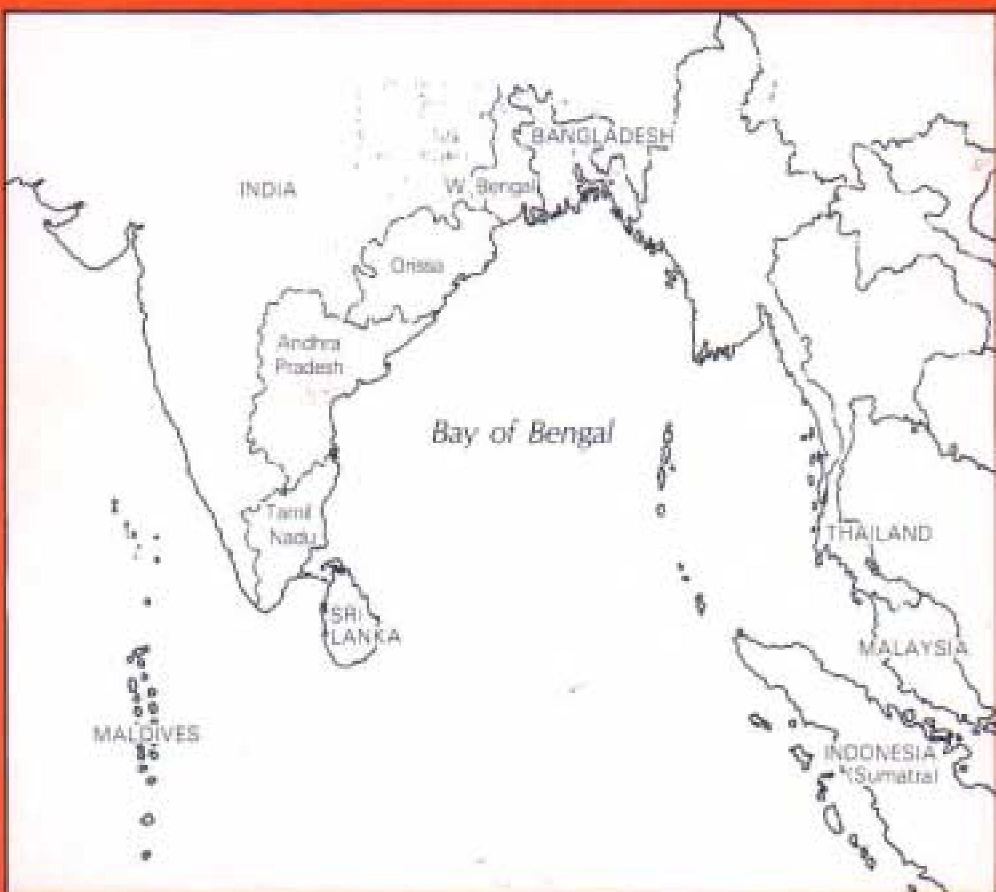
BAY OF BENGAL PROGRAMME BOBP/REP/36
Marine Fishery Resources Management RAS/81/051

Hilsa Investigations in Bangladesh



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HILSA INVESTIGATIONS IN BANGLADESH

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The ***Hilsa ilisha*** constitutes the largest single-species fishery of Bangladesh. It accounts for about 30% of the country's total fish production; the fishery employs more than 1.5 million people.

At the request of the Bangladesh Government the BOBP's project "Marine Fishery Resources Management in the Bay of Bengal" conducted a series of investigations on the ***Hilsa ilisha*** during 1985-86. As a first step, current literature on the biology and fishery of ***Hilsa ilisha*** in the Upper Bay of Bengal was reviewed and published in October 1985 as BOBP/WP/37.

The Hilsa investigations covered marine, estuarine and riverine environments; the main areas of investigation were catch statistics, biological studies, racial studies and experimental fishing. Four sampling stations were selected for the investigation, Chittagong and Cox's Bazar being the marine stations. Five biologists were trained in the programme, and the data obtained were processed later at a training session in Colombo.

This paper sets out the results of the investigations, which were conducted under the overall supervision of BOBP's Senior Fishery Biologist, Dr. K. Sivasubramaniam. A consultant, Dr. B.T. Antony Raja, reviewed literature on the subject, trained national biologists, helped them to prepare the Annexures found in this report, and in general monitored the programme. Mr. J. Hertel Wulff (BOBP Biologist — Associate Professional Officer), stationed at Chittagong, assisted the national biologists and processed the data using the micro computer Apple IIe. Mr. M.Van der Knaap (Biologist — Associate Professional Officer) and Mr. T. Nishida (Statistician — Associate Professional Officer) also helped the five Bangladesh biologists- Mr. M. Hossain, Mr. N. N. Das, Mr. Sujjat Al Azad, Mr. Q. Mahbubul Huq and Mr. M. Serajul Islam-to process the data.

The Hilsa investigations and this paper which reports on them were sponsored by the "Marine Fisheries Resources Management" component of the Bay of Bengal Programme (BOBP). The project commenced in January 1983 and terminated in December 1986. It was funded by the UNDP (United Nations Development Programme) and executed by the FAO (Food and Agriculture Organization of the United Nations) ; its immediate objective was to improve the practice of fishery resources assessment among participating countries and to stimulate and assist in joint management activities between countries sharing stocks.

CONTENTS

SUMMARY

This report describes investigations undertaken on the Hilsa shad, ***Hilsa ilisha,*** in Bangladesh in 1985/86. Prior to the investigations, current literature on the fishery and biology of ***Hilsa ilisha*** of the Upper Bay of Bengal was reviewed and published as BOBP/WP/37.

The investigations covered all environments — riverine, estuarine and marine -with four sampling stations: Chandpur (riverine), Khepupara (estuarine), Chittagong and Cox's Bazar (marine).

A sampling programme was devised and four biologists were trained in all the disciplines included in the programme. Subsequently, one more biologist was included to carry out racial studies. At the end of the programme the biologists processed their data at a training session in Colombo.

The main items of the work plan were catch statistics, biological studies, racial studies and experimental fishing.

The hilsa investigation project was funded by the BOBP. The salaries and allowances of the biologists and their assistants and of an official who oversaw the experimental fishing activities were met by the government. Some laboratory and field equipment was also provided by the government.

The proposal to have a university do the racial studies on hilsa led to a lot of delay. Some other problems and handicaps also held up progress and impaired data collection machinery. The biologists did not have enough experience in such work; consequently, some of the government inputs were delayed.

The following are, in brief, the salient findings:

It has been estimated that hilsa production from the sea may be 140,000 t, and from inland waters 90,000 t. But the figure of 230,000 t may be an overestimate, for the number of active fishing boats in the marine sector is less than the registered number and the estimate of inland production may include marine catch also,

A length-based analysis of the population parameters from Chittagong data showed no evidence of the hilsa resource being overexploited. But conclusions can be drawn only after the fishery is monitored through comprehensive studies for a few more years. It would also appear that the fishery is self-managed, because hilsa appears to enter the commercial fishery after attainment of maturity.

Regarding growth, the provisional findings are that hilsa grows fast to a maximum size of 56 or 57 cm. The length frequencies indicate four or five modal size groups within the size range caught. The modal sizes were generally found to be higher for females than for males. There are usually two major recruitments in a year, August and October; there may be another in April. How far these observations will be applicable for the entire population cannot be indicated with the present limited data.

The males mature at size 26-29 cm, the females at 31-33 cm. There are indications of intermittent spawnings between peak spawnings.

Spawning appears to take place almost around the year, except perhaps in December-January, but the major spawning activity seems to be in October, followed by another but relatively less intense activity in March and June. There is so far no evidence of spawning taking place in the sea. One of the spawning grounds seems to be around Sandwip. Some nursery grounds are around Khepupara and Chandpur.

Areas where satisfactory results could not be obtained were experimental fishing and racial studies.

In the case of experimental fishing the inexperience of the crew in operating the special design of sampling net, the difficulties of the biologists undertaking fishing voyages in country craft, and the absence of an expert in fishing technology, were some of the reasons for the poor results. The provisional findings are that the hilsa not only get gilled but also get entangled in the gillnet, thus providing a wide range of sizes of fish; the catch was comparatively better at night than during the day; fishing time for one setting need not be more than four hours.

Racial studies suffered mainly because of two reasons; delayed start, restricting the choice of characters to a manageable few, and non-adherence to the methodology advocated. For the latter reason, results obtained on all but two characters had to be rejected. The remaining two characters did not exhibit any significant differences between the fishes of different areas.

This one-year programme was only a model approach to promote awareness of the need for a comprehensive study of hilsa in Bangladesh waters. Hilsa production is a big industry; the work ahead is stupendous and strenuous. The future programme should be more extensive in scope, and more intensive in some areas. This calls for serious attention from all, massive assistance, funds and expertise and the cooperation of both national and international agencies.

The nucleus of the present hilsa team should continue; there has to be *more* training, constant supervision, and proper guidance in order to strengthen their background and their skills so that they in turn train others.

1. INTRODUCTION

The marine fish landings in the Bay of Bengal region, including the Malacca Straits and the waters around Sri Lanka, are of the order of 2.4 million tonnes, about 60% of the Indian Ocean's catch of nearly 4 million tonnes,

The UNDP/FAO inter-country project "Marine Fishery Resources Management in the Bay of Bengal" was established under the Bay of Bengal Programme (BOBP) in 1983 for a duration of four years with Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka and Thailand as participating countries. In 1984, India decided not to participate in the activities of the project, although certain areas had already been identified for cooperation activity.

The aim of the project is to improve the practice of fisheries resources assessment among the participating countries and stimulate and assist in joint assessment and management activities among countries having the same species or allied group of species contributing to important fisheries. The project activities were expected to lead to:

— Overall assessment of the present level of exploitation of marine fishery resources in the region, with estimates of development potential by stocks and by geographical areas.

— Upgrading the technical skill of biologists to collect, interpret and report on the fishery and on biological data from the standpoint of stock assessment.

— Identifying exploitation techniques, management strategies and regulatory resources for selected species of common identity to facilitate their optimum exploitation in the region and

— Better understanding of the sociological, economic and social variables in the exploitation of these selected fishery resources.

The Technical Liaison Officers (TLOs) of the participating countries met in Madras, India from 16 to 20 August, 1983 to identify stocks of mutual interest requiring assessment and management measures, to outline a work plan and to indicate operational arrangements for executing the work plan. The anadromous hilsa belonging to the *Hilsa ilisha* of the Upper Bay of Bengal was one such resource identified by Bangladesh and India. It was also recommended that the existing historical data may be evaluated so as to draw up a detailed programme of research.

The Hilsa shad was estimated to yield about 180,000 t a year in the countries bordering the Upper Bay of Bengal -i.e. Bangladesh, Burma and India, with an estimated boat side value of about US $ 110 million. Bangladesh was the major contributor to this large resource; its share was about 80% of the total catch. An important characteristic of this species is its availability in all the three eco-systems, namely, rivers, estuaries and the sea. It was reported that in its area of distribution in the northern Indian Ocean there are purely riverine stock, an anadromous stock which migrates between the sea and the river (the river-ward migration is for spawning) and a purely marine stock. Studies carried out in the past in the Bay of Bengal region were almost exclusively on the hilsa of inland waters including the estuaries; practically no attention was paid to the marine phase of the life history of the fish except for some work in Burma.

2. PREPARATORY ACTIVITIES

2.1 Review of past records

On the basis of the recommendation of the TLO meeting, it was decided to review the existing literature and records available in Bangladesh and India for chalking out a common work programme for both the countries. A consultant was engaged to review current knowledge on the biology and fishery of *Hilsa ilisha* of the Upper Bay of Bengal; to report on the present status of exploitation and the nature of studies undertaken in Bangladesh and in India and to recommend sampling programmes for understanding better the nature of the stocks exploited in the respective countries. This study, entitled "A review of the biology and fisheries of *Hilisa ilisha* in the Upper Bay of Bengal" has been published (BOBP/WP/37).

The review of the literature brought out the following salient features:

1. There is practically no scientific information on the marine segment/phase of the life history of hilsa.

2. In India, a variety of studies has been undertaken in the riverine/estuarine areas in almost all the major river systems; in Bangladesh, some studies have been carried out in the past, and more recently interest has been revived especially becaus e of the declining returns from the rivers and increased exploitation from the sea; in Burma, available information is scanty.

3. There are at least two distinct eco-types — a stock which remains in the rivers throughout its lifespan, and another which migrates from the sea to the river for spawning. Besides these two there is possibly a marine stock.

4. The construction of dams, anicuts and weirs has definitely affected the fishery for anadromous fishes-here, as elsewhere in the world.

5, There are conflicting and confusing views on some of the basic biological features of the fish, such as age, growth and reproduction.

6. Precise and comparable catch data with reference to areas and time are lacking.

7. Various factors have been held responsible for the oscillating annual yield from the fishery. Evidence for some of them is not convincing.

8. The subject of racial composition has received a good deal of attention mainly through biometric studies. Each river system appears to have its own endemic stock with no evidence of intermingling. A recent dimension added to this issue is the possibility of segregation of stocks further into broad and slender forms. However, no studies have been made on the composition, continuity, independence or interdependence of the marine sector stocks, and the relationships, if any, with those of the inland waters.

9. Studies on migration through tagging experiments conducted by India indicated a homing instinct among hilsa to the natal river. But other deductions were difficult because of the low rate of recovery of tagged fish.

10. Farming of hilsa has been successfully developed in India and self-propagating stocks established in confined reservoir waters.

2.2 First working group meeting

The first working group meeting on hilsa investigations in the Upper Bay of Bengal was organized in Dhaka, Bangladesh, 22-26 September 1984. The review of past records and the suggestions for a sampling programme were discussed in detail at this meeting. Invitations had been sent to the Governments of Burma and India, but no representative from these countries was present. Hence a work plan was proposed for Bangladesh only on the following aspects:

— Structural statistics (census of craft and gear).

— Catch statistics (sampling of landings for catch and effort estimates).

— Biological studies (analysis of length composition in the catch, leading to age determination and status of exploited stocks; determination of sex ratio, maturity size and spawning habits and seasons.)

— Racial studies (to find out whether the stocks exploited in various environments are homogeneous or not by employing different approaches such as biometric and cytogenetic methods).

— Experimental fishing (to determine the structure and parameters of the population at large; to study selectivity of gillnets employed in commercial activity; to collect environmental data for correlating them with the fishery).

The work plan took into consideration the recommendations of other recent studies and the activities envisaged under the IDRC (International Development Research Centre of Canada) project for hilsa in Bangladesh. Thus the work plan was common for all the environments, rivers, estuaries and the sea. A list of required personnel and equipment was drawn up together with the work plan.

It was then envisaged that the BOBP support would be limited to the marine (Chittagong, Cox's Bazar) and estuarine (Bhola) environment. Subsequently, in view of the time lag in implementing the IDRC project, the riverine station at Chandpur was added to the BOBP programme so that a comparative picture of hilsa in all the three habitats could be obtained at the same time, adopting a common method of approach.

3. IMPLEMENTATION OF WORK PROGRAMME

3.1 Training of biologists

The four national biologists assigned to the hilsa investigations were trained in collection of catch statistics, in biological data and in experimental fishing. How such data could **be** used and for what purpose was explained. They visited landing sites to get first hand experience of how the data have to be collected; they observed how the samples are examined at the laboratory, how stages of maturity are determined and other data recorded. Lest these instructions were forgotten, a manual on the sampling programme and on the pro *forma* was distributed for their permanent guidance. Particulars of methodology and the prescribed *pro forma* for their tasks are set down by the biologists in their respective papers (Annexures).

The progress of the programme was monitored by the consultant once in two months for 2 to 3 weeks each time. The BOBP's Senior Fishery Biologist also visited Chittagong three or four times to appraise the biologists' performance and to sort out administrative matters.

Towards the end of the study period, the biologists were given oral and written guidelines for undertaking analytical exercises on the data collected. This effort was further elaborated during a group training exercise conducted at the project's headquarters in Colombo during two weeks in May 1986. All the data collected were then collectively analyzed.

3.2 Identification of sampling stations

While Chittagong and Cox's Bazar (marine) and Chandpur (riverine) came to be selected automatically, by virtue of their importance to the fishery and the facilities available, it was more difficult to select a station for the estuarine sector. Bhola, Charfesson, Barisal and Khepupara were suggested. Bhola and Barisal did not represent estuarine conditions; the hilsa landings there were also a mixture of catch from marine, estuarine and riverine areas brought by carrier boats. Charfesson and Khepupara have an estuarine environment but the former had very poor facilities for transport and communication, and problems in berthing the experimental boat. Hence, by process of elimination, Khepupara was selected. The location of stations is shown in Appendix 1.

3.3 Inputs

Government

— Salaries, travelling and daily allowances for the biologists and their assistants.

— Laboratory and field support identified by the project.

— Services of an official to help maintain operational schedules of experimental fishing, including supply of fuel and ice to the boat.

— Office and laboratory accommodation for the national biologistsandfor expatriate personnel.

Project

— Hire charges and running expenses for the boat engaged for experimental fishing.

— Supply of fishing gear of different specifications for experimental fishing.

— Microcomputer (Apple IIe) with programmes.

-Transport charges for the biologists and their assistants to visit the landing centres and sea allowance during experimental fishing.

— Cost of fish samples purchased at each station for biological studies.

— Engagement of a consultant for intermittent assignments.

— A full-time Associate Professional Officer (Biologist) at Chittagong.

— Cost of travel and subsistence allowance for the biologists for the training held at Colombo.

— Supply of scientific calculators and transistor radios.

3.4 Work calendar

The studies extended from March/April 1985 to March/April 1986 in respect of all activities except biometric studies; the latter were initiated during September/October 1985 and extended up **to** March 1986.

Appendix 2 gives the work calendar for each station on the major items of activity. The dates were adhered to strictly, except when unavoidable (breakdown of the experimental boat, festivals, the biologists falling ill, etc.).

3.5 Shortcomings

While the work plan was by and large implemented as envisaged, the work suffered several shortcomings which, to a varying degree, affected the substance and quality of the anticipated results.

— The inexperience of the biologists in the collection, processing and analysis of data hampered work throughout the investigations.

— Delays in the delivery of equipment components e.g., weighing scales, diminished the usefulness of data recorded during the early phase of the investigations.

— Operational and administrative difficulties were encountered because of staff changes (concerning one biologist, the supervisor of the experimental fishing operations and the Technical Liaison Officer). Furthermore, the responsibilities of hilsa research were split between a newly established National Fishery Research Institute (FRI) concerned with the riverine and estuarine environment and the Directorate of Fisheries responsible for **the** marine sector.

— The experimental fishing from the riverine and estuarine stations failed to a large extent; the experiments were mainly based on experiences from the marine sector and the master fisherman and his crew had little or no experience of riverine/estuarine fishing.

— An attempt was made to engage a sub-contractor (from a university) to undertake the racial studies. It failed for various reasons and the work could not therefore be taken up until six months after the start of the investigations.

— The processing of data was delayed because of problems with software development for the microcomputer.

4. RESULTS

The findings of the investigations on the following aspects are presented in detail in Annexures 1-6 :

1. Hilsa fishery
2. Experimental fishing
3. Size composition in the fishery
4. Analysis of length frequencies
5. Maturity and spawning
6. Analysis of some morphometric and meristic characters.

The results were presented and discussed at the Second Working Group Meeting held at Dhaka 6-10 July 1986. The following is a summary ‘of these results.

4.1 Commercial fishery

Given fair weather, fishing for hilsa can be done almost throughout the year. Total absence of fishing for hilsa was noticed around the Khepupara area during April/May. The peak season on the marine and riverine side is September/October, some minor peaks occur in February, April and June. The catch from the estuarine sector was sold mostly at the fishing ground itself to carrier boats, hence the shore landings were poor. The main peak was seen in July/August and a feeble one in January/February. The lean season seems to be during December/January in the riverine sector, probably because there are no major or minor spawning runs, and during June/ July in the marine sector, because of the monsoon. The estimated annual landings at Chandpur, Chittagong and Cox’s Bazar were 4500,4400 and 8000 t. It is quite possible that the Chittagong figure is an underestimate.

Some correlation between the trends in temperature/salinity and those in catch rates was seen. In view of the limited data and period of coverage, firm conclusions were not drawn.

It has been reported that there are about 3000 mechanised boats engaged in hilsa fishing in the marine sector. Based on an average catch per boat of about 47 t per annum, it has been provisionally estimated that the production for the marine sector may be of the order of 140,000 t. But since the estimated number of boats at Chittagong and Cox’s Bazar was far less than the reported number of registered boats, the estimated production figure should be taken as purely tentative. Perhaps some boats may not be engaged in hilsa fishing, some may be landing elsewhere and some might have been missed in the count by the investigators. Another independent estimate by the Marine Fisheries Department, Chittagong, puts the average catch per boat per annum at 36 t. This may be an underestimate because it is the figure for only eight months of the fishery. An estimate of 45 to 50 t per boat per annum is considered reasonable. The country’s production estimate from the marine sector would thus largely depend on the effective number of mechanized boats engaged in hilsa fishing.

The Fisheries Resources Survey System Project of the Government of Bangladesh has estimated that annual production of hilsa in the riverine and estuarine sector is about 90,000 t. Thus even if it is presumed that in the marine sector only about 2000 boats are effectively engaged in hilsa fishing, an equivalent figure of 90-100,000 t for the marine sector may be got. But it has to be borne in mind that the estimate for the riverine/estuarine area would include the landings from the marine side by carrier boats. Hence the provisional estimate for the whole country of about 230,000 t may be on the higher side. On the other hand, according to the Bangladesh Bureau of Statistics, hilsa production was 305,000 t in 1982/83 from inland waters alone, out of a total inland fish production of 583,000 t (1983/84 Statistical Yearbook of Bangladesh).

Such a vast difference in estimates underscores the need for a more realistic estimate of production. The immediate concern should be not on how to increase hilsa production from capture fisheries but on how to maintain the present production level till it can be stepped up. Fortunately there is some evidence that the hilsa fishery is self-managed at present even without introducing any management measures.

4.2 Experimental fishing

This activity was accorded a lot of importance, and fairly sizable funds were provided as well. Unfortunately, the results were disappointing at all stations, more so in the riverine and estuarine areas. In the first six months, there was practically no catch. The situation improved during the next six months, partly because of the peak season, but it was still not quite satisfactory. The reasons are listed in Annexure 2. In the main:

— Inexperience of the crew in operating a sampling gear with so many mesh sizes.

-The problem of biologists going out on a fishing cruise for the first time, and that too in a country craft-thus forcing them to curtail or abandon operations whenever they fell sick or uneasy.

— Absence of a fishing technologist on board.

— Experimental gear had shorter panels (100/1 25 mm mesh sizes) than the commonly used commercial gear.

— Short fishing voyages.

Another experimental gear, which was a miniature commercial gear, performed much better; **the** results to some extent reflected the commercial fishery situation.

Increased gear soaking time did not improve the catch. A soaking time of four hours brought in as good or as bad a catch as that of 10 to 15 hours. In general the catch was better at night.

All sizes of hilsa ranging from 27 to 55 cm were caught in all the three mesh sizes, 7.5,10.0 and 12.5 cm. It is seen that hilsa not only get gilled but entangled too, thus accounting for the wide size range of fish captured.

The negligible amount of fish in smaller mesh sizes, 2.5 and 5.0 cm, probably indicated that the smaller fish were not abundant in the normal fishing grounds. On the rare occasions when juveniles were present, they were found caught in the 2.5 cm mesh size panels.

4.3 Size composition in the commercial fishery

Although a wide range of sizes, from 22 to 56 cm, enter the fishery taking all the environments together, more than 90% of the catch falls within a range of 30 to 50 cm. In the estuarine station at Khepupara, hilsa over 50 cm were seldom recorded; in the marine stations and the riverine station fish smaller than 30 cm was rare. It is possible that Khepupara is not in the migratory route of hilsa above 50 cm, or fishing during April/May was perhaps suspended. The scantiness of fish smaller than 30 cm, especially in the riverine and marine stations, perhaps indicates that they do not frequent the normal fishing grounds but have sanctuariessomewhere else, yet to be detected.

The normally expected temporal progression of modal sizes was not seen, thus eluding visible detection of growth. In fact, a reversal of the picture, a retrogression, was noticed especially in the riverine and estuarine stations. This was due to a combination of factors like seasonal changes in the mesh sizes of the gear used, emigration and mortality of fish in the 40-50 cm group, immigration of medium sizes into the fishing areas and perhaps intermittent recruitment of the fishery. In general, it can be stated that the mean length of hilsa in Bangladesh is the largest in the range of 40 to 45 cm during April/August; in the middle range of 38 to 43 cm during September/November; and in the lower range of 33 to 40 cm during December/March. If, as is shown later, major recruitment takes place in October, and the fish attain about 30 cm in one year, it will be possible to connect the last mentioned group in December/March with that of **the** subsequent period, April/August. The recruits of subsidiary recruitment probably manifest themselves during September/November.

A broad grouping of the size ranges into two main classes, a smaller 3039 cm and a larger 40-49 cm fish, indicated the following picture.

in the marine sector from June through next March there is very little difference in the catch rates of these two groups of fishes, but considering that the longer fish are heavier, it would appear that the smaller fish are numerically more during this period; during April to June, the larger fish distinctly predominated.

At the riverine station, the large sized fish are dominant from April to October. From November to February, in general, hilsa abundance is low and the smaller fish are more numerous than the larger fish.

In the estuarine station also, the picture is somewhat similar, the smaller fish being dominant for a longer period (September to March).

In general, the smaller fish are numerically more during September to March in all the environments; thereafter from April to June the larger fish distinctly dominate the smaller. This change is perhaps because the younger (smaller) fish entering the commercial fishery have suffered less mortality due to fishing as compared to the older ones; and the subsequent dominance of larger fish is because the smaller fish have grown during the intervening period. From June, the same group suffers increasing fishing mortality and is overtaken by the freshly recruited younger groupfrom September, thus completing the one year cycle.

Although conventional analysis of the length frequency distribution did not permit deduction of growth increments, recently developed methods of electronic length frequency analysis (ELEFAN I) and other methods such as the Bhattacharya method were employed on the data collected at Chittagong from the commercial fishery and data obtained from experimental fishing at Chittagong and Cox's Bazar.

ELEFAN I analysis to determine how fast the fish grows (K) to reach the maximum size (L,) showed that the hilsa grows fast (K=0.9 to 1 .15) and reaches a maximum size of 56 to 57 cm. Separation of the mixed length frequency distribution by the Bhattacharya method indicated that there were four or five modal groups, at 22, 37, 41, 47 and 50 cm within the exploited size range. What age these size groups could be assigned to is rather difficult to determine in view of the likelihood of more than one major recruitment.

4.4 Maturity and Spawning

Except at Khepupara, there were no significant differences in the sex ratio at any station ; at Khepupara, males were distinctly dominant during half the observation period. Generally, up to about 35 cm, the males are likely to be more numerous in a sample and it would be difficult to find their representation beyond 46-48 cm length. This difference may have been caused by a differential rate of growth, the males growing slower than the females, hence the dominance of males in the smaller sizes and their absence in the larger sizes.

The males attain their first maturity around 26-29 cm, as compared to 31-33 cm in the case of females. There are indications of intermittent spawnings in between the peak spawnings.

Spawning appears to be almost year-round but the major activity takes place in October and less intense activity in June and March. The activities in June and October constitute the 'summer' spawning and those in March the 'winter' spawning. Perhaps, it is more appropriate to refer to monsoon, post-monsoon and pre-monsoon spawnings.

There is no evidence of spawning in the sea; the fish advance to maturity in the estuarine area and may spawn both in the estuaries and in the rivers. One of the spawning grounds was found to be the estuarine Sandwip area, in October. Juveniles in the size range of 4 to 15 cm caught in the Khepupara area from December to April indicate that they may be progenies from the October/November spawning.

4.5 Current state of exploitation

On the basis of the growth parameters obtained earlier, the ELEFAN II programme was employed to obtain more information on the exploited population. The following are the salient findings:

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(i) There may be two major recruitments a year; these may be in August and October; there is some indication of another recruitment in April.

(ii) There is no clear evidence of over-exploitation of the hilsa resource at present. However, it is prudent not to increase the fishing pressure beyond the present level, because catch rate may decline with higher fishing effort. Moreover, even a marginal increase in yield will require a very high additional fishing effort, which may not be economical.

(iii) The length at first capture seems to be around 39 cm, and this is well above the size at first maturity which is around 30 cm. This is corroborated by the scarce availability of fish less than 30 cm in length in the areas now fished. This phenomenon testifies to a unique feature of self-regulation.

However it must be borne in mind that the results are based largely on data in one place and that too not even for a full year. There is nothing to guarantee the veracity of the data; hence these results have to be viewed with caution.

4.6 Racial studies

A preliminary study was attempted on eight morphological characters to see whether any or some of them might exhibit significant differences between the hilsa in different environments and between different months/different sizes. Unfortunately as the method advocated was not followed the results from six *measurable* characters had to be rejected. The two *countable* characters chosen did not exhibit any significant differences between hilsa of different areas/ months/sizes.

4.7 Economic studies

The wholesale prices ranged from Tk 13000 to Tk 43000 a tonne (US $ 1 =Tk 30) with an average price of Tk 25000 at the marine stations and Tk 30000 at the riverine stations. Prices drop when landings are the highest in September/October and rise when the landings decline. The highest prices are obtained in June/July (marine side) and January (both marine and inland sectors).

Collection of some data on investment costs and earnings in the hilsa fishery indicated the profitability of the fishery and also the need for an in-depth study estimating the rate of return more precisely.

5. SUGGESTIONS

The one-year programme just ended is a model approach to promote awareness of the need for a comprehensive study of an important Bangladesh fishery. The programme should be more extensive in scope and more intensive in some areas; it requires fairly sizeable funding.

Although there is no clear evidence that the hilsa fishery is being over-exploited, it might be prudent not to encourage an increase in fishing pressure for at least a couple of years more-till comprehensive studies can be organized to monitor the fishery. Different designs have to be evolved for data collection for different environments, more personnel and sampling stations have to be included, and a regular machinery established, subject to review at regular intervals, say, once in two years.

Major biological aspects to be focussed on are age, growth and spawning. The length-based methodologies developed in recent years have to be tried often using computer programmes for assessing age and growth parameters and for stock assessment.

Studies to establish whether the stock exploited is homogeneous or not have to be more serious and extensive; the approach could be conventional to begin with, and should later be extended to include more sophisticated methods. It is essential that the problem be taken up without any pre-conceived bias.

Three broad areas-experimental fishing, tagging and management studies-will have immediate priority :

Experimental fishing should be an exclusive programme by itself; it is the only tool to overcome lacunae or shortcomings in data emanating from the commercial fishery. It should be used for collecting evidence on missing size groups, on spawning and nursery grounds, on sanctuaries for young fish; it should also be used to monitor the state of the fishery.

Jagging as a means to study migration should be taken up when the programme is assured of enough funds, for it is an expensive venture. Even the simple staining technique, if proved applicable in the case of hilsa, will require a well-planned publicity and extension programme; it will also require the cooperation of the public and of neighbouring countries; and perhaps some incentive reward to fishermen for returning tagged fish which they capture.

Management studies must also incorporate the socio-economic aspects of the fishery. Since these are largely unknown, a suitable initial remedial step could be the conduct of pilot surveys.

The nucleus team created now for hilsa should continue to handle hilsa investigations at least until two more successive cadres of capable scientists are created. It is only through such an organised team totally, conscientiously and continuously involved in research activity, that concrete results can be achieved. The present team requires further training, guidance and supervision to strengthen their understanding, skills and ability.

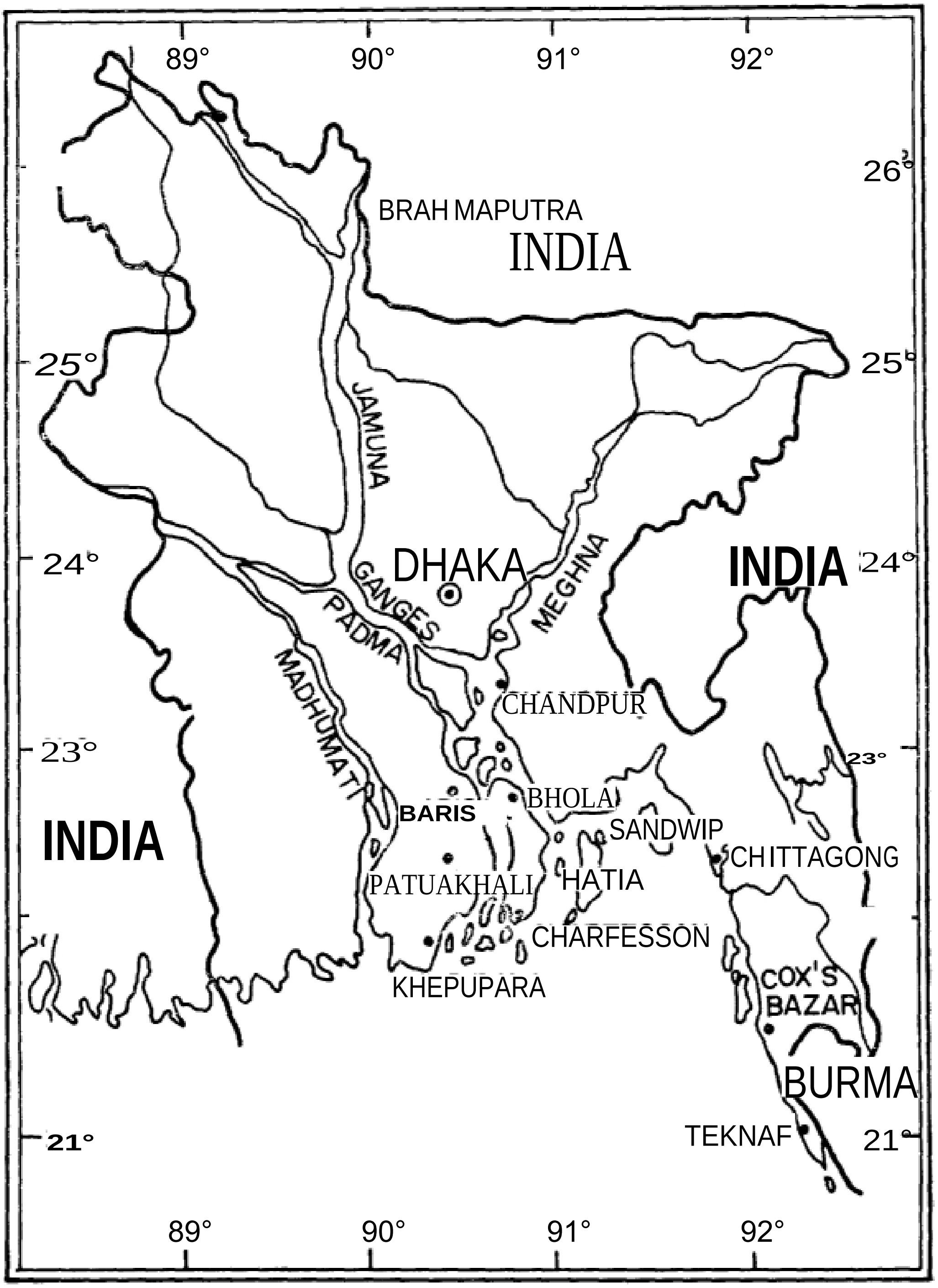
The supervision and guidance given to the team should be on the basis of familiarity with the fish, the terrain and the conditions available or obtained in a developing country.

The magnitude of the work and the extent of the resource is such that all agencies and institutions concerned with hilsa research should be mobilized, after identifying the activity and the agency undertaking it.

The funding assistance expected from IDRC will not be sufficient to cover the envisaged programme. More finance, expertise, equipment and facilities are necessary.

Appendix 1

HILSA SAMPLING STATIONS



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Appendix 2

WORK CALENDAR

(Note: Figures here refer to dates of the month)

Cox's Bazar:	**Catch and effort**	: **1,3,5; 11,13,15; 17,19,21; 24,26,28.**
	Length frequency	: **1, 2, 3; 17, 18, 19.**
	Biological sample	: **3; 19.**
	Experimental fishing	: **7, 8, 9.**
Chittagong:	**Catch and effort**	: **1,3,5; 7,9,11; 18, 20, 22 ; 24, 26, 28.**
	Length frequency	: **1, 2,3; 18, 19,20.**
	Biological sample	: **3, 20.**
	Experimental fishing	: **13,14,15.**
Khepupara:	**Catch and effort**	: **1,3,5; 7,9,11; 13, 15, 17; 25, 27, 29.**
	Length frequency	: **1,2,3; 15,16,17.**
	Biological sample	: **3; 17.**
Charfesson:	**Experimental fishing**	: **20, 21, 22.**
Chandpur:	**Catch and effort**	: **1,3,5; 8,10,12; 15,17,19; 21,23,28.**
	Length frequency	: **1,2, 3; 15, 16, 17.**
	Biological sample	: **3; 17.**
	Experimental fishing	
	(gillnet)	: **24, 25, 26.**
	(seine)	: **14, 29.**

Annexure 1

HILSA FISHERY OF BANGLADESH IN 1985-1986

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1. INTRODUCTION

Hilsa ilisha, the HIlsa Shad, constitutes the largest single species fishery in Bangladesh in almost all the river systems, estuaries and the sea, contributing perhaps to 30 per cent of the total fish production in the country. The country's population of 100 million people is heavily dependent on this fish, which is the most popular dietary fish in Bangladesh.

About 2 per cent of the total population is directly or indirectly employed in this single fishery. The fishery is exploited by some 18,000 fishing units, and provides employment to about 1.5 to 2 million people in the country (Sanaullah, 1984). Historically, the location of major hilsa fishing grounds was restricted to the upper reaches of the main rivers. At present, the major fishing activities are confined to the lower reaches, estuariesand the coastal waters. However, past studies have been confined to the hilsa in the inland waters only. Since the catches were reported to be declining in the upper reaches of the rivers and were increasing rapidly in the marine environment, the Directorate of Fisheries, Government of Bangladesh, wanted to initiate a research programme to study the hilsa fishery in its totality. The FAO/UNDP project "Marine Fisheries Resources Management in Bay of Bengal" chalked out a programme to investigate the fishery for this species in all the three environments. This paper describes the results of investigations conducted from April 1985 to March 1986 on the commercial fishery for hilsa, from four selected sampling stations.

2. MATERIALS AND METHODS

The sampling centres selected for the study were Cox's Bazar, Chittagong (marine), Khepupara (estuarine) and Chandpur (riverine). At each of these places one biologist was assisted by a field assistant for collection of data.

At Cox's Bazar and Chittagong, estimates of catch rates and landings of hilsa were made by sampling the catches and operating mechanized boats. At Chandpur the bulk of the data was collected from non-mechanized carrier boats; the rest, from mechanized fishing boats. The latter, however, were not local boats but were from the coastal districts and used for fishing in the sea. At Khepupara, two sampling centres were selected, i.e., Nayahata (about 5 km southeast of Khepupara) and Mohipur (about 14 km south of Khepupara). At Nayahata, fishing is undertaken only by traditional, non-mechanized boats; at Mohipur, it is by both mechanized and non-mechanized boats. A set of pro forma was designed for collecting data on catch and effort (Appendix I and II). At each station, the catch and effort data were collected on alternate days, three times a week (12 days in a month). Data were collected by direct observation and also on the basis of interviews. The number of boats sampled was a certain percentage of the total number of fishing/carrier boats that unloaded their catches on the sampling day. It was about 100 per cent when the total number of boats unloading the catches was between 1 to 10; about 50, 35, 25, 20 and 10 per cent were sampled when the number of boats landing on a sampling day was 11 to 20, 21 to 30, 31 to 40, 41 to 50 and above 50, respectively. Any fraction of such percentage was rounded off to the nearest higher number.

At Chittagong three landing centres, namely, Chirmanghat, Bridgeghat and Fisheryghat (Patherghata) were chosen for collecting the data; each of these three ghats was covered every week on alternate days. At Khepupara, the two centres were usually observed on alternate weeks; sometimes both were covered during the same week. In either case, the total number of observation days was 12 every month.

Estimation of catch for the day and the month was done as follows. The day's observed total catch was raised on the basis of the ratio of the number of boats observed to the total number of boats landed. The month's estimated catch is the product of the average landing per day for the observed number of days and the total number of days in the month. The unit of effort is a fishing day.

The types and other specifications of fishing boats involved in catching and transporting hilsa in the rivers, in the estuaries and in the sea are listed in Table I. The different types of fishing gear used in catching hilsa in the sampling stations are listed in Table II. For a description of boats and gear, reference may be made to Anonymous (1985) and Raja (1985).

3. OBSERVATIONS

3.1 Landings

Month-wise landings of all hilsa and the latter's percentage of the total fish landings are shown in Table III from which it may be seen that the total landings of hilsa at Chandpur peaked in April, June and October. The landings were very poor in December and January. The peak landings at Mohipur and Nayahata were in July and August respectively, while the lean season at both centres was in November (the marginally lower landings in January at Nayahata can be ignored).

Similarly, hilsa landings in Chittagong showed two peaks -a major one in September and a minor one in April. June and July in summer and December-January during winter can be considered a comparatively lean period for hilsa landings at Chittagong. In Cox's Bazar, the order of importance of peak landing seasons was April, October and February. Thus, while April and the September-October period were peak periods at both the marine stations, the month of February was a peak season for Cox's Bazar alone. The leanest month was July for both the stations, when weather conditions brought fishing operations at sea to a grinding halt. Thus, the common peak landings were in April and in September-October in the marine and riverine stations; in June-August in estuarine and riverine stations and to some extent in January-February at the Cox's Bazar and Khepupara areas.

The annual landings estimated for the sampling stations Chandpur, Mohipur, Nayahata, Chittagong and Cox's Bazar were 2678, 162, 33, 4430 and 8012 tonnes respectively (Table III). The poor landings at Khepupara area were attributed to the catches being collected and taken away by the carrier boats at the fishing grounds, low abundance of fish in the area and/or the very short duration of each fishing trip.

Railway's shipment data for 1985-86, at Chandpur, indicated that transhipment from the station was of the order of 4958 tonnes. This figure was arrived at after reducing the actual railway records by 31 per cent to account for the weight of ice (23%) and that of baskets (8%). The present estimate of 2,678 t may thus appear to be considerably less than the actual arrival. It may be remembered that the sampling was done only during day time (0700 to 1700 hrs) ; during the monsoon season (from May to October) the night landings were almost as much as the day landings. Hence if the corresponding figure of 1,870 t (to account for night landings) were to be added to the day's estimate, the total would be about 4,550 t, a figure reasonably close to the transhipment data.

3.1.1. Species composition

From the catch statistics collected, an attempt was made to find out the relative importance of Hilisa spp with others. The percentage composition at different sampling stations is shown in Table IV. The dominance of *Hilsa ilisha* in the gillnet catches was as high as 85 to 97 per cent. *Hilsa toli* was available only at the marine stations, mostly close to Cox's Bazar.

Among the miscellaneous fishes, some species were predominant. There was a similarity in the identity of species landed in riverine and estuarine stations on the one hand and in marine stations on the other. In the former, the cat fishes ***Silonia silondia*** and Mystus sp, the sciaenid ***Pama pama*** and the anchovy ***Setipinna phasa*** were more common ; the Bombay duck ***(Harpodon nehereus)*** and small sharks and rays were also found in the estuaries. In the marine sector, the white pomfret ***(Pampus argenteus),*** **the** Indian mackerel ***(Rastrelliger kanagurta),*** cat fish ***(Arius*** spp.), croakers, Bombay duck, elasmobranchs and eastern little tuna ***(futhynnus affinis),*** were the important components in the miscellaneous catch.

3.2 Effort

The estimated number of boats landing the catches every month is given in Table V. It is apparent that at Chandpur the principal contributors were the non-mechanized carrier boats, the largest numbers operating from June to August and the lowest during December-January. While the latter period coincided with lean daily landings of hilsa (Fig. I), such a relation could not be seen in respect of peak daily landings in May and in September. It was the mechanized carrier boats which appeared to have influenced the peak daily landings in September. The daily landings in May attained a peak in spite of the fewer non-mechanized carrier boats and the absence of any mechanized carrier boats.

At Khepupara, unfortunately, records were not maintained separately for the non-mechanized and mechanized boats at Mohipur centre. At Nayahata, the peak catch rate in September roughly coincides with the highest number of boats in August-September. It may however be remembered that in the Khepupara area, the catches of the fishing boats are largely taken over by the carrier boats; hence the shore landings do not truly reflect the catches.

At Chittagong, it is hard to explain why the boat landings were so low in June when the catch rates were high. This single phenomenon apart, there seems to be a correlation between the catch rates and the number of boats.

At Cox's Bazar, except for June-July when inclement weather and rough monsoon conditions hindered fishing activities, the number of boats fluctuated only between 450 and 700.

3.3 Catch rates

Catch per boat per fishing day has been taken as the catch rate in Chittagong, Cox's Bazar, Mohipur and Nayahata sampling stations. As it was not possible to collect information on the catch per boat per fishing day at Chandpur, the total amount of hilsa landed per day (almost exclusively by the non-mechanized carrier boats) was taken as an index of catch rate in the Meghna river (Fig. 1).

Catch rates of hilsa at Chittagong attained major peaks in June and October and one minor peak in February. Similarly catch rates at the other marine station (Cox's Bazar) attained two major peaks in April and October and a minor one in February. The minor peak value in February at Cox's Bazar was higher than the value at Chittagong. At both stations the catch rates showed low values in July and January. Thus the major difference between the two marine stations lay in the timing of the first peak-April in Cox's Bazar and June in Chittagong. This difference apart, the similarities in catch rates at both the stations could be because the fishing grounds covered by the crafts from both stations were more or less the same. The peak in April at Cox's Bazar was caused by the entry of a size group of 0-39 cm which subsequently dwindled. It is possible that these originated from the south (probably from Burmese waters), and that they returned south after a month or so.

In the estuarine region, the principal peak was observed in July at Mohipur, but in September at Nayahata. A second small peak also appeared in January-February in this area. It must be recalled that July and January were the leanest months at both the marine stations. While the contrasting of peak and lean months in the marine and estuarine environments in July and January may offer some evidence of hilsa migration from the sea to the estuaries during the respective periods, the secondary peak in September in Nayahata may have to be considered as a minor aberration in the records because there was not much difference in the catch rates

Annexure 1

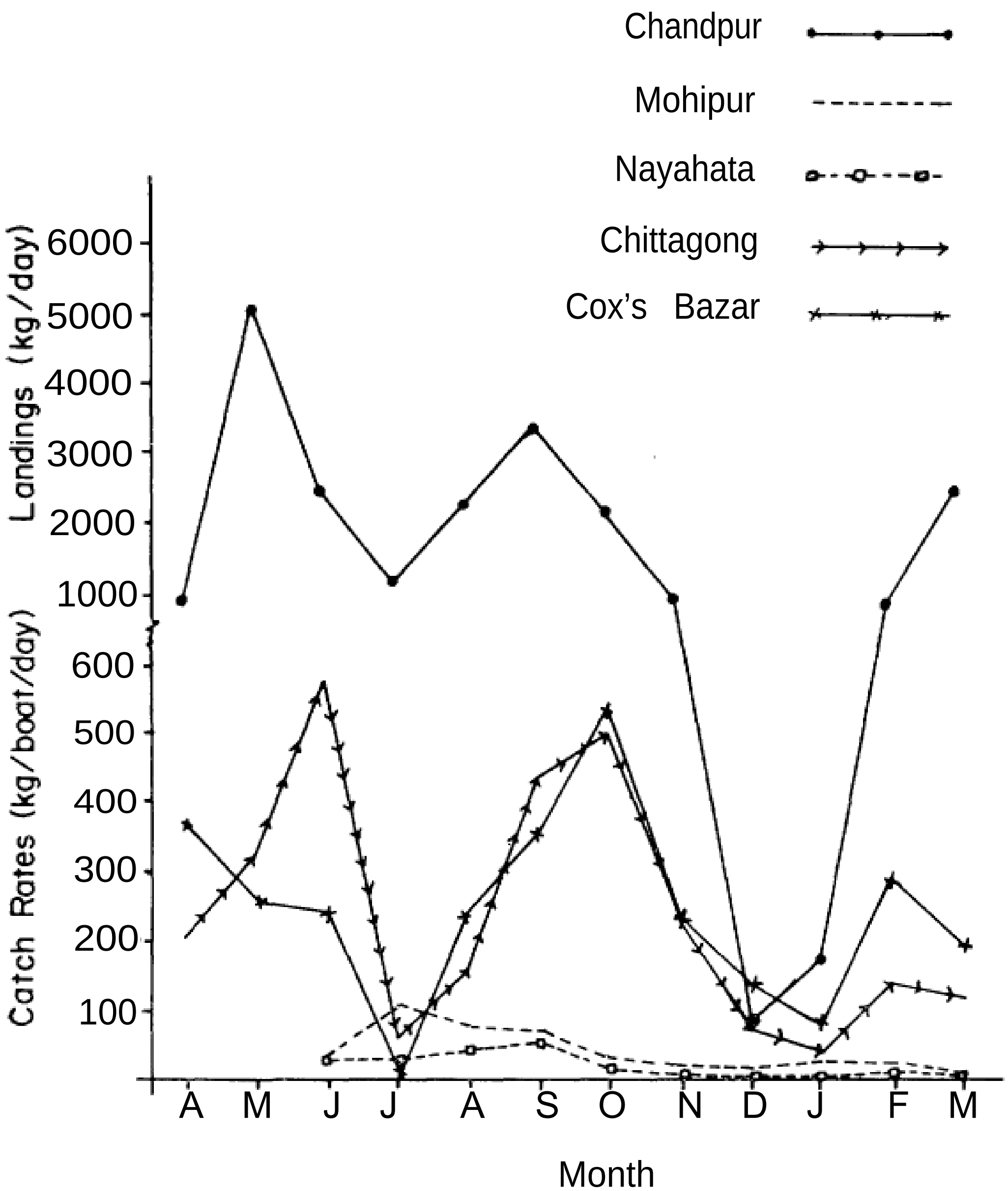

Fig. 1 Seasonal variation in the catch rates of *H/lsa ilisha* during 1985/86 at the different sampling stations. Note— Chandpur values show landings per day by non-mechanised carrier boats.

Annexure 1

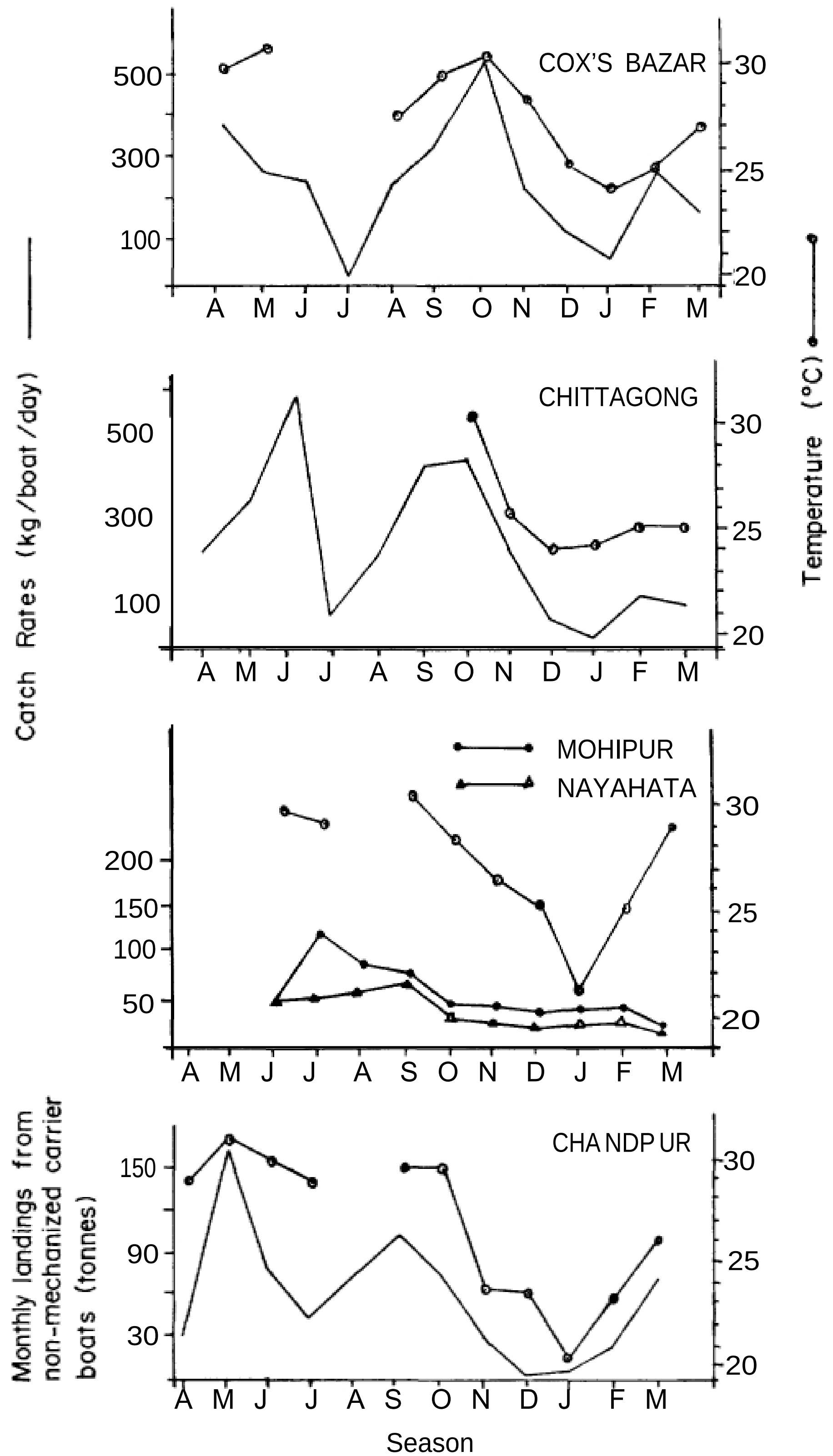

Fig. 2 Seasonal variations in surface temperature and catch rates ol *Hilsa ilisha* **at the four sampling stations.**

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Annexure 1

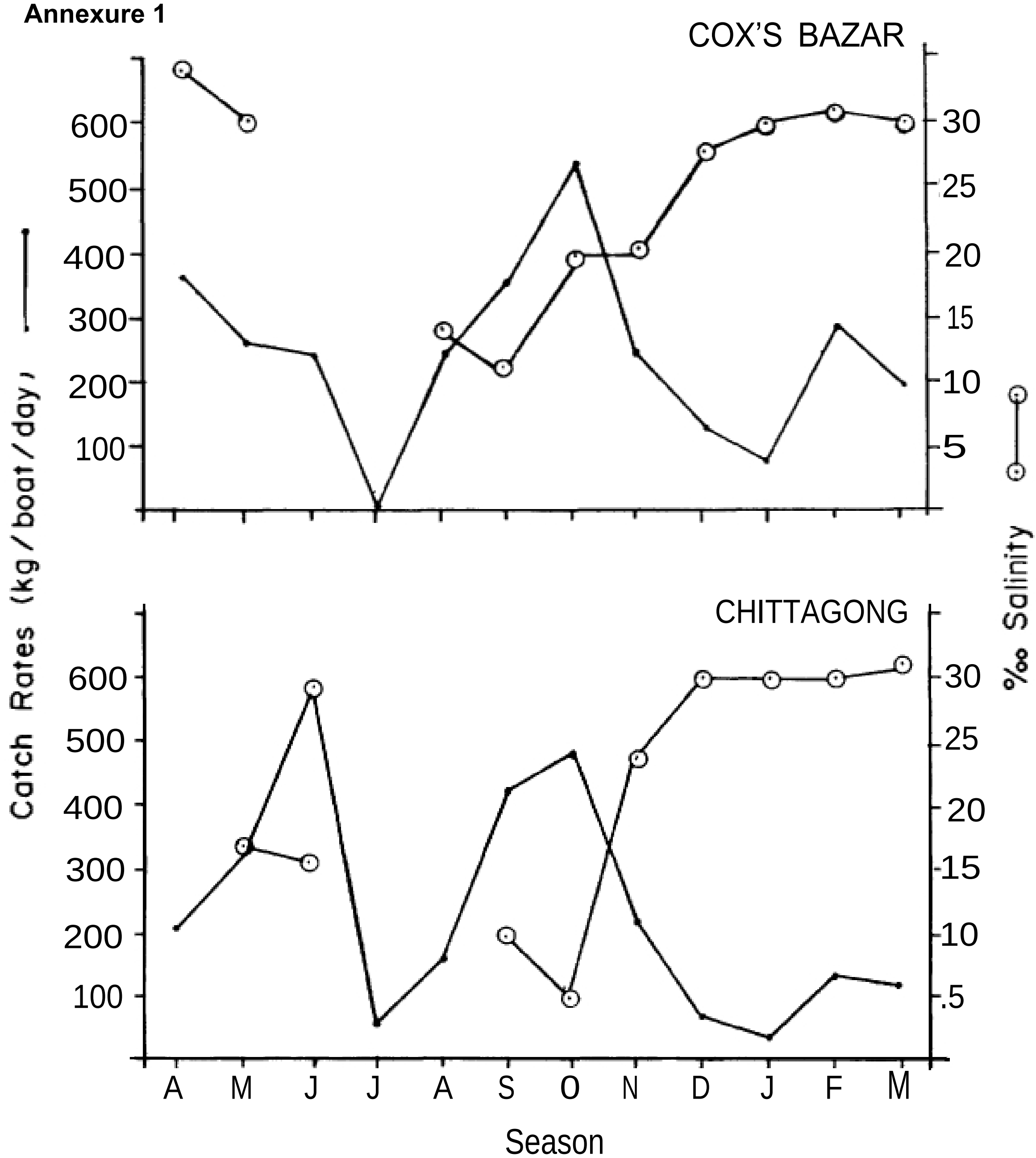

Fig. 3 Seasonal variations in the salinity and catth rate of *Hilsa ilisha* **at two sampling stations.**

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Annexure 1

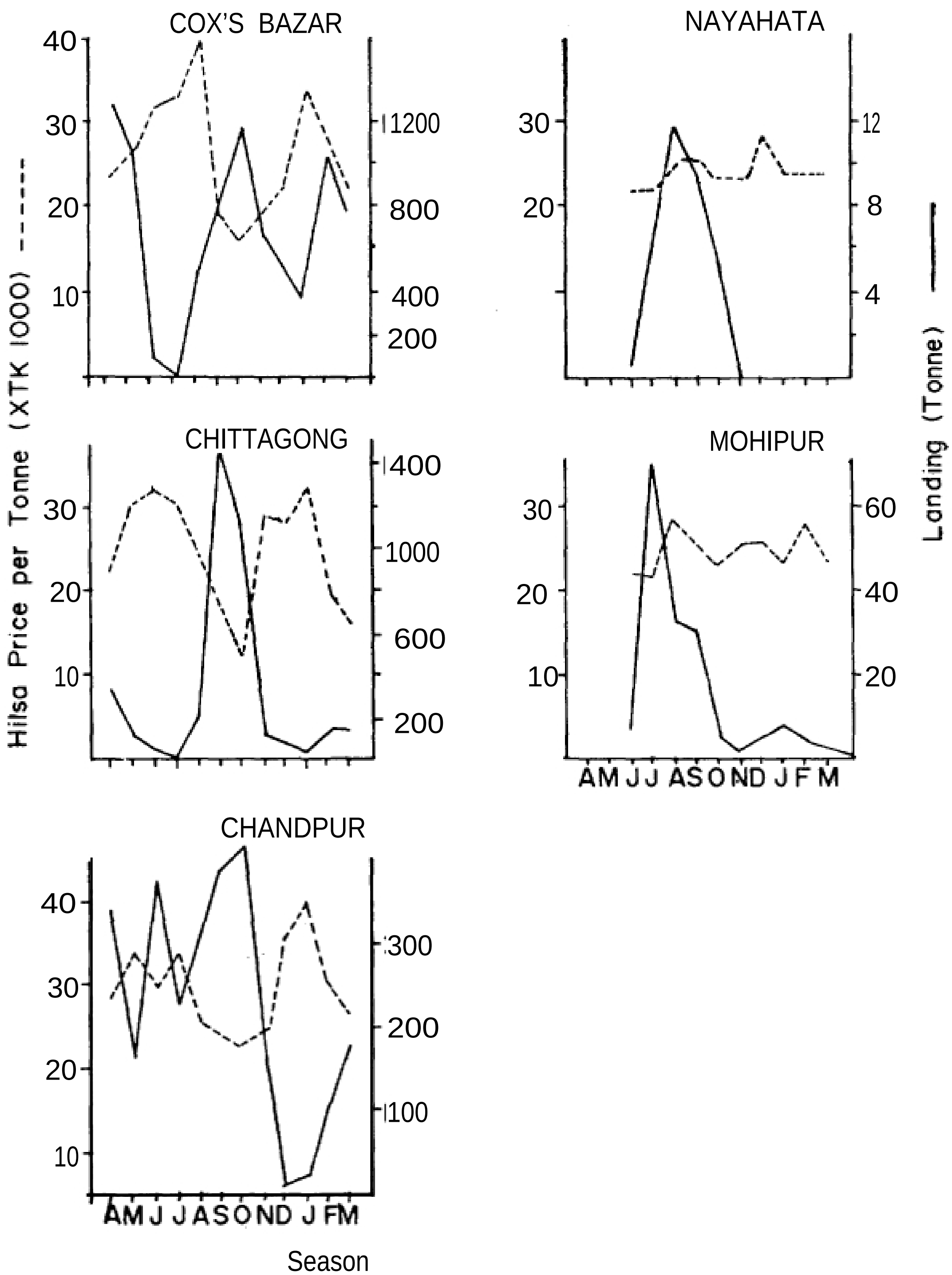

Fig. 4 Seasonal changes in the landings of *Hilsa ilisha* and the price per tonne at the sampling stations.

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between Nayahata and Mohipur in September. At Chandpur (the riverine station) the peaks occurred in May and September, the latter somewhat less dominant than the former; in addition there was an indication of a rising trend in February-March and this may perhaps end in a peak in May. The lean period here is December-January.

In the absence of comparable statistics, it is not possible to state unequivocally that the catch rates in the marine sector are higher than those of the riverine area. But looking broadly at all the data, it is difficult to reject this inference. Although the fishery in the selected sampling station for the estuarine environment was on a low key, it is indicative of the connection between the fisheries in the marine and riverine sectors. It may also be stated that part of the catches landed in Chandpur came from estuarine areas around Patuakhali, Bhola, Natiya and Sandwip.

3.4 Relationship with environmental factors

(i) *Surface water temperature* and catch *rates:* The seasonal variations in surface water temperature and catch rate (kg/boat/day) at different sampling stations are shown in Fig. 2. In Chandpur, there seems to be a direct relationship between temperature and the landings -the rise and fall in temperature coinciding with the rise and fall in the landings. At Cox's Bazar and Chittagong, the peak value of temperature in October coincides with the peak catch rate in that month but such a situation does not obtain for the other temperature peak in May.

(ii) *Salinity and catch rates:* Salinity and catch rate dates are plotted in Fig. 3. In Chittagong a significant inverse relationship ($r=-0.90$) was observed between salinity and catch rate. In October, salinity was low while the catch rate was high. During winter high salinity was recorded when the catches were low. However, Cox's Bazar data do not show such a trend.

No comparison could be attempted for the Khepupara area because the salinity records relate to the adjacent Charfession area. As the temperature and salinity appear to be dependent variables, it is not possible to state whether either or both environmental parameters influence the seasonal changes in the distribution of this species in Bangladesh waters.

3.5 Fish price

The wholesale price of hilsa at different sampling stations in relation to the respective total landings is shown in Fig. 4. The price ranged from Tk. 12,860 to Tk. 43,000 per tonne. The average price for the year was around Tk. 25,000 in the marine stations and Tk. 30,000 in the riverine station. It was noticed that prices of hilsa had declined during September-October when landings were at their highest while the prices tended to rise when the landings declined. The highest prices were generally in the June-August period and again in January. The only exception to this general inverse relationship is the situation obtained in Khepupara, where the prices did not fluctuate much, irrespective of the amount of landings. In fact when the catches were high the price also went up probably because of increased competition from buyers during the peak period-from both the carrier boats and those engaged in the dry fish trade. The prices also ruled high when the catches were low, because of local market demand.

4. DISCUSSION

One of the objectives of the present investigation was to estimate, at least for the marine sector, the total hilsa production, because there was no well designed sampling programme for estimating the catches; also because almost all the mechanized boats of the Chittagong — Cox's Bazar coastal belt were primarily directed towards gillnetting for hilsa.

Table VI lists the estimated monthly production of total catch and hilsa catch per boat at Chittagong and Cox's Bazar. The annual hilsa production per boat was estimated to be 43.4 t and 50.2 t respectively at the two centres. The Fisheries Resources Survey System Project of the Government of Bangladesh has carried out a census survey of mechanized boats engaged in the hilsa fishery. It was learnt from that project that for Cox's Bazar and Chittagong districts, the boats numbered 1,822 and 1,128 respectively, totalling 2,950 boats. If there are 2,950 boats engaged in hilsa fishing, then their hilsa returns totalled about 140,000 t, on the basis of an average catch of 47.1 t per boat. Shahidullah (1986) has indicated that there are 3,000 mechanized boats in the gillnet fishery and from the data collected by him at Chittagong, an estimate of hilsa production can be made. His latest figure for catch per boat per trip is 1.96 t, of which 76.2 per cent consist of hilsa — 1.5 t of hilsa. He has assumed three trips a month and 8 months of fishery. On this basis, the average annual catch per boat is 36 t (as against 47 t estimated during the present study). Projected for 3,000 boats, the total hilsa production is about 108,000 t, about 32,000 t less than the present estimate. This appears to be an underestimate, because even according to his data there is only one lean month in the fishery. On the other hand, McNeilly (1985) has estimated a production of 200,000 t assuming that each boat produces an average of 100 t per annum and the fleet consists of 2,000 boats. It is difficult to test the accuracy of his estimate.

Ali (1985) has mentioned that hilsa production in the riverine and estuarine sectors is 40.4 per cent of 207,786 t, i.e., about 90,000 t. With the present estimate of 140,000 t from the marine sector, the total hilsa production in Bangladesh appears to be in the vicinity of 230,000 t. Assuming that the total fish production from all sources is of the order of 780,000 t, consisting of 580,000 t from inland waters (Ali, 1985) and 200,000 t from the marine sector (Shahidullah, 1986), the contribution from the hilsa fishery is nearly 30 per cent of total fish production of the country.

The erstwhile Freshwater Fisheries Research Station at Chandpur (the present Riverine Fisheries Research Station of FRI) had been collecting the landings records at Cox's Bazar from the mechanized boats. Their records show (Raja, 1985) that during the five-year period ending 1982-83, the average catch was only about 1,000 t. The present estimate in this study is about 8,000 t. Even allowing for growth of the fleet, it is very obvious that the catches at Cox's Bazar have been grossly underestimated in the earlier years. Perhaps the underestimation may be due to the simple reason that, as per existing government orders, there is a landing cess of 6% of the value of landings to be paid by the boat owners to the Bangladesh Fisheries Development Corporation.

Even after allowing for underestimation and reconciling with the railway transhipment records at Chandpur, it will be seen that, as compared to past records (Dunn 1982, Melvin, 1984), the present level of landings is the second lowest for the last 14-l 5 years and is only about one half of the landings in 1982 and 1983. If this is the situation at the most important riverine landing stations, it would be extremely difficult to make any projections for other landing stations. Is it possible that catches are larger further down in Meghna river?

In the case of Chittagong, the railway transhipment records (Dunn, 1982, Melvin, 1984) have been showing a rapid increase since the beginning of the eighties, the last figure being about 13,000 t for 1983. On the other hand, the present estimate of 44,000 t represents a big departure from earlier records. Had the railway records been compiled (as it was in Chandpur), it would have been possible to have a little more light thrown on this subject. Unfortunately the data for the comparison could not be collected. Hence it can only be stated that (as with Chandpur), it is possible that the landings during the night time may have been missed. There is also yet another factor-two other landing centres at Chittagong were not covered during the present investigation. During peak seasons, the boats land their catches at the non-sampled centres also. No weightage was given to such landings in the present estimation.

A comparative picture of the peak catch rate seasons (both major and minor, in the order of importance) at different stations is indicated below:

Stations		*Months of peak catch rates*
Chandpur		May, September, March
Khepupara	(Mohipur)	July, January
	(Nayahata)	September, February
Chittagong		June, October, February
Cox's Bazar		April, October, February

A close look at the records of size groups and maturity stages indicates that the stock which contributed to the April peak in Cox's Bazar appears to be a stock that came from elsewhere. It most probably came from the south and returned south, since this peak could not be traced into the peak fishery anywhere further north. If this is the case, then there is room for suspicion that the hilsa caught off and south of Cox's Bazar is an intermingling of the components from the north of Cox's Bazar and also from the Burmese waters in the south.

The other possibility is a migration of a segment of population within and in between the riverine and estuarine environment — a situation not uncommon and already reported for Indian waters in the Hooghly river system (Pillay 1957 and 1958). One such migration may take place in the winter between January and March, the other in the summer between July and September. Probably this may be limited to the fish till they attain first maturity at about 30 cm ; after spawning, they move down to the sea, and re-enter the rivers next year for spawning. Thus, it is suggested that some future studies may focus on the possibilities of:

(i) a stock of Cox's Bazar consisting of races from south and north;

(ii) a segment of population which migrates within the inland waters till the first spawning;

(iii) an anadromous component, especially of age 1 and above, migrating between the sea and the river.

It may be very rightly questioned how and why such segmentation should be suspected. It is difficult to answer such a question without acceptable evidence. The attempt here is to pose the question to others who are involved in interpreting data for growth, maturity and spawning and in the analysis of biometric data.

Other biologists concentrating on the above aspects could not throw much light on the question posed except to state that fish less than 30 cm, i.e., till first spawning, seldom appear in the commercial fishery in any environment and that the migration between sea and river is evident only for the size groups 30 cm and above. These may partially answer the questions (ii) and (iii) raised above.

5. SUMMARY

Systematic random sampling of hilsa landings were carried out at four stations — Cox's Bazar and Chittagong (marine), Khepupara (estuarine) and Chandpur (riverine) -for a period of one year (1985-86) with collection of statistics on catches and effort for 12 days a month. The observed landings were raised to the total landings of the day, on the basis of the ratio between observed number of boats and the total number of boats landing that day. The average daily catch of 12 days was raised to the monthly catch.

The estimated landings were 4,550 t, 4,330 t and 8,012 t for Chandpur, Chittagong and Cox's Bazar respectively. At Khepupara the estimated catches were poor because most of the catches were taken away from the fishing ground by the carrier boats.

For the marine sector, it has been estimated that if there were 3,000 mechanized gillnetters engaged in hilsa fishing, then the total annual hilsa production from the marine sector would be 140,000 t. Add to this, the reported production of 90,000 t from riverine and estuarine sectors; however the total production of 230,000 t may be an over-estimate because the number of mechanized gillnetters actively operating in the marine sector may be less than those registered, and the estimated figures for riverine/estuarine areas are likely to comprise marine catch also, as brought by carrier boats.

The common peak landings were in April and September-October respectively in marine and riverine stations and also in June-August in estuarine and riverine stations. There were indications of a minor peak at Cox's Bazar and Khepupara in January-February. The leanest period is June-July in the marine sector, because of rough monsoon conditions, and during December-January in the riverine side, probably because no spawning run takes place at that time.

With regard to effort, the principal contributors at Chandpur were the non-mechanized carrier boats, the largest number of which landed in June-August, the lowest during December-January. However, the peak landings in September appear to have been contributed by the mechanized carrier boats.

In the Khepupara area the peak catch rates roughly coincided with the higher number of boats in August-September.

At Chittagong, except for one month, the catch rates and the number of boats appear to be directly related to each other. Such a situation is not observed in Cox's Bazar, where a fairly large number of boats varying between 450 and 700 operate all through the year, except in June-July, irrespective of catch rates.

Taking catch rates as the index of abundance, it is seen that the peak periods at the two marine stations are either in April or June and the next in October; a minor peak was seen in February at both the places. In the estuarine station the principal peak was observed in July in Mohipur and in September at Nayahata. A secondary small peak appeared in January-February. At Chandpur, the peaks occurred in May and September.

No firm relationship could be established between temperature or salinity and catch rates, though indications of a correlation were evident.

The wholesale prices of hilsa varied between Tk 12,860 and Tk 48,000 per tonne; the average price was around Tk 25,000 in the marine sector and Tk 30,000 in the riverine station. Usually the prices tended to dip low during peak seasons and shoot up during the lean period. The exception to this was in Khepupara where the fluctuation in prices was small irrespective of the seasons.

The results are discussed in the light of past records on the subject. On the basis of present data, certain suggestions have been posed on the question of identity of stocks and their movement.

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Table I

Characteristics of the fishing craft and duration of trips and fishing time at the sampling stations

(MB=Mechanized fishing boat; MCB-Mechanized carrier boat; NMC=Non-mechanized carrier boat; NMB=Non-mechanized fishing boat)

Parameter	Chandpur			Mohipur	Nayahata	Chitta-gong	Cox's Bazar
Types of fishing craft	MB	MCB	NMC	MB	NMB	MB	MB
Size of the boat (m)	6-9	10-13	3-5	12-13	11-14	13-15	13-15
Horse power	21-23	22-49	—	22-24	—	32-35	29-33
Crew size	4-12	4-12	3-5	8-9	5-10	10-11	12-13
Period of absence from port	1-11 days	1-7 days	—	9-18 hrs.	10-12 hrs.	3-11 days	2-7 days
Period of fishing	1-9 days	—	4-12 hrs.	5-14 hrs.	5-10 hrs.	2-9 days	2-5 days

Table II

Types of fishing gear used in the hilsa fishery at the sampling stations

Gear	Chandpur	Mohipur	Nayahata	Chittagong	Cox's Bazar
1. Types	1. Drift gillnet without pocket (Chandi) 2. Bottom set gillnet 3. Clap net 4. Drift gillnet with pocket (Gulti)	Drift gillnet	Drift gillnet Bottom set gillnet	Drift gillnet	Drift gillnet
2. Size of drift gillnet (m) (length x depth)	400 to 1300 x 6to 13	1100 to 1400 x 8to 11	900 to 1300x 6to 13	1500 to 1800x 18 to 21	1700 to 2000 x 19 to 22
3. Mesh size (cm)	7.5 to 12.0	7.4 to 12.0	8.0 to 12.0	8.5 to 12.0	8.5 to 12.0

Table III

Monthly hilsa landings and their percentage in the total fish landings at the sampling stations

Months	Chandpur		Mohipur			Nayahata			Chittagong			Cox's Bazar		
	Total landing	Hilsa landing	Total landing	Hilsa landing	Per cent Hilsa	Total landing	Hilsa landing	Per cent Hilsa	Total landing	Hilsa landing	Per cent Hilsa	Total landing	Hilsa landing	Per cent Hilsa
April		328.08	–	–	–	–	–	–	558.79	339.55	60.8	1507.26	1275.59	84.6
May		159.05	–	–	–	–	–	–	140.52	122.28	87.0	1201.92	1060.22	88.2
June		372.29	6.90	6.90	100.0	0.54	0.54	100.0	52.70	50.06	94.9	133.66	99.70	74.5
July		232.08	69.44	66.96	96.4	5.58	5.58	100.0	7.72	5.05	65.4	2.20	0.51	23.1
August		308.66	32.42	32.47	100.0	11.48	11.48	100.0	244.61	205.98	84.2	608.95	499.34	82.0
September		385.24	29.52	29.52	100.0	9.18	9.18	100.0	2084.41	2032.0	97.4	867.81	814.57	93.8
October		410.58	5.51	5.51	100.0	5.18	5.18	100.0	1218.09	1112.43	91.3	1168.04	1151.66	98.6
November		155.69	2.08	2.08	100.0	0.10	0.10	100.0	157.26	127.77	81.2	742.55	650.88	87.6
December		12.81	13.89	5.95	42.8	0.62	0.16	25.0	163.64	91.38	55.8	781.37	483.44	61.8
January		25.94	14.11	8.06	57.1	0.19	0.09	48.9	103.22	30.71	29.7	527.46	375.06	71.1
February		109.30	12.01	4.37	36.4	0.56	0.28	50.0	235.83	148.43	62.9	1289.65	1043.37	80.9
March		178.68	2.39	0.68	28.5	0.31	0.16	50.0	270.65	164.79	60.8	646.84	557.03	86.1
Total(t)		2678.40	188.27	162.50	86.3	33.74	32.75	97.0	5237.24	4430.43	84.6	9477.71	8012.37	84.5

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Table IV

Percentage of Hilsa spp. and miscellaneous varieties in the gillnet catches at the sampling stations

Species	Chandpur	Mohipur	Nayahata	Chittagong	Cox's Bazar
Hilsa ilisha	***90.0***	86.30	97.06	84.60	84.54
Hilsa toli	—	—	—	0.08	6.01
Miscellaneous	10.0	13.70	2.94	15.32	9.45

Table V

Estimated number of boats landing at the sampling centres

(NMB=Non-mechanized boats; MB=Mechanized boats)

Month	Chandpur				Mohipur	Nayahata	Chitta-gong	Cox's Bazar
	Carrier boat	Fishing boat	Carrier boat	Fishing boat	NMB	NMB	MB	MB
	Mechanized		*Non-mechanized*					
April 1985	15	3	622	4	—	—	227	692
May	—	—	720	4	—	—	73	710
June	10	—	1325	—	690	60	4 5	167
July	13	—	1227	—	2480	930	26	44
August	96	—	1003	—	2494	1276	314	457
September	180	—	778	—	2460	1020	967	522
October	126	—	576	—	1377	864	409	648
November	217	***10***	407	—	416	104	79	532
December	46	5	137	—	1984	155	133	695
January 1986	56	11	162	—	2015	93	92	478
February	105	5	537	—	1092	140	152	657
March	119	1	602	—	341	155	167	560
Average	89	6	675	4	1535	480	224	514

Table VI

Monthly and annual production of all species and hilsa species from a gillnet fishing craft at the two marine sampling stations

Months	Chittagong		Cox's Bazar	
	Total catch (t)	Hilsa catch (t)	Total catch (t)	Hilsa catch (t)
April 1985	7.4	4.5	7.4	6.4
May	5.6	4.9	4.9	4.3
June	5.6	5.3	5.6	4.2
July	1.1	0.7	0.8	0.1
August	2.8	2.3	5.7	4.6
September	6.9	6.7	6.4	6.0
October	8.6	7.8	7.7	7.0
November	5.0	4.16	4.8	4.2
December	2.7	1.5	3.9	2.9
January 1986	2.7	0.8	2.5	1.8
February	3.4	2.1	6.2	3.0
March	4.4	2.7	4.3	3.7
Total percentage of hilsa	56.2	43.4 (93)	60.2	50.2 (83)

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Appendix I

RECORDS OF CATCH AND EFFORT ON HILSA (FISHING BOATS)

Landing centre :
Biologist:

Date of observation :
Time : From. . . . . . . .To. . . . .

Total no. of fishing boats landed :
No. of boats observed :
Price per tonne :

Sl. No. Name of boat	Length of boat HP of engine	Name of gear	Details of gear			Time absent from port (days)	No. of fishing days/hrs.	No. of fishermen	Particulars about fishing ground	Total catch (kg)	*Hilsa* catch (kg)			Remarks
			Total length (m)	Depth (cm)	Mesh size (cm)						*ilisha*	*toli*	*kelee*	

Appendix II

RECORD OF CATCH AND EFFORT ON HILSA (CARRIER BOATS)

Landing centre :
Biologist:

Date of observation :
Time: From.. . . . . . . To.. . , . . .

Total no. of carrier boats landed :
No. of carrier boats observed :
Price per tonne :

Sl. No. and Name of carrier boat	Absence from port (Date & Time)		Details of the fishing boats from which collections were made								Area of Collection	Remark
						Weight of fish						
	From	To	No. of fishing boats	Name of gear & length depth & mesh size	Size of boat and HP of engine	ilisha	toli	kelee	Others	Total		

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Annexure 2

NOTES ON EXPERIMENTAL FISHING FOR HILSA SHAD IN 1985-86

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1. INTRODUCTION

One of the characteristic features of the commercial fishery for hilsa in Bangladesh is that it is predominantly carried out by drift gillnet, a selective gear, with a mesh size more commonly of 10.0 to 12.5 cm. In order to sample the popuiation to obtain growth/population parameters it is necessary to have a non-selective gear. But since hilsa has been found vulnerable to gillnets in all three environments, it was decided to fabricate a multi-panelled gillnet having a range of mesh sizes from 2.5 to 12.5 cm.

Four centres were selected for sampling — Cox's Bazar and Chittagong on the marine side, Khepupara for the estuarine sector and Chandpur for the riverine section.

2. MATERIAL AND METHODS

A local mechanized gillnetter of 13.7 m OAL fitted with a 33 hp Yanmar engine was employed for test fishing. The strength of the crew varied from 9 to 11 including the master fisherman.

The length of the multi-panelled sampling gillnet for marine and estuarine stations was 1250 m and each panel 50 m with a hanging ratio of 0.65 to 0.70. Each fleet of gillnet consisted of 5 panels of five different meshes, 2.5, 5.0, 7.5, 10.0 and 12.5 cm laced together and repeated five times. However, the depth of the net differed; it was deeper for the marine sector (15.0 m) and shallower for the estuarine station (10.5 m). The actual fishing depth was 11.5 m and 8.0 m respectively. For the riverine station the only difference was that the five different mesh panels were repeated only three times, thus making the total length of the net 750 m.

In view of the poor returns obtained from the sampling gear, and in order to obtain the required material for racial and biological studies, an experimental gear on the pattern of commercial gear, with 11 .O cm mesh size, was also operated since September 1985 from the marine stations. The length and depth of this net were 1000 m and 22 m, with a hanging ratio of 0.50. The broad specifications of both the sampling and experimental gear are given in Appendix 1.

After investigating the poor results from the sampling gear, the following modifications were made. For the marine sector, the panels of the smallest two mesh sizes i.e. 2.5 and 5.0 cm were removed from the remainder of the fleet of nets. In order to get the required length of gear, the two nets of Chittagong and Cox's Bazar were laced together. The length of each panel was reduced to 40 m to effect a little more slack. The total length of the gear having 7.5, 10.0 and 12.5 cm mesh size was thus 1,200 m with a hanging ratio reduced to 0.53. For estuarine and riverine sectors, the 2.5 cm mesh panels were detached, the depth of the gear reduced by 2 m and the sinkers rearranged so as to add a little more weight to the foot rope.

The days of sampling of each station were prefixed and were generally complied with except during emergencies. These days were fixed taking into consideration the requirements of sampl-ing the commercial catches for collection of catch, effort and biological data. The prefixed days were :

Station	***Calendar days***
Cox's Bazar	7, 8, 9
Chittagong	13, 14, 15
Khepupara (Charfession)	20, 21,22
Chandpur	24, 25, 26

After initial trials at Khepupara (where it was found that the area of fishing was too shallow for operation of the sampling gear), the experimental fishing activity for the estuarine sector was shifted to the Charfession area.

The *pro forma* used for collecting data are given in Appendix 2. The principal data to be collected was oriented towards catch rates, the environmental features such as surface temperature, salinity, weather and tidal conditions, the size distribution in different mesh sizes and biological parameters.

A log book was kept on board to record the principal data and any special observations and also to list difficulties encountered and requirements for follow up.

Soaking time in this account is expressed as

$$T_S = \frac{T_t + T_w}{2}$$

where T_8 = Soaking time

T_t = Total time from the start of shooting the gear till the time of completion of hauling

T_w = Time interval between end of shooting and commencement of hauling.

3. RESULTS AND DISCUSSION

The catch rates of hilsa (number of fish per set) for different stations during different months in the sampling gear and experimental gear are shown in Table I. It may be seen that generally the catch rate was very low in the sampling gear at all stations, during all months. During the first six months there was practically no catch except occasionally. The situation improved somewhat during the next 6-7 months, yet it cannot be considered completely satisfactory. The results were more disappointing in the riverine and estuarine regions.

The poor catch was due to a combination of many factors. Some of them could be:

- inexperience of the crew in the operation of such poly-meshed gillnets and their inability to adjust themselves to the operations for riverine and estuarine environments (they were successful with the commercial type of gear used as experimental gear in the sea);
- reluctance to operate the gear at night, especially in the inland and estuarine waters, for fear of dacoity;
- problems and difficulties of the biologists facing fishing conditions from country craft for the first time;
- absence of a leader with knowledge of fishing methods and gear technology;
- rolling up of large-mesh panels since the contiguous small-mesh panels roll up due to water resistance.
- shorter effective length of the gear with such mesh sizes as most commonly used in the commercial sector; in other words, the effective length of 100/125 mm mesh sizes in the sampling gear was only 100 m after every 250 m of other small mesh sizes as compared to about 1500-1200 m employed in the commercial fishery;
- limited duration of fishing days (unlike the commercial operations when boats stay out for longer periods) and irregularities in the number, duration and timing of sets employed.

The experimental gear, which was a miniature commercial gear, performed much better and almost achieved the results obtained in the commercial fishery, thereby confirming some of the factors listed above as responsible for the poor performance of the sampling gear. The catch rate was the best, varying between 55 and 180 fish, during September and October which is the peak commercial season.

Besides *Hilsa* spp., quite a variety of species was caught off Cox's Bazar, of which the principal components were silver pomfret, croakers, cat fish, hard tail scad and anchovies. In the estuarine and riverine stations the anchovies and the cat fishes were the important ones.

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Fig. 1 compares the catch rates obtained in the sampling and experimental gear with those recorded in the commercial sector at Cox's Bazar. Such a comparison could not be attempted for the other stations because of paucity or absence of data. The purpose was to see how far the results obtained in the experimental fishing were reflective of the trends seen in the commercial fishery. While the catch rate reckoned for the former two gears was catch in numbers per set, it was catch by weight per boat day for the commercial fishery. Although one is not strictly comparable with the other, in view of the limitations of experimental fishing data for the limited purpose in view, such a comparison can be partially justified. Broadly, it may be seen that there is a close correlation among the three sets of data. In all the sets of data, the peak is in October, reflecting the greater abundance of fish in the fishing grounds. After a decline between November and January, there is an indication of a rise during February-March, but the picture is not as distinct as in October.

Regarding environmental factors, a comparison of temperature and salinity records with catch records (Table II) indicates that there does not appear to be any correlation between the rise and fall in catches and rise and fall in temperature or salinity, except that one of the peak values of temperature in October coincides with peak catches, but the same was not true of the other peak in temperature in May, which may be due to emigration of fish to inland waters for spawning.

An attempt was made to find out whether increase in soaking time of the gear influenced the catches. The present data (Fig. 2) do not offer evidence of any relationship between the two. If the two highest values reiating to October and March were omitted as due to the general high density of the stocks in the fishing grounds, most of the values of catch rates are within 20 fish per set. A soaking time of four hours appears to be as good as that of 15 hours.

The tabulated records of catch rates of hilsa and other fishes obtained for day and night fishing at Cox's Bazar and Chittagong (Table III) indicate that generally the catch rates were higher during the night than during the day time both for hilsa and for other fishes. Perhaps the fishes are more vulnerable to the gear in the night because of poorer visibility. It would also partially explain the reason for the low catch rates of the sampling gear of the estuarine and riverine areas where no night fishing was undertaken.

A couple of instances of almost similar or higher catch rates during the day, off Chittagong, in September-October can be attributed to greater abundance of hilsa in the nearshore waters during that period.

Fig. 3 depicts the percentage frequency of length distribution of fish at Cox's Bazar for the three mesh sizes — 7.5, 10.0, and 12.5 cm. It may be seen that all sizes of hilsa ranging from 27 to 55 cm were caught in all the three types of panels. However, the 12.5 cm mesh size panels caught more of the larger sized fishes. The average sizes obtained in different months in the different mesh sizes at Cox's Bazar are listed in Table IV. It may be seen that the individual months do not give a clear picture of selectivity, but the overall picture for the data period shows that the mean sizes were larger with increasing mesh size. It appears that selectivity is not clearly projected in the size composition because fish are not only gilled but also entangled.

From length frequencies, selectivity curves were drawn for the data obtained from sampling gear at Cox's Bazar and from commercial gear at Chittagong and Khepupara, for different mesh sizes (Fig. 4). The optimum lengths obtained for different mesh sizes at these centres are indicated below:

Station	Mesh size (cm) 9.0	10.0	12.0	12.5
Cox's Bazar	—	29.7	—	37.2 (mixed with 11 .0 cm mesh of experimental gear)
Chittagong	34.7	39.0	—	—
Khepupara	—	—	42.7	44.5

Annexure 2

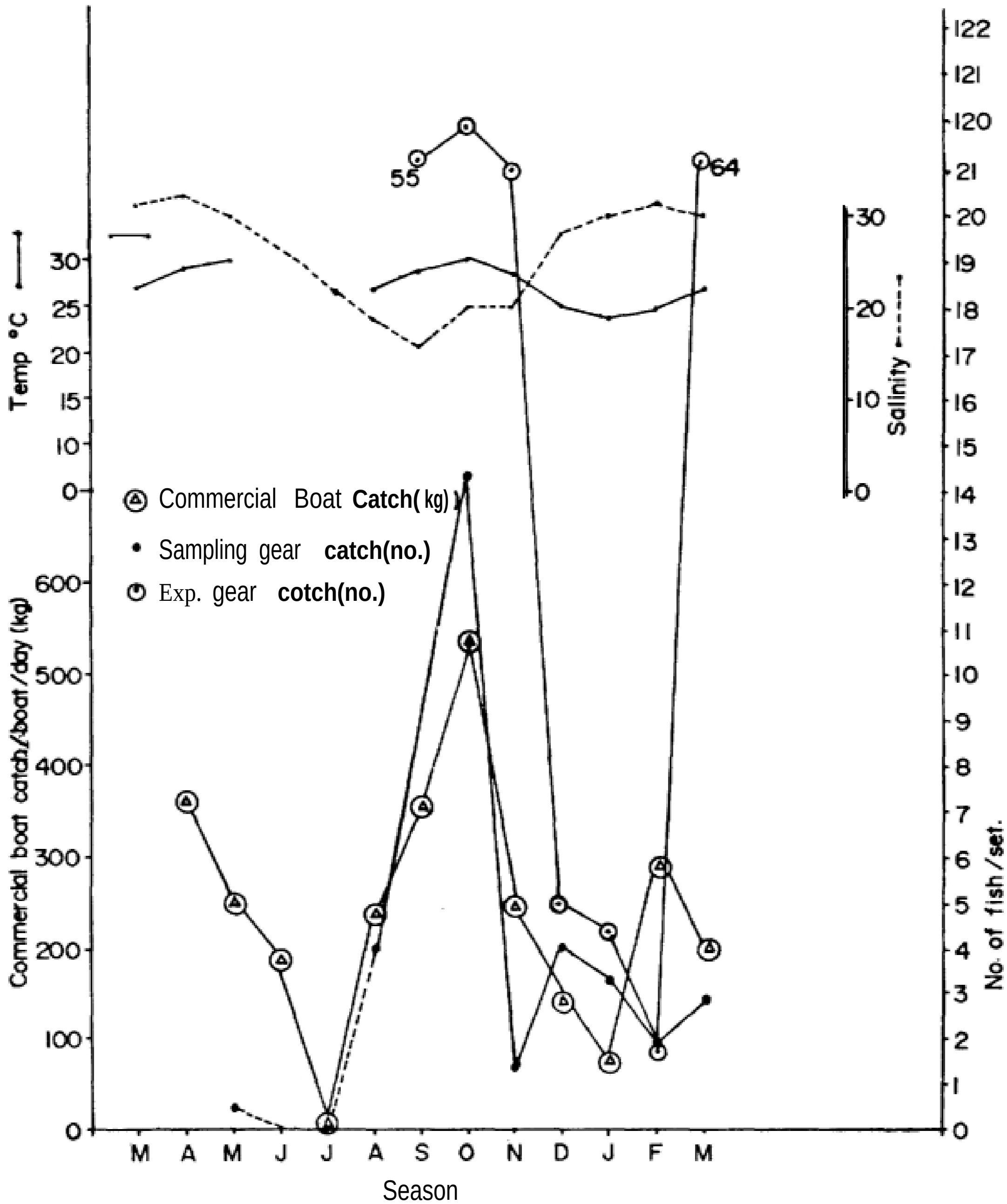

Fig. 1 Comparison of catch rates from commercial, experimental and sampling gear at Cox's Bazar.

Annexure 2

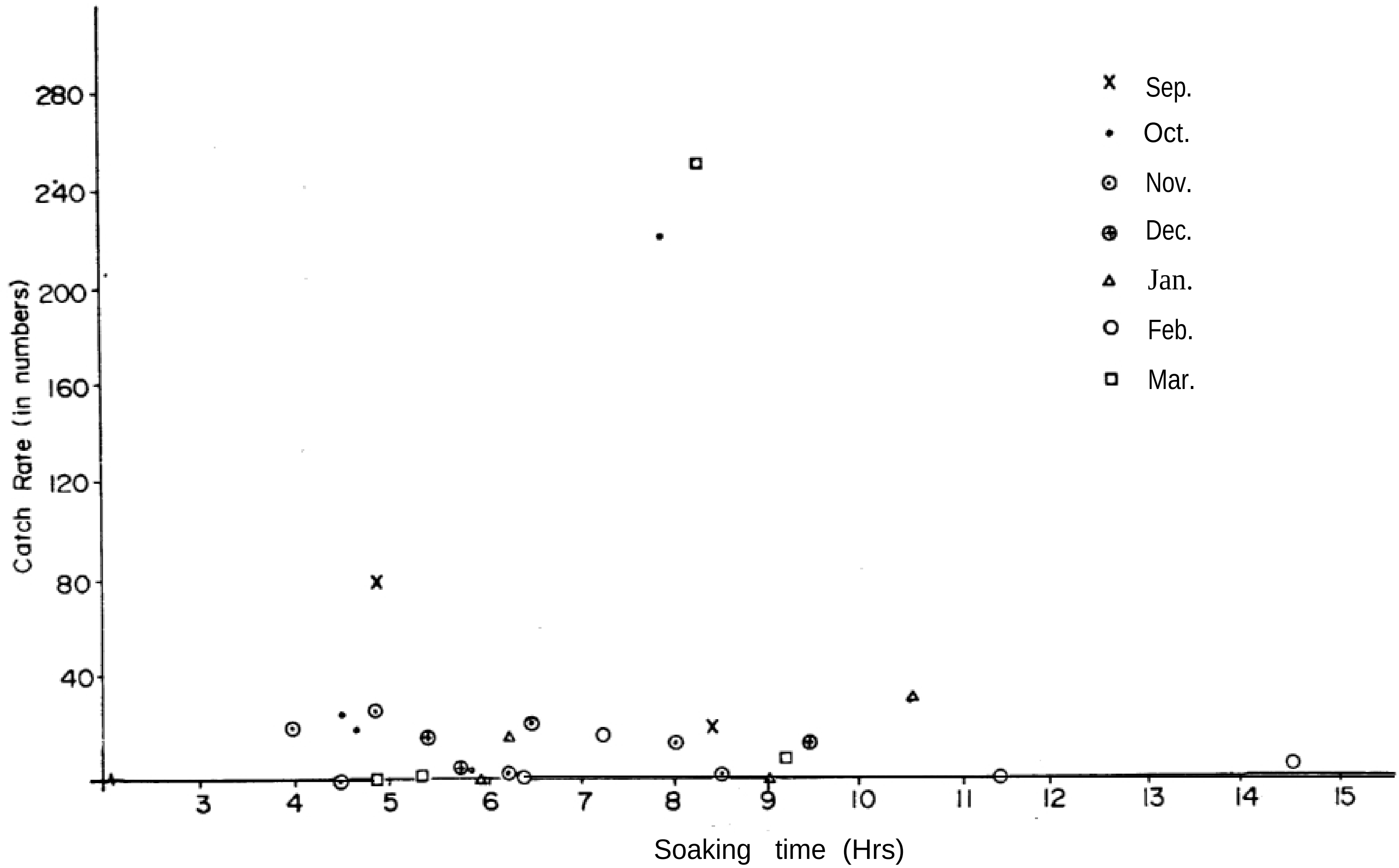

Fig. 2 Relationship between catch rate of *Hilsa ilisha* and soaking time of gilinets at Cox's Bazar.

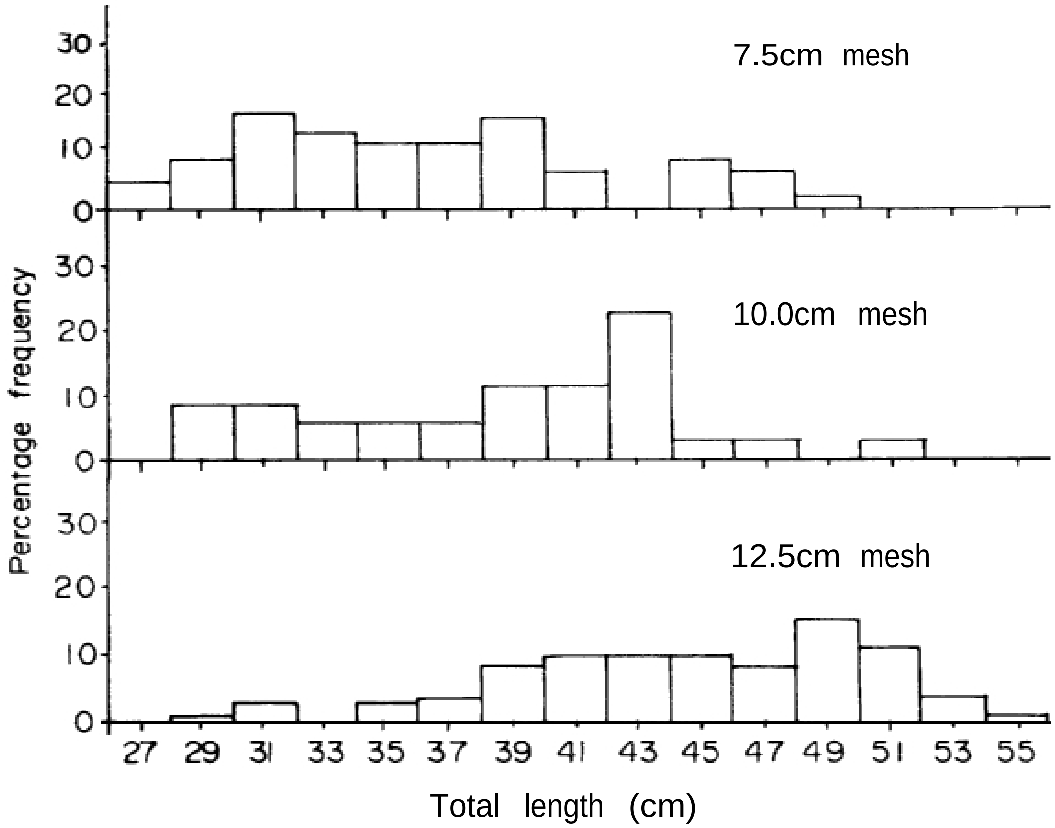

Fig. 3 Length frequency distribution of *Hilsa ilisha* in different mesh sizes in the sampling gear.

Annexure 2

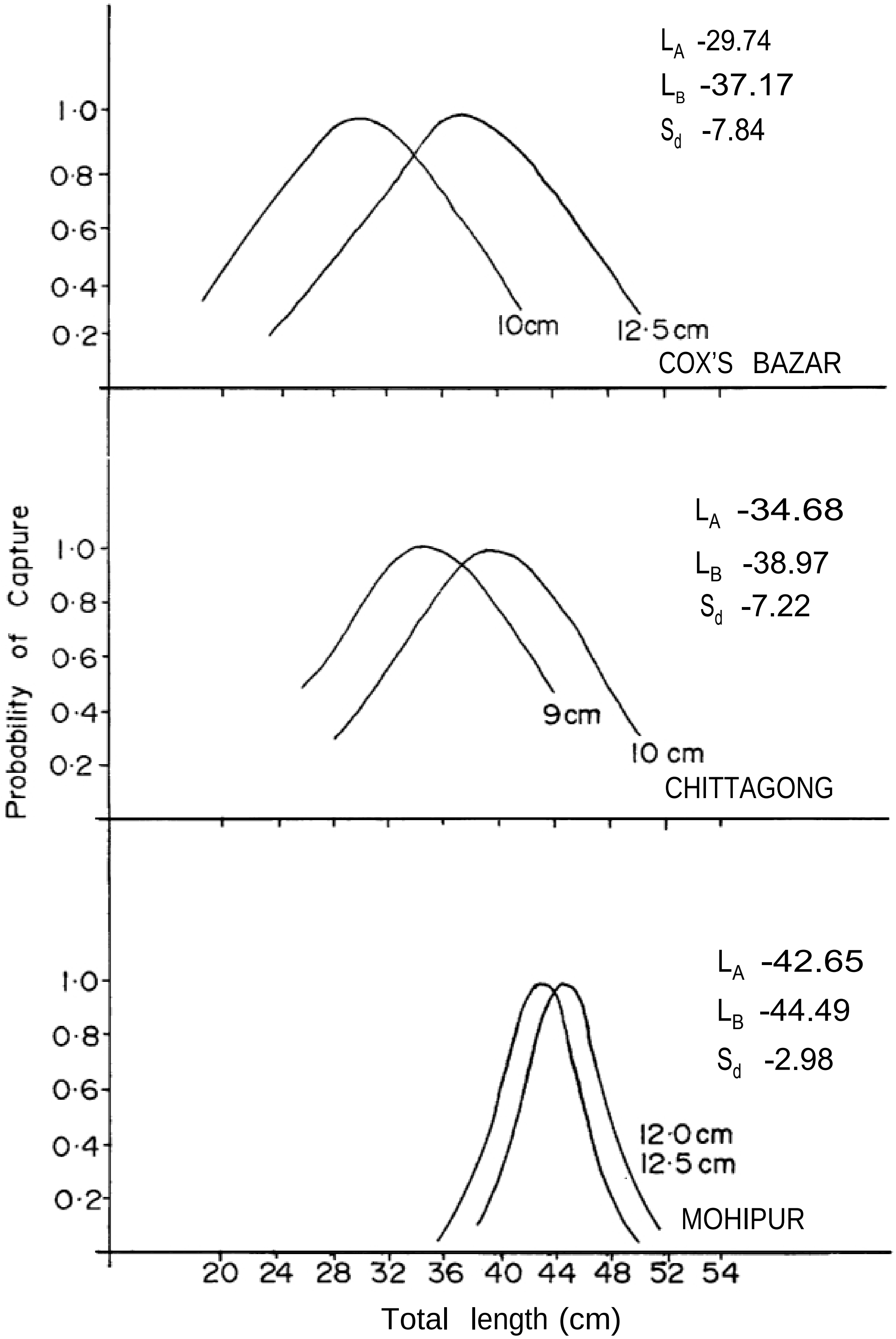

Fig 4. **Selectivity curves for *Hilsa ilisha* caught in different mesh sizes of gilinets, c!ose to Cox's Bazar, Chittagong and Mohipur.**

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As far as data relating to Cox's Bazar is concerned, the optimum length obtained from the selection curve is lower than the mean sizes of fish caught (Table IV) in the respective mesh sizes.

The optimum lengths obtained for the same mesh sizes for two adjacent stations, Cox's Bazar and Chittagong as well as two distant stations, Cox's Bazar and Khepupara, can be seen to differ markedly. This could be due to the fact that size composition of hilsa occurring in the respective areas may be different and also due to the fact that hilsa not only get gilled but also get entangled.

It may be also noticed that the values differ by nearly 2 cm for a difference of only 0.5 cm in the mesh size. It was seen that this was also due more to the presence of different size composition in the fishing ground rather than due to mesh selectivity.

Entanglement results in wide variations in the size composition of fish caught by any specific mesh size and significant overlapping of the size composition of two different mesh sizes. As a result, the standard deviation of the size distribution for any two mesh sizes compared is larger than the difference between the optimum lengths observed. Thus the significance of using different mesh sizes in the commercial hilsa fishery is not evident from the results obtained during this brief period of investigation.

Considering the fact that the 10.0/12.5 cm mesh sizes caught relatively more fish than the 7.5 cm mesh panels, and that extremely negligible quantities of fish were caught in the 2.5 and 5.0 cm mesh sizes, it would probably indicate that the smaller sizes of fish were not available in the normal fishing grounds.

In February 1986 at Chandpur, the sampling panel of 2.5 cm mesh caught as many as 1262 juveniles with an average individual weight of 4.3 gm; this would further confirm the above observation that had there been juveniles in the fishing grounds, the sampling gear would have caught them.

4. SUMMARY

The commercial fishery for hilsa is predominantly carried out by a selective gear, drift gillnet, more commonly with mesh sizes of 10.0 to 12.5 cm. In order to sample the population at large to obtain growth and population parameters at roughly the same point of time in the different environments, rivers, estuaries and sea, sampling experiments were carried out from a local mechanized gillnetter employing a newly fabricated mesh panelled gillnet having a range of mesh sizes from 2.5 to 12.5 cm. The length and breadth of the net differed for the three environments. Each month, each of the stations was sampled on certain pre-fixed dates which were the same throughout.

In addition to the sampling gear, an experimental gear which was a miniature version of the commercial gear was also employed.

The results from the sampling gear were disappointing, more so in the riverine and estuarine areas. The experimental gear performed better. The reasons for the poor performance of the experimental fishing are many, but the main ones are:

– the inexperience of the crew in operating such multi-meshed, multi-panelled gillnets;

– difficulties of the biologists in withstanding the conditions of a fishing voyage and performing in a country craft;

– absence of a person with knowledge of fishing methods and gear technology.

A comparison of results between the catch rates of sampling gear, experimental net and the commercial gear at Cox's Bazar showed some consistent trends, at least during periods of peak abundance in the fishing grounds.

There were indications of correlation between the catch rates and the variations in temperature or salinity but firm conclusions could not be drawn.

The catches at night were found to be better than those in the day time.

There was no relationship between the soaking time of the gear and the number of fish caught. A soaking time of four hours was as good or as bad as a soaking of 10-15 hours.

A comparison of the length distribution of hilsa at Cox's Bazar in the three mesh sizes 7.5, 10.0 and 12.5 cm showed that all sizes of hilsa ranging from 27 to 55 cm were caught in all the three mesh sizes of the panels. Gillnet selectivity was not clearly projected in the size composition, because hilsa not only get gilled but also entangled.

From length frequencies, selectivity curves were drawn. Different optimum lengths were obtained for identical mesh sizes for two adjacent stations as well as two distant stations. This may be due to differences in size composition of hilsa occurring in the respective areas and also due to the fact that hilsa are not only gilled but also get entangled.

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Table I

Hilsa Catch/Set (Number)

S — Sampling gear   E — Experimental gear   C-Combined both S & E

	COX'S BAZAR Mesh size (cm)						CHITTAGONG Mesh size (cm)							CHARFESSION Mesh size (cm)						CHANDPUR Mesh size (cm)					
	Net Type	2.5	5.0	7.5	10.0	11.0/12.5	Net Type	2.5	5.0	7.5	10.0	11.0/12.5	Total Catch	Net Type	2.5	5.0	7.5	10.5	12.5	Net Type	2.5	5.0	7.5	10.0	12.5
March	S	0	0	0	0	0	S	0	0	0	0	0			Not done						Not done				
April	S	0	0	0	0	0	S	0	0	0	0	2		S	0	0	0	0	0	s	0.8	0.3	0	0	0.8
May	S	0	0	0	0	0.5	s	0	0.4	6.6	5.4	1.4		S	0	0	0.3	0	0	s	0	0	0	0	0.2
June		Not operated					s	0	0	0	0	0		S	0	0	0	0	2.0	s	0	0	0.2	0	0
July		Not operated						Not operated						S	0.3	0	0	0	0.7	s	0.5	0	0	0	0.5
Aug.	S	0	0	0	0	4		Not operated							Not operated						Not operated				
Sept.	S	Not operated					S	0	0	0	0	5		S	0	0	0	0	0	s	0	0	0	1.0	0.7
	E					55	E					180													
Oct.	S	0	1.5	1.5	1.5	10	C						150.1	S	0	0	0.2	0.2	2.0	s	0	0	0.3	0.3	0.3
	E					119																			
Nov.	S	0	0	0	1.3	0	C						8.9	S	0	0	0	0	0.2	s	0	0	0.2	0	0
	E					21																			
Dec.	S	0	0	1.3	1.7	0.9	S	0	0	5	1	0.1		S	0	0	0	0.4	0	s	0	0	0	0	0
	E					5.0	E					0.5													
Jan.	S	0	0	1.0	1.5	0.8	C						4.0	s	0	0	0	0.4	0	s	0	0	0.4	0	0
	E					4.4																			
Feb.	S	0	0	0.8	1.0	0.1	S	0	0	0	2	8.6		S	0.1	0	0	0.2	1.1	s	2.6	0.8	0.5	0	0.2
	E					0.2	E	0	0	0	0	34.4													
March	S	0	0	0	1.0	1.8	C						5.0	s	0.3	0	0	0	0	s	0	0.8	1.4	0.7	0.4
	E					64																			

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Table II

Comparison of catch rates with temperature and salinity at Cox's Bazar

Month	Catch Set (No) Sampling Gear	Catch Set (No) Experimental Gear	Commercial Catch,/Boat Day (kg)	Salinity °/00	Temperature (°C)
March 1985	00	00	—	31	27
April	00	00	368	34	29
May	0.5	00	256	30	30
June	—	—	243	—	—
July	—	—	8	—	—
August	4	**00**	243	14	27
September	—	155	357	11	29
October	14.5	119	542	20	30
November	1.3	21	248	20	28
December	3.93	5	142	28	25.27
January 1986	3.3	44	81	30	24
February	1.8	1.8	293	31	25
March	2.8	64	199	30	27

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Table III

Comparison of catch rates by day and night

(Wherever there are two rows of figures, the top row relates to sampling gear and the bottom row to the experimental gear)

	Hilsa Average No./Set (kg)				Other Fish No./Set (kg)			
	Cox's Bazar		Chittagong		Cox's Bazar		Chittagong	
	Day	Night	Day	Night	Day	Night	Day	Night
March	**00**	**00**	—	—	7.5	8.0	—	—
April	**00**	**00**	—	—	20	13	—	—
May	**00**	**1**	26	11	20	25	5	25
June	—	—	2	—	—	—	6.5	—
July	—	—	—	—	—	—	—	—
August	—	4	—	—	—	4	—	—
September	80	21	6 / 207	4 / 128	10	87	8 / 145	4 / 130
October	—	15.5 / 119	150	156	—	95	153	161
November	— / 21	2 / 21	—	9	6.5	37	—	10
December	—	13	**0**	8	—	—	00	8
January	19	11	**0**	4	45	89	—	40
February	4	6		45	19	45	—	85
March	1	87	**0**	6	1	31	2	34

Table IV

Mean length of hilsa in the sampling gear during different months at Cox's Bazar

Mesh size:	7.5 cm	10.0 cm	12.5 cm
August	—	—	35.5
September	—	—	—
October	36.3	39.7	40.6
November	—	—	—
December	37.1	42.0	40.0
January	33.6	36.0	41.7
February	34.4	32.7	40.0
March	—	43.9	44.2
Average	35.9	38.8	43.0

<<

Appendix I ,

BROAD SPECIFICATIONS OF SAMPLING AND EXPERIMENTAL GEAR

Sampling gear	*Marine*	*EstuarinelRiverine*
Material	**PA Multifilament Nylon**	**PA Multifilament Nylon**
Colour	**Natural white**	**Natural white**
Twine size denier	**210d3 (210d6 for 100 & 125 mm mesh)**	**210d3 (210d6 for 100 & 125 mm mesh)**
Stretched mesh size (mm)	**25/50/75/1 00/1 25**	**25/50/75/1 00/1 25**
Length (meshes)	**3000/1 500/1 000/750/600**	**3000/1 500/1 000/750/600**
Depth (meshes)	**600/300/200/150/120**	**420/210/1 40/1 05/85**
Experimental gear		
Material	**Multifilament 0, 15 x 6**	
Colour	**Blue**	
Mesh size (mm)	**110**	
Total length (m)	**1000**	
Total depth (m)	**22**	

Appendix II

EXPERIMENTAL FISHING RECORDS

Biologist:
Duration of
fishing trip
(Date and hour)
From:.
To:
Duration of fishing
(in hours)

Station:
1st day
2nd day
3rd day

Environmental data for each
fishing operation:

Set No.	Time of setting		Time of hauling		Approximate location		Setting	Hauling
	Start	End	Start	End				
1.						Surface temperature:		
2.						Surface salinity:		
3.						Socchi disc reading:		
						Weather:		

Total weight (kg) and No. of fish

Set No.		$S_{1.1}$	$S_{1.2}$	$S_{1.3}$	$S_{2.1}$	$S_{2.2}$	$S_{2.3}$	$S_{3.1}$	$S_{3.2}$	$S_{3.3}$
H. ilisha	Wt.									
	No.									
H. toli	Wt.									
	No.									
H. kelee	Wt.									
	No.									
Other species (specify)	Wt.									

Note(1) $S_{1.1}$ —first, $S_{1.2}$ — second, $S_{1.3}$ — third } of 1st day; $S_{2.1}$ -first, $S_{2.2}$ —second, $S_{2.3}$ —thirdset } of 2nd day; $S_{3.1}$ -first, $S_{3.2}$ —second, $S_{3.3}$ —thirdset } of 3rd day

Note (2) 1st set 0000—0400 hrs. Tidal situation:
2nd set 0800—1 200 hrs. Tidal situation:

Annexure 3

SOME OBSERVATIONS ON SIZE GROUPS IN THE FISHERY AND MIGRATION OF HILSA IN BANGLADESH WATERS DURING 1985-86

by S.A. Azad, J. Hertel-Wulff, M. Hossain, MS. Islam, Q.M. Huq and N.N. Das*

1. INTRODUCTION

Although one of the aspects which received the attention of many workers on Hilsa shad *(Hilsa ilisha)* was the length composition in the fishery, practically all the efforts were directed on the fish that frequented Indian inland waters (Refer Raja, 1985 for compilation of information). There is little information on the length frequency distribution of hilsa in the Bangladesh environment. Also, length frequency distribution of the hilsa population in the marine environment has received no attention so far. In view of the anadromous behaviour of the fish, a programme to collect length frequency data from all the three environments is necessary in order to:

(i) identify the seasonal changes, modal progression and the occurrence of various size groups in the three environments,

(ii) estimate growth and population parameters,

(iii) detect migratory trends that may become evident from length frequency distribution and

(iv) determine the selectivity of the commercial nets that are being used for hilsa fishing.

2. MATERIAL AND METHODS

To include all the three major habitats — i.e. river, estuary and sea — Cox's Bazar and Chittagong (marine), Khepupara (estuarine) and Chandpur (riverine) were selected as suitable sampling stations for collecting data. Each place was taken as a functional unit and the one biologist assigned to each station was given the responsibility of collecting data. The four biologists were each assisted by a field assistant. The sampling was conducted during a one-year period, from March 1985 to April 1986.

Random samples of fish were taken on three consecutive days per fortnight at each station, two of these days being the sampling days for catch and effort data collection. The length frequency sample size was 50 fish per observation day from each station, but sometimes non-availability of hilsa or poor catches due to unfavourable weather conditions, festivals, etc. resulted in the measurement of less than 50 fish per day. The total weight of all the 50 fish measured was taken with the help of a spring balance. Since it has been repeatedly mentioned in the literature that there are slender and broad bodied hilsa in the fishery, a two-way table was devised to simultaneously record the length and the corresponding depth of the fish, in the field itself (Appendix 1).

In the case of Chittagong and Khepupara, samples for length frequency distribution were taken directly from hilsa fishing boats, but in Cox's Bazar and Chandpur the samples were taken from the landing centre. Further it was observed by the biologist in Cox's Bazar that smaller sizes of hilsa were being segregated away for inclusion among the other fishes and only the remainder were brought by the small conveyor boats to the landing place. However, it was later found that non-inclusion of these small-sized hilsa, which were very few in number, did not materially affect the distribution pattern of the size groups. At Chandpur, the mechanized carrier boats brought fish from marine and estuarine areas while the non-mechanized boats landed fish that were caught from the river, especially the Meghna. The length frequency samples in Chandpur were taken from the latter type of craft.

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In all cases the total length was measured with a measuring board. Length frequency by sex was not possible when the fish was commercially landed because of the cost of purchasing large numbers of fish for cutting and determining the sex.

3. OBSERVATIONS

3.1 **Mesh-size ranges**

Normally in the riverine and estuarine areas, fishermen use larger mesh nets during the pre-monsoon and monsoon period and small mesh gillnets in winter. In the marine sector, large mesh nets are used also during the winter months. In Chandpur and Khepupara, 10.5 to 12.8 cm mesh sizes are used from July to November, but during winter, gillnets of different mesh sizes, ranging from 6 to 12 cm, are employed. In Cox's Bazar and Chittagong 10.0 to 12.0 cm mesh sizes are more commonly used throughout the year (Figures 1a and 1 b).

3.2 Size ranges

The annual picture of length frequency distributions of hilsa caught during March 1985 to April 1986 from the four selected sampling places is shown in Fig. 2. The size ranges entering the commercial fishery in the three environments were almost the same, from 25 to 55 cm mid-length. However, more than 90% of the catch falls within the range of 30 cm to 50 cm. In Khepupara 23 cm fish have been recorded, but seldom fish above the 50 cm length group. In the other areas i.e. in riverine and marine, length groups of 52-54 cm and 54-56 cm were recorded, but no length group below the 27 cm group was observed in the commercial fishery.

Length frequency distribution showed modal lengths around 41 and 47 cm in the riverine station, around 37 cm in the estuarine station and 39 cm in the marine stations. It appears that practically all the size groups occur in all environments but not necessarily at the same time.

The juveniles landed by the set bagnet fishery in Khepupara, observed during December 1985 to March 1986 (Figs. 3 and 6), were 4.2 cm to 15.1 cm, from December 1985 to April 1986.

Earlier one of the authors had collected juveniles ranging from 2.1 cm to 9.3 cm during December 1983 to August 1984 at Chandpur. (Hossain, unpublished thesis, 1985). It was reported by the biologist based at Cox's Bazar that in the channel Moheskhali (close to Cox's Bazar) several hilsa of about 10-11 cm were observed in the set bagnets during February. Small-sized groups (20-30 cm) were not significantly reported during this investigation in the catches of any of the environments. The only occasion when they were found to form some significant portion of the catch, was in Khepupara in January.

3.3 Seasonal changes in size distribution

Length frequency distributions in Figures 4A, 4B. 4C, 4D, representing the picture at Chandpur, Khepupara (Mohipur), Chittagong and Cox's Bazar respectively, show modal sizes. Modal progressions were not very clearly established and this may be due to the use of gillnets with different mesh sizes in the fishery. A negative progression is seen in the monthly length frequency distributions of all the stations, due to emigration and fishing mortality of larger fish and immigration of smaller sizes into the fishery. This probably indicates a continuous movement of hilsa into and out of each area. Negative modal progression is more clear in riverine and estuarine areas than in the marine sector. The entry of a smaller-sized group indicates the appearance of another year's class/brood of hilsa.

Monthly mean sizes of hilsa in the fishery of the four stations are shown in Fig. 5. Chandpur has a wide range of mean lengths, ranging from 35 to 45 cm, the highest in July and the lowest in December. An almost similar picture is obtained at Khepupara where the range of mean sizes was 33 to 44 cm with the highest in July and the lowest in January. On the other hand, ranges of mean length in marine sector were not so wide, 39 to 44 cm. It is also significant to note that the estuarine fish were most of the time smaller in size than the marine and smaller than the riverine fish except in December.

This situation which is rather intriguing is also reflected in the annual picture (Figure 2). It is not clear why the mean lengths of fish at the estuarine station should be smaller than those at the marine stations. If the estuarine station is in the migratory route between **the** sea and the Meghna river, whether upstream or downstream, the mean size should be higher than that of the fish from the marine side.

However, it can be concluded that the general mean length of hilsa in Bangladesh is 40.5 to 45.5 cm from April to August, 38.3 to 42.5 cm during September to November and 33.3 to 43.1 cm from December to March. If we connect the last mentioned group in December to March with the one from April to August, then the group found between September and November belongs to a fresh batch of recruits. As is seen in the study reported by Islam et al. (1986), a major spawning occurs in October and subsidiary spawnings in March/June. If the December-March group is considered as recruits from previous October, they are 1½ years old, attaining about 46 cm by the end of the second year. The recruits of the subsidiary spawning manifest themselves in September-November when they can be back-calculated to an age of 1½ years. Thus it can be stated provisionallythat the limited evidence of a one year period appears to indicate that the fish grow to a length of about 30 cm in one year, 40 cm in 1½years and 46 cm in 2 years. Observations contained in the paper by Van der Knaap *et* al (1986) appear to lend support to these presumptions.

3.4 Migration

For convenience of discussion, the observed size group of the fishery may be classified into four major groups viz. small size less than 30 cm, medium size 30 cm to 39 cm, large size 40 cm to 49 cm and extra large size, above 50 cm. In order to study the movement of these groups through the passage of time, the values of catch rates (catch/boat/day) for each of these groups for each month are shown in Fig. 7.

In the riverine area the large size group of fish are abundant roughly between May and October. After October this group declined to a minimum by December. The catch rates for Chandpur area revealed two peaks, one in May and another in August, but the Gonado-Somatic index (GSI) value was found to peak in October (Islam et al., 1986). The medium-sized group was available all through the year. From November to March, medium-sized groups showed dominance over the large-sized group. Fishermen during this time also fished with smaller-meshed nets, because of the predominance of smaller sized hilsa. The catch rate and GSI value were found to be higher during March. The catch rate of this medium sized fish in winter indicates a lesser degree of migration into the river. This migration is also supposed to be for breeding.

In Khepupara, it was observed that fishermen fish for hilsa only 10 months in a year, from June to the beginning of April. The abundance of high-priced varieties such as prawn and other species in the canal and river as well as in the nearby estuarine belt, also diverts the fishermen's interest away from the hilsa fishery during this two-month period. All fishermen during this period were engaged in catching prawns with set bagnets.

In Khepupara estuaries, the large-sized group outnumbered the medium-sized fish only between June and August. In all the other months, it is the medium-sized fish which were dominant.

The large-sized group at a slightly advanced stage of maturity was also found in the estuary in July. The medium-sized group also showed greater abundance from September to March with peaks in September and January. The mean GSI value also showed a rising trend in January, February and March. (Islam *et* al., 1986). This medium-sized group may also be moving into the estuaries for spawning in 'winter'.

In the marine sector, Cox's Bazar showed that the large-sized group was always slightly more conspicuous than the medium-sized fish between August and March. The large-sized fish were distinctly more abundant from April to June. In Chittagong also the picture was roughly the same, with the catch rate of medium and large-sized group being similar from July to March; from April to June, as in Cox's Bazar, the larger-sized group clearly dominated. The medium-size group had a minor peak in winter with a corresponding minor peak for catch in the same month. So large-sized fish was greater during the pre-monsoon and monsoon periods both in

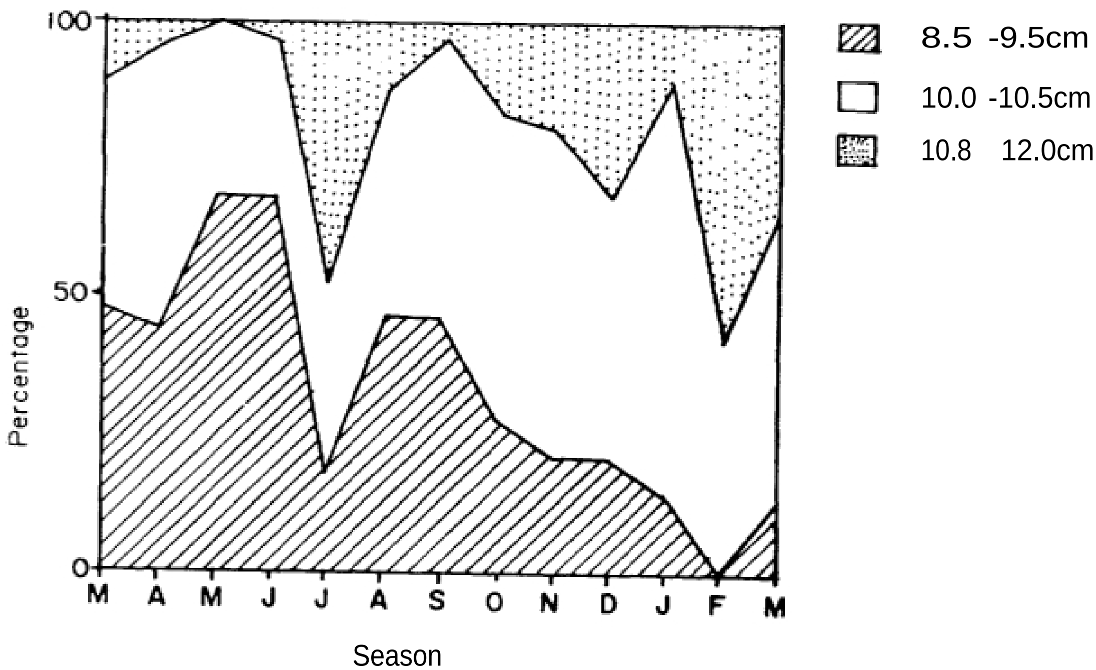

Fig. la Seasonal changes in the proportions (%) of different mesh sized giliflets in the hilsa fishery at Cox's Bazar, 1985/1986.

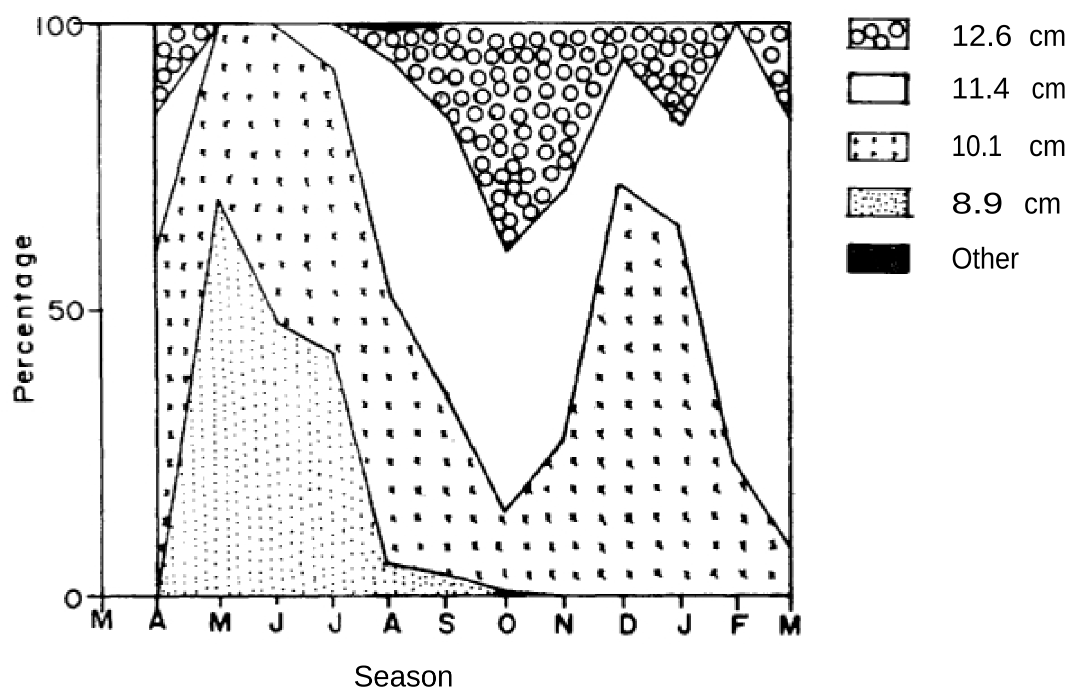

Fig. 1b Seasonal changes in the proportions (%) of different sized glilnets operated in the hilsa fishery at Chittagong, 1985/86.

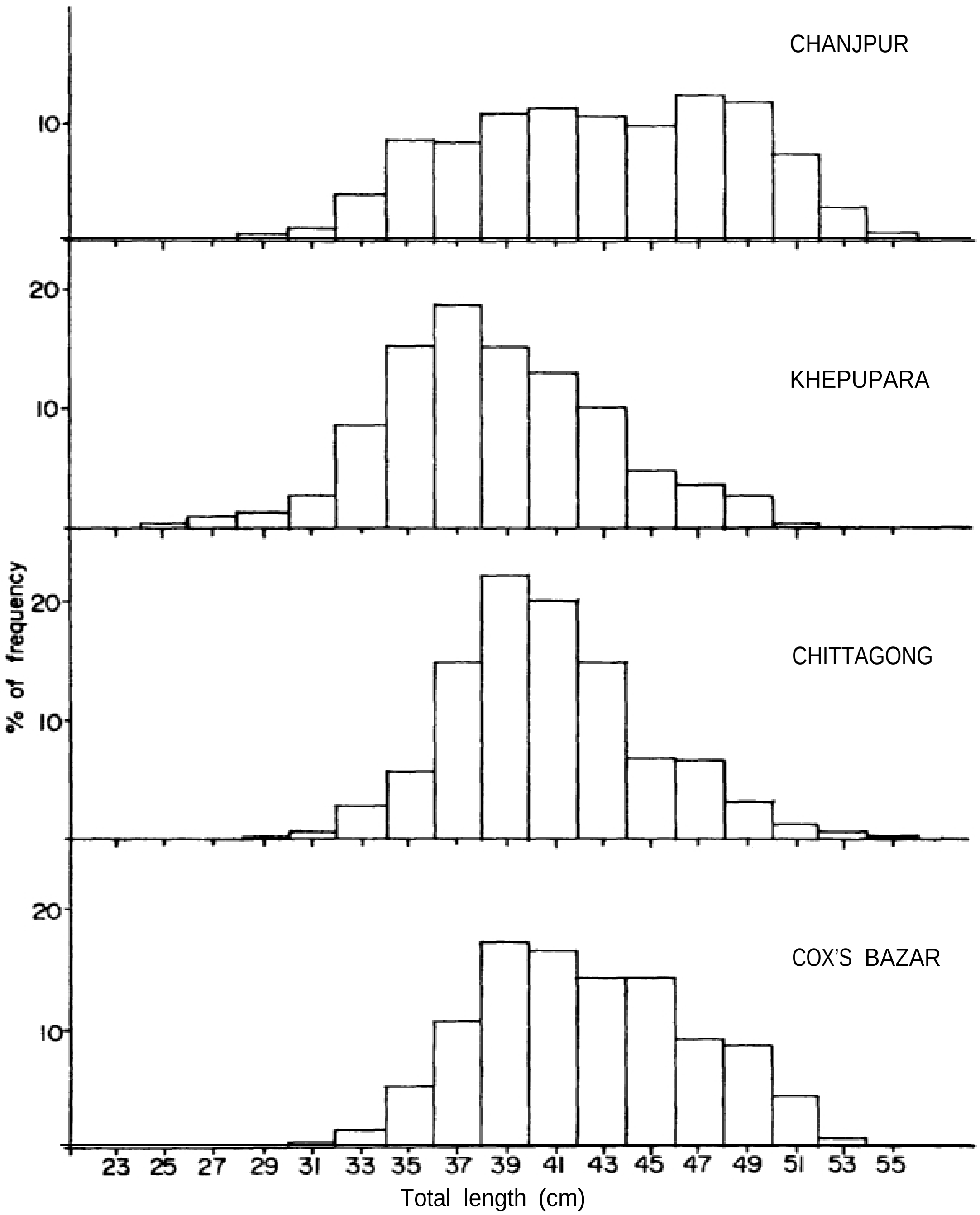

Fig. 2 Size composition of the catch of *Hilsa ilisha,* between March 1985 and April 1986, at the four sampling stations.

Annexure 3

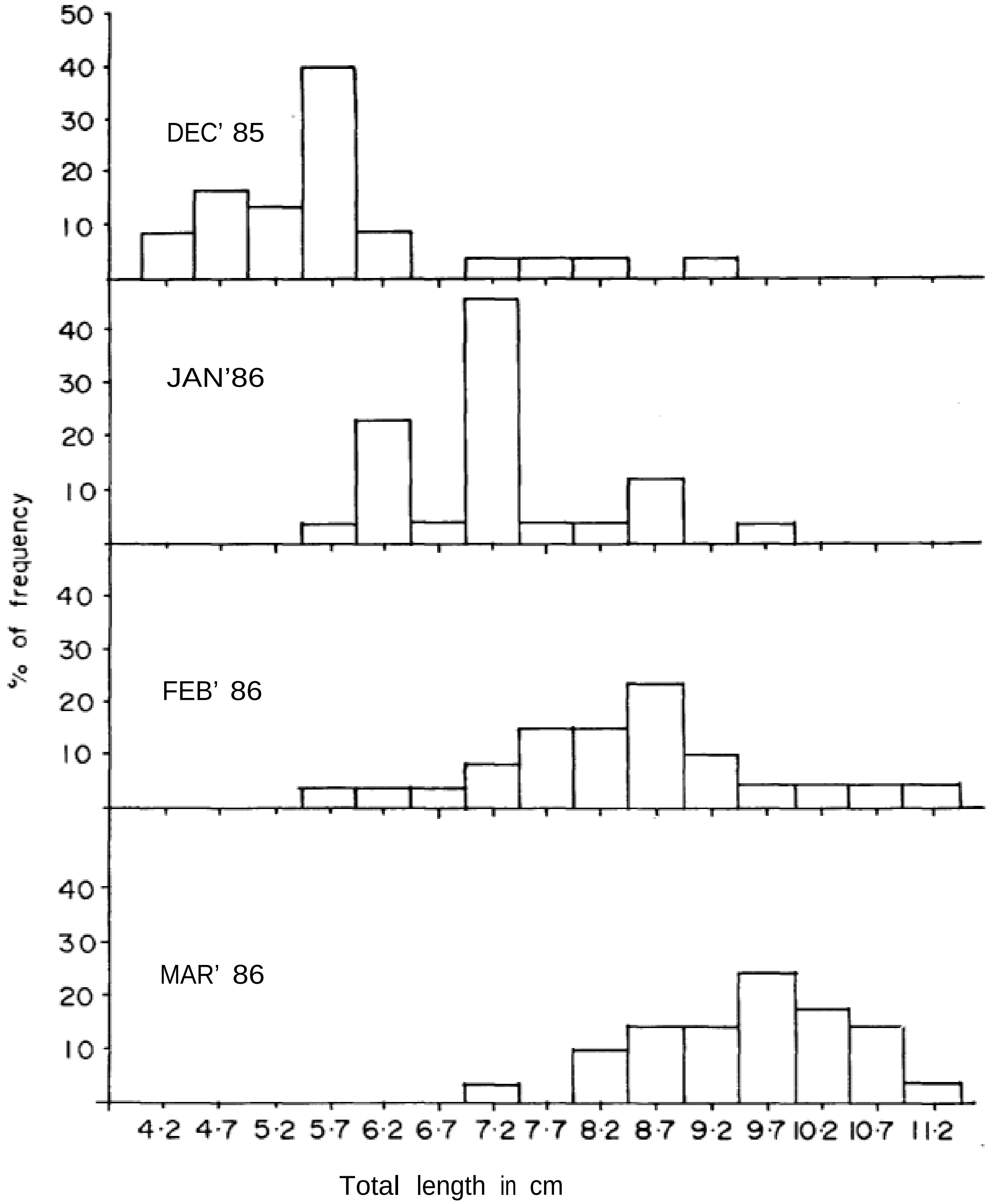

Fig. 3 Length frequency distribution of juvenile *Hilsa ilisha* in Khepupara.

Annexure 3

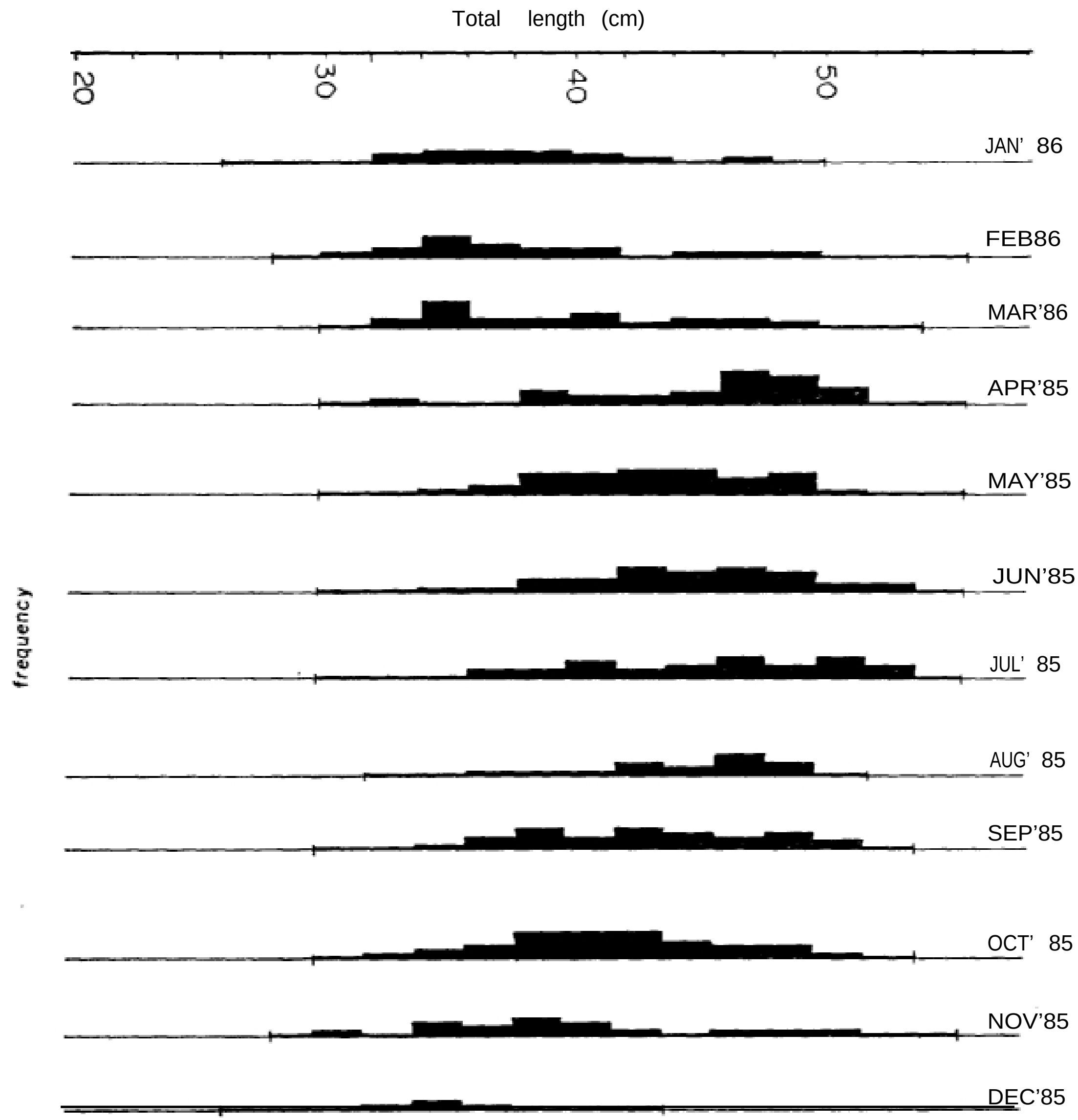

Fig. 4a Length frequency distribution at Chandpur, 1985-86 with 2 cm group intervals.

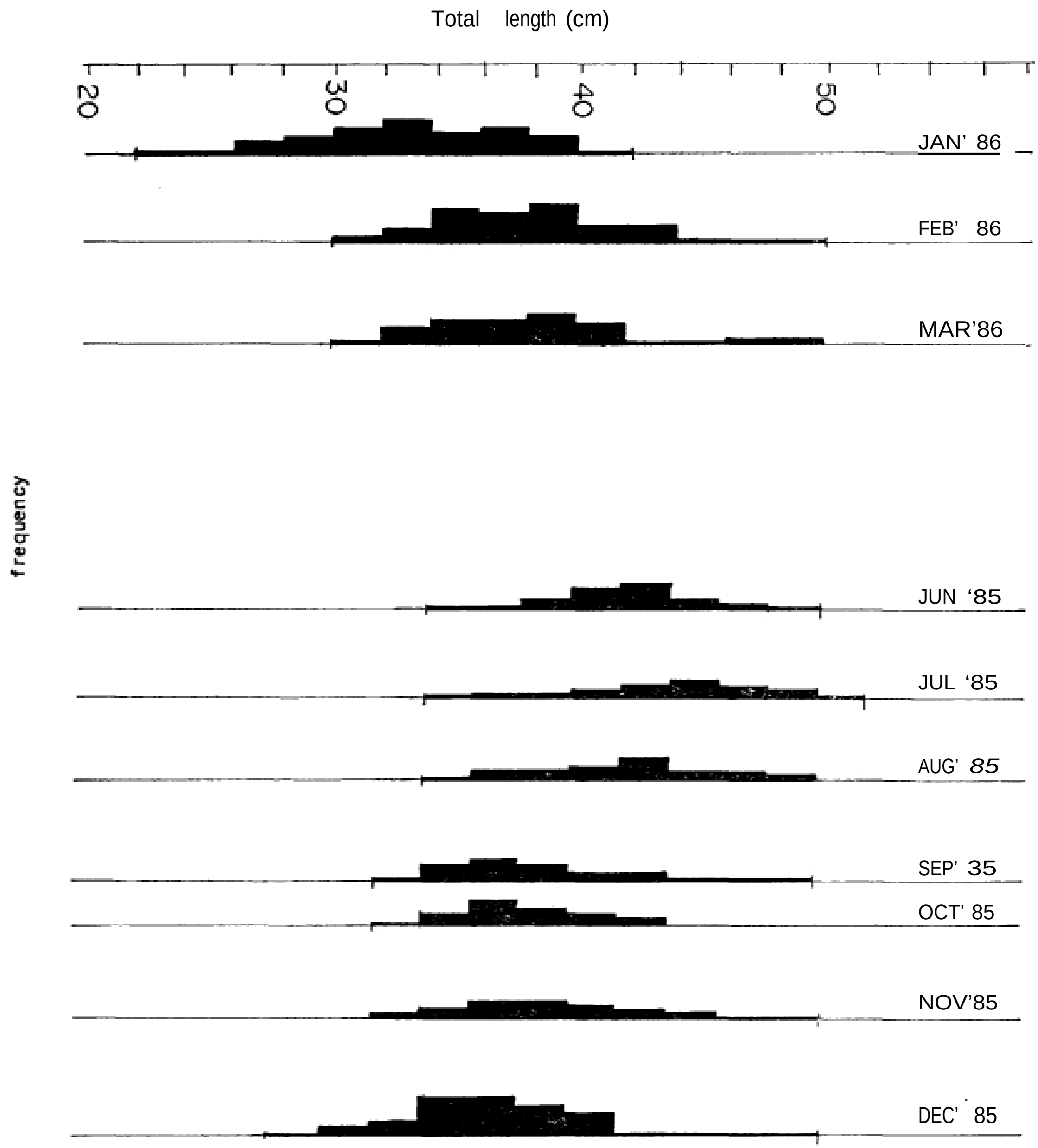

Fig. 4b Length frequency distribution at Mohipur (Khepupara) 1985-86 with 2 cm group intervals.

Annexure 3

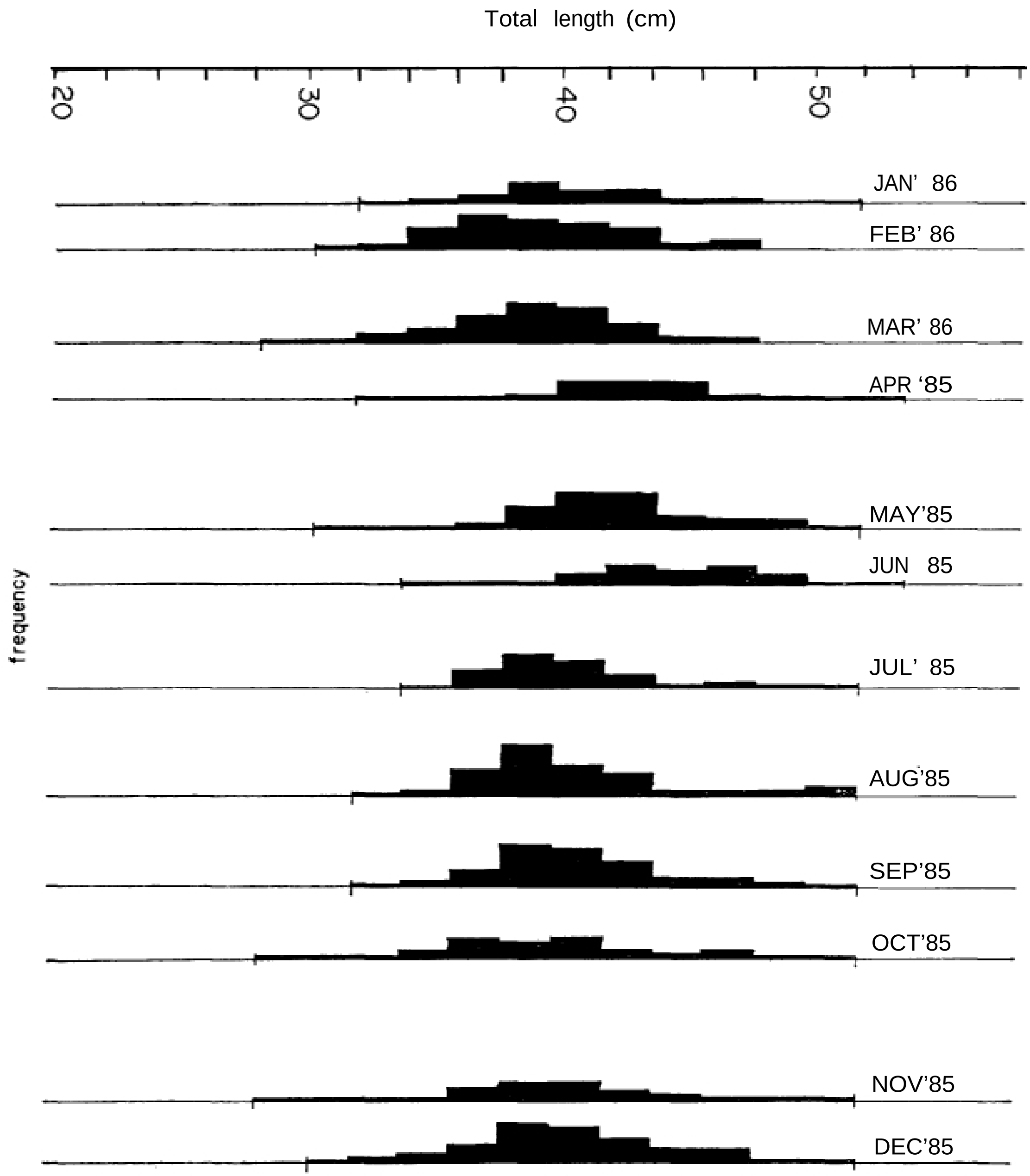

Fig. 4c Length frequency distribution at Chittagong, 1985-86 with 2 cm group intervals.

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Annexure 3

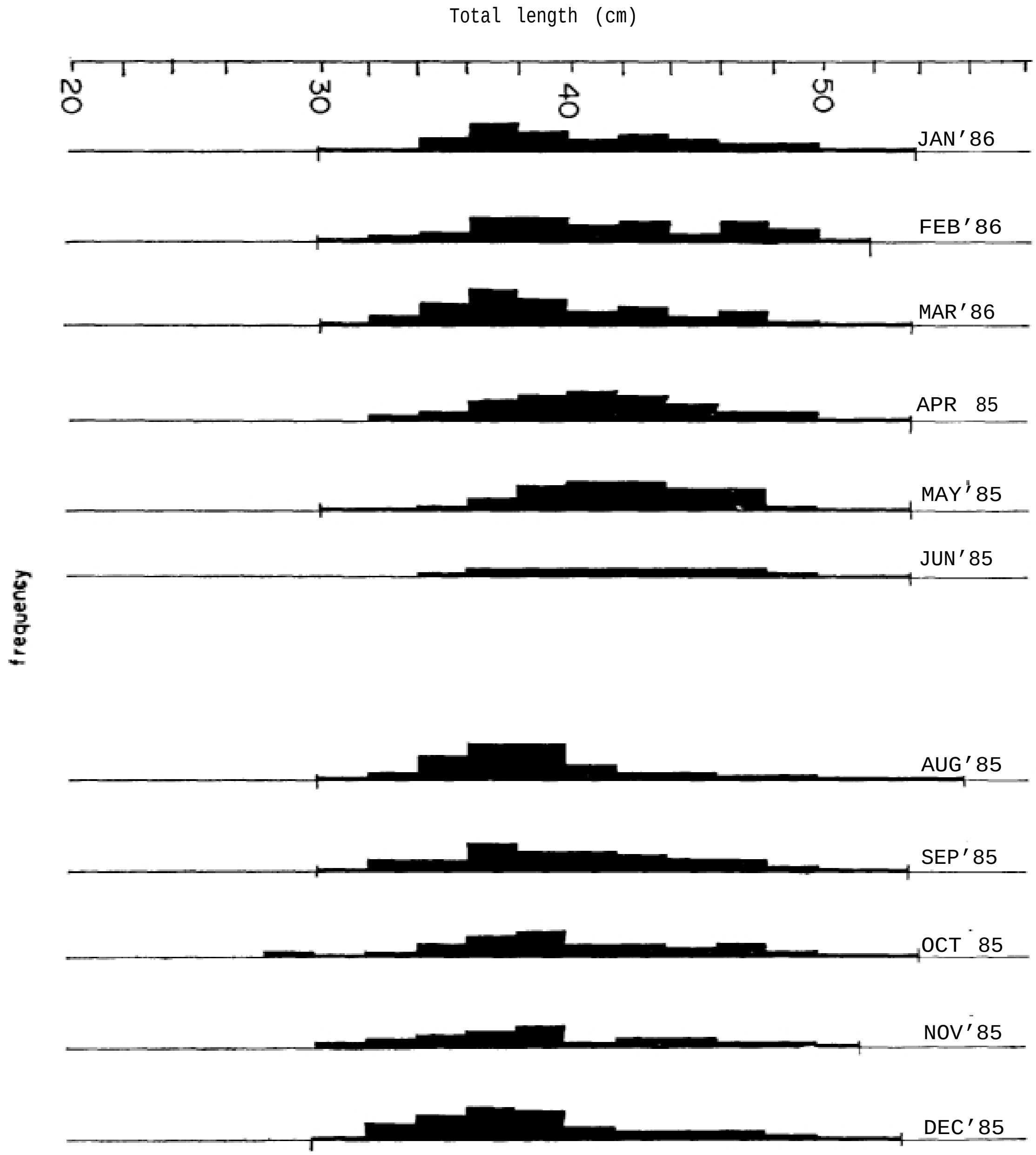

Fig. 4d Length frequency distribution at Cox's Bazar, 1985-86 with 2 cm group intervals.

Annexure 3

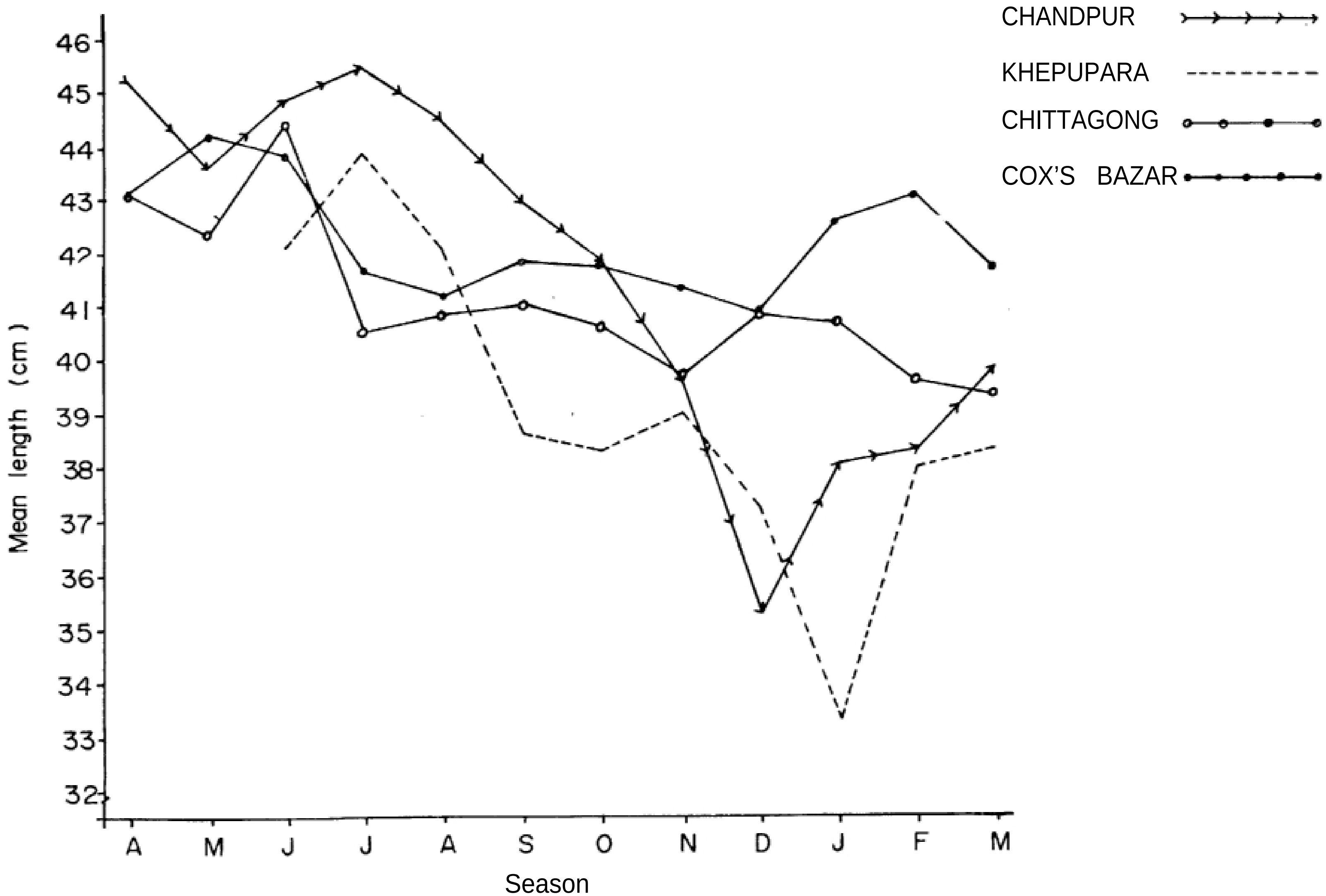

Fig. 5 Seasonal variations in the mean length of Hilsa ilisha at the four sampling stations iuring

Annexure 3

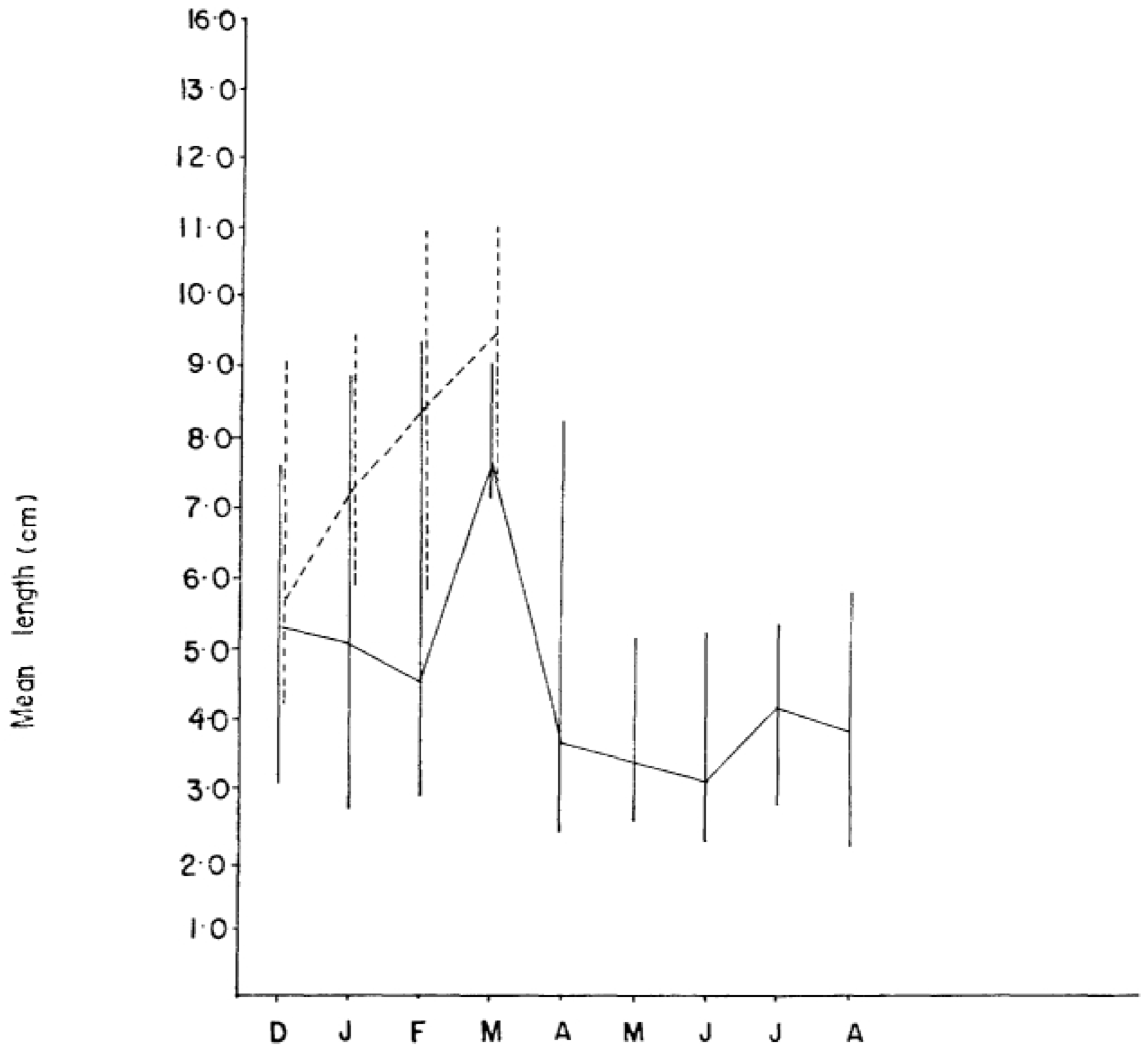

Fig. 6 Mean total length (continuous horizontal line) and length range (vertical line continuous) of juvenile hilsa caught by beach seine at Chandpur and set bagnet at Khepupara (broken line).
(data from the thesis by M. Hossain)

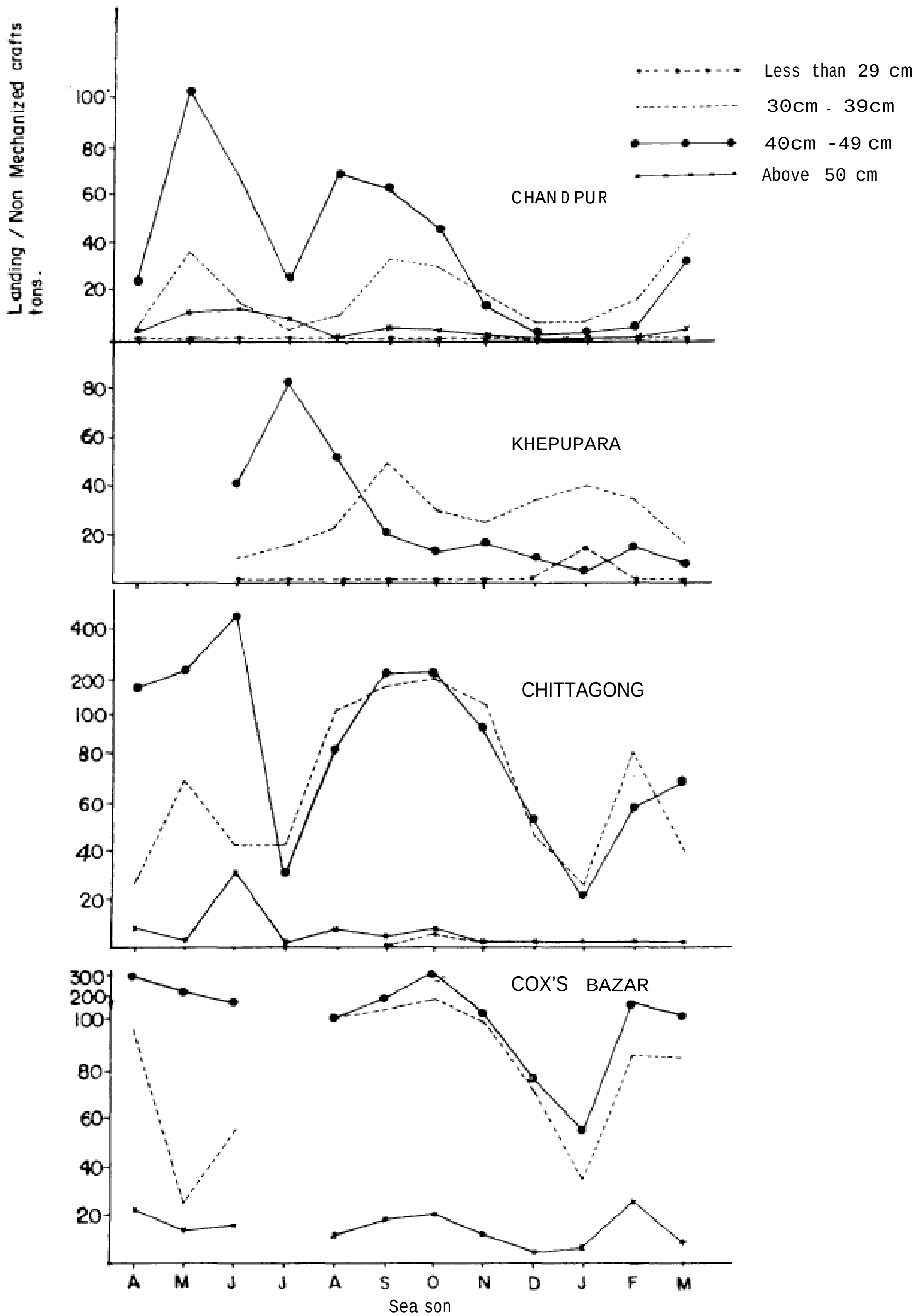

Fig. 7 Abundance of different size groups by month.

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Annexure 3 Appendix I

LENGTH/DEPTH DISTRIBUTION OF HILSA

Landing centre :
Biologist:
Date of observation :

No./Name of boat:
Length of boat/HP of engine:
Name, length and depth of gear:
Total catch in the observed boat (kg) :
Sample weight (kg) :

-- ----

Depth TL (cm)	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	Total
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23												
24												
25												
26												
27												
28												
29												
30												
Total												

Annexure 3 Appendix 1 (contd.)

Length/Depth distribution of hilsa

Landing centre:
No/Name of boat:
Name, length and depth of gear:
Biologist:
Length of boat/
Total catch in the observed boat (kg)
Date of observation:
HP of engine:
Sample weight (kg):

DEP TI(m)	6.0	6.5	7.0	6.5	8.0	8.5	9.0	9.5	10.0	10 .5	11.0	11 .5	12 .0	12 .5	3.0	13.5	1.0	14 .5	15.0	Total
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Chittagong and Cox's Bazar, and the appearance of a small peak of the medium-size group in February was also witnessed in both places. However, during winter there was a relative decline in the strength of the large-sized group in Chittagong, which resulted in medium-size groups becoming dominant during this period.

It may be that the large-size group of fish, which shows a peak in April at Cox's Bazar (the same happens in Chittagong around June), moves into the estuarine and riverine areas. In Khepupara and Chandpur, peak catches of the large-size group of fishes were observed in July and August respectively, which probably remained in these environments until spawning. From October there was a sharp fall of the large-sized group of hilsa in all the stations. The general decline could also be due to the fish moving into upstream areas beyond the sampling station. As regards the winter spawning on the other hand, the medium-sized group was abundant from July in the marine sector and migrated towards the estuarine and riverine areas where it was believed to spawn in winter.

The small-size group 20-29 cm had not made a significant contribution to the hilsa catches in any of the environment strata, probably because they were concentrated in an eco-system not covered by the fishery. Small quantities of this group were captured from Khepupara during January and off Chittagong in October. There were a few records of this size from the fresh water from November to February. They probably become available to the fishery only when they attain 30 cm size.

Similarly, the extra-large size group above 50 cm was also relatively low. It appeared in the fishery throughout the year in the Cox's Bazar and Chittagong landings, and from March to November in Chandpur, but almost nil in Khepupara at any time of the year.

Restricting the discussion only to the two important groups, the large and the medium, it appears that in the marine stations from July to next March, the catch rates (by weight) are similar. Considering the fact that the medium-sized fish would be certainly more numerous for a unit weight, it is obvious that they are the backbone of the fishery from July through March. It is then that most of the annual landings take place. It is only from April to June that the larger fish dominate the landings and contribute to heavy catches, especially at Cox's Bazar. There is also no doubt that the medium-sized fish outnumber the larger fish at Khepupara right from September to March and from November to March in Chandpur. There, it is the medium-sized fish which are the mainstay in the fishery for about eight months in the year, starting in July in the marine sector but shifting to September in the estuaries and November in the rivers. This group during the period goes into the next category; the large one, 40-49 cm now, becomes dominant from April onwards in all the sectors, till the first batch of medium-sized fish appear in the fishery, first in the marine sector.

In the Sunderbans, the commercial fishery is supported by the medium-sized 30-38 cm group (Sarkar, 1957). In the river Jamuna, it is seen from the tabulated statement of Ghosh (1967) showing the distribution of dominant size groups, that the small-cum-medium sized fish in the size range of 23 to 38 cm was more frequently represented than the other size groups, while the success of the fishery depends upon additional contributions from the larger fish in the 38 to 50 cm group. This is very similar to the situation obtained in the previous study also. In Chilka lake, it is the small and medium-sized fish in the size range of 24 to 40 cm which support the fishery (Thingson and Natarajan, 1969; Ramakrishnaiah, 1972). Although the reasons are rather outdated, the only information available indicates that the larger fish were dominant in the central and southern parts of the Burmese coast and the medium-sized fish in the northern Arakan coast. Interestingly, the small-sized fish in the 20-29 cm group were seen in the northern coast in January, November and September (FAO, 1970 and 1971).

The upstream migration of winter spawners and the downstream migration of summer spawners as spent fish are likely to intermingle at various positions in one or the other environment. Such intermingling may also be caused by use of different mesh sizes in the fishery. More intensive and extensive investigations in Bangladesh, Burma and India would help to obtain a clearer picture of movement and distribution of *Hilsa ilisha* in the Upper Bay of Bengal.

3.5 Mesh selectivity

A wide range of mesh sizes are used in the hilsa gillnet; more than one mesh size may be used in any one locality or area during a particular season. As a result, the selectivity effect of all the mesh sizes on the length frequency distribution becomes complex and quite often tends to produce confusing results. Further, the combination of mesh sizes used in any area changes seasonally. Based on years of fishing experience, fishermen determine the mesh sizes to be used during a particular time, in a particular area. The combination may influence the size composition of catch, in which the observed composition may not be representative of the actual population in that area. In another paper in this series (Huq et *al.,* 1986) this aspect has been dealt with in some detail. Suffice to say that the results of the analysis of gilling of hilsa show a wide range of length size being caught by each mesh size and considerable overlapping of size distribution of two nets of different mesh sizes.

Entangling and gilling collectively produced a wider range of distribution than that which could be expected if the fish were only gilled in a particular size of mesh. As a result, modal progressions are evident to some extent and these may have to be used for estimating the growth parameter. When length frequency of different mesh sizes is combined for an area and season, the modal progression tends to get destroyed and the data fail to reveal useful information. It is therefore necessary to separate the length frequencies according to mesh sizes, in which case, as Van der Knaap et *al.* (1986) showed, it would be possible to obtain growth and population parameters from the length frequency data.

4. SUMMARY

1. Length frequency data collected from March 1985 to April 1986 from the four selected sampling places show that the general size range of hilsa in Bangladesh is 21 to 56 cm total length. More than 90 per cent of the catch falls within the range of 30 to 50 cm. Modal length is around 41 and 47 cm in riverine stations, 37 cm in the estuary and 39 cm in the marine area. Smaller sizes were observed in Khepupara. Juveniles from the set bagnet fishery of Khepupara and the shore seine fishery of Chandpur exhibited a length range of 2.1 to 15.1 cm from December 1985 to April 1986.

2. The length frequency diagram shows negative progression of modal sizes and is clearer in riverine and estuarine stations than in the marine station.

3. Chandpur and Khepupara have wide mean length size ranges of 33-34 cm to 44-45 cm. In Cox's Bazar and Chittagong the range is shorter, 39 to 44 cm. The general mean length size in Bangladesh is 40.5 to 45.5 cm from April to August, 38.3 to 42.5 cm during September to November and 33.3 to 43.1 cm from December to March.

4. Hilsa have been classified into four size groups, small (less than 30 cm), medium (30 to 39 cm), large (40 to 49 cm) and extra large (above 50 cm).

Catches of large-size groups in rivers improve mainly during the south-west monsoon; these are probably for spawning migration. Medium size groups, again based on CPUE, are dominant in winter; they also probably migrate for winter breeding. This is roughly the picture in both Chandpur and Khepupara. In marine areas, the large-size group distinctly dominates over the medium size one for about four months from April-July. Thereafter, from the next month there is not much difference in the catch rates between the two groups. But the medium-sized fish are numerically more than the large-sized fish. The small-sized group (20-29 cm) has not appeared significantly in the observation. Small quantities of this group were obtained from Khepupara during January and off Chittagong in October. This size group is mentioned in riverine records during November to February. The large-size group was poorly represented in marine and freshwater areas and was almost absent in the catches in Khepupara.

5. A wide range of mesh sizes is used in the hilsa gillnet fishery during different seasons and

at different stations. So the selectivity effect of all mesh sizes makes analysis and length frequency data very complex.

6. The results are discussed vis-a-vis the information in some earlier reports, and certain postulations made.

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Annexure 4

RESULTS OF THE ANALYSIS OF *HILSA ILISHA* LENGTH FREQUENCIES

by M. Van der Knaap, K. Sivasubramaniam, S.A. Azad, M. Islam,
M. Hossain and Q.M. Huq*

1. INTRODUCTION

In March 1985, a survey program commenced in the Upper Bay of Bengal under the regional UNDP/FAO project for "Marine Fishery Resources Management in the Bay of Bengal". The main purpose of the programme was to determine the relative abundance of *Hilsa* species, their distribution in the different environments, spawning areas and seasons, migration patterns and the state of the *Hilsa* fishery.

Catch and effort and length frequency data are not available over a reasonable number of years to attempt to fit production models or to apply the Virtual Population Analysis. In view of this the ELEFAN method of analysis was applied to the length frequency data of *Hilsa ilisha,* collected during 1985/86, for preliminary indication of the characteristics of this exploited population.

2. MATERIALS AND METHODS

Gillnetting is the primary method of fishing for *Hilsa* and mesh sizes ranging from 7.6 to 12.6 cm are used by the fishermen in all environments, in different periods of the year. Length frequencies (1 cm length classes, males and females combined) were collected during the period March 1985 to April 1986. Commercial landings were sampled regularly and also fish caught by experimental gears were measured. In all cases the total length was taken. Samples taken were weighed and the length frequencies were raised to the total catch of the boat sampled. Wherever possible, the mesh size of the gillnets used was measured.

The length frequencies (with 2 cm intervals) were analyzed in the project's headquarters in Colombo using an Apple IIe computer and the ELEFAN I program written by Pauly and David (1981). As suggested by Pauly (1985), the program should be improved by counting the positive point values in the restructured samples only once during the compilation of the explained sum of peaks (ESP) instead of several times as in the original version. This problem could be solved by "flagging" out any peak hit by the growth curve. The project's system analyst provided the necessary amendments, which resulted in the so-called "post-Sicily version".

The parameters thus obtained were used in the ELEFAN II program and the results were used in the relative yield per recruit analysis.

The Bhattacharya method (after Pauly and Caddy, 1984) was applied to the length frequency data as well. The project's system analyst rewrote the program for use on the Apple IIe computer (Goonetilleke and Sivasubramaniam, 1986, manuscript).

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3. RESULTS

3.1 Length frequencies

All samples from the four sampling centres were combined and attempts were made to find growth parameters. Due to the absence of a well defined modal progression (in fact a negative progression was observed) in the restructured samples, further analysis was suspended. Separation of the length frequencies by mesh size was possible only for the Chittagong data. Time series of reasonable length were available for the 10.1, 11.4 and 12.6 cm mesh sizes.

A preliminary analysis of the length frequencies was initially carried out using the original ELEFAN I program, followed by a more precise determination of the growth parameters with the post-Sicily (PS) version. In all cases the WP, C and D parameters in the ELEFAN analyses were 0, 0 and 1 respectively. It appeared that the PS version strongly reduces the number of parameter combinations which results in the best fit of a growth curve to the available length frequencies (i.e. the highest ESP/ASP ratio). Using the original version numerous combinations with the same ESP/ASP ratio were observed, bringing in a subjective element in the choice of parameters. This problem was only partly solved by the PS version because in some cases still more than one combination could be obtained. Starting points were searched not only by the computer, but also by eye, using the restructured samples. Several starting points and numerous parameter combinations were tried out before the final growth parameters were decided upon.

The analysis of the length frequencies from the 10.1 cm mesh sizegearresulted in two growth curves, passing through the majority of the peaks. The two growth curves represent two different broods. The L_{∞} values for the two curves were more or less equal (56.4 and 56.8 cm). A difference may be found in the k-value and in the ESP/ASP ratio; the two k-values were 0.91 and 1 .1 5 respectively. The restructured frequencies and the two growth curves are presented in Figure 1 a. The growth parameters are summarized in Table 1.

The analysis of the data from the experimental fishing gear (12.5 cm mesh size), however, allowed the plotting of three growth curves, representing three broods. The L_{∞} values varied from 56.2 to 56.7 and the k-values from 0.95 to 1 .1 0. These values were of the same order of magnitude as the parameters from the commercial data. The sum of the three ESP/ASP ratios was reasonably high, although it should be taken into account that some peaks are hit by more than one curve, especially the peaks in the part close to L,. The growth curves are presented in Figure 1 b.

The length frequencies for two other mesh sizes, 11.4 and 12.6 cm, also presented two growth curves with comparable parameters (cf Table 1). However, the combination of the frequencies from the several mesh sizes did not result in the same parameters as those obtained by the analysis of the data for each mesh size separately. When the ELEFAN I program was run with the above meant parameters as input, either the fitness of the growth curve was very poor or even negative, or there was a certain fit but with very high L_{∞} or low k-values; this fit was considered to be a “forced” one.

The analysis of the Chandpur length frequencies irrespective of the mesh sizes resulted in a relatively poor fit. Two growth curves (for two broods) could be drawn, connecting the majority of the peaks. However, the two ESP/ASP values obtained were rather low: 0.197394 and 0.145611 respectively. The k-values for the two broods were considerably lower (0.78 and 0.825) than those from the individual Chittagong data series (cf Table 1). Results of the analysis of the length frequency data from Chandpur or Chittagong, combined without respect to different mesh sizes used, suggest larger longevity for *Hilsa ilisha* than that indicated by the results from the analysis of the data for different mesh sizes.

The length frequencies used in the analyses figure in Appendix 1.

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Annexure 4

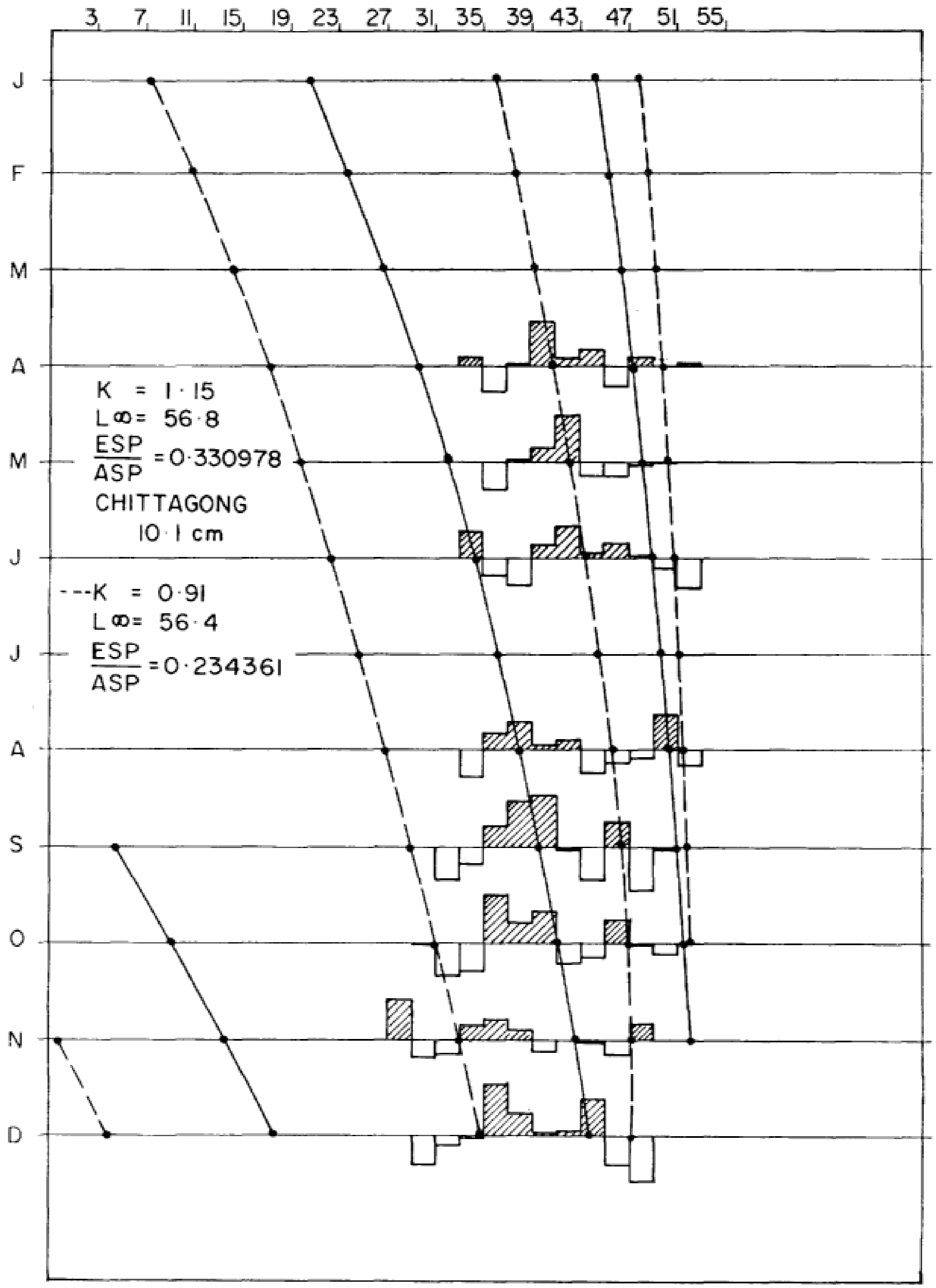

Fig. 1a Restructured length frequency distribution of *Hilsa ilisha* caught in 10.1 cm mesh gillnets at Chittagong and the growth curves fitted.

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Annexure 4

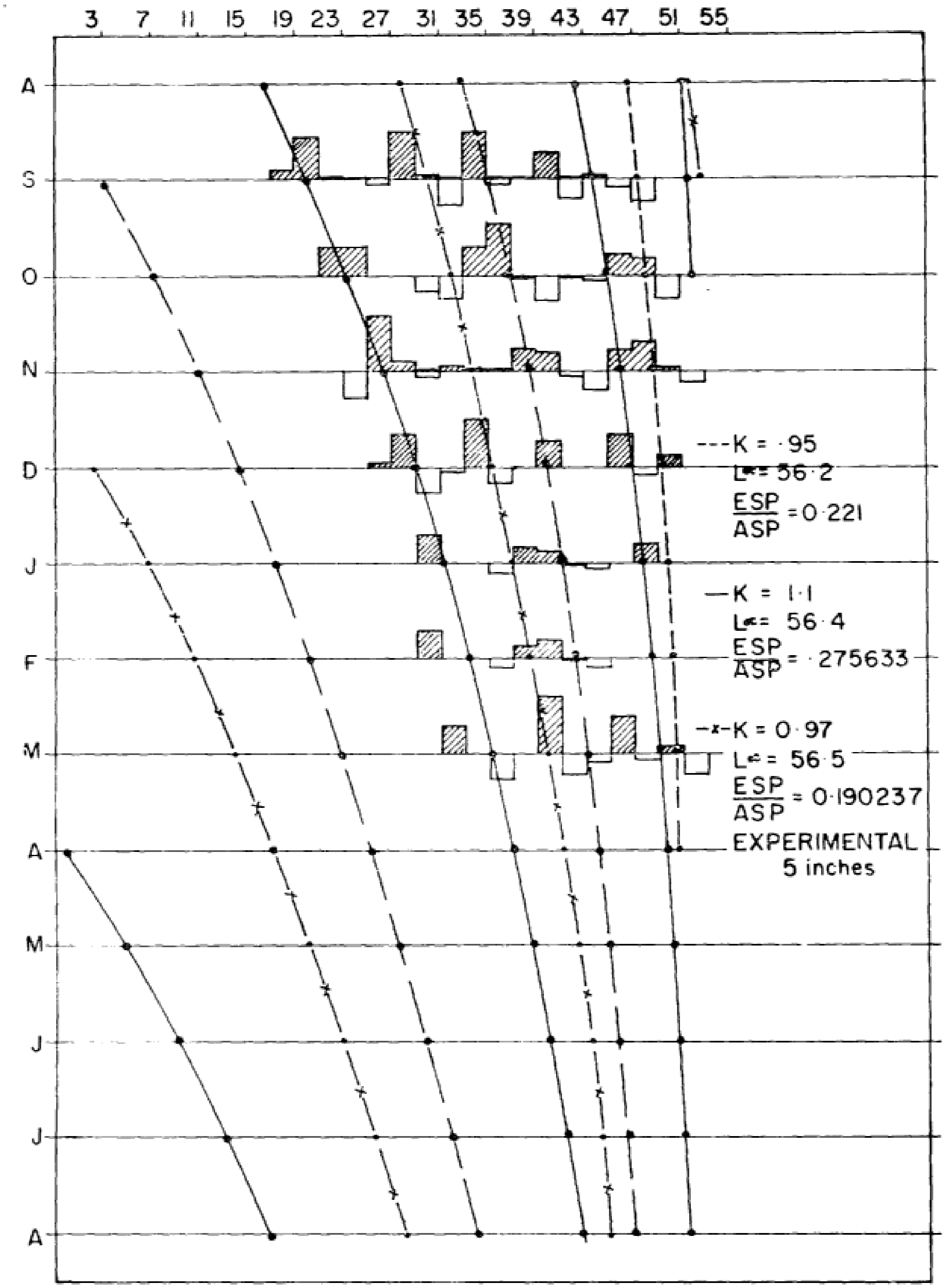

Fig. 1b Restructured length frequency distribution of *Hilsa ilisha* caught in the 5" mesh experimental net and the growth curves fitted.

3.2 Recruitment

In Figure 2a, the recruitment pattern, determined through the ELEFAN II analysis (Pau!y ct a/., 1981) for the length frequencies from the 10.1 cm mesh size gillnet, is shown, with the separation of the normal distributions of the peaks by means of the NORMSEP program (Pauly et al., 1986). The pattern clearly shows two peaks. As may be derived from the growth curves also, two spawnings appear to take place, one in August, and the other in November; in the case of the separated normal distributions the time lapse between the two peaks is around four to five months, which corresponds with the period between two spawnings.

The ELEFAN II analysis, using the parameters obtained from the analysis of the length frequencies from the different mesh sizes, resulted in similar recruit patterns. In all cases at least two peaks of recruitment were observed (in some cases small skews were found). The combination of length frequencies from the different mesh sizes (Chittagong and Chandpur data), indicated only a single annual recruitment.

Three peaks were observed in the recruitment pattern of the experimental data, which is presented in Figure 2b. One peak is of a rather small size, but the probability of fitness for the three peaks is vary good, of the level of 0.1%. The intervals between the peaks are 3 and 5.4 months. The origins of the growth curves are around April, August and November, which correspond with the intervals between the recruitment peaks.

3.3 Mortality and exploitation rate

By means of the ELEFAN II program the total mortality (Z) could be estimated from a length converted catch curve and from the mean length in the samples. Natural mortality (M) could be calculated from Pauly's empiric formula (Pauly, 1980) and subsequently the fishing mortality (F) could be obtained. In Table 2 the parameters obtained from the ELEFAN II analysis are summarized for the growth parameter combinations of Table 1. Natural mortality varied between 1.23 and 1.63; total mortality for the brood with a k-value of 1.15 varied between 3.1 and 4.7 and for the other brood (k: 0.90-1.05) between 2.2 and 3.7. The Chandpur and experimental gear data indicated low total mortality rates.

The exploitation rate gives an interesting picture: the exploitation rate for the 10.1 and 11.4 mesh sizes is higher than 0.50 (i.e. $F>M$), viz. 0.53-0.66, while the exploitation rate for the 12.6 cm mesh is lower than 0.50 ($F<M$), viz. 0.42-0.48. The E-values for the experimental and Chandpur data are much lower: 0.27-0.41 (Table 2). The exploitation rates for the experimental and 12.6 cm mesh size gears are low, because only a part of the population is being exploited, while the low E-value for Chandpur may be explained by the low total mortality rate.

3.4 IVlean length at first capture

The mean lengths at first capture for the 10.1, 11.4 and 12.6 cm mesh sizes are 38.9, 39.0 and 39.2 cm respectively. The L_e value for the experimental data (mesh size 12.5 cm), however, is considerably lower: 34.5 cm probably because of the poor catches made with this gear. The L_e value for the Chandpur data is 38.1 cm, but in this case the data are obtained from various mesh sizes.

3.5 Bhattacharya method

The Bhattacharya method was applied to the total length frequencies (1 cm intervals) by mesh size and also to the total of all mesh sizes combined. The total length frequencies from the other stations and the experimental data were analyzed in the same way. All mean lengths obtained from this analysis were compiled and grouped. Of each group the average was calculated, which resulted in the following modal lengths: 22.1, 36.8, 40.7, 47.2 and 49.9 cm total length, of which 22.1, 40.7 and 49.9 cm would represent one brood and 36.8 and 47.2 cm the other. The expected length frequency was calculated and subtracted from the observed frequency which resulted in the so-called residuals. The latter were analyzed using the Bhattacharya method again and there were indications that modal lengths appear at 31.8, 42.3 and 51.7 cm of which one or two may be assigned to a possible third brood. Some other modal lengths were found

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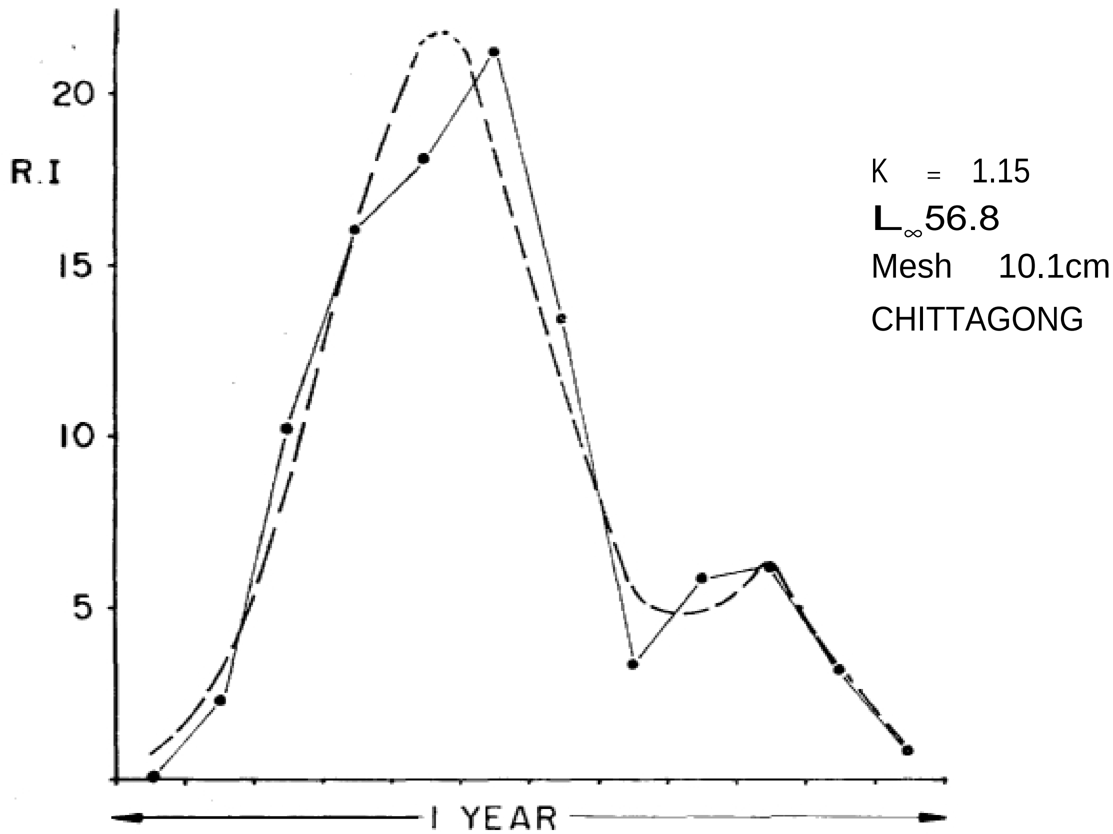


Fig. 2a Recruitment pattern for Hilsa. Data from 10.1 cm mesh gear (R. I. = Recruitment Intensity). Normal distributions of the recruitment peaks after separation by the NORMSEP program (dotted line).

Annexure 4

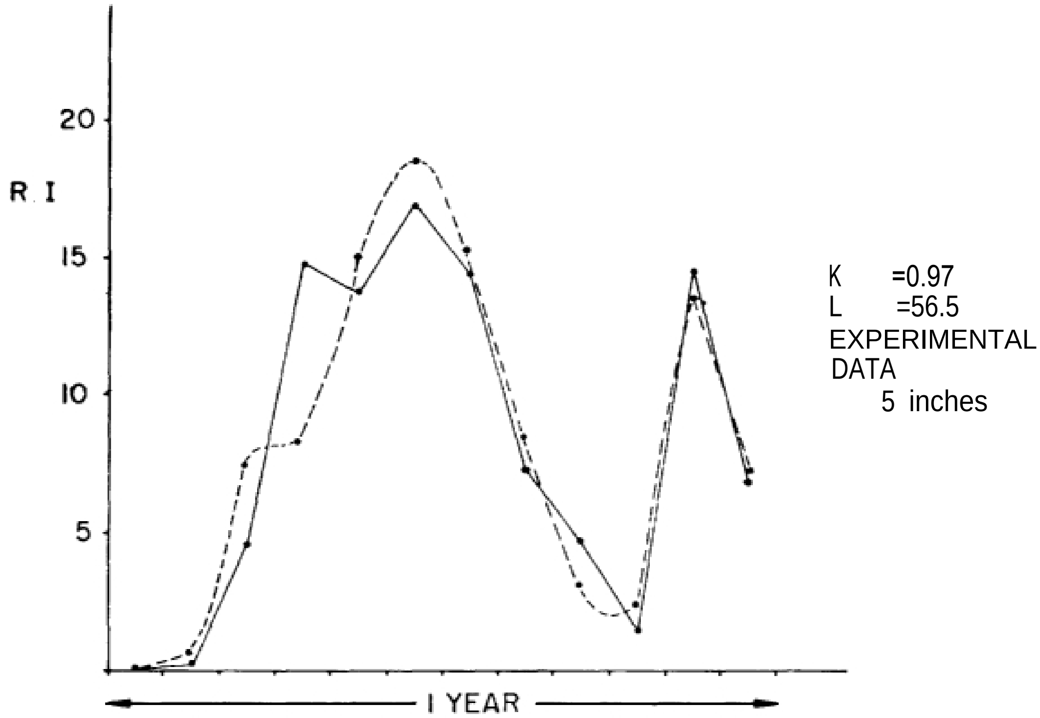


Fig. 2b Recruitment pattern from the length frequencies of *Hilsa ilisha* caught with 5" mesh gilinets. Normal distribution of the recruitment peaks after separation by the NORMSEP program (dotted line).

Annexure 4

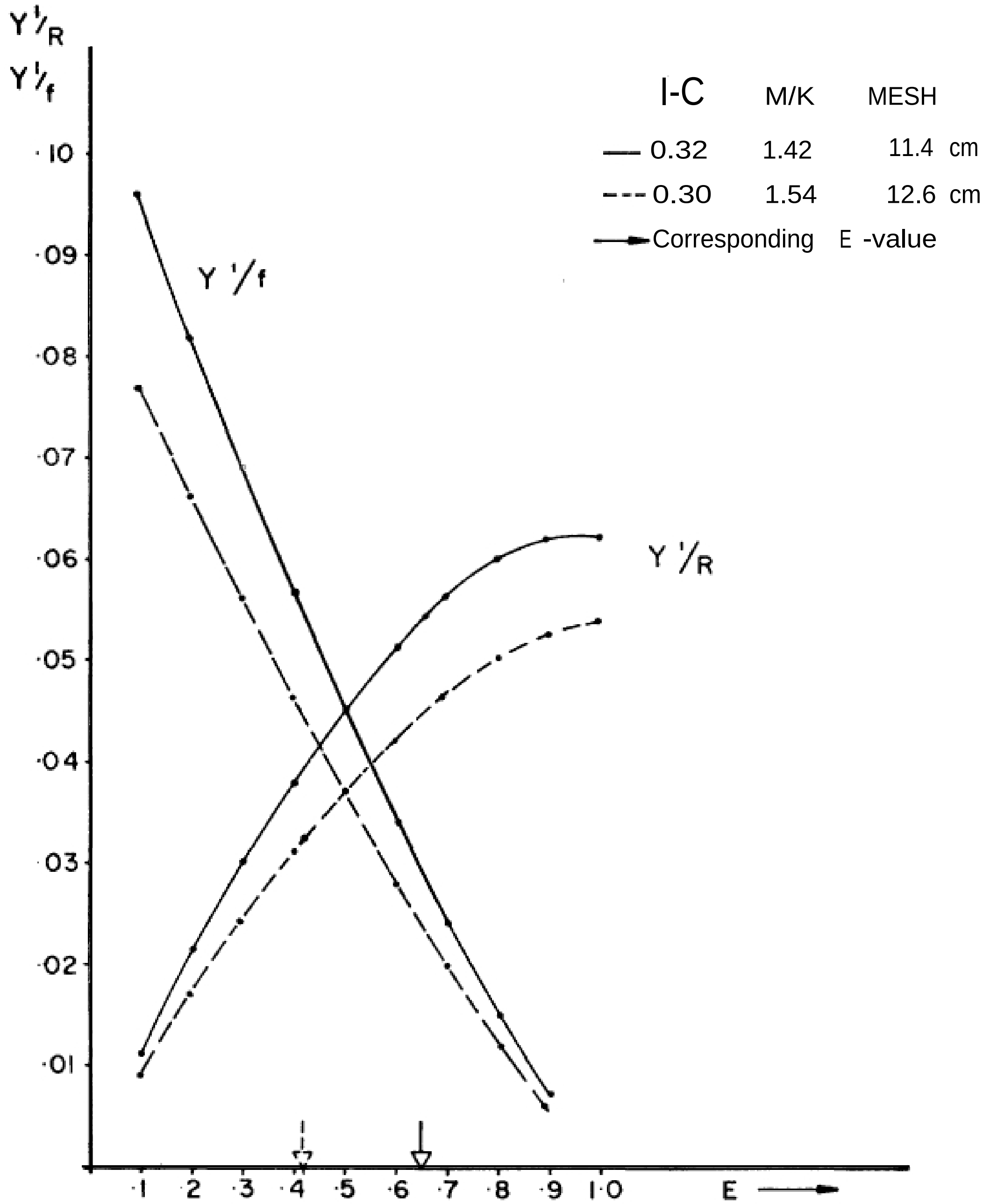
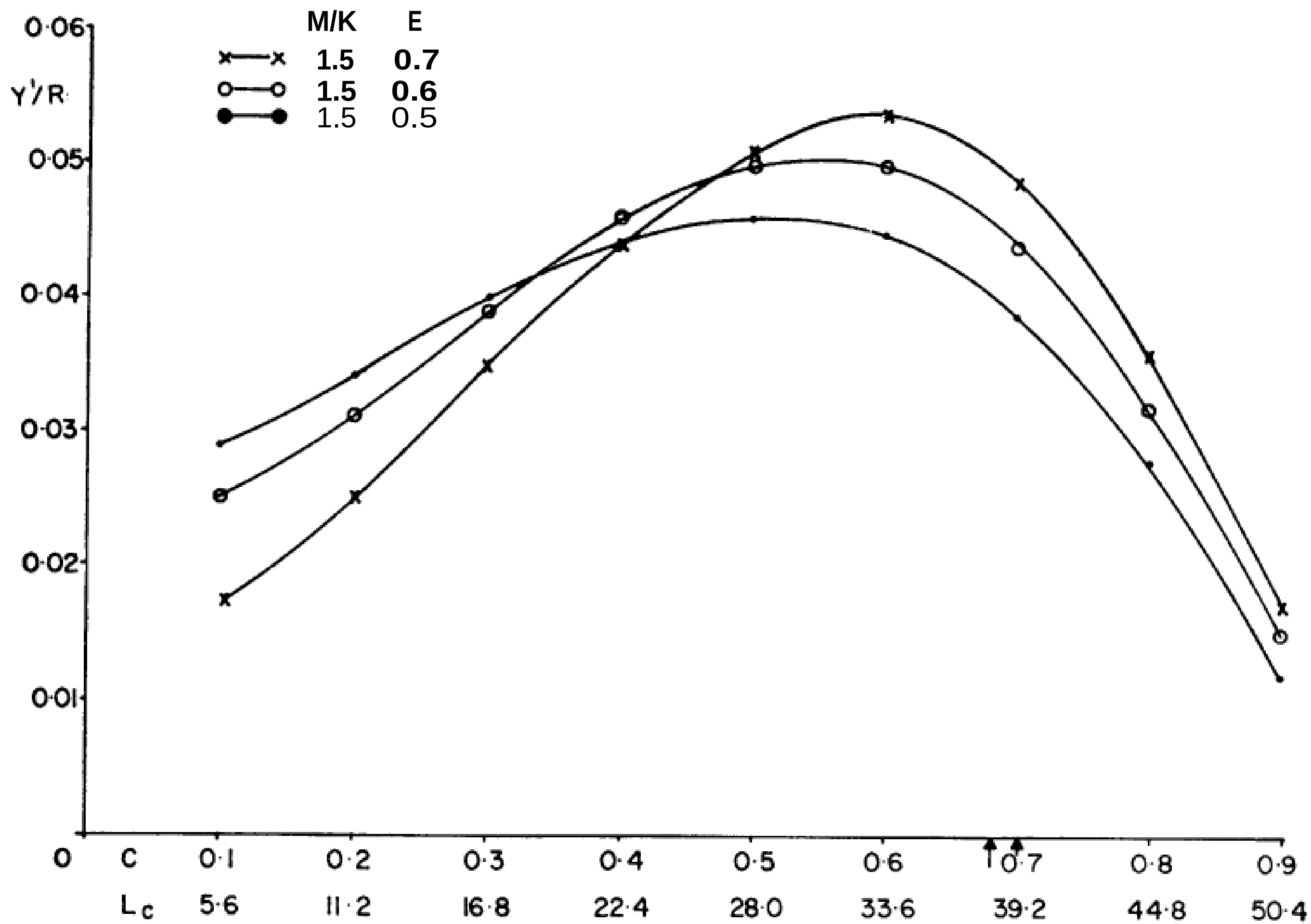


Fig. 3 Relative yield per recruit and per effort, curves for *Hilsa ilisha* as a function of the exploitation rate (E).

Annexure 4, Fig. 4



Relative yield per recruit curves for three levels of exploitation for <u>Hilsa</u> as a function of C(Lc/Lω) and Lc (L∞= 56)

In the several data series which confirmed the modes found in the analyses of the original length frequencies.

The Gulland-Holt, Ford-Walford and Von Bertalanffy plots were applied to the modal length data for the two broods. The results are presented in Figs. 5, 6 and 7.

In Figure 5 two Gulland-Holt plots are presented : one using a time interval of one year (Δ_t=1.0) and the other six months (Δ_t=0.5). In the case of Δ_t=1.0, two points were derived for one brood and one point only for the other. Linear regression analysis applied to these points resulted in an L_∞ and k-values of 57.7 cm and 0.52 respectively. This L_∞ value is slightly higher than the one which was found through the ELEFAN I analysis, while the k-value is very much lower. In the case of Δ_t=0.5, the modal length data were considered to represent one virtual brood. A straight line was fitted to the four points obtained through linear regression analysis, which resulted in L_∞ and k-values of 55 cm and 0.94 respectively. These parameters are fairly close to the ELEFAN I results.

Figure 6 shows a Ford-Walford plot, resulting in an L_∞ of 57.7 cm and a k of 0.73. The plot fits two points for one brood and one point for the other. The modal lengths obtained from the analysis of the residual frequencies do not fit very well in this plot.

The logarithmic generalized Von Bertalanffy growth formula, where $(-l_n((L_\infty-L_t)/L_\infty))$ was plotted as a function of t, resulted in an L_∞ value of 55 cm with a corresponding k-value of 0.90. For the time intervals between the modal lengths six months were chosen. The L_∞ was obtained by applying linear regression analyses to the data and by selecting the highest r^2 value, corresponding to the most appropriate L_∞ (after Pauly, 1984). It must be pointed out that the data for the assumed two broods were combined in this analysis and thus resulted in parameters somewhat different from those found through other methods. An estimation was made for t,, which appeared to be positive and of a rather high value: 0.40. This value may change when other ages are being chosen for the modal lengths. The modal lengths obtained through the Bhattacharya method represent age groups and not absolute age.

3.6 Relative yield per recruit

Using the k and L_∞ values obtained with ELEFAN I and the Z, M and L_c values (and subsequently F, E and C) with ELEFAN II (cf Table 2), a relative yield per recruit analysis was accomplished (it must be noted that this analysis is entirely based on the length frequencies from Chittagong, separated by mesh size). Three sets of data with various exploitation rates (E=F/Z) were chosen for the analysis. The relative yield per recruit and per effort have been plotted as a function of the exploitation rate and are presented in Figure 3. In Figure 4 the relationship between the relative yield per recruit and the mean length at first capture is presented.

Annexure 4

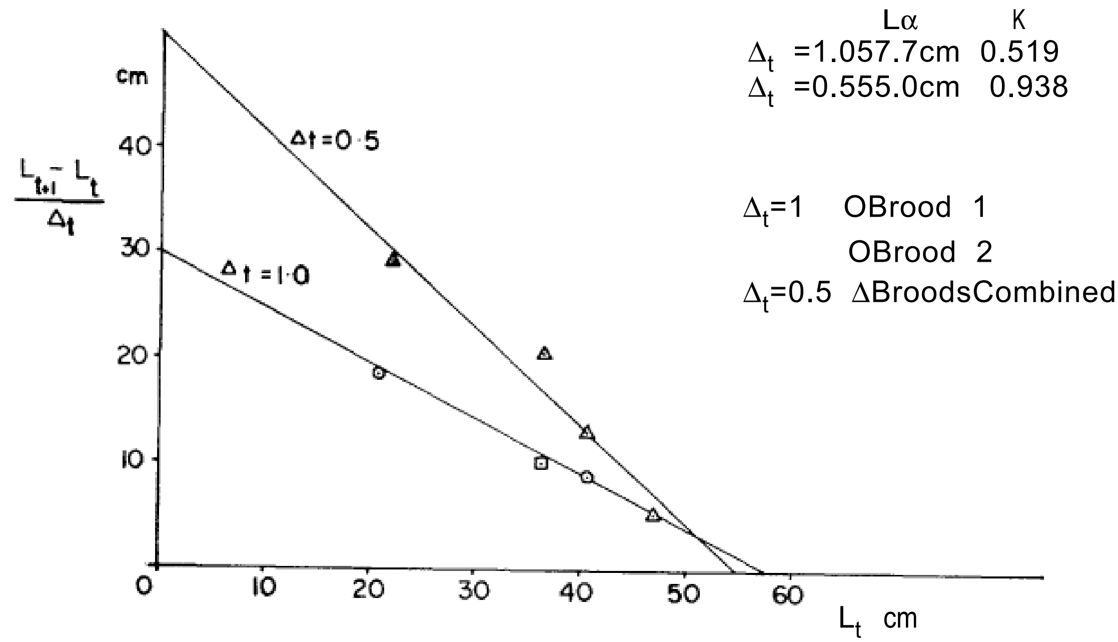


Fig. 5 A Gulland-Holt plot with points derived from Bhattacharya method on length frequency distribution of *H/lsa ilisha.*

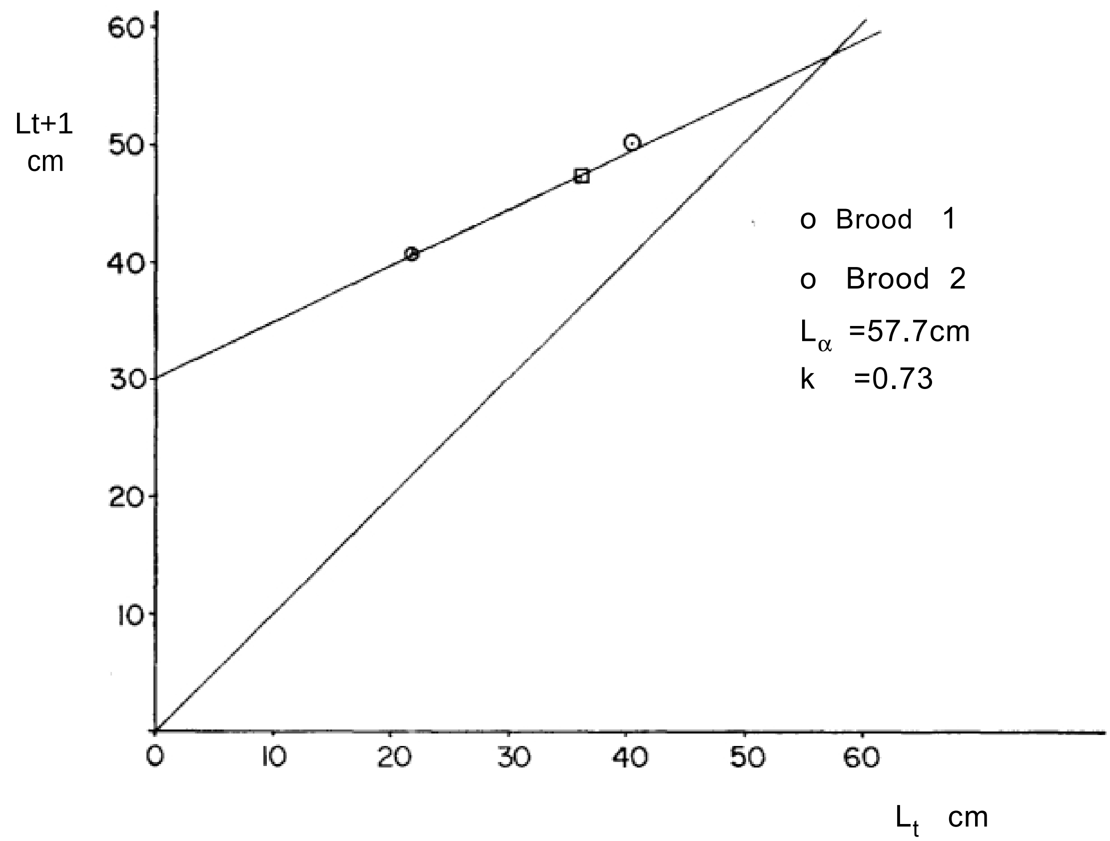


Fig. 6 A Ford-Walford plot with points derived from Bhattacharya method on length frequency distribution of *Hilsa ilisha.*

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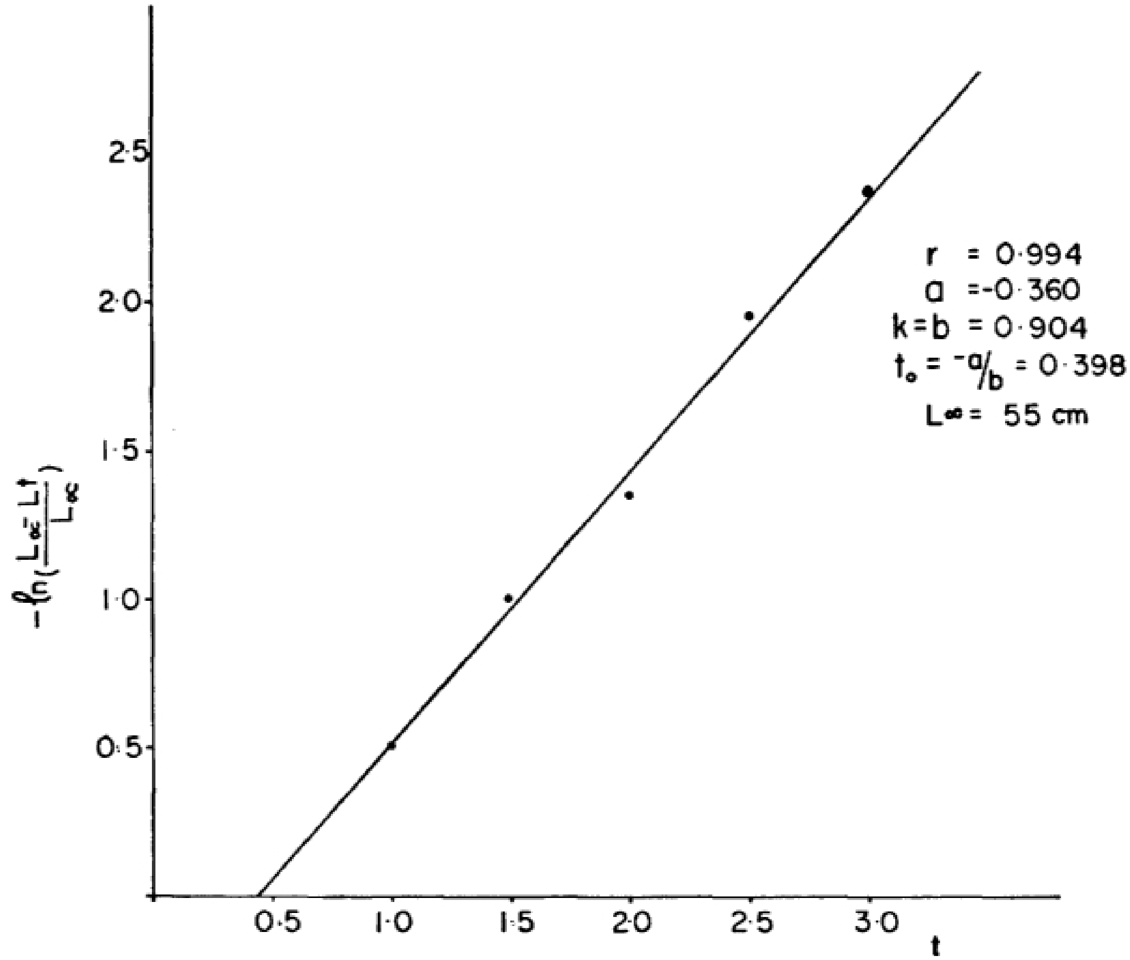

Fig. 7 Von Bertalanffy plot of points derived from Bhattacharya method on the length frequency distribution of *Hilsa iisha.*

4. SUMMARY AND DISCUSSION

For the analysis of growth parameters of *Hilsa ilisha* the data sets from Chittagong are being considered the most appropriate. Of all commercial fishery length frequency data collected during the survey program, only these could be raised to the total catch per boat sampled, and also the frequencies are known by mesh size. Two broods could be observed in all sets of commercial data. From the Chittagong frequencies two recruitments may be found, in August and in October/November. The experimental data permitted the fitting of three growth curves; the recruitment appeared to take place in April, August and November/December. The commercial data did not allow a third growth curve. The gonad somatic index values for *Hilsa* show peaks in February/March, June/July and October/November (Islam et al., 1986). These results would indicate recruitment in April, August and November; however, regarding the points of origin of the growth curves, the selectivity effect of the mesh sizes may influence the positions of the modes resulting in a possible shift of the points of origin.

The L_∞ is estimated to be between 56 and 57 cm total length and the k-value (annual basis) between 1.05 and 1 .1 5 for the main brood and between 0.90 and 0.95 for the second brood. When studying Table 1, it should be noted that for the three data series from Chittagong the first brood (August or summer brood) has a k-value of 1 .15, while the k-value for the winter brood (October/November) is of the order of 0.90-0.91. On the other hand the summer brood from the experimental data has a lower k-value: 0.95 ; the winter (November) and spring broods (April) have k-values of 0.97 and 1.05 respectively. The difference between the results from the commercial and experimental data may be due to sampling errors or the selective character of the gears, which may cause shifts in the positions of the peaks. Another reason might be a possible seasonality in the growth, which may be expressed in the growth parameters because the periods of sampling did not entirely overlap (April to December for the commercial data and from September to March for experimental data) (Figures la and 1 b). Quddus et *al.* (1984) determined the Von Bertalanffy growth equation for two races of *Hilsa ilisha.* In these equations the L_∞ value is of the order of 642 and 680 mm and the k-values of the order of 0.19 and 0.16 respectively. The age and growth determinations are based on otolith readings; the longevity would be about five years. The results from the ELEFAN analysis presented in this paper differ considerably from Quddus' results.

If, however, the length frequencies for the several mesh sizes are being combined (in the case of the Chittagong data series), the results from the individual mesh size analysis cannot be obtained any more. This observation indicates that length frequencies combined for several different mesh sizes are not suitable for the ELEFAN growth parameter analysis. The results from the combined Chittagong data analysis resemble those from the Chandpur data, i.e. relatively high L_∞ and low k-values. In this study it is believed that length frequencies obtained from different mesh sizes disturb the modal progression and that length frequencies may only be analyzed when data from a specific mesh size is used. The modal progression, however, may be biased due to the entangling capacity of the gear, resulting in a large range of sizes that is being caught. Nevertheless, the results of the analyses of the frequencies by mesh size are of the same order of magnitude, which is a justification for the use of the ELEFAN analysis of length frequencies obtained from a selective gear like a gillnet.

The growth parameters estimated by the analysis of the data from commercial catches match considerably with the results of the experimental data analysis, although the number and time of recruitment show some differences.

Concerning the 2 cm intervals, the following observation was made: in the case of Chandpur the largest length class with midlength 55 cm resulted in a minimum analyzable L_∞ of 57 cm (i.e. the minimum input value for L_∞ in the ELEFAN I analysis must be 57 cm), while the L_∞ values from the Chittagong data indicate an L_∞ smaller than 57. In the other environments no fish of the 55 cm (mid-length) length class were recorded; this phenomenon might influence

It should be noted that the length frequencies were not adjusted for mesh selection, because data needed for analysis of the mesh selectivity of the different mesh sizes were only available for a small number of overlapping months.

The post-Sicily version of ELEFAN I appeared to strongly reduce the number of growth parameter combinations with the best fit or highest ESP/ASP ratio. Due to “flagging out” of any peak hit by the growth curve, the ESP/ASP ratio could have a lower value than the ESP/ASP ratio obtained by the original ELEFAN I version, and this observation may be very important in the choice of the best fitting growth parameters for a set of length frequency data.

During finalization of the report, ICLARM’s latest version of ELEFAN reached the project’s headquarters. Analyses were carried out using this version and the results appeared to be of the same order of magnitude as obtained with the project’s post-Sicily version. In the latest version, however, the ESP/ASP ratios tended to be slightly higher, because ASP values have been lowered by adjustment of peaks surrounded by “zero-neighbours” (Brey and Pauly, 1986).

The Bhattacharya method gives interesting results, which may be compared with the results of other researchers, compiled by Raja (1985). Estimates of 217 and 357 mm were obtained for fish 1 and 2 years old in one case. In another case, modal groups were identified as 247, 343 and 393 mm for males and 265, 391 and 436 mm for females. The series identified from the present study, in combination with the growth parameter results, would indicate modal lengths of 22.1, 40.7 and 49.9 cm for one brood and 36.8 and 47.2 cm for the other. Analysis of these results, using Gulland-Holt, Ford-Walford and Von Bettalanffy plots results in growth parameters well comparable with those obtained from the ELEFAN analysis. The obtained t_o value, however, is considered to be unusually high. This result should be interpreted cautiously.

If tha highest exploitation rate obtained in Chapter 3.3 is accepted, the optimum exploitation rate for the maximum relative yield per recruit has not yet been reached. This would indicate that the Hilsa resources are not being overexploited and some degree of increase of fishing effort may be realized. A significant increase in effort will not result in a much higher production due to the lower catch rates that may be realized closer to the optimum yield level. It may also be stated that the yield curves show signs of levelling off beyond the optimum values which may give the wrong impression that the exploitation rate could be increased indefinitely without a decline in yield. This is not the case and such abnormal situations are commonly met with in tropical fisheries. The validity of the results of the relative yield per recruit analysis in this case appears to be questionable.

The relative yield per recruit in relation to the mean length at first capture (L_c) indicates that the optimum mean size is smaller than the values observed (Figure 4, arrows), for the 10.1, 11.4 and 12.6 cm mesh sizes (no data available for smaller mesh sizes). The L_c values may be higher due to entanglement of fish and the absence of smaller size groups on the fishing grounds (Azad et al., in press). The L_c values given in Table 2 were calculated from the Chittagong data only. Due to the lack of length frequencies by mesh size for other areas, no L_c values could be estimated. The L_c values for other areas, however, may differ from the values observed in Chittagong area because the exploited size ranges may differ from place to place and also from season to season due to the migratory character of *Hilsa.*

Theoretically the relative yield per recruit may be improved by catching more of the smaller sizes (by the use of nets with smaller mesh sizes). However, non-availability of smaller sizes of fish on the fishing grounds and entangling of fish besides gilling will create practical difficulties in implementing this. In general, the hilsa fishery in Bangladesh, by virtue of the behavioural factors of the fish and the gear, have regulated the exploitation in a unique way. It is emphasized once more that the results are based on the ELEFAN analysis of the Chittagong length frequencies only and so are of a tentative nature.

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Table 1

Annexure 4

Summary of the results of the ELEFAN I analysis of *Hilsa ilisha* **length frequencies**

Source	Brood	L_∞	k	ESP/ASP	Origin of growth curve
Chittagong 10.1 cm	1	56.8	1.15	**0.330978**	August
	2	56.4	0.91	0.234361	October/November
Chittagong 11.4 cm	1	56	1.15	0.429422	August
	2	56	0.90	0.110465	November
Chittagong 12.6 cm	1	56.1	0.91	0.317996	October
	2	56.8	1.15	0.181985	August
Experimental data	1	56.7	1.05	0.312734	April
	2	56.2	0.95	0.22187	August
	3	56.5	0.97	0.190237	November
Chandpur	1	58	0.825	0.197394	January
	2	57	0.78	0.145611	October/November

Table 2

Parameters obtained from the ELEFAN II analysis of *Hilsa* frequencies and some derived parameters used in the relative yield per recruit analysis (for the source of the L_∞ and k-values (see Table 1) $C = L_c/L_\infty$

Mesh Size(cm)	L_∞	k	Z	L	Lmean	Z from mean L	M	F	E=F/Z	L_c	T	$C=L_c/L_\infty$	I-C	M/k
10.1	56.8	1.15	3.89	40	43.8	3.997	1.62	2.27	0.58	38.9	27.4	0.68	0.32	**1.41**
10.1	56.4	0.91	2.98	40	43.8	3.065	1.39	1.59	0.53	38.9	27.4	0.69	0.37	**1.53**
11.4	56	1.15	4.73	41	42.2	4.964	1.63	3.10	0.66	39.0	27.4	0.70	0.30	**1.42**
11.4	56	0.90	3.65	41	43.6	4.210	1.39	2.27	0.62	39.0	27.4	0.70	0.30	**1.54**
12.6	56.1	0.91	2.39	40	44.4	2.453	1.40	1 .oo	0.42	39.2	27.4	0.70	0.30	**1.54**
12.6	56.8	1.15	3.12	40	44.4	3.285	1.62	1.50	0.48	39.2	27.4	0.69	0.31	**1.41**
12.0	56.7	1.05	2.53	36	41.8	2.718	1.49	1.04	0.41	34.5	26	0.61	0.39	**1.42**
12.0	56.2	0.95	2.23	36	41.8	2.377	1.40	0.82	0.37	34.5	26	0.61	0.39	**1.47**
12.0	56.5	0.97	2.31	36	41.8	2.477	1.42	0.90	0.39	34.5	26	0.61	0.39	**1.46**
Mixed	58	0.825	1.89	40	45.7	1.760	1.27	0.62	0.33	38.1	26	0.66	0.34	**1.54**
Mixed	57	0.78	1.68	40	45.7	1.529	1.23	0.45	0.27	38.1	26	0.67	0.33	**1.58**

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Annexure 5

MATURITY AND SPAWNING OF HILSA SHAD, HILSA *ILISHA* OF BANGLADESH

by M.S. Islam, Q.M. Huq, M. Hossain, S.A. Azad and N.N. Das
Directorate of Fisheries, Bangladesh

1. INTRODUCTION

Studies on maturity and spawning of hilsa in Bangladesh waters have received very little attention in the past and that too only from the riverine environment (Shafi, Quddus and Islam, 1976, 1977 and 1978 ; Quddus ***et al.,*** 1984b).

So far there have been no comparative studies of the fish available in all the three environments. A comprehensive knowledge about reproductive biology, i.e., sex ratio, maturity, spawning season, spawning frequency and fecundity, is essential for understanding the population, behaviour and migration of the stock in the different environments so as to embark on measures for management and propagation of the population.

Considering the above aspects, a research programme was undertaken with the collaboration of BOBP, in 1985, with sampling stations at Cox's Bazar, Chittagong, Khepupara, and Chandpur.

Since the research facilities were limited, some of the aspects intended to be investigated, namely spawning frequency and fecundity studies, could not be carried out.

This paper deals with aspects like sex ratio, size at first maturity, length-weight relationship, gonado-somatic index and relative condition. This study was carried out from April 1985 to March 1986.

2. MATERIALS AND METHODS

Samples were collected for biological studies from the commercial catches at the landing places of each station. Every month 2 samples of 25 fishes each were collected, once during each fortnight, and the dates were pre-fixed for each station, usually on the 3rd for the first half of the month and between the 17th and 20th in the second half. It was ensured to the best possible extent that the sample was taken randomly from one of the boats. The pro forma for recording the biological data is given in Appendix 1.

Total length, fork length, body depth, body weight, sex, maturity and gonad weight were the features recorded. The stages of maturity as classified by Raja (1970) were followed during this study.

The biological examinations were made either from fresh fish or at the earliest opportunity after preserving them in the deep freeze. Gonado-somatic index (GSI) was calculated using the conventional formula :

$$GSI = \frac{\text{Gonad Weight}}{\text{Body Weight}} \times 100$$

The length weight relationship was examined employing the conventional equation $W=aL^b$.

The relative condition factor, Kn, is expressed as W/W, where W is the observed weight of a fish of a certain length and $\hat{w}$ is the expected value for a fish of the same length obtained from the length-weight relationship.

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3. RESULTS AND DISCUSSIONS

3.1 Sex Ratio

Table I and II give the month-wise and size-wise proportion of sexes in the catches from the four sampling stations.

Chittagong: Out of 525 specimens, 252 were males and 273 were females, giving a ratio of 1 : 1.08 (Table I). It is observed from the table that females were more numerous from September to January but dominance by males was observed in the subsequent two months. However, the Chi-square test showed that the dominance of females was statistically significant only in August. This, however, did not influence the value for the whole period which did not show any significant difference in the sex ratio.

The size-wise sex ratios show that up to 33 cm there was no female representation, and that from 46 cm to 53 cm there were no males in the samples examined. Within the size groups 34 cm to 45 cm, there were no significant differences between sexes, although the males were more numerous up to 41 cm and females thereafter.

Cox's Bazar: Out of 395 specimens examined, 181 were males and 214 were females. The sex ratio of 1 : 1 .18 was found significantly different from 1 : 1 at 5% level but there was no significant difference if September data were omitted. Size-wise sex distribution shows that within the size range of 32 cm and 46 cm, there was no significant difference in the ratio, although numerically more males were observed up to 41 cm; thereafter the females were more numerous. Beyond 46 cm length, no males were encountered in the samples.

Khepupara: At this station there was very distinct dominance by males, to the extent of 316 against 132 females. The observed sex ratio of 1 : 0.42 was significantly different from the expected ratio of 1 : 1. Month-wise, there were no significant differences in September, November, January, February and March. In the remaining five months starting from June significant differences were obtained. The size-wise distribution of sexes also showed highly significant dominance by males in all sizes up to 34 cm and also thereafter at 36 cm, 41 cm, 42 cm. Beyond 45 cm there was seldom any representation of males.

Chandpur: Of a total of 536 specimens, 258 were males and 278 females. The observed ratio of 0.93 was found to differ significantly from 1 .O at 5% level but if December data were to be removed there was no significant difference. Size-wise proportions of sexes exhibited roughly the situation obtained at Khepupara. Up to 37 cm, the males were significantly more numerous. Even thereafter at 41 cm and 43 cm they were highly dominant. On the other hand from 48 cm onwards there were no males in the samples.

From the above results it is found that the monthly sex ratios at Chittagong, Cox's Bazar and Chandpur satisfied the 1 : 1 ratio, barring occasional deviations, On the other hand, at Khepupara the males were distinctly and significantly dominant in 5 out of 10 months. In the size-wise distribution it is seen that in the riverine and estuarine stations, either the males were significantly more numerous, up to about 34-37 cm, or they were absent in the samples, while in the marine stations, there were hardly any males in sizes up to about 33 cm. Another significant feature was that beyond 46 cm, there were no males at all in the samples at any stations. In Bangladesh, studies on sex ratio in hilsa have been made by Quereshi (1968), Shafi, Quddus and Islam (1976 and 1977), and Quddus et *al.* (1984a). However, although these authors have reported dominance of either males or females in some months or seasons, it is not known whether they were subjected to statistical test. It is now more or less clear that generally up to about 35 cm, the males are likely to be more numerous in a sample and that it would be difficult to find their representation beyond roughly 46-48 cm length. It is very likely that this difference is caused by a differential rate of growth, because earlier investigators have observed a faster rate of growth for females. (Pillay, 1958; Pillay and Rosa, 1963; Jhingran and Natarajan, 1966 ;

Quddus *et* a/., 1984a). Hence the dominance of males in the smaller sizes and their absence in the larger sizes.

3.2 Length-weight relationship

The following equations were obtained for hilsa of Chittagong, Khepupara and Chandpur:

Chittagong	Khepupara	Chandpur
$W = 0.0305\ L^{2.73}$	Male. $W = 0.0177\ L^{2.76}$	$W = 0\ 028\ L^{2.74}$
$(r^2 = 0.85)$	$(r^2 = 0.97)$	$(r^2 = 0.98)$
	Female* $W = 0\ ,0269\ L^{2.89}$	$W = 0.021\ L^{2.87}$
	$(r^2 = 0.98)$	$(r^2 = 0.98)$

Since the data recorded at Cox's Bazar were considered to be unreliable, probably due to malfunctioning of the balance, the data were not used for obtaining the relationship. It may be seen that in all cases the correlation coefficient was highly significant.

3.3 Relative condition factor

Having worked out the length-weight relationship, it was used to study the fluctuations in the relative condition factor, Kn, for the hilsa of the three stations (Figs. 1, 2 and 3).

3.3.1 Monthly condition: Generally values of Kn fluctuated between 0.9 and 1.1 for different months. At Chittagong, the trend for both sexes was almost the same, every alternate month the values rising or falling. The peak values were in April, June, August, October, December and February. The significance of such a rhythmic wave was not clear and will have to remain so especially in the absence of comparable data from the other marine station.

But for some minor differences, the data for both sexes followed each other's pattern at both Khepupara and Chandpur. At Khepupara, there were peaks during June-August and October-November. In Chandpur, the peaks were in March (only males), May-June, August-September. Connecting both pictures, a continuous period from March to November is obtained, followed by a rising trend from January to March.

3.3.2 Size-wise condition: The range in Kn values for different size groups is 0.75 to 1.1 5. The relevant Figs. 1, 2, and 3 clearly demonstrate a multiplicity of peaks for both males and females at all the three stations. For example, at Chittagong the males exhibited declensions at 34 cm, 41 cm and 44 cm, and the females at 37 cm, 42 cm, 45 cm, 47 cm and 51 cm.

Multiplicity of peaks is more pronounced in the cases of Khepupara and Chandpur. Since these declensions are signs of spawning activity, a broad generalization of the results obtained is that:

- the males appear to attain first maturity at sizes 26-29 cm as compared to 31-33 cm in the case of females.
- other evidence of sizes at subsequent spawning are at 33-38 cm, 40-46 cm and 49-54 cm, for males and females combined.
- the males reportedly having a slower growth may be spawning at sizes 26-29 cm, 33-35 cm, 41-44 cm and 46 cm as compared to the females at 31-33 cm, 35-40 cm, 49 cm and 54 cm.
- the major spawning seasons being suspected to be two, summer and winter, it would appear that the winter recruits may have the first spawning at sizes 26-33 cm and the second spawning at 41-49 cm; the summer recruits have the first spawning at 33-40 cm and the second spawning at 46-54 cm.
- the above hypothesis is further based on the assumption that the summer spawning is prolonged from June to November and that the summer recruits have a faster rate of growth than the winter recruits do, during January-March.

Annexure 5

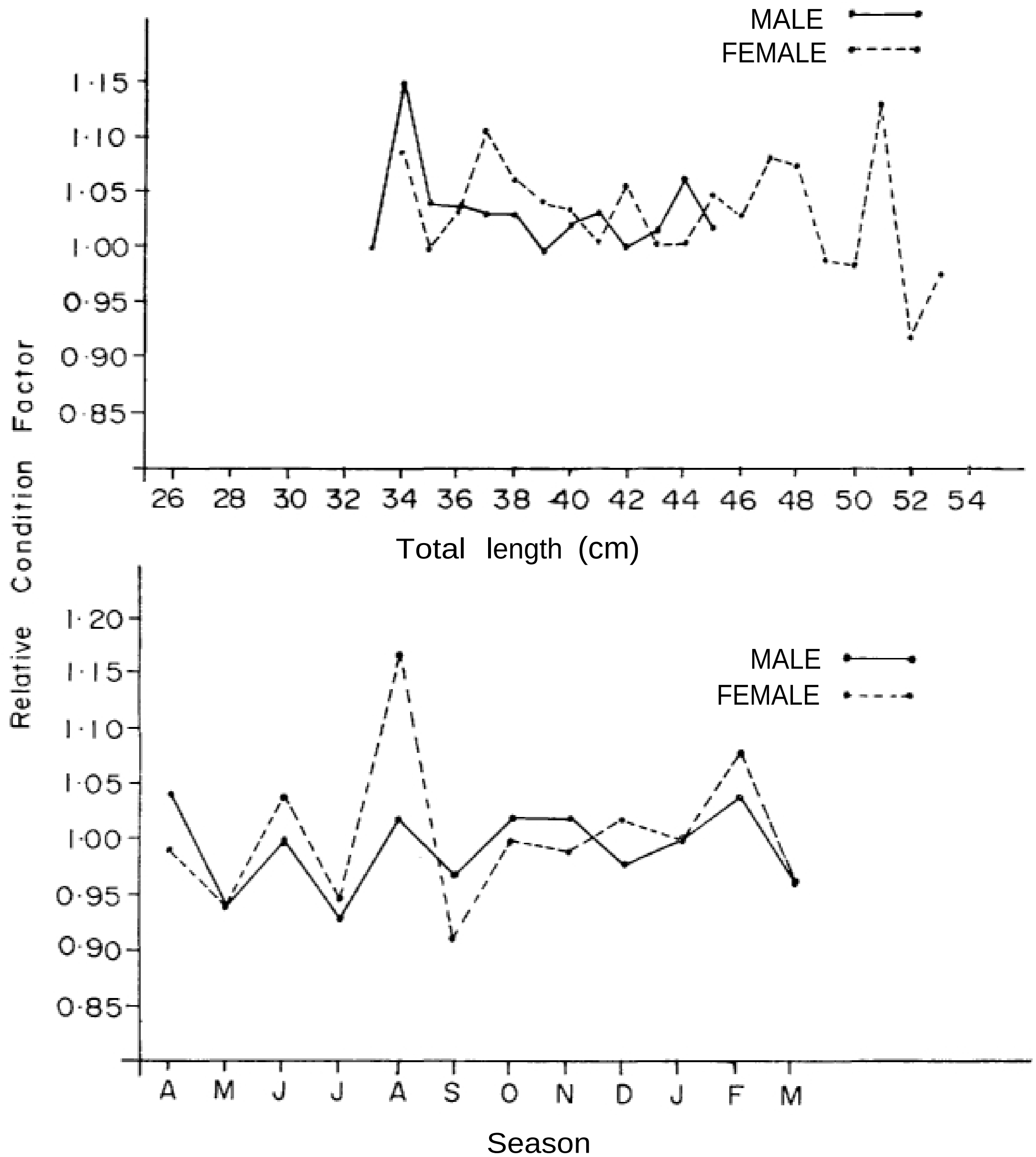

Fig. 1 Size-wise and month-wise mean values of relative condition factor in Chittagong area.

Annexure 5

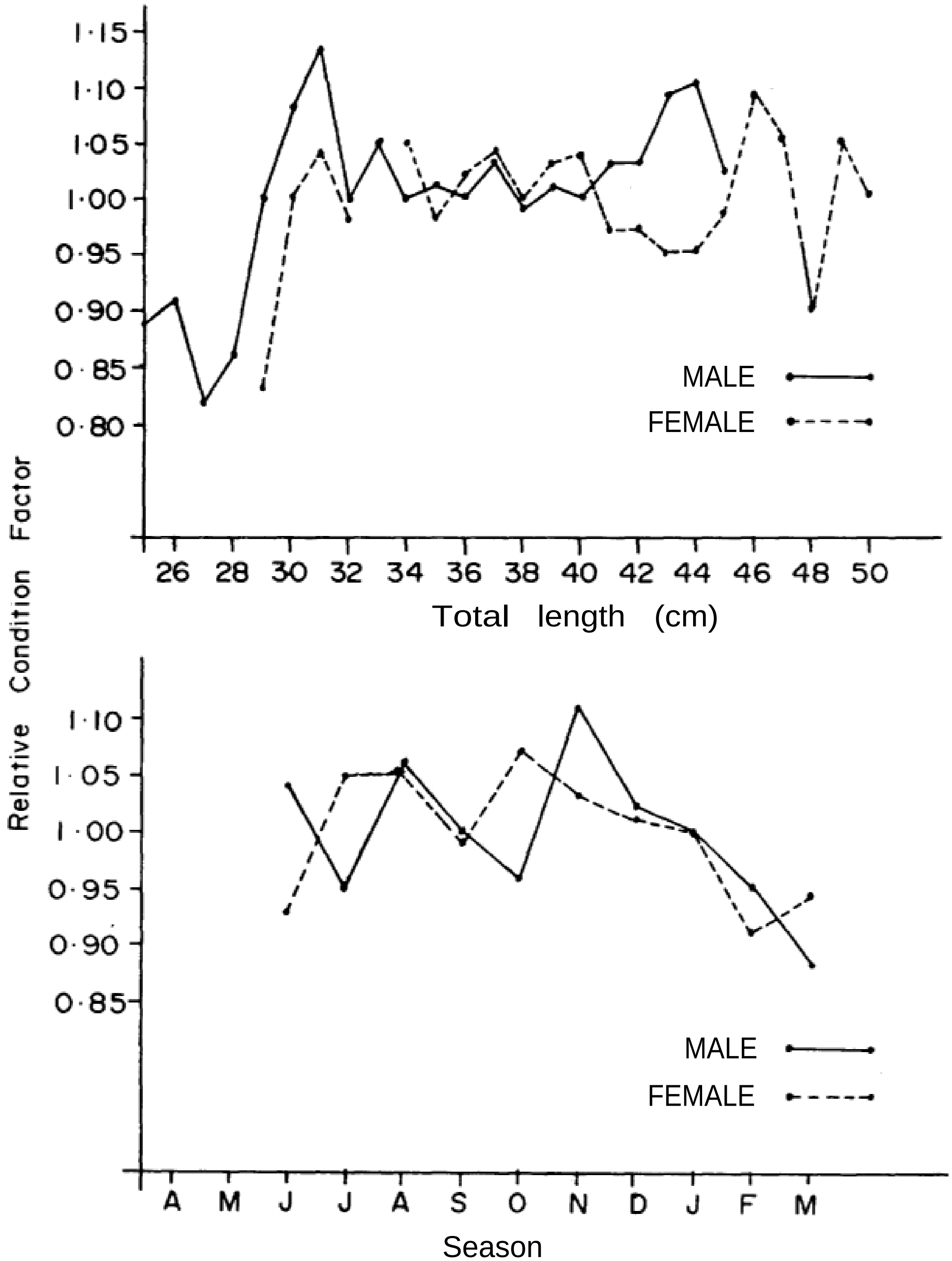

Fig. 2 Size-wise and month-wise mean values of relative condition factor, Khepupara area.

Annexure 5

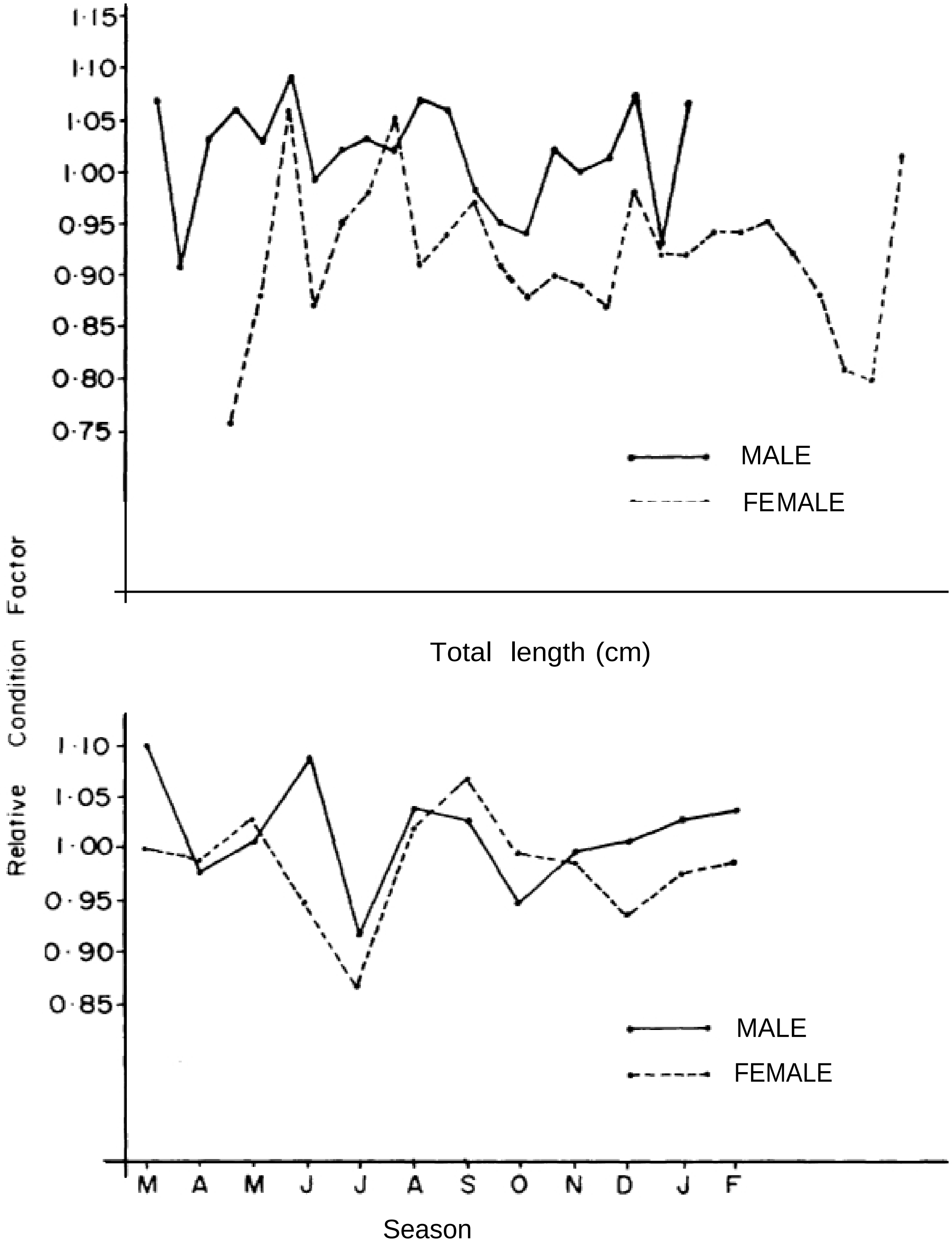

Fig. 3 Size-wise and month-wise mean values of relative condition factor in Chandpur area.

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3.4 Gonado-Somatic index

To detect the sizes at first maturity and at subsequent spawning and the period of peak spawning activity, one of the approaches was to calculate the Gonado-Somatic Index (GSI) and observe its fluctuations throughout the year and for different sizes. The values have been plotted in Fig. 4 for different months and in Fig. 5 for different sizes.

A perusal of these figures would show that the GSI values for males are low, less than 1.0 whether they are in respect of size or whether they relate to different months and even in the case of Chandpur in the vicinity of which spawning was believed to take place. For females, the **lowest** values were obtained at Cox's Bazar and the highest in Chandpur; Khepupara values were closer to those for Chandpur.

(i) *Cox's Bazac* Records were available only for six months, October 1985 to March 1986, showing a peak in October for both sexes. But the values are so low as to rule out any possibility of spawning in the marine environment.

The GSI values when plotted against length showed peaks at 34 cm, 36 cm and 41 cm in males and at 36 cm, 39 cm, 46 cm and 49 cm in females.

(ii) *Khepupara:* The months of October and February in the case of males and October for females showed peak values of GSI, with signs of forming other peaks in June and in March. With regard to size, the peak values were at 25 cm, 31/32 cm, 34 cm, 37 cm, 41 cm and 44 cm for males and at 31 cm, 34 cm, 37/39 cm, 44 cm, 47 cm and 50 cm for females.

(iii) *Chandpur:* The GSI values for females showed three peaks, in June, October and March, with the highest value in October. But for males, the peaks were observed in July, November and February. In respect of size, the values of GSI of females show many peaks-the first peak at 32 cm. The peaks following this are at 34 cm, 39 cm, 41 cm, 43 cm, 47 cm, 49 cm and 53 cm. For the males, the peaks are at 29 cm, 33 cm, 38 cm, 40 cm and 45 cm.

The conclusions that can be drawn from what appears, on the surface, to be a confusing conglomeration of months and sizes are:

(a) There is no evidence of any spawning taking place in the sea; the fish advance to maturity in the estuarine area and may spawn both in the estuaries and in the rivers. Oozing specimens were actually obtained in Sandwip area (estuarine) during experimental fishing in October 1985.

(b) Fish less than 20 cm were not available in the samples studied. Hence although technically speaking the first peak could not be ascertained, from the fact that for males in Khepupara the peak was at 25 cm and in Chandpur it was at 29 cm, and for females at 31 cm and 32 cm respectively, it can be tentatively indicated that the size at first maturity is around that size, the males becoming mature at a lower length than the females. The spawning thereafter may be at very short intervals, almost at every 2-4 cm, more frequent in females than in males.

(c) The major spawning appears to take place in October-November, and subsidiary spawnings in June-July and January-March (sexes combined) ; the former two are considered as summer spawning and the latter as winter spawning. The marine stations did not offer any evidence of ripening of gonads in winter.

Hossain (1985) studied the GSI of female hilsa in three environments-freshwater, estuarine and marine habitats -for each month, and his findings were as follows: There were three peaks in GSI values for Meghna hilsa, in October, June and February. The GSI values of estuarine hilsa showed two peaks, one in March, another in June. (His 'estuarine' sample came from Barisal, where the landings are a combination of riverine, estuarine and marine hilsa). On the other hand, the values of marine hilsa exhibited a rise in the value starting in June and reaching a peak in August. A small ascent of value was also noted in February with a fall in March. The findings of the present study are thus in close conformity with the observations of Hossain, the major difference being that Hossain had not recorded from the estuarine environment any peaking of GSI value in October-for the simple reason that his observation period did not cover September-October.

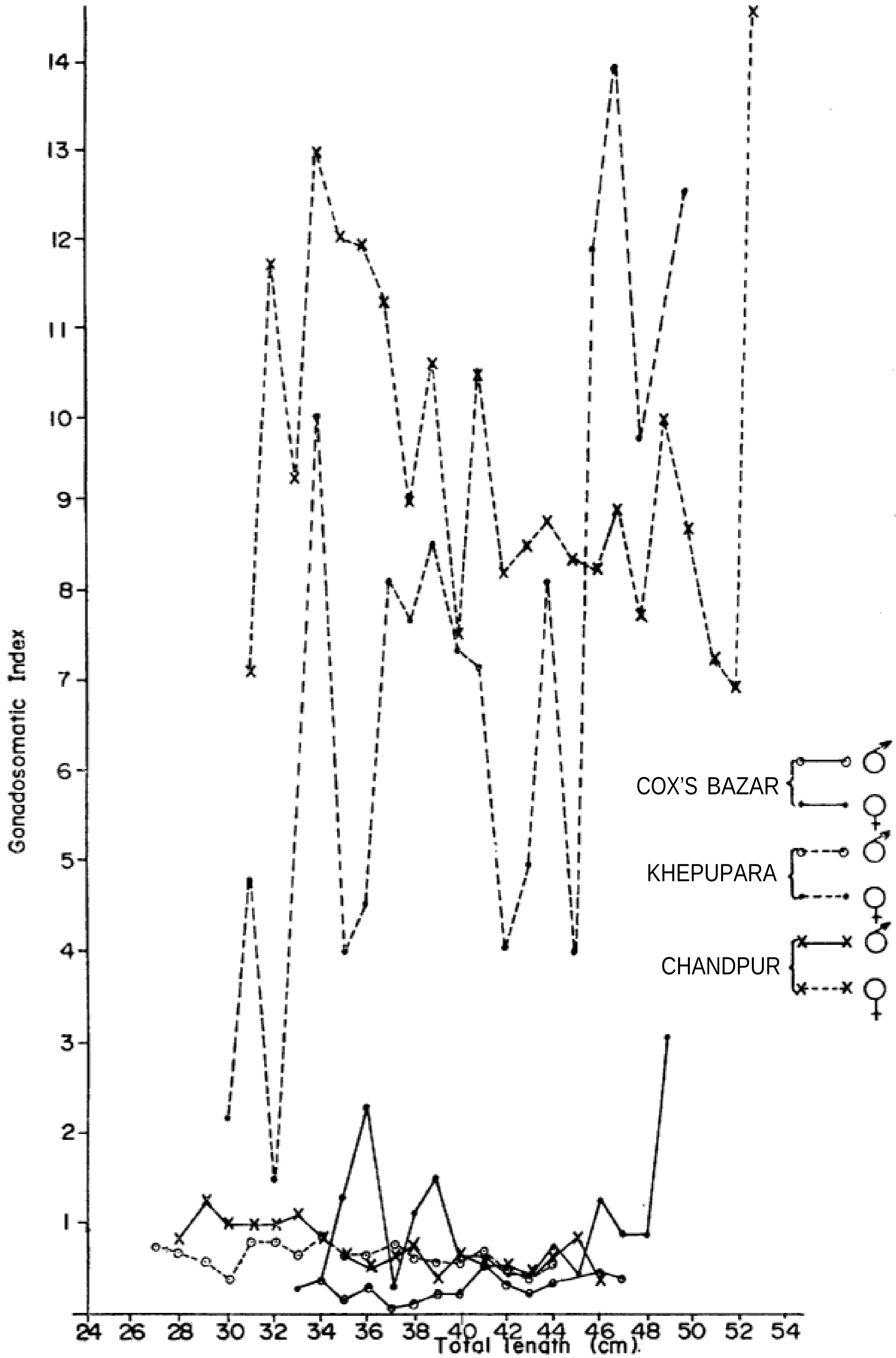

Fig. 4 Size-wise mean Gonado-somatic Index values for Cox's Bazar, Khepupara and Chandpur areas.

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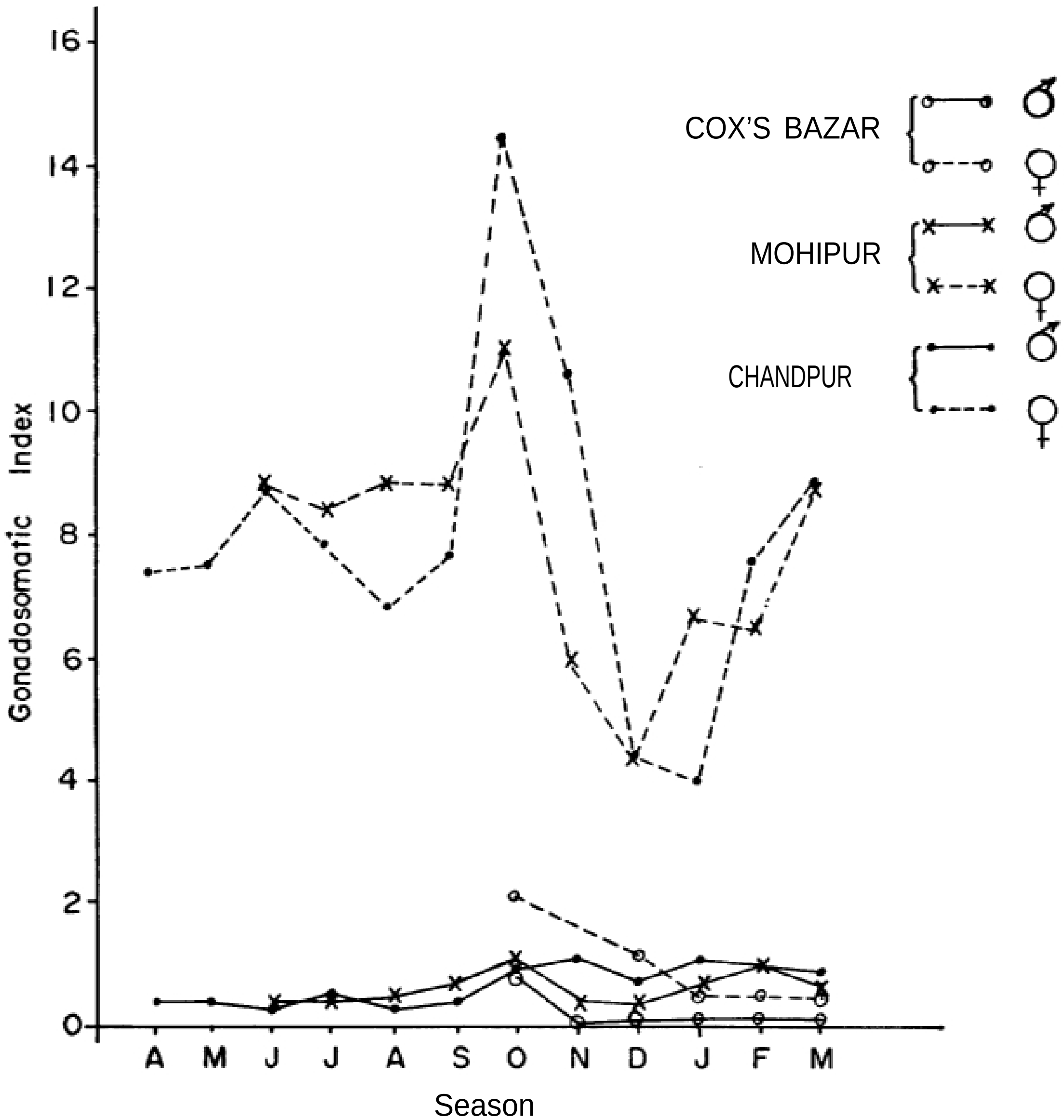

Fig. 5 Month-wise mean Gonado-somatic Index values in Cox's Bazar, Khepupara and Chandpur areas.

Quddus (1984b) determined the spawning season from GSI for the riverine hilsa and stated that type A (broader type hilsa) breeds from July to October with peak in the month of September and type B (slender) from January to March, peaking in February. The present study did not indicate any such distinction.

3.5 Occurrence of juvenile hilsa

Occurrence of early stages of juveniles (Jatka) offers evidence of a likely spawning season. Two juveniles of 10 and 11 cm were reported from Moheskhali channel at Cox's Bazar in February 1985. But in the estuarine and fresh water environment, more numerous juvenile hilsa were available. In Khepupara, juveniles were found during five months, from December to April 1986. The size range, mean, and modal sizes of Jatka in different months were as follows:

Month	Size range (cm)	Mean size (cm)	Modal size (cm)
December	4.2-9.1	5.6	6.0
January	5.9-9.5	7.2	5.0, 6.5
February	5.8-11.0	8.4	6.5, 7.5
March	7.3-11.0	9.5	9.5
April	7.2-15.1	12.7	11.5

The above records confirm the suspected spawning during October-November in the estuary/river. It also appears that they belonged to more than one brood. Probably the recruits of late spawning in October-November attain a length of 11.5 cm by April. In other words, the modal length of 11.5 cm may represent a growth of 4-5 months.

In Chandpur, from the data collected by Hossain (unpublished) it is seen that the juveniles were available throughout the period of observation, from December to August. It is suspected that as reported earlier for the Hooghly estuary in India (Bhanot, 1973), intermittent spawning occurs throughout the year.

4. SUMMARY

There were no significant monthly differences in sex ratio at Chittagong, Cox's Bazar and Chandpur. However, at Khepupara, there was distinct dominance of males in 5 out of 10 months. In the size-wise distribution, it is more or less clear that generally up to 35 cm, the males are likely to be more numerous and it would be difficult to find their representation beyond roughly 46 to 48 cm length. It is very likely that this difference is caused by differential rate of growth, the females growing faster, hence the dominance of males in the smaller sizes and their absence in the larger sizes.

The length-weight relationship for the samples from Chittagong, Khepupara, and Chandpur have been worked out.

Generally the value of the relative condition factor, Kn, fluctuates between 0.9 and 1.1 for different months and between 0.75 and 1.15 for different size groups. With regard to the monthly picture, there was almost a regular rhythmic pattern at Chittagong, the values rising and falling on alternate months. Combining the situations obtained at Khepupara and Chandpur, an almost continuous period from March to November shows the values at high level.

The males appear to attain first maturity at size range of 26-29 cm as compared to 31-33 cm in the case of females, This may probably be followed by spawning at 32-35 cm, 41-44 cm and 46 cm in the case of males and 31-33 cm, 35-40 cm, 49 cm and 54 cm in the case of females.

There is as yet no evidence of spawning in the sea; the fish are likely to spawn in the estuaries and the rivers. One of the spawning grounds is in the estuarine Sandwip area. There are nursery grounds around Khepupara and Chandpur.

Major spawning appears to take place in October-November, and subsidiary spawning in June-July and January-March. Past records of juveniles at Chandpur from December to August appear to justify the suspicion that intermittent spawning may take place throughout the year but intensive activities may be in the periods indicated above.

Records of juveniles from Khepupara indicate a growth of about 11.5 cm in 4 to 5 months.

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Table 1

Proportion of sexes for different months at the four sampling stations

Months	Chittagong		Cox's Bazar		Khepupara		Chandpur	
	Male	Female	Male	Female	Male	Female	Male	Female
April	11	14	19	31	—	—	16	29
May	13	12	12	38	—	—	20	30
June	26	24	—	—	46	4	25	24
July	12	13	—	—	30	5	28	17
August	40	10	32	18	40	10	9	16
September	21	29	21	4	32	18	25	25
October	13	37	25	25	19	6	40	36
November	17	33	24	26	22	23	17	33
December	20	30	20	25	34	11	17	4
January	20	30	8	17	32	17	19	20
February	27	23	12	13	35	15	18	23
March	32	18	8	17	26	23	24	21
Total	252	273	181	214	316	132	258	278
Ratios	1 : 1.08		1 : 1.18		1 : 0.42		1 : 1.08	
Sum of chi-square	10.65		19.90*		175.85**		11.78*	

*Significance at 5% level

**Significance at 1% level

Table II

Size-wise distribution of sexes at the four sampling stations

Length Group	Chittagong Male	Chittagong Female	Cox's Bazar Male	Cox's Bazar Female	Khepupara Male	Khepupara Female	Chandpur Male	Chandpur Female
21	-	—	—	—	3	—	—	—
22	-	—	—	—	2	1	—	—
23	-	—	—	—	-	—	—	—
24	-	—	—	—	-	1	—	—
25	-	—	—	—	5	—	—	—
26	-	—	—	—	4	1	—	—
27	-	—	—	—	5	—	2	—
28	1	—	—	—	2	—	1	—
29	-	—	—	—	1	1	3	—
30	-	—	1	—	8	1	9	1
31	-	—	—	—	8	1	10	3
32	-	—	2	1	16	1	14	2
33	3	—	2	1	21	—	12	2
34	7	4	2	4	30	4	13	2
35	8	5	11	4	25	9	13	1
36	14	13	17	9	32	10	17	1
37	33	12	15	9	22	14	15	3
38	37	24	26	13	25	13	21	13
39	34	22	30	18	19	9	22	12
40	35	29	18	12	14	13	16	15
41	32	21	23	18	32	9	31	5
42	24	25	17	18	20	5	28	11
43	18	22	10	14	8	3	31	7
44	5	21	7	17	7	5	16	15
45	1	24	1	13	4	2	7	12
46	-	18	1	13	-	8	3	32
47	-	11	—	16	-	9	5	41
48	-	10	—	13	3	8	—	43
49	-	4	—	6	-	3	—	28
50	-	5	—	3	-	1	—	25
51	-	1	—	3	-	—	—	10
52	-	1	—	—	-	—	—	7
53	-	1	—	—	-	—	—	4
54	-	—	—	—	-	—	—	1
55	-	—	—	—	-	—	—	1
Sum of chi-square	6.43		10.42		395.14**		620.32**	

Appendix I

BIOLOGICAL RECORD

Landing centre :

Biologist:

Sample weight:

Details of the boat sampled

Date of collection :

Date of examination :

Sl.No.	TL (cm)	FL (cm)	DP (cm)	WT (gm)	Sex	Maturity	Gd. wt. (gm)	Remarks
1								
2								
3								
4								
5								
6								
7								
8								
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25								

Annexure 6

ANALYSIS OF SOME MORPHOMETRIC AND MERISTIC CHARACTERS OF *HILSA ILISHA* OF BANGLADESH WATERS

by N.N. Das, T. Nishida, S.A. Azad, M.S. Islam, M. Hossain and Q.M. Huq*

1. INTRODUCTION

The Hilsa Shad, *Hilsa ilisha* (Hamilton), is one of the most important species of food fish caught in Bangladesh and is a major source of protein in the people's diet and for providing employment. Over the past four decades or so, a number of reports have dealt with morphometric and meristic differences in *Hilsa ilisha* in the Indo-Bangladesh region. The important work on Bangladesh hilsa is that of Quddus et *al.* (1984), besides brief studies of Quereshi (1968) and Shafi, Quddus and Hossain (1977). However, all these investigations had covered inland waters only — riverine and estuarine. From the review attempted by Raja (1985), it seems that these investigations have resulted in establishing individually different stocks in each of the major river systems in the Indo-Bangladesh region. In addition he had also drawn attention to the report of segregation of stocks into at least two varieties, a broad and slender one, in India, Bangladesh and Burma. It was also pointed out by him that no studies have been made on the composition, continuity, independence or interdependence of the stocks of the marine sector. Provisionally, based purely on the evidence of available literature, he suggested that there may be at least four stocks in the region, three anadromous and one marine. The three anadromous stocks may be distributed thus: one in the Indo-Bangladesh area, one in eastern Bangladesh and one in the central and southern regions of Burma. The marine stock may be contributing to the fishery of south-eastern Bangladesh coast contiguous with the Arakan coast of Burma. These are supposed to be in addition to the purely fluviatile stocks in the upper reaches of the five major river systems in India, Bangladesh and perhaps in Burma.

Because of the total lack of any racial studies on the hilsa of the marine environment, the investigations launched by the UNDP/FAO project "Marine Fishery Resources Management in the Bay of Bengal" included the aspect of racial studies in the programme to cover the hilsa from riverine, estuarine and marine environments,

All approaches were considered -biometric, biochemical, cytogenetic and tagging. It was also originally planned to subcontract the work to a university. Financial demands for undertaking biochemical/cytogenetic studies were too high to be accommodated within the project's budget. Tagging experiments are a still more expensive undertaking. Hence it was decided to limit the approach to the conventional one, biometrics. In its attempt at exploring the possibilities of subcontracting the studies to the university, the project lost considerable time. Hence the studies could be initiated only during the middle of the project period, September 1985, thus limiting the study period to about 6-7 months.

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2. MATERIALS AND METHODS

The samples were collected from September/October 1985 to March 1986 from the experimental and commercial catches from Cox's Bazar, Chittagong, Khepupara and Chandpur.

From Chandpur, an adequate sample size could not be obtained from experimental fishing; hence a part of the samples of Chandpur was procured either from the fishing ground or from the landing centre. For Khepupara, all the samples were procured from commercial catches since no experimental fishing could be conducted in that area. The number of fish examined from different stations by month and sex is shown in Table I.

Originally the plan was to examine the fish the same day they were procured in respect of Chandpur, Khepupara and Chittagong stations. Only with regard to Cox's Bazar would there be some delay in the arrival of iced samples at Chittagong, but they were to be examined immediately after. For this purpose the senior author was expected to be at Chittagong when the samples arrived but unfortunately he could not adhere to this plan. Consequently, the samples caught during experimental fishing were preserved in ice on board, and transferred to deep freeze after landing until they were taken up for examination. Except the Khepupara samples which were examined fresh, the other samples from the fishing grounds or from the landing centre were also kept in deep freeze for later examination. The period that elapsed between the time of procurement and the time of examination is shown in Table II.

The morphometric and meristic characters chosen ware those which had in the past been found to have exhibited significant differences. Such selected morphometric characters were the total length (TL), depth at dorsal origin (DP), head length (HL), thickness of body (TH), eye diameter (ED) and caudal peduncle length (CPL). The meristic characters selected are post-pelvic scutes (PS) and pectoral fin rays (PF).

Total length was measured with the help of a metre scale to the nearest millimeter, while body depth, caudal peduncle length, head length, thickness of body and eye diameter were measured with the help of a slide caliper. The accuracy of the slide caliper was 0.5 mm. All meristic counts and morphometric measurements were made following Pillay (1957).

The following definitions were applied to the characteristics measured or counted.

Total length (TL) is the distance from the tip of snout, when the mouth is closed, to the tip of the lower lobe of the caudal fin, when stretched out.

Depth at dorsal origin (DP) is the distance between the dorsal and ventral edges of the body as measured from the origin of dorsal fin.

Head length (HL) is the distance from the tip of snout, when mouth is closed, to the posteriormost point of the operculum.

Thickness of ***body*** (TH) is measured across the thickest part, usually at the 5th-6th lateral line scale of each side.

Eye diameter (ED) is measured longitudinally across the left eye.

Caudal peduncle length (CPL) is the distance from the posterior edge of the base of the anal fin to the base of caudal fin.

Pectoral fin rays (PF) is the number of the fin rays in the pectoral fin.

Post-pelvic scutes (PS) is the number of scutes posterior to the origin of the pelvic fin at the anal opening.

In addition, the individual weights of fish and stages of maturity were also recorded.

The data were subjected to regression analysis and analysis of covariance with the help of the Microstat Programme on an Apple IIe microcomputer.

The descriptive statistics of morphometric characters and those of meristic characters are shown in Table III and IV.

3. RESULTS

(i) Morphometric characters

Among all the morphometric characters, the estimated regression statistics between TL vs DP, TL vs HL, TL vs TH, TL vs CPL and HL. vs ED between months and stations are shown in Table V to IX. It may be seen from these tables that only for the relationship between TL and HL (Table VI) was the r^2 value more or less uniformly high, at the level of 85 to 100% at all the stations, for the months of November to February. The data were therefore subjected to analysis of covariance. Since the r^2 values of other morphometric characters were very erratic and were not of a significant order, analysis of combinations of these variables, month-wise and station-wise, could not be justified. The erratic and/or low value of r^2 is attributed to the data being affected by a certain factor or factors. Hence no further treatment of data was taken up for other morphometric characters.

Total length and head length

The scatter diagrams for the variables is shown in Fig. 1, and the estimated parameters of the regression equation for the pooled data of each station in Table X. The analysis of covariance for the relationship between total length and head length showed that there were no significant differences in the slopes of the regression lines between stations, but the intercepts exhibited significant differences. The test for the intercepts indicated that those relating to Chittagong and Cox's Bazar were not different from each other and the same was the case between Chandpur and Khepupara. It was hence concluded that some factor could be responsible for this separation of Chittagong/Cox's Bazar fish on the one hand and Chandpur/Khepupara fish on the other.

It may be recalled that the frozen periods for different stations were different (Table II). In order to see whether differences in the frozen period could have affected the intercept, a dozen Hilsa from Chandpur were collected on 12-6-1986 and frozen till they were analysed on 1-7-1986.

Fig. 2 shows the relationship between the number of days of preservation and the values of intercept in the regression equation. It may be seen that the values of intercept increase as the days of preservation increased. After analysis it was found that while the value of the slope remained the same, i.e., 0.23, the value of intercept, 3.0278, falls on the line for the values obtained earlier on the basis of which Fig. 2 was drawn.

Since in the case of samples from Chittagong and Cox's Bazar the preservation days were more than double that of Chandpur, it is possible that the high values of intercept obtained for Chittagong and Cox's Bazar was due to the longer period of preservation. If this difference were to be rejected on the basis of this causal factor, the conclusion is that between TL and HL there is no significant difference between the samples of the four stations.

(ii) Meristic characters

Post-pelvic scutes: Analysis of variance to test the significance of averages among four stations (Table XI) showed that there was no significant difference in the number of post-pelvic scutes among four stations, a conclusion which is completely different from earlier investigations on this character (Pillay, 1957 ; Rao, 1969 ; Quddus *et al., 1984).*

Pectoral fin rays: The results of analysis (Table XII) indicated the same conclusions as for the post-pelvic scutes, namely, no significant difference between the stations, which again is a departure from some of the earlier works (Rao, 1969, Quddus et *al., 1984).*

In general, the results from these two characters did not indicate the existence of more than one race of ***Hilsa ilisha*** at the stations investigated, and there was no evidence or basis for an unbiased separation of samples for any comparative study.

4. SUMMARY

Nearly 500 specimens were measured from four stations representing marine, estuarine and riverine sectors. The morphometric characters selected for the study were total length, depth at dorsal origin, thickness of body, caudal peduncle length, head length and eye diameter; the meristic characters were post-pelvic scutes and pectoral fin rays.

Among the five different pairs of non-meristic characters, the correlation between four of them was found to be erratic and not significant. Although in the case of total length versus head length, the correlation was of high order and there were no significant differences in the regression coefficient, the differences in the values of intercept were traced to the differences in the period of storage under frozen conditions. Thus the results obtained on the morphometric data have to be totally rejected for reasons of defective methodology in preservation of fish.

Analysis of variance on the two meristic characters showed that there were no significant differences in the mean values between stations.

5. LITERATURE CITED

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Annexure 6

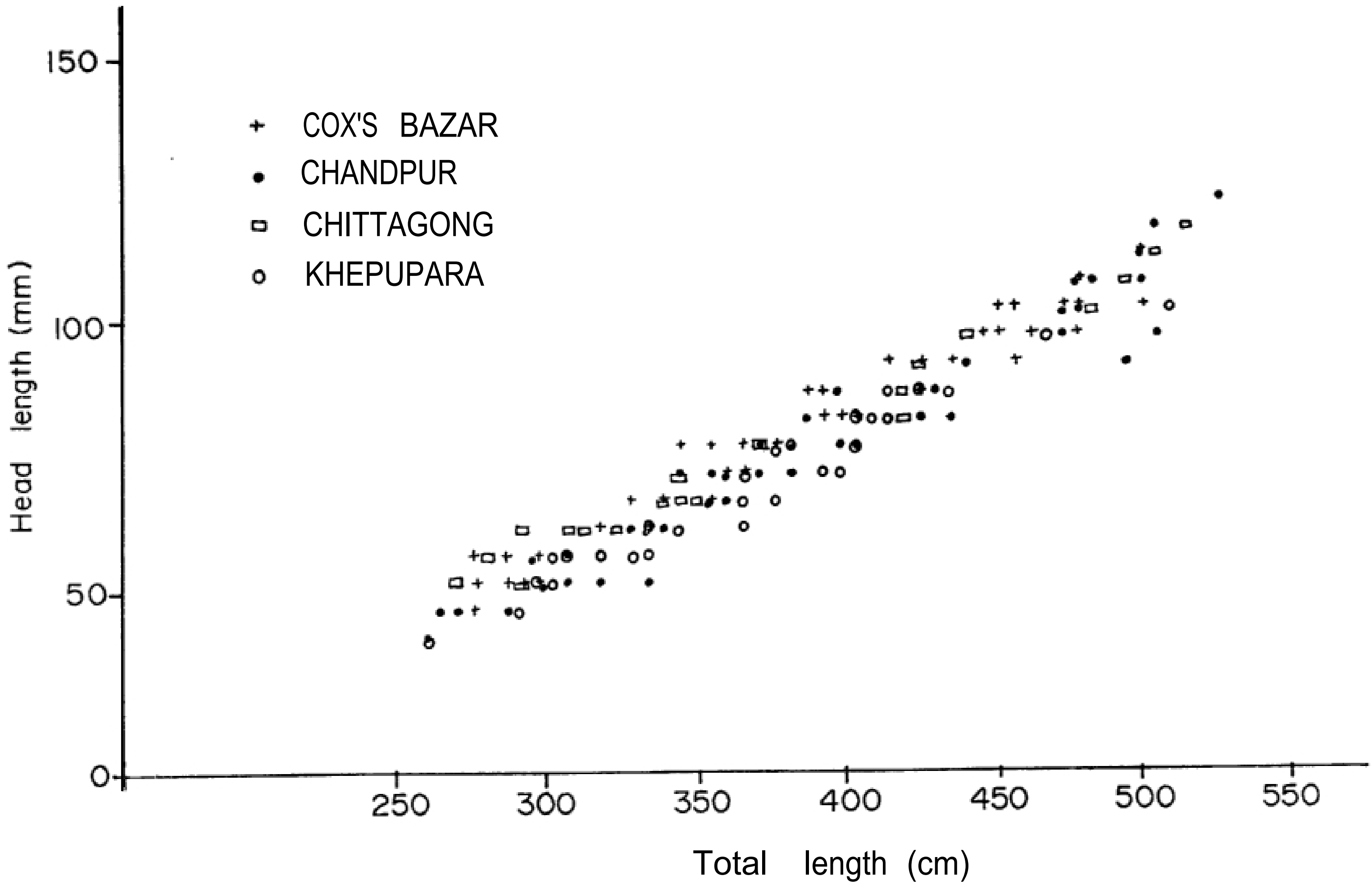

Fig. 1 Scatter diagram of Total Length (TL) versus Head Length (HL) of *Hilsa ilisha,* at Cox's Bazar Chittagong, Khepupara and Chandpur.

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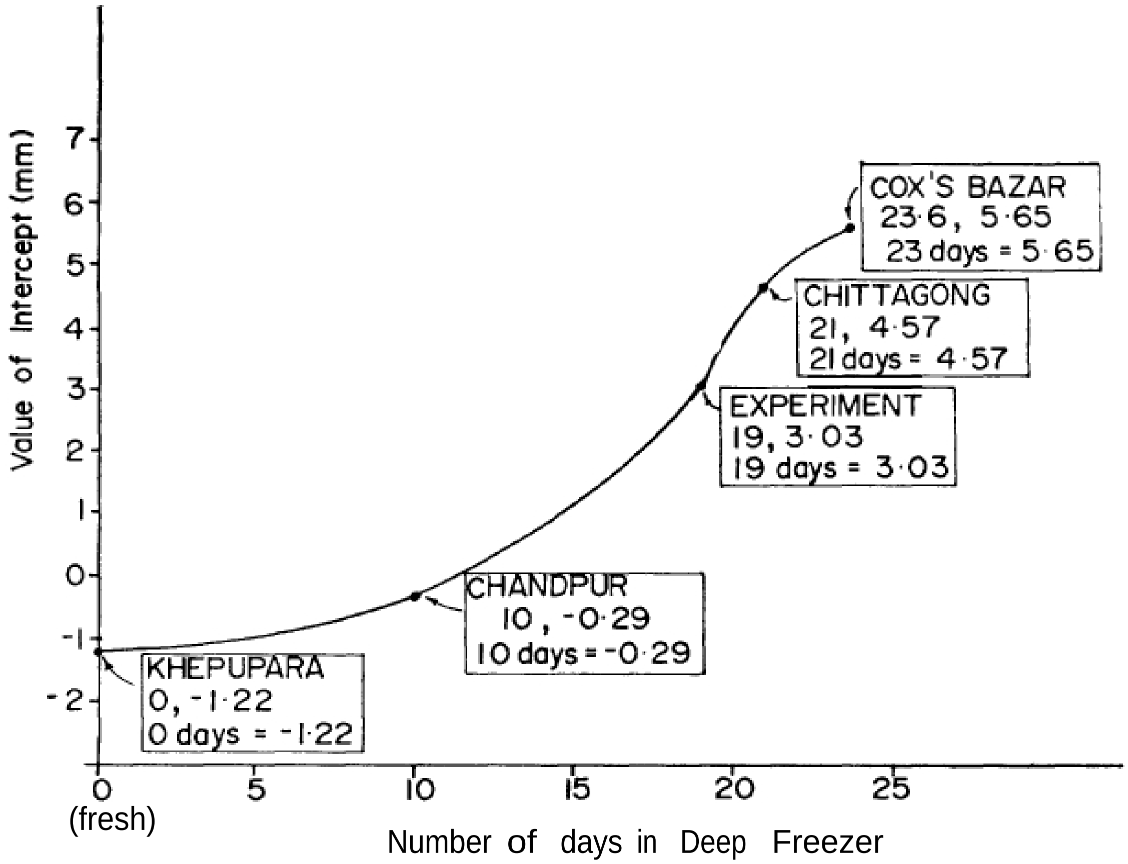

Fig. 2 Relationship between period of preservation of *Hilsa ilisha* in deep-freezer and intercept values obtained from regression analysis of "total length versus head length".

Table I

Number of fish examined by month, sex and station

Month	Cox's Bazar			Chittagong			Chandpur			Khepupara		
	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
Sep. 1985	—	—	—	—	—	—	5	21	26	—	—	—
Oct. 1985	14	7	21	18	5	23	10	10	20	—	—	—
Nov. 1985	15	3	18	9	12	21	12	12	24	8	12	20
Dec. 1985	14	10	24	11	12	23	4	15	19	2	18	20
Jan. 1986	12	7	19	—	—	—	7	8	15	14	10	24
Feb. 1986	3	15	18	7	11	18	7	8	15	10	14	24
March 1986	13	10	23	15	10	25	10	14	24	6	18	24
Total	71	52	123	60	50	110	55	88	143	40	72	112

Table II

Interval between collection of samples and their examination

Station	Date of collection	Date of examination	Period under frozen condition	Average period of preservation
Chittagong	Sept. 15	Oct. 10	25	21 days
	Oct. 14	Oct. 29	15	
	Nov. 14	Nov. 27	13	
	Dec. 23	Jan. 25	33	
	Feb. 20	Mar. 21	29	
	Mar. 15	Mar. 26	11	
Chandpur	Sept. 25	Oct. 7	12	10 days
	Oct. 28	Nov. 12	15	
	Nov. 28	Dec. 1	4	
	Dec. 26	Dec. 27	1	
	Jan. 26	Jan. 28	2	
	Feb. 27	Mar. 23	24	
	Mar. 25	Apr. 5	12	
Cox's Bazar	Sept. 7	Oct. 2	25	23.6 days
	Oct. 7	Oct. 30	23	
	Nov. 7	Nov. 28	21	
	Dec. 27	Jan. 25	29	
	Jan. 7	Jan. 26	19	
	Feb. 20	Mar. 21	29	
	Mar. 7	Mar. 26	19	
Khepupara	Nov. 19	Nov. 19	0	0 days
	Dec. 23	Dec. 23	0	
	Jan. 19	Jan. 19	0	
	Feb. 19	Feb. 19	0	
	Mar. 31	Mar. 31	0	

Table III

Minimum and maximum values of morphometric characters and weight of fish at different sampling stations

		Chittagong	Chandpur	Cox's Bazar	Khepupara
Total length (TL)	Min	288	262	287	279
	Max	488	529	488	488
Depth at dorsal origin (DP)	Min	72.3	44.4	58.5	75.8
	Max	123.4	138.6	135.3	136.8
Head length (HL)	Min	69.85	40.6	68.2	63.4
	Max	117.1	122.3	114.4	115.6
,Caudal peduncle length (CPL)	Min	19.5	10.8	19.6	20.2
	Max	39.1	51.2	35.45	35.2
Eye diameter (ED)	Min	9.8	10	10.4	10.08
	Max	15.8	20.3	15.4	18.2
Weight (WT)	Min	190	140	220	260
	Max	1330	1600	1420	1320

Table IV

Descriptive statistics for meristic character examined

Meristic character		Chittagong	Chandpur	Cox's Bazar	Khepupara
		n=136	n=121	n=130	n=113
	Min	12	11	10	12
Post-pelvic scutes (PS)	Max	15	15	14	15
	Mean	13.1324	13.1135	12.9813	13.1681
	Std. Dev.	0.541723	0.631246	0.507452	0.532894
		n=142	n=111	n=133	n=111
	Min	14	13	14	13
'Pectoral fin rays (PF)	Max	16	15	16	16
	Mean	14.7817	14.5594	14.7929	14.5664
	Std. Dev.	0.49273	0.51214	0.533137	0.564992

Table V

Regression statistics on the relationship between depth (DP) at dorsal origin and total length (TL) with sex combined and separated by station and by month

(CTG=-Chittagong; CHA=Chandpur; CB=Cox's Bazar; KHE=Khepupara)

Month	Station	Sex Slope	Combined Intercept	n	r^2	n	Male r^2	Female r^2	n
October	CTG	0.27	0.97	23	0.42	5	0.8243	0.4049	18
	CHA	0.19	30.36	20	0.51	10	0.8029	0.2752	10
	CB	0.28	-4.97	21	0.76	7	0.9111	0.4311	14
	KHE	-	-	—	—	—	—	—	—
November	CTG	0.21	17.90	21	0.91	12	0.9258	0.9696	9
	CHA	0.26	4.00	24	0.88	12	0.9604	0.5636	12
	CB	0.1 9	33.18	18	0.62	3	0.6955	0.7889	15
	KHE	0.21	21.89	20	0.76	12	0.7059	0.9643	8
December	CTG	0.27	-4.66	23	0.91	12	0.9567	0.9228	11
	CHA	0.24	10.47	19	0.95	15	0.8684	0.9821	4
	CB	0.22	13.85	24	0.82	10	0.7764	0.8427	14
	KHE	0.18	30.64	20	0.70	18	0.7599	-	2
January	CTG	-	-	—	—	—	—	—	—
	CHA	0.27	-1.05	15	0.92	8	0.6872	0.8966	7
	CB	0.25	-3.55	19	0.90	7	0.9072	0.8847	12
	KHE	0.27	1.51	24	0.70	10	0.5584	0.5751	14
February	CTG	0.18	35.36	18	0.44	11	0.5728	0.0781	7
	CHA	0.32	-19.52	15	0.96	8	0.9188	0.8325	7
	CB	0.22	10.94	18	0.30	15	0.2871	0.9996	3
	KHE	0.23	13.13	24	0.84	14	0.8327	0.6341	10
March	CTG	0.23	8.50	25	0.74	10	0.0317	0.7120	15
	CHA	0.17	31.41	24	0.57	14	0.4678	0.7294	10
	CB	0.26	-4.36	23	0.80	10	0.8199	0.7670	13
	KHE	0.30	-16.83	24	0.88	18	0.8567	0.8417	6

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Table VI

Regression statistics on the relationship between head length (HL) and total length (TL) by month and station

Month	Station	Slope	Intercept	r^2	n
	CTG	0.23	5.28	0.86	23
October	CHA	0.22	9.64	0.80	20
	CB	0.21	12.88	0.93	21
	KHE	—	—	—	—
	CTG	0.23	2.56	1.00	21
November	CHA	0.23	1.17	0.94	24
	CB	0.20	16.16	0.94	18
	KHE	—	—	—	—
	CTG	0.22	6.01	0.97	23
December	CHA	0.22	3.49	0.99	19
	CB	0.22	6.29	0.96	24
	KHE	0.25	-7.28	0.97	20
	CTG	—	—	—	—
January	CHA	0.23	0.82	0.95	15
	CB	0.22	4.85	0.99	19
	KHE	0.23	-0.68	0.93	24
	CTG	0.26	-9.67	0.75	18
February	CHA	0.24	-2.64	0.99	15
	CB	0.27	-8.89	0.95	18
	KHE	0.22	6.81	0.92	24
	CTG	0.25	-7.59	0.85	25
March	CHA	0.13	31.89	0.58	24
	CB	0.21	12.86	0.89	23
	KHE	0.24	-2.92	0.92	24

Table VII

Regression statistics on the relationship between thickness of body (TH) and total length (TL) by sex, month and station

Month	Sex	Station	Slope	Intercept	r^2	n
October	Female	CTG	0.0769	13.6226	0.2989	18
		CHA	0.0509	26.4186	0.4301	10
		CB	0.0961	8.7043	0.5021	14
		KHE	-	-	-	-
October	Male	CTG	0.2410	-1.3907	0.9558	5
		CHA	0.0646	18.0475	0.4192	10
		CB	0.1362	-9.0618	0.8224	7
		KHE	-	-	-	-
November	Female	CTG	0.1019	3.8713	0.9598	9
		CHA	0.0836	14.3803	0.4943	12
		CB	0.0802	16.2136	0.3195	15
		KHE	0.0867	11.0026	0.8268	8
November	Male	CTG	0.2140	7.8892	0.9917	12
		CHA	0.1122	6.6294	0.7296	12
		CB	-0.1036	82.0281	0.2379	3
		KHE	0.0727	13.7824	0.3010	12
December	Female	CTG	0.1385	-7.5309	0.7289	11
		CHA	0.0471	30.3289	0.6222	4
		CB	0.1369	-8.7068	0.9298	14
		KHE	-	-	-	-
December	Male	CTG	0.1049	1.8133	0.7180	12
		CHA	0.1063	7.3638	0.7477	15
		CB	0.0869	9.5123	0.7121	10
		KHE	0.0620	21.3347	0.6524	18
January	Female	CTG	-		-	-
		CHA	0.0907	10.4579	0.8761	7
		CB	0.1540	-16.7977	0.8970	12
		KHE	0.0727	17.7859	0.6830	14
January	Male	CTG	-	-	-	-
		CHA	0.0014	-8.1417	0.5233	8
		CB	0.1131	0.3027	0.7894	7
		KHE	0.0616	20.9932	0.4488	10
February	Female	CTG	-0.0253	60.5406	0.0220	7
		CHA	0.1789	-31.3052	0.6197	7
		CB	0.2275	-35.4532	0.8620	3
		KHE	0.0446	27.7230	0.4253	10
February	Male	CTG	0.0545	24.8258	0.1570	11
		CHA	**0.1378**	**-8.5301**	**0.6512**	8
		CB	0.1279	-4.4318	0.7527	15
		KHE	0.0923	9.1503	0.6555	14
March	Female	CTG	0.0412	29.5690	0.2502	15
		CHA	0.0699	21.4957	0.3496	10
		CB	0.1070	0.3080	0.7781	13
		KHE	0.0961	4.4403	0.7327	6
March	Male	CTG	0.1524	-17.4828	0.3301	10
		CHA	0.0492	17.3203	0.3831	14
		CB	0.1138	0.7238	0.7183	10
		KHE	0.1325	-7.3213	0.6199	18

Table VIII

Regression statistics on the relationship between caudal peduncle length (CPL) and total length (TL) by month and station (sex combined)

Month	Station	Slope	Intercept	r^2	n
October	CTG	0.0930	-8.5158	0.5074	23
	CHA	0.0704	0.7623	0.7683	20
	CB	0.0625	4.1248	0.6015	21
	KHE	—	—	—	—
November	CTG	0.0885	-5.0843	0.9471	21
	CHA	0.1065	-12.6249	0.7679	24
	CB	0.0651	3.1477	0.6448	18
	KHE	0.0685	1.4547	0.6703	20
December	CTG	0.0712	0.4181	0.8285	23
	CHA	0.0843	-4.8500	0.8812	19
	CB	0.0641	2.5350	0.8901	24
	KHE	0.0759	-0.9208	0.8158	20
January	CTG	—	—	—	—
	CHA	0.0493	6.8991	0.8750	15
	CB	0.0499	8.1233	0.7994	19
	KHE	0.0551	5.6477	0.4954	24
February	CTG	0.0510	8.3137	0.1712	18
	CHA	0.0503	9.4707	0.4312	15
	CB	0.0607	4.6054	0.3470	18
	KHE	0.0601	3.4518	0.6703	24
March	CTG	0.0669	1.3451	0.2788	25
	CHA	0.0426	9.4204	0.5868	24
	CB	0.0410	13.9919	0.3975	23
	KHE	0.0263	16.8228	0.2331	24

Table IX

Regression statistics on the relationship between Head Length (HL) and Eye Diameter (ED) by month and by station (sex combined)

Month	Station	Slope	Intercept	r^2	n
October	CTG	0.0738	6.0068	0.3623	23
	CHA	0.1439	-1 .1 495	0.3835	20
	CB	0.0749	5.7675	0.6068	21
	KHE	—	—	—	—
November	CTG	**0.0922**	4.2445	**0.9042**	21
	CHA	0.0823	5.4694	0.8512	24
	CB	0.1180	1.6617	0.7776	18
	KHE	—	—	—	—
December	CTG	**0.0936**	4.0142	0.8201	23
	CHA	0.0787	5.5047	0.7247	19
	CB	0.0782	5.8367	0.6687	24
	KHE	0.1119	3.3214	0.8114	20
January	CTG	—	—	—	—
	CHA	0.0623	**7.2982**	0.4714	15
	CB	0.0820	5.2841	0.7601	19
	KHE	0.0821	6.0749	0.2793	24
February	CTG	0.0475	8.7574	0.1699	18
	CHA	0.0794	5.0583	0.8404	15
	CB	0.0701	6.2683	0.4071	18
	KHE	0.0478	9.1752	0.3277	24
March	CTG	0.0371	**9.7882**	0.0800	25
	CHA	0.0774	5.8876	0.8432	24
	CB	0.0493	8.2810	0.0821	23
	KHE	0.0864	5.1045	0.6961	24

Table X

Regression statistics of the posted data on the relationship between Head Length (HL) and Total Length (TL) by stations

Station	N	Pooled months	r^2	Slope	Intercept	TL (Max; Min) in mm	Average number of days after freezing
Chittagong	44	Nov. to Feb.	0.9890	0.2268	4.5702	487; 288	21 .0
Chandpur[1]	99	Nov. to Feb.	0.9732	0.2351	-0.2862	529; 278	10.0
Cox's Bazar	79	Nov. to Feb.	0.9688	0.2245	5.6538	473; 287	23.6
Khepupara[2]	68	Nov. to Feb.	0.9517	0.2365	-1.2254	488; 279	0

[1]Sept. data included
[2]No data for November

Table XI

Analysis of variance on mean values of post-pelvic scutes for the four sampling stations

Analysis of variance
One-way anova

Station	Range	Mean	In
Chittagong	12-15	13.132	136
Chandpur	11-15	13.116	121
Cox's Bazar	10-14	12.992	130
Khepupara	12-15	13.168	113
Pooled	10-15	13.100	500

Analysis of variance

Source	Sum of squares	D.F.	Mean square	F Ratio
Between	2.205	3	0.735	2.267
Within	160.795	496	0.324	
Total	163.000	499		

Table XII

Analysis of variance on mean values of pectoral fin rays for the four sampling stations

Analysis of variance
One-way anova

Station	Range	Mean	In
Chittagong	14-16	14.782	142
Chandpur	13-15	14.613	111
Cox's Bazar	14-16	14.722	1333
Khepupara	13-16	14.676	111
Pooled	13-16	14.704	497

Analysis of variance

Source	Sum of squares	D.F.	Mean square	F Ratio
Between	1.915	3	0.638	2.321
Within	135.606	493	0.275	
Total	137.52 1	496		

Publications of the Ray of Bengal Programme (BOBP)

The BOBP brings out six types of publications:

Reports (BOBP/REP/. . . .) describe and analyze completed activities such as seminars, annual meetings of BOBP's Advisory Committee, and projects in member-countries for which BOBP inputs have ended.

Working *Papers* (BOBP/WP/. . .) are progress reports that discuss the findings of ongoing BOBP work.

Manuals and Guides (BOBP/MAG/ . .) are instructional documents for specific audiences.

Miscellaneous *Papers* (BOBP/MIS/. . .) **concern** work not originated by BOBP — but which is relevant to the Programme's objectives.

Information Documents (BOBP/INF. .) are bibliographies and descriptive documents on the fisheries of member-countries in the region.

Newsletters (Bay *of* Bengal News), issued quarterly, contain illustrated articles and features in non-technical style on BOBP work and related subjects.

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