishing methods and also to motivate the fisherfolk to take up these alternative methods.

17.3 *Shrimp seed-collectors and hatcheries, for culture*

- DOF should conduct training programmes for the shrimp seed-collectors/farmers to help them reduce mortality rates in transportation and in the culture ponds.

- **DOF should also motivate these** seed-collectors to return all other seed, caught as by-catch, to their natural environment.

- Further investigations should be undertaken to confirm the present estimate, or improve that estimate, of tiger shrimp collected by the seed-collectors, and determine requirements for reducing the shrimp seed mortalities (in collection techniques, in the ponds and in transportation of seed) and yield rates in culture fishing.

- Methods of selectively collecting tiger shrimp seed from the natural environment should be investigated to identify ways and means of reducing the 'by-catch' of other species.

- Possibilities of utilizing seed other than those of tiger shrimp, but collected along with it, should be investigated, *e.g.* seed of white shrimp, brown shrimp, freshwater prawns, mullets etc.

- A closed season and/or closed area for shrimp seed-collectors should be identified and established, on the basis of the relative quantities of seed collected from different areas, seasonal variation and availability of seed, to reduce any effects of seed-collection on the natural stocks exploited by the trawl and trammel fisheries.

17.4 *Socioeconomics and extension services*

- In order to manage the existing marine fishery resources, the rapid growth of fisherfolk **population** has to be addressed, through family planning education.

- Extension programmes, to educate fisherfolk on resources and management issues, should be undertaken and extension material prepared before management measures are introduced. Understanding and participation of fisherfolk and NGOs in the implementation of management measures are essential.

- Before introducing any restrictions on estuarine set bagnet operations, the economic effect of it on the very poor set bagnet fisherfolk should be assessed, and they must be motivated to. take up already tested alternative fishing methods that might compensate for loss of income from the set bagnet fishery as well as enhance their **incomes.**

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APPENDIX I

Relative vulnerability of different species to different gear

Species	*PN/DN*	*BS*	*ESBN*	*MSBN*	*TRN*	*TWL*
Tiger shrimp		-	+	+	++	
White shrimp	++	-	++	+	+++	+++
Brown shrimp	++	+	+++	+	++	
Ribbonfish	-	++	+++	++++	++	++
Bombay duck	-	++	++	++++	++	++
Croaker	+	++	+++	++++	++++	+++

++++	Abundantly represented
+++	Commonly represented
++	Fairly represented
+	Rarely represented
-	Absent

APPENDIX II

Regression coefficients for (A) Length *vs* Weight, and (B) Carapace length *vs* Total length of selected species

Species		*Sex*	*mm*	
Tiger shrimp				
L (mm) *vs* W (g)	(A)	Male	a = 0.01749	b = 2.7767
		Female	a = 0.009712	b = 2.9628
CL *vs* TL (mm)	**(B)**	**Male**	**a** = - 7.0468	b = 0.2886
		Female	a = - 9.67	b = 0.3044
Brown shrimp				
L **(mm)** *vs* W (g)	(A)	Male	a = 0.072	b = 2.049
		Female	a = 0.0121	b = 2.899
CL *vs* **TL** (mm)	(B)	Male	a = 0.6110	b = 0.2368
		Female	a = 3.82703	b = 2.753 195

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1. *Helping Fisherfolk to Help Themselves : A Study in People's Participation,* (Madras, 1990.).
2. *The Shark Fisheries of the Maldives.* R C Andersen, H Ahmed. Ministry of Fisheries and Agriculture, Maldives. (Madras, 1993).

NOTE: Apart from these publications, the BOBP has brought out several folders, leaflets, posters etc., as part of its extension activities. These include Post-harvest Fisheries folders in English and in some South Indian languages on anchovy drying, insulated fish boxes, fish containers, ice boxes, the use of ice etc. Several unpublished reports connected with BOBP's activities over the years are also available in its Library.

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