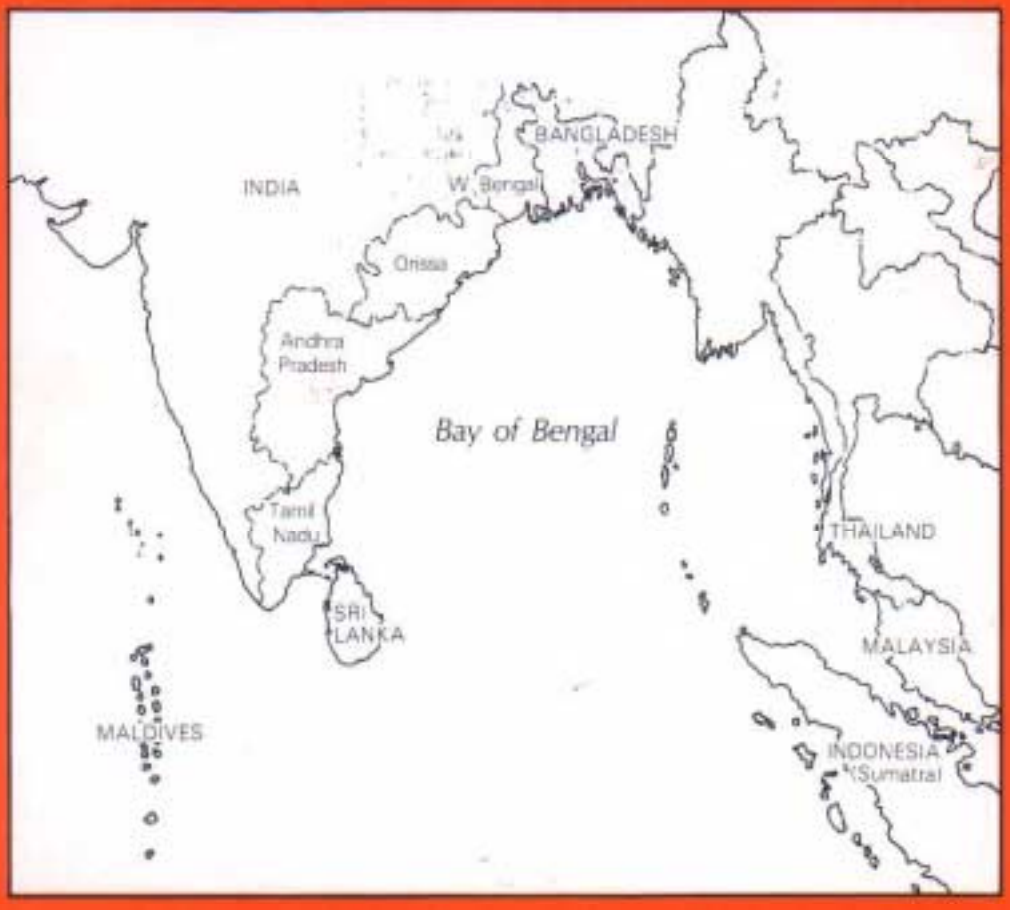
BAY OF BENGAL PROGRAMME
BOBP/REP/36

Marine Fishery Resources Management
RAS/81/051

Hilsa Investigations in Bangladesh



UNITED NATIONS DEVELOPMENT PROGRAMME

FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS

BAY OF BENGAL PROGRAMME
Marine Fishery Resources Management

BOBP/REP/36
(RAS/81/051)

HILSA INVESTIGATIONS IN BANGLADESH

Executing Agency :

Food and Agriculture Organization
of the United Nations

Funding Agency:

United Nations
Development Programme

Marine Fishery Resources Management in the Bay of Bengal.
Colombo, Sri Lanka, June 1987.
Mailing Address : C/o FAO, P-O. Box 1505, Colombo 7, Sri Lanka.
Street Address : NARA Building, Crow Island, Mattakuliya, Colombo 15.

Telex: 22203 A/B FAOR CE. Tel : 522380,522382.

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:

(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.