
***Fisheries Dynamics of Modified Floodplains in
Southern Asia***

Survey Methodologies

Project R5953

**Fisheries Management Science Programme
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1. Introduction

This project document outlines the survey methodologies to be used in the FMSP project R5953: 'Fisheries Dynamics of Modified Floodplains in Southern Asia'. This project will involve fieldwork at sites in three different countries, with, as far as possible, similar data being collected at each site, to enable comparative analyses to be made. The surveys outlined in this document will primarily be undertaken by country nationals employed at each site, under the supervision of *MRAG* and local collaborators.

1.1. The surveys

Five main types of data will be collected under the following surveys:

- Catch & Effort (CE) survey
- Length Frequency (LF) survey
- Mark & Recapture (MR) survey
- Biological (B) survey
- Hydrological (H) survey

For each of these five surveys, this document provides a 'project methodology' outlining the following details:

- parameters to be estimated
- survey objectives (the purpose of the parameters)
- planning approaches (sampling locations, randomisation, biases....)
- routine sampling methodologies (sample selection, timing....)
- summary of fieldwork activities

In some instances, different approaches will be required for each of the three countries. These are identified where appropriate.

These five surveys will generate the central project database for the analysis of the fisheries dynamics of the three sites, as affected by fishing activities, fish population dynamics, migration patterns and hydrological factors. It is also intended that other smaller surveys or short experiments will be undertaken to examine key questions, when time and resources permit.

1.2. Data management

The data collected in these surveys will initially be recorded on paper, as 'hard copies'. Forms are provided for this purpose in the appendix of this document. For computer processing of the data, *MRAG* will provide a database application for routine data entry and reliable backups. Local collaborating staff will be trained in the use of this project database. A second methodological manual will accompany this training.

1.3. Site selection

A crucial aspect in the planning of all surveys for the achievement of the overall project objectives is the choice or definition of water bodies. Given the need to determine the effects of floodplain modifications, sites will need to be chosen both inside and outside of impoundments. At the broadest scale, this will be done by comparing the hydrologically pristine site in Indonesia with the modified one in Bangladesh.

In Bangladesh, however, many different types of flood control structures exist, from passive sluices of various designs to more active pump systems. The selection of a site in Bangladesh will thus determine which type of structures, and what level of floodplain modification are studied. Such sites will be selected after the frame survey during the November/December 1994 field visit. It is intended that the Bangladesh site will also be subdivided into two discrete sampling zones 'inside' and 'outside' a flood control, drainage and/or irrigation (FCD/I) scheme. This will allow a fine scale comparison of the direct effect of impoundment on the biology of the fish species at this important site.

1.4. Survey activities in each study country

For practical and logistical reasons, it is initially anticipated that slightly different survey activities will be conducted in each of the three study countries as indicated in the following table:

Years of survey activity
(1 ~ 1995, 2 ~ 1996 for Bangladesh and Indonesia; earlier for India)

Survey	Bangladesh	Indonesia	India
Catch & Effort (CE)	1, 2	1, 2	(1, 2)
Length Frequency (LF)	1, 2	1, 2	(1, 2)
Mark & Recapture (MR)	M:1, R:1, 2	M:1, R:1, 2	-
Biological (B)	1, 2	2	-
Hydrological (H)	1, 2	1, 2	(1, 2)

The most complete survey activities will thus take place in the Bangladesh site with its contrasting sites inside and outside flood control structures. In Indonesia, biological data may only be sampled in the second sampling year after the first year of intensive tag release activity. The mark recapture and biological programmes will not be conducted at the mainly riverine Indian site. As noted earlier, it is also intended that separate, additional experiments may be conducted at certain sites if resources permit.

2. Project Methodology: Catch & Effort Survey

2.1. CE: Parameter Outputs

- Monthly estimates of *total catches* for defined water bodies, subdivided by gear type and fish species.
- Monthly estimates of *total fishing effort* for defined water bodies, subdivided by gear type.

2.2. CE: Survey Objectives

- C1. To examine the *timing of fish movements* between floodplain/river habitats by comparing seasonalities of fish catches/CPUEs in different/adjacent locations.
- C2. To compare overall *productivity* (catch per unit area, CPUA) of sites in relation to existing flood control structures.
- C3. To determine which species (and hence, which gears) are impacted by which flood control structures, by in/out comparisons.
- C4. To understand the *technical interactions* between fish species and fishing gears at each site, and provide data for modelling the effects of management strategies and hydrology on the fisheries.

2.3. CE: Survey Planning

2.3.1. Overall sampling strategy

For each site, the required CE parameters (see above) will be estimated from a combination of three separate sources of data. Firstly, the broad activities of the fishing community will be estimated by initial interviews and random sampling of the labour force from voter lists. This will provide a 'frame survey' or inventory of the active fishing communities and the relative uses of the different gear types which will enable a statistically adequate sampling design to be made. Secondly, a sample of 'CE respondent' fishermen will be randomly selected (based on the frame survey) and monitored to provide monthly data on their total catch weights and fishing efforts by gear type. Thirdly, the species composition of the catches from different gears in each month will be estimated by visual observations (calibrated by weighed samples).

The details of these methodologies are given in the following sections. The relationships between the different surveys, the sampling units, and the information collected at each stage are summarised in table 1. The final report version of this manual will include the statistical formulae used to make parameter estimates.

2.3.2. Reasons for choice of sampling strategy

This overall approach differs from the methods usually recommended for sampling CE data (see eg Bazigos, 1974; Caddy & Bazigos, 1985). For most fisheries, the second and third data types in the above list would be obtained during randomly ordered visits to the various landing sites in the fishery, for sampling of the catches available on that day. Such sampling would often be stratified by areas, and gear types (ie 'fleets'). Repeated, regular sampling of a number of

randomly selected respondents is recommended for the artisanal fisheries in this project (rather than random visits to landing sites) because many floodplain fishermen do not visit landing sites. Using a sample of regular CE respondents ensures that all types of fishermen are monitored, including the most artisanal, occasional or casual ones.

On the negative side, a respondent-based survey necessitates a recall approach to data collection rather than direct measurements of catches. This is because the landing sites that do exist are widely scattered, and it would be virtually impossible to routinely intercept the respondent fishermen at the particular times they happen to be landing their catches. Fishermen must instead be searched for and questioned *when they can be found* on their catches and effort of the preceding day. The data for 'yesterday' is used rather than for the interview day to avoid biases associated with the actions of the fishermen on the days that they are available (eg when they happen to be at home villages, rather than on the waterbody).

Such recall sampling can only give approximate data on catch weights. The figures recalled by the fishermen should, however, be reliable for these artisanal fisheries since only small weights are landed daily and the fishermen are actively involved in negotiating the sale of their catches. Catch *composition* data, on the other hand, will not be requested from the CE respondents because the memory recall of such information is likely to be far less reliable than that of their total weights landed and sold. These data will instead be sampled directly by project field staff.

In general, this survey approach is similar to the logbook-based sampling design used for the UK bass (*Dicentrarchus labrax*) fishery (Pickett & Pawson, 1991). Like a tropical floodplain, this fishery also employs a wide variety of different catching methods operating seasonally and opportunistically over a widely dispersed area.

2.3.3. Identifying the fishing communities: the frame survey

A 'frame survey' is used to determine the number of fishermen in the sampling region and their distribution and activities. The data from such a survey comprise what is known as the 'sampling frame': this is used to divide the region into a number of sampling 'strata' for the optimal random selection of CE respondents. This sampling frame should be both mapped and tabulated to show the locations and importance of the various communities working in the fishery. A large 'thematic map' should be drawn to show the numbers of fishermen working in each community, the gears they use, where and when they fish and where they land their fish.

As shown in the following sections, the frame survey comprises two distinct stages; the first one to identify the villages active in fishing, and the second to provide quantitative estimates of the numbers of fishermen and gears.

Frame survey - initial interviews

In the first stage, a sample of up to 100 'key respondents' will be questioned about the seasonality of the fishing activities in their localities, the gears used, the catches taken, and where the fish are landed. To adequately cover the range of activities and habitats in the selected study area, the key respondents should include different categories of fishermen (rich and poor, full-time and part-time...) in addition to fish traders, leaseholders, government officials, and other interested parties.

These interviews should generally be conducted on the key respondent's 'home territory', and the amicable objectives of the study should be carefully explained. A more casual, conversational interview helps to put the interviewee at rest and increases the likelihood of obtaining reliable, unbiased replies. The key questions on form CE1a should be asked for each gear type used: the replies for up to three gears can be entered on each form. Two or more

forms may be used if the interviewee has experience of more than three gears.

Frame survey - random sampling

Quantitative estimates of the numbers of active fishermen and fishing gears can only be obtained by random sampling. In this second stage of the frame survey, working population sizes should be determined for each village from voter lists available from local government offices. A sub-sample of the villages should then be selected, and a random sample of up to 200 of the working population should finally be selected from the voter lists and interviewed on their fishing activities using form CE1b.

This procedure will provide estimates of the fractions of the working population involved in fishing (either 'full-time', 'part-time' or for food only). The total population of fishermen on the waterbody can then be estimated by combining the fractions with the census data from the voter lists.

Secondary information should be entered on form CE1b on the numbers of gear units owned by each interviewee (separate rows should be used for each gear type used). This information will be used to determine if the CE sampling should be stratified by gear type.

2.3.4. Selection of CE respondents

For regular monitoring of CE data, a random sample of approximately 30-50 respondents should be selected from those workers identified in the frame survey as either full- or part-time fishermen. An equal number of fishermen should be selected as respondents in each of the villages sub-sampled.

These 'CE respondent's will be requested to provide details on their catches and fishing efforts on a monthly basis. It should be made clear to the fishing community as a whole that the CE respondents have been *randomly selected*, by chance and without favouritism. During selection, it should also be made clear to the respondents that their collaboration may be required for a period of up to two years. Selected CE respondents who do not feel able to commit themselves to such a period of scrutiny should not be included in the CE survey and should be replaced by others (also randomly selected). During this period, considerable time must be spent explaining the objectives of the surveys, to win the trust and cooperation of the fishermen.

2.3.5. Statistical aspects

This survey design is broadly known as two-stage sampling. In this application, the primary units are the villages, and the secondary units are the fishermen. This design clearly assumes that the selected 'defined waterbody' (section 2.1.) is exploited by fishermen from several villages, as is likely to be the case in Bangladesh. At the Indian and Indonesian sites, the fishing populations may be less widespread, or more easily identified and enumerated, and simpler sampling schemes may be possible.

In the 'first-stage', then, the optimal sampling scheme for the villages depends on their degree of heterogeneity, both in terms of size and fishing activity. If all the villages are much the same, then the sub-sample should be selected by simple random sampling. If (as seems more likely) the villages are quite different in size, they should be selected with probabilities proportional to their sizes (PPS sampling). On a practical, more than statistical level, if one village clearly dominates the fishing activity of the region, it *must* be monitored, and a stratification can be

introduced between it and the other less important villages. In addition, if there are clear differences in the activities taking place between certain villages, then they should be classified into appropriate strata before sub-sampling (two-stage sampling *with stratification*). These aspects will be determined after the frame surveys have been conducted at each site.

In the second stage, an equal number of fishermen should be randomly selected as respondents in each village. With PPS sampling, this gives each fisherman in all the villages an equal chance of selection (Snedecor & Cochran, 1980). If some stratification is adopted, appropriate raising factors should be used during parameter estimation.

The number of fishermen selected as respondents will be determined mainly by practical aspects. Given a constraint on the total number of fishermen who can reasonably be interviewed within a year, a choice must be made between monitoring many fishermen infrequently, or monitoring few fishermen regularly. The optimal choice depends on whether there is more variability in the seasonality of catches over the year or between individual fishermen (eg due to the gears they use). In these fisheries, a respondent sample of 30-50 fishermen should ensure that all gears have a good chance of being sampled. To detect seasonality in the fisheries, monthly estimates are required. A twice-monthly sampling frequency is, however, recommended to increase the chances of detecting those gears used most infrequently, perhaps for only a short period in the dry season. An alternative scheme of sampling 60-100 fishermen for interview only once a month, could give a better coverage of gears but would require greater effort to locate the extra respondents.

2.3.6. Labour, equipment and funding requirements

The frame survey interviews will be jointly undertaken by the RA/FA team and the visiting MRAG staff. It is hoped that the initial interviews and the planning of the randomised interviews can be achieved within a two-week period at each site. The majority of the randomised interviews should be carried out by the RA/FA team. Where the sites are already well known by local collaborators, or by the employed RAs or FAs, the process of community identification and thematic mapping may be much quicker.

The routine sampling of CE data from respondent fishermen (see following sections) could be undertaken by either the RAs or the FAs. No capital equipment is required but substantial time will be needed to visit all the fishermen in all the sampling periods, and suitable transport will need to be provided at each site.

The separate sampling of species composition data should be undertaken in conjunction with the LF sampling programme, during visits to the primary markets. No special equipment is required for routine observations, but weighing scales will be needed for occasional calibration of observations.

2.4. CE: Routine Sampling Methodologies

2.4.1. Interview sampling of CE respondents

For the routine CE sampling, the survey enumerators should travel around the study site searching for the respondent fishermen to interview. As each CE respondent is found, he should be interviewed for the required catch and effort statistics, as detailed in form CE2 (see appendix).

Each CE respondent fisherman should always be interviewed once in each survey period of 15 days (two periods per month). Records should be kept on a standard form of which respondents have so far been interviewed in each period. Considerable efforts may sometimes be required to find the last few respondents in each period. Such efforts, however, are essential to ensure that the results are not biased by the regular omission of those respondents with unusual behaviour patterns.

It is assumed that each fisherman has a random and equal chance of being encountered on all the days in each sampling period. To minimise potential biases in the CE survey, the data should relate to the following time intervals. For gears usually hauled every day, the data should relate to the *day before* the interview. In this case, a '-1' should be recorded for the recall period on form CE2. For gears hauled less frequently (such as dewatering, brushpile traps, or other seines fished in isolated pools) a recall period of the preceding 7 days should be used and a '+7' should be recorded for the recall period. If the CE respondent can remember his catches for days before yesterday, these may also be recorded in form CE2 with the appropriate recall periods '-2', '-3' etc.

2.4.2. Measurement of fishing effort

Different measures of fishing effort are used for different gear types. For fishing gears of a standard size, fishing effort must be measured in terms of the numbers of units of each gear used for defined lengths of time (eg *Number of cast-net-hours*). For gill nets, the length of net used also needs to be defined: effort for this gear should thus be recorded as the numbers of gill net-*metre*-hours. The appropriate effort measures for the gear types used in these fisheries are provided in table 2.

Simple effort measures such as the overall numbers of fishermen or boats may provide rough comparisons of total fishing activity between sites. They are inadequate, however, for a detailed understanding of these artisanal fisheries because the seasonality patterns of individual gear types are so variable over the year. Only the detailed effort measures shown above will enable gear use patterns, and relative abundances, to be quantified and modelled over the cyclical flood season.

2.4.3. Completing the CE respondent data form CE2

CE data from the survey respondents should be recorded on data form CE2. Separate forms should be used for each survey period. The data from several respondents may be entered on to a single form. Separate lines should be used for each gear type used by each respondent (see example in appendix).

The 'CER Hours Fishing' column should be used to record the number of hours actively spent fishing by the respondent, on each different gear type. This information will be used to estimate the mean daily fishing hours of fishermen at each water body.

Several gears, such as seine nets and barrier traps, are fished by teams of fishermen. When the respondent is a member of such a team, the fishing effort and catch details should relate to the full equipment of the team, and the size of the team (number of men) should be recorded.

2.4.4. Sampling of species composition data

Information on % species compositions by gear types will be used to apportion the CE respondent's total catches between different fish species.

Species composition data should be collected opportunistically at primary landing sites.

Baskets of fish should be randomly sampled from those available. Before taking records from a selected basket, the origin (fishing ground?, gear type?) and integrity (whole, unsorted catch?) of the sample should be determined from the owner. If any origin information is not available, or the catch has been sorted, or mixed with catches from other gear types, *the basket should not be sampled*.

For selected samples meeting the above criteria, the % species composition of the catch should be recorded on data form CE3 (see appendix). Percentages should indicate the weight (not the number) of each species in the catch. When species identities are uncertain, eg for mixed juvenile cyprinids, %s may be recorded for groups of species. Separate forms should be used for each day's sampling, and each catch observation should be recorded in a separate box (up to nine on each form).

2.4.5. Data coding

For reliable interpretation, data should always be recorded in concise and consistent formats. Suitable codes should be chosen for each different fish species, gear type, fishing area, CE respondent etc, as given in the examples below, and only these codes should be used on the forms. (Note: mnemonic codes may be best based on the common names used in local languages.)

Fish Species		Fishing Gears	
<i>Channa striatus</i>	CS	Gill Net	GN
<i>Notopterus notopterus</i>	NN	Seine Net	SN
<i>Anabas testudineus</i>	AT	Brushpile & Seine Net	SNB

2.5. CE: Summary of Fieldwork Activities

1. Frame survey

The initial frame survey and the resulting sampling design will be undertaken jointly by the local and MRAG staff.

2. CE respondent interview sampling

All CE respondent's should be searched for and interviewed once every 15 day period (two survey periods per month). CE data should be recorded on form CE2.

CE data should be recalled by the respondent for yesterday (and earlier days if memory permits) for gears hauled every day, or for the preceding 7 days overall for gears hauled infrequently.

3. Species composition sampling

Species compositions of the catches of different gear types should be estimated by visual observations, when practical, during market visits. Species composition data should be recorded on form CE3.

The origin (gear type & location) and integrity of the catch should always be determined. Only whole, unsorted catches should be sampled.

3. Project Methodology: Length Frequency Survey

3.1. LF: Parameter Outputs

- Bimonthly estimates (once every two months) of LF structure of catches of key species from least selective gears to estimate growth and mortality rates.
- Occasional estimates of LF structure of catches of key species from all gears to estimate selectivities.
- Opportunistic estimates of LF structure of catches of key species from interceptory gears at known locations to identify ages of migrating fish.

3.2. LF: Survey Objectives

- L1. To provide an age basis to the interpretation of fish migration patterns.
- L2. To examine the effect of flood control structures on growth and mortality rates of key species, by in/out comparisons.
- L3. To estimate parameters required for modelling the effects of management strategies and hydrology on the fisheries.

3.3. LF: Survey Planning

3.3.1. Selection of key fish species

The primary objective of the LF survey is to estimate growth and mortality rates. For this, a *time series* of samples is required, covering at least a year, from which the changes in mean lengths of cohorts of fish can be observed. This is a data-intensive procedure which can only be done for a few of the different fish species caught at each site. The first step is thus to select around 5 'key' fish species for LF sampling.

Key fish species should be selected to provide information on the population dynamics of the different types of fish in the ecosystem. These could perhaps include one large herbivore, one large carnivore, one small blackfish, one small whitefish and one shrimp species. Where possible, to enable comparative analyses, the same species should be selected at all sites. However, it is more important that the chosen species must be regularly caught in large enough numbers to provide large samples.

3.3.2. Selection of sampling sites

To estimate population parameters from LF surveys, the data must represent, as far as possible, the true LFs of the wild population of fish. Samples must therefore be collected at sites where such fish can be found. Ideally this means collecting fish from their wild habitat using non-selective sampling equipment. Such an approach, however, may be prohibitively expensive. As a second best solution, samples may be collected from the catches of fishermen when they are brought to market for sale. In this case, it is essential that sampling should be carried out at a *primary market*, ie the *point of first sale*. At such a market, the fishermen themselves can be interviewed to ensure that 1) the fish have not been sorted into size classes

and 2) the catch sampled has been taken by only one known gear type. LF sampling should *not* be conducted at secondary markets or any site where the origin of the fish can not be reliably ascertained.

3.3.3. Selection of gear types

As noted in section 3.1., estimates of LFs are required from different types of gears for different purposes. The primary requirement is for LF samples from the least selective gears to estimate population parameters. Such gears will generally be the most small meshed, taking the widest possible size range of fish. They may include seine nets of various types, lift nets, pot traps or barrier traps. For each key species, samples should be taken from each low-selectivity gear that makes a major contribution to the total catch.

Secondary sampling is required to provide estimates of the LFs from other gear types. These would include gears such as gill nets and hooks which are selective towards particular size classes of fish, and barrier traps which can provide useful information on the migration of fishes.

Sampling from these gears should be done as opportunities arise, but as a lower priority, perhaps when no fish are available from the primary, low-selectivity gears.

3.3.4. Labour, equipment and funding requirements

LF sampling should be undertaken by two field operators, one to handle and measure the fish and a second to remain clean and dry to record the measurements on the LF form. LF sampling can only be undertaken when fish are available at markets, often for a short, regular period each day. LF sampling will thus require only a few hours in each of the 10 days in the sampling window, every 2-months (see section 3.4.1.).

The sampling teams will require a LF measuring board, with a minimum 50cm length, and various containers for securely retaining live fish during measurement.

Some fishermen may be more willing than others to cooperate with such a sampling scheme. Where possible, a relationship of goodwill should be developed, enabling fish to be borrowed temporarily from the fishermen, measured and returned in a short period of time. In some locations, it may be helpful to pay the fishermen a small amount for each sample measured, to compensate them for the inconvenience and delay caused. It should not be necessary to buy the fish for measuring alone.

3.4. LF: Routine Sampling Methodologies

3.4.1. Sample sizes and frequencies

Sampling should be planned to give LF data for each of the key species within a 10-day period, or 'sampling window', every 2-months. Time series of six evenly-spaced samples should thus be collected for each year of sampling.

Populations of small floodplain fish species will generally be comprised of less age classes than large ones, and hence require less LF data for estimating population parameters. For small fish, up to a maximum 20cm in length, a total sample size of 200 fish should be measured for each key species from each important, low-selectivity gear type. For larger fish species, with populations that may be comprised of several age classes, samples of 300 fish per key species per gear type should be measured in each time period.

Depending on the availability of fish, the total sample sizes of 200-300 fish will usually be made up from a number of separate sub-samples, perhaps taken from different fishermen or collected on different days. During periods when few fish are caught, it will sometimes be impossible to achieve the recommended sample sizes within the sampling window.

For the secondary LF sampling on selective and interceptory gear types, samples should simply be taken when available up to a maximum size of 200 fish per time period.

3.4.2. Selection of unbiased samples

To obtain representative and *unbiased* samples of the LF structures of the catches of chosen gears, it is essential that either a whole catch from that gear is measured, or, if the catch is very large, a randomly selected part of it. Samplers must also make sure that only the catch of the intended gear is being measured. It must thus be explained to the fishermen that the *whole, unsorted catch* is required for sampling.

Where fish catches are landed in baskets, these containers may make useful sampling units from which a sample may be randomly selected. Care must always be taken, however, to ensure that large and small fish have not been sorted into different baskets. When this is the case, the best option is to measure all the fish in all the baskets being landed. When this would involve too much work, random samples should be taken from the different baskets in proportion to the relative numbers of fish of different sizes.

3.4.3. Recording of LF data

The source details of LF samples and the fish lengths should be recorded on the sampling form provided (see appendix). Separate sheets should be used for different sampling sites and dates, but up to five sub-samples may be recorded on each form. For each sub-sample, the following source details should be recorded:

- species,
- gear type (and mesh size/ hook gape),
- location of capture.

Locations should be recorded to a reasonable accuracy, to distinguish different river, floodplain and other habitats at each site.

For each (and every) fish in the sample, the *fork length* should be measured to the nearest cm *below* (or ½cm below for small fish) and entered as a tick on the LF data form (see example in appendix). The fork length is the distance from the tip of the snout to the fork in the tail. It is equivalent to the total length of round-tailed fish.

3.5. LF: Summary of Fieldwork Activities

1. LF samples should be taken for each of *approximately 5 key fish species* during a *10-day sampling window* in each two-month period.
2. For each key species/time period, LF samples should be taken to produce *total sample sizes* of 200 fish (for small species) to 300 fish (for large species) from each important low-selectivity gear. Additional samples should be taken, as a second priority, from other selective or interceptory gears.

3. To obtain *unbiased samples*, they should only be taken from the catches of fishermen landed at *primary markets*. Care must always be taken to question the fishermen to ensure that their catch has not been *sorted* and contains only fish from a *single, known gear type*.
4. For each separate *sub-sample*, record the LF details on the sampling sheets provided (see appendix). Separate sheets should be used for different sampling sites and dates, but up to five sub-samples may be recorded on each form. For each sub-sample, record the *species, gear type (and mesh size/ hook gape)* and the *location where the fish were caught*.
5. For each fish, measure the *fork length* to the nearest cm *below* (or $\frac{1}{2}$ cm below for small fish) and enter the lengths as ticks on the form (see example in appendix).

4. Project Methodology: Mark & Recapture Survey

4.1. MR: Parameter Outputs

- Distances moved in known time periods by marked individuals of key fish species.
- Growth achieved in known time periods by marked individuals of key fish species.

4.2. MR: Survey Objectives

- M1. To determine the scales of seasonal movements of different key fish species between different river/floodplain habitats, and draw conclusions on appropriate areas for reserves and for licensing, and on stocking activities.
- M2. To determine the impact of flood control structures on migration patterns, by comparing the movements of marked fish in pristine and modified sites.
- M3. To provide secondary estimates of growth rates of key fish species to support the estimates from the LF and B surveys.

4.3. MR: Survey Planning

4.3.1. Overall design and precautions

The *marking* stage of a MR survey involves the capture, holding, marking and release of fish by project staff. The subsequent *recapture* stage involves the recovery of the animals and the detection and reporting of the mark, primarily, in this survey, by fishermen. The methodologies for the various stages are detailed in the following sections.

The success of this component of the project depends on the ability (and willingness) of fishermen to recognise marked fish and return them to the project. Given the remote nature of some of the project sites, and the difficulties of local transport and communication, It will be necessary to determine the best method for the fishermen to report their recaptures. This will be discussed with the local collaborators at each site.

4.3.2. Publicity

To ensure reasonable return rates of marked fish, each MR survey needs to be widely publicised. The best locations and media for such publicity will also be discussed with the local collaborators. It is presently anticipated that details of tag rewards, lotteries and return facilities should be given on posters to be widely displayed around the study sites. These should be printed in local languages, and take account of the variable literacy rates among fishermen at each site. At the Indonesian site, publicity announcements should also be made by project staff at the annual licensing auctions for the study areas, during November and December, 1994.

4.3.3. Labour, equipment and funding requirements

Tagging and releasing fish for the MR survey should be undertaken by the RA/FA team when they are not engaged on the CE and LF/B surveys. It should be possible to develop a fieldwork

itinerary in which regular journeys are made around the study sites to enable all three surveys to be completed at the same time.

Equipment for the tagging work will be provided by MRAG. Appropriate tag designs and methodologies will be determined during the field trials planned for August 1994. The major expenses involved will be the initial purchase of fish for tagging and release, and the subsequent reward money paid for recaptured fish. It is hoped that fish in good condition can be purchased from the fishermen either at market value or an agreed percentage above this. Suitable amounts for rewards will be discussed with local collaborators prior to the surveys.

4.4. MR: Routine Methodologies

The following notes draw heavily upon the synopsis of tagging methodologies by Jones (1979).

4.4.1. Capture / supply of fish

Live fish for marking should be bought from fishermen at the market price (or a standard percentage above this). At the Indonesian site, fish are generally held alive in cages for sale to visiting traders, and could be purchased by visiting the fishing camps. In Bangladesh, fish are usually brought to market dry (though often still alive). It may therefore be necessary to visit the actual fishing sites by boat to obtain fish in good condition in Bangladesh.

To minimise arguments over the correct prices for fish, field staff will be provided with weighing scales. Only freshly caught fish in good condition should be used for marking. Fish with missing scales or broken fins should not be used. Suitable fish will generally only be available from passive fishing gears such as portable traps, barrier traps, dewatering and active seines.

To study the movement of fish *from* different areas, fish for marking must be obtained, and then re-released, from as many different locations as possible within each study site. This will necessitate a 'roving' approach to MR fish supply, probably using a boat to access a variety of fishing areas.

4.4.2. Holding and handling of fish

To minimise the stresses associated with marking, and maximise the survival of marked fish, experimental animals must always be handled very carefully during the marking operations. Fortunately, floodplain fish are generally hardy, being adapted to a hazardous environment, and should prove to be ideal subjects for MR study.

While waiting to be marked, fish should be kept in a holding cage suspended in the river. They should then be transferred to the marking area by a soft, knotless net (fish should not be lifted by dry hands as this removes the protective layer of slime from their skin). During marking, fish should not be exposed to direct sunlight or other bright lights.

4.4.3. Marking and releasing of fish

The marking operation should be designed to be as quick and as stress-free to the fish as possible. Holding fish in cages and tanks for extended periods should be avoided. Fish should be handled gently and carefully, using knotless nets and suitable containers.

If tagging causes excessive struggling by the fish, they may be anaesthetised before tagging in

Benzocaine or other suitable chemicals. Anaesthesia may alternatively be avoided by developing a suitable holding trough or cradle to prevent the fish struggling.

After the tag mortality/loss experiment in Indonesia in Autumn 1994 (see separate report), two types of tags have been obtained for marking the fish: T-bar tags and streamer tags. T-bar tags (numbered T0001 - T4500 in the first batch) should be inserted under the dorsal fin using the applicators provided, as demonstrated by MRAG staff in the field. Streamer tags (numbered S0001 - S4000 and P0001 - P0500) should also be inserted under the dorsal fin so that the two ends 'stream' down both sides of the fish. In general, the more robust T-bar tags should be used for the larger, round-bodied key species such as *Channa striatus*, *Mystus nemurus*, *Wallago attu* and the larger *Catla catla*; the more light-weight streamer tags should be used the smaller and/or narrow-bodied key species such as *Puntius sophore*, *Osteochilus hasselti*, *Helostoma temmincki*, *Glossogobius giurus* and for the Indonesian prawn *Macrobrachium rosenbergii*.

After marking, the fish (or prawns) should be allowed to recover in suitable containers or keep nets, and then released as soon as possible. Where possible, fish should always be released into the same habitat in which they were originally captured. Some fish may thus need to be held in a second cage temporarily, and transferred to their release site in a suitable tank on board a boat. Battery powered aerators, or simple hand splashing, may be used to assist this transport.

4.4.4. Recording marking and release details

A form is attached for recording marking and release details (form MR1, appendix). Recorded information should include the date, species, tag number, location caught, location released, gear type used for capture, total and fork lengths (nearest *mm* below) and any comments. For locations, a coding system should be developed which accurately identifies water areas on a thematic map in relation to well-known local landmarks. Such maps will need to be prepared prior to the start of the MR surveys at each site.

4.4.5. Recapture of marked fish

Marked fish will be recaptured by fishermen and provision will need to be made to enable them to report the required information to the project. To obtain the maximum information from the recaptures, the actual fish, with their tags still in place, should ideally be returned as quickly as possible to the project staff. This should be feasible for fish recaptured within project areas where the fishermen are regularly visited by the project staff for CE and LF sampling. At more distant sites, it may be more practical to request that only the basic recapture information (see form MR2) is returned, accompanied by the tag as proof of capture. Procedures for this part of the survey will be discussed with local collaborators.

It is anticipated that a reward such as a project T-shirt will be issued for each tag recaptured and returned to the project. To qualify for the reward, the fish must either (1) be returned to the project alive or fresh, with the tag still in position, and the fishermen must report exactly where and when the fish was caught or (2) the tag alone must be returned to the project with the appropriate details. Tag return forms will be widely distributed for this purpose. For tags returned still attached to the fish, in addition to the cash reward, the value of the fish (or a standard percentage above the market value) should be refunded to the fishermen by the project. Provision must be made for the fishermen to be paid for their recaptures immediately on presentation of tagged fish. The use of a lottery may also be considered, with substantial cash prizes being drawn at the end of the first and second years of fieldwork. In Indonesia, such prizes could be presented at the 1995/96 auction meetings.

4.4.6. Recording of recapture details

Details of the recaptures of marked fish should be recorded on the second form provided (see appendix, form MR2). As for the released fish, the date, species, tag number, location recaptured, gear type used for recapture, total and fork lengths (nearest *mm* below) and any comments should all be recorded for every fish returned. The name and rough address of the fisherman returning the fish should also be recorded for possible later use in any lotteries or for data verification. A check should always be made to verify the identities of the returned fish, to ensure that the tags have not been switched with other (larger, more valuable?) fish. A photocopied list of the release details for all tags should always be carried for this purpose.

For those recaptured fish repurchased by the project in good condition, the full value should be gained by dissecting fish to determine the biological data outlined in the following section 5.5.2. Recaptured fish which are returned to the project in poor condition may not provide useful data on weights or stomach contents, but should still be measured for the other characteristics.

4.5. MR: Summary of Fieldwork Activities

1. For the mark and recapture survey, live, healthy fish will first be bought direct from fishermen, marked with small, highly visible, numbered tags and released back to the wild. Fish will be released throughout the study location, and, where possible, fish will be released back to the site and habitat in which they were captured.
2. It is hoped that recaptured fish carrying tags will be returned to the project by fishermen. Various forms of publicity will be employed to educate the local communities about the survey. In the immediate study location, facilities will be provided for fishermen to return the fish to the project with the tag still in place for recording by project staff. For fish recaptured in more distant waterbodies, provisions will be made for fishermen to return only the tag and information about the fish to the project by post.
3. Suitable rewards will be given for each tag returned to the project, and annual lotteries will be conducted at the Indonesian site as an additional incentive.

5. Project Methodology: Biological Survey

5.1. B: Parameter Outputs

The following parameter outputs will be produced for each of the 'key species' referred to in section 3.3.1 for sites both inside and outside flood control and irrigation structures.

- Average length at age data to estimate (seasonal) von Bertalanffy growth parameters and thereby model the average length at age over the lifespan of each species.
- Stomach contents and fullness in relation to habitat type and season.
- Paired length and weight measurements.
- Spawning period(s)/sites/areas/habitats.
- Length at maturity (Lm50).
- Length-fecundity relationships including spatial and temporal variations.

5.2. B: Survey Objectives

- B1. To determine the impact of flood control structures on the growth of fish by comparing growth parameters of fish sampled from modified and pristine sites. To provide additional estimates of growth parameters for cross validation with other methods employed in the study and to assess the most appropriate technique(s) to estimate growth parameters of tropical floodplain fish.
- B2. To identify the trophic categories of the key species and to quantify and describe seasonal and spatial changes in diet in relation to flood control.
- B3. To provide keys to calculate average weight at length or age for yield modelling purposes and to calculate condition factors to determine spawning period and seasonal variations in feeding intensity in relation to flood control.
- B4. To identify the site and seasonal timing of spawning to assist selecting and enforcing potential refuges.
- B5. To determine the length (age) at first maturity and the relationship between length and fecundity including any spatial and temporal variations to provide further understanding of the ecology and production of these species in relation to flood control. To model the effects of fishing and/or the environment on spawning stock biomass and egg-per-recruit.

5.3. B: Survey Planning

5.3.1. Overall sampling strategy

The biological sampling programme has been designed to provide information on the growth and mortality rates of fish, their feeding activities and life history strategies. Most of the information will be collected by stratified sub-sampling of fish measured in the LF programme. Six samples will thus be taken per year at two-monthly intervals to demonstrate the seasonality of growth, feeding and reproduction. One component of the life history pattern, fecundity, however, will be sampled under a separate methodology at only a single time period, just before the fish are ready to spawn.

5.3.2. Selection of key fish species

See section 3.3.1

5.3.3. Selection of sampling sites

Data collected as part of the biological survey must be representative of the true wild fish populations both through space and time inhabiting both modified and pristine sites. For this reason sampling sites should be selected on the same basis as that for the LF sampling programme outlined in section 3.3.2. That is biological sampling should be conducted on fish purchased from the primary fish markets where the fishermen themselves can be interviewed to 1) ensure that the location, habitat type and time of landing can be determined 2) the fish have not been sorted into size classes 3) the catch sampled has been taken by gears that are not size-selective.

5.3.4. Selection of gear types

As noted in the previous section, samples for biological analysis must be purchased from those fishermen operating non-selective gear types. These gears will generally be small meshed which catch the widest possible range of fish size. They may include seine nets of various types, lift nets, traps, bag nets.

5.3.5. Selection of unbiased samples

All of the methods described below require regular, representative and unbiased sampling of fish with respect to length, weight, age, sex and fecundity throughout the year *and in Bangladesh, from sites inside and outside the FCD/I scheme*. Unlike the LF sampling programme, it is not essential that the actual length (age) structure of the population be represented in the sample. This is not to say that sampling of all lengths (ages) of fish is not required, but simply that the sample should contain, if possible, equal numbers of fish of all sizes. For this reason, it is recommended that a stratified sub-sample be taken from whole unsorted catches taken by non-selective gear types so that large numbers of early dominant age classes do not have to be sampled. It is therefore recommended that the purchase and examination of these sub-samples be done in conjunction with the LF sampling. Twenty individuals of each species sampled six times per year should provide a sufficiently large sub-sample for all of the BS programme components except for the fecundity sampling. The latter component will require very intensive sampling over a short period of time.

5.3.6. Labour and equipment requirements

The routine, bi-monthly biological measurements should be undertaken by two researchers in a temporary field laboratory. The first researcher should take the measurements and samples from the fish while the second remains clean and dry to prepare the sample envelopes and record the data on form B. The separate, once-a-year sampling for fecundity will be labour intensive and may require the support of one other member of the project who would also transport samples back to the UK if necessary.

The following equipment requirements for the biological sampling programme will be provided by MRAG:

- Dissection kit
- Scale envelopes
- Sealable plastic flasks
- Laboratory pens
- Hand lens
- Alcohol
- 5% formalin
- 50cm measuring board
- Top pan balance
- Sample containers
- Blotting paper
- Various size spring balances
- Petri dishes

5.4. B: Introduction to Methodologies

The following notes draw largely on the methodologies of Bagenal, (1978) and Wootton, (1991).

5.4.1. Age determination from 'hard parts'

A commonly employed method of age determination to model the growth of fish is the interpretation and counting of growth 'checks', marks or zones which are laid down in the hard calcified parts (scales, ear otoliths, bones or spines) of fish as they grow. This type of ageing technique is often referred to as osteochronometry. The growth checks that are visible in the hard structures reflect periods of faster and slower growth which are often related to changes in various environmental or internal influences. Growth checks that are formed annually are called annual rings or annuli. Generally speaking, the greater the seasonal temperature difference, the clearer the growth checks. For this reason they are generally more distinct in seasonal climates than in tropical, aseasonal environments. Nonetheless, growth checks are often visible on hard structures of fish from tropical areas though they are not necessarily annual. Instead they may be associated with one or more of the following:

- Dry season
- Changes in food supply
- Changes in stock density
- Spawning
- Stress or loss of condition.

Age determination using this technique must be validated using other methods such as length frequency methods (section 3) and or mark-recapture methods (section 4).

The choice of hard parts to use for each species should begin with an examination of scales, otoliths, dried bones (opercular, vertebrae, cross sections of spines, fin rays) from ten individuals of each species.

The aim is to find a structure that satisfies the following two criteria:

1. A recognizable pattern, visible either by direct viewing or after some form of preparation.
2. A regular time scale must be allocated to the visible pattern.

An important means by which age determination can be validated is by examining the position of the annuli relative to the edge of the ageing structure. If the checks are true annuli they will appear at the edge of the hard part during a relatively short period of the year. This validation method requires relatively large samples to be collected throughout the year. Other methods for validating the chosen method are listed in Bagenal, (1978).

5.4.2. Temporal and spatial changes in diet and feeding intensity.

A description of the composition of the diets of individual species should indicate the relative importance of the items eaten, including any temporal and spatial changes.

Fish sampled for stomach contents should be chosen to minimise regurgitation of food, feeding under abnormal conditions, and digestion after capture. Fish caught by *gill nets or traps should not therefore be used*. Instead, fish should be sampled from seines, cast nets, hook and line etc and the time interval between capture and analysis or preservation should be minimised.

In order to detect possible seasonal changes in diet composition, it is necessary to sample throughout the year. For this reason it is recommended that the analysis of stomach contents, along with the other components of the biological sampling programme, be conducted alongside the length frequency sampling programme. A record should also be taken of the time when the fish were caught. This information, in conjunction with stomach fullness data (see below), can be used to assess diel changes in feeding intensity and diet.

The methodology for analysing stomach contents described in section 5.5.4. is a numerical type, which emphasizes the contribution of each food type to the volume of material consumed. This is essentially a modification of the volumetric method that is quicker and easier to use.

5.4.3. Length and weight sampling

It is important to obtain a wide and representative set of paired values for length and weight to ensure that the derived length-weight key is equally applicable over the range of observations. This should be achievable providing representative stratified samples are taken. Length and weight measurements should be taken from freshly dead fish before any desiccation has begun.

5.4.4. Spawning period and location

Spawning period(s) and locations may be assessed through temporal and spatial changes in the gonadosomatic index, supported by visual observations of the stage of maturity. This will require continual sampling throughout the year for measurements of gonad and somatic weight and determination of stage of maturity including details of the locations from which the samples were caught.

5.4.5. Fecundity

The fecundity of fish is defined by Bagenal, (1978) as "the number of ripening eggs in the female prior to the next spawning period". Estimation of fecundity should be measured just prior to the spawning period over a very short period of time (days as opposed to weeks) since all the specimens are then likely to be near the same stage of development and fecundity can be related to somatic and gonad weight. These relationships cannot be derived if the species exhibits seasonal changes in condition and the samples have been collected over a long period.

The precise spawning period and behaviour (batch or multiple spawning) of the key species is still uncertain. These will be determined from the analysis of temporal changes in the gonadosomatic index based upon data collected during the first year of sampling. In the meantime, it is proposed that fecundity sampling should be conducted just prior or during the period of flooding based upon the findings of Lowe-McConnell, (1975,1987).

Sampling of fecundity should thus only occur only once per year and therefore will not form part of the routine sampling programme. Fecundity sampling may in the future become part of the routine sampling programme if it is found that any of the key species are multiple spawners.

5.5. B: Routine methodologies

5.5.1. Sample sizes and frequencies

As outlined in section 5.3.5, fish for biological analysis will be sub-sampled from those fish sampled for the LF programme. Therefore sampling and subsequent analysis for this component of the programme should occur within the same 10-day 'sampling window' as the LF survey at regular two monthly intervals throughout the year, for the duration of the study. Time series of six evenly-spaced samples should thus be collected for each sampling year. These samples should comprise *20 individuals of each species*. *NB: In the case of Bangladesh 20 individuals will be required from catches taken from both inside and outside the FCD/I scheme giving a total of 40 individuals per two monthly period.*

As noted in section 5.3.5, these sub-samples taken from the LF survey should be *stratified* so that an even number of all size (age) classes are sampled. They should be stratified also according to habitat type ie rivers (which includes main rivers, secondary rivers and canals) and floodplains/beels. Table 3. provides an initial guide as to how the sub-samples should be stratified according to size and habitat for each of the key species in Bangladesh. Depending on availability, these sample sizes may be made up of a number of separate sub-samples, perhaps taken from different fishermen or collected on different days. During each sampling window, a log should be kept by the data recorder of how many fish have so far been sampled in each species/habitat/size class category. The log should be used to guide the selection of fish for retention for later laboratory analysis.

Those fish selected for biological measurements should be retained in good condition for later laboratory analysis. Samples obtained from different sources should be kept separately so that the locations and times of capture can later be entered on to form B.

5.5.2. Laboratory Methodology

After selection and purchase, the sub-sample of fish should be taken back to the field laboratory and work should begin as soon as possible before the fish desiccate and the stomach contents decompose.

As noted above, the date, time and location of capture should first be recorded for each fish. The following measurements and samples should then be taken systematically and recorded on data form B. It is very important that the order of work described below is followed to ensure that meaningful measurements are recorded (eg total weight must be recorded before the gonads, stomachs etc have been removed from the fish) and for ease of operations. The measurements should be taken in the following order:

Length and weight data

For each fish in the sample, both the total length and the fork length should be measured using a measuring board and recorded to the nearest mm below. The fork length is the distance from the tip of the snout to the tip of the median rays (fork) of the tail. The fork length and total length are equivalent to each other for round-tailed fish. In addition, the corresponding weight in grammes (g) of the fish should be recorded to the nearest gramme using the top pan balance or, if the fish exceeds 100g, a spring balance.

Reproductive and life history sampling

The gonad of the fish should be inspected and the sex determined and recorded. In mature females, eggs are present in the ovaries. In mature males, the testes are smooth, whitish and non-granular in appearance (care should be taken not to confuse testes with adipose (fat) tissue and bodies).

The gonad of each fish should then be dissected from the fish and placed on blotting paper to remove any excess water. Particular care should be given to ensuring that the entire gonad is removed from the fish *intact* and that the surrounding tissue is not damaged. The weight should then be measured using the top pan balance and recorded to the nearest 0.1 grams (g). The gonad should then be inspected with a hand lens to determine the stage of sexual maturity. The stage of maturity should be classified as follows:

- I Immature- Young individuals which have not yet engaged in reproduction. Gonads very small, with no eggs or sperm present or easily visible.
- M Mature- Eggs and sperms are distinguishable with the naked eye; testes change from a transparent to a pale rose colour.
- R Ripe- Gonads have achieved their maximum weight. Gonads contain obvious eggs or sperm.
- S Spent- The sexual products have been discharged. Ovaries are often flaccid and bloodshot with the appearance of deflated sacs.

Stomach fullness and contents

The stomach fullness should first be measured by gently drawing its contents down towards the blind end of the stomach sac with a finger. Fullness should be recorded on a scale of between 1-10 where 10 indicates a full stomach, 5 a half full stomach and so on. Next, the stomach should be removed using a scalpel or scissors and its contents removed into a petri dish. Food items within the stomach should be identified using a hand lens if necessary. If, for any reason, the stomach contents cannot be identified at this time, they may be temporarily preserved in a sealable plastic flask containing 5% formalin or alcohol until a later date. The flask should be labelled with the date, time, location, species, in/out, and length. The percentages by volume of

each food item in the stomach should be estimated and recorded as separate lines on data form B. Food items should be assigned the following codes (these are likely to increase with time):

AE Algae
AN Annelids
CA Crustacea
DS Detritus
FH Fish
FT Fruit
GS Grass
HP Higher plants
IS Insects (and their larvae)
MS Molluscs
MD Mud
PN Phytoplankton
SS Seeds
ZN Zooplankton

Hard parts for age determinations

■ *Scales*

Scale samples should be removed with a pair of pointed tweezers or a scalpel. Several scales are required due to potential differences in size and morphology and because some scales may have been replaced. Initially, 20 scales should be collected, though this number may change after the first 'batch' has been read. In order to minimise the variation in scale size for the fish of a given length, it is desirable to use 'key scales' that is, scales taken from the same scale row and at the same point for each fish (Bagenal, 1978). The precise locations of key scales will be determined following initial field investigations in November/December 1994. Scales should be cleaned of any tissue or mucus and placed in the paper scale envelopes provided.

■ *Otoliths*

Otoliths should be removed by making incisions laterally and/or horizontally to either side of the fishes head. The large 'sagitta' should be removed using fine tweezers to prevent breakage. (This technique will be refined in the field in November/December 1994). After removal, the otolith should be rubbed between the fingers to remove any mucus, etc. and placed in the same envelope as the scales.

■ *Bones and other hard parts*

Opercula, vertebrae and fin and pectoral spines should be dissected out of the fish and cleaned of skin, flesh and mucus. After drying they should be placed in the scale envelope with the scales and otoliths.

All hard parts from individual fish should be placed in the same paper envelopes, which should be labelled with the following data:

Date,
Sampler initials,
Species,
Envelope number (see below).

Envelope numbers should be recorded in a simple series 1,2,3... for each day of sampling. In

combination with the date and species codes also recorded, this will give a unique reference for each envelope used to store hard parts. The same envelope numbers should also be recorded on data form B, along with the type(s) of hard part(s) removed using the following codes:

<i>Hard Part</i>	<i>Code</i>
Scales	S
Otoliths	O
Opercula bone	B
Vertebrae	V
Pectoral spine	P
Dorsal spine	D

5.6. B: Non-routine sampling of fecundity

As outlined in section 5.4.5., fecundity determination of batch spawners should be conducted over a relatively short period of time just prior to spawning so that all the specimens sampled are likely to be near the same stage of development.

5.6.1. Sample sizes and frequency

The sampling of ovaries to determine fecundity will require the purchase and dissection of approximately 50 fish per day over 5 working days from both inside and outside the FCD/I for each key species to generate sufficiently large samples for assessment. Samples should be taken just prior to the spawning period (around the time of the onset of the flood). Samples should be stratified according to size (age) class, habitat type and whether they were caught from inside or outside the FCD/I as outlined in Table 4.

5.6.2. Recording of data

Fecundity determination is time consuming, requiring individual eggs to be counted from accurately measured sub-samples of ovarian tissue. This type of work is not suited to field conditions, therefore it is proposed that ovaries sampled in the field be preserved and brought back to the UK for analysis within the laboratory.

Full use should, however, be made of the purchased fish and therefore it is recommended that all other biological attributes of the purchased fish be sampled according to the methodology outlined in section 5.5.2. and recorded on the Biological Sampling Form B.

5.6.3. Laboratory Methodology

The following routine should be conducted after length and weight measurements have been recorded as set out in the preceding section 5.5.2.

The ovary should be removed from the fish by dissection and placed on blotting paper to remove any excess water. Particular care should be given to ensuring that the entire ovary is removed from the fish *intact* and that the ovarian tissue surrounding the oocytes is not damaged. Ovary weight should then be measured using the top pan balance and recorded to the nearest 0.1 grams (g). The ovary should then be placed in a labelled jar containing 5% formalin and sealed tightly. Jars containing ovaries should be handled with care to prevent the breakdown of the ovary.

Each jar should be labelled with the following:

Date,
Sampler initials,
Species,
Ovary jar number (see below).

Like envelope numbers, ovary jar numbers should be recorded in a simple series 1,2,3... for each day of sampling. These numbers should be recorded on data form B in the comments column.

The remaining components of the biological sampling programme should then be conducted as outlined in section 5.5.2.

5.7. B: Summary of fieldwork Activities

1. In conjunction with the LF sampling programme, sub-samples should be taken for biological data for each of the key species during each 10-day sampling window within each two-month period.
2. For each key species/time period (and in/out site in Bangladesh), *stratified samples* of 20 fish from low-selectivity gears should be selected from the LF samples and taken back to the laboratory for dissection and measurement.
3. For each individual sampled, the methodology outlined in section 5.5.2. should be conducted and the information recorded on the Biological Sampling Form B.
4. Each spawning period, the methodology outlined in section 5.6.3. should be conducted to determine the fecundity of the key species.

6. Project Methodology: Hydrology Survey

6.1. H: Parameter Outputs

- Daily estimates of water heights at identified sites inside/outside impacted river/floodplain habitats.
- Weekly estimates of current velocities at riverine sites.
- Weekly estimates of water quality parameters, possibly including temperature, dissolved oxygen, turbidity, conductivity, total dissolved solids, biological oxygen demand and pH, from identified sites inside/outside impacted river/floodplain habitats. (*Depending on equipment, this may only be possible for the Indian and maybe the Bangladesh sites?*)

6.2. H: Survey Objectives

- H1. To provide a hydrological basis to the interpretation of the seasonality of fish migration patterns.
- H2. To determine river discharge rates (as the product of current velocities and cross-sectional areas) for comparison with productivity estimates.
- H3. To provide information on water quality changes associated with flood seasonality which may act as stimuli for migratory activities.

6.3. H: Survey Planning and Routine Sampling

This minor but important component of the sampling programme will simply involve *daily* readings of water levels and *weekly* recordings of flow and water quality parameters.

6.3.1. Water height recording

Daily water height records should be taken once every day, if possible always at the same time. Records may be taken from any stable and secure gauges which are available, and should ideally cover a number of different habitat types in the area. It may be possible, or convenient, to enlist the help of a *reliable* local person living near to the gauge to record daily heights.

Where possible, it would be extremely useful to obtain data on historical water levels from gauges either within or close to the field sites. These may be available from water resources agencies.

6.3.2. Water flow recording

Current velocities (river flows) should be recorded each week, always at the same mid-stream positions at convenient sites in the main river and in any subsidiary channels. In the absence of calibrated electronic equipment, flows may be adequately recorded by measuring the time taken for an immersed object to travel a given distance. This may be achieved in one of two ways: 1) by releasing a neutrally buoyant object (eg a piece of dense wood) attached to a string of known length, and timing how many seconds it takes for the string to become taut, or 2) by releasing a semi-buoyant object (eg an orange) and timing how many seconds it takes to travel a

measured distance downstream. On each weekly sampling occasion, two such measurements should be taken and the mean velocity recorded in m.s^{-1} .

6.3.3. *Water quality sampling and measurements*

A full range of water quality indices, including dissolved oxygen, turbidity, conductivity, total dissolved solids, biological oxygen demand, pH and temperature are presently being recorded at the Indian study sites.

Facilities are not available for such indices to be measured at the other sites, but it is assumed that such characters will be directly linked to water heights and flow rates; these will thus be used as the primary hydrological feature at each site.

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Tables

Table 1. Components of the Catch/Effort Survey Design

Survey Component	Sampling Units	Data Recorded	Sampling Frequency	Data Form
Frame Survey Initial Interviews	Key Respondents: fishermen, traders, leaseholders, fisheries officers.....	Qualitative information on fishing seasonality by locality and gear type	Once only	CE1a
Frame Survey Random Interviews	Randomly selected working males (from voter lists), clustered in PPS sampled fishing villages	Quantitative information on fishing populations and gear use for a subset of fishing villages	Once only	CE1b
CE Respondent Interviews	Randomly selected full- & part-time fishermen, clustered in PPS sampled fishing villages	Interview/recall estimates of fishing effort and total catch by gear type	Once during each 15 day period (2 survey periods per month)	CE2
Species Composition Sampling	Randomly selected whole, unsorted catches from a single gear type (usually, a basket)	Visual observations of % species compositions of catches by gear type	Opportunistically, during market visits	CE3

NB: PPS = probability proportional to size

Table 2. Fishing Effort Units by Gear Type

Gear Type	Effort unit
Passive Filters / Barriers	Barrier trap-hours ¹
Active Filters / Seines Open water (many hauls per day) Restricted water (few hauls per year), including Bangladesh <i>Katha</i> FADs	Net-hour Site ²
Drag / Push Nets	Net-hour
Lift Nets	Net-hour
Cast Nets	Net-hour
Gill Nets	Net-metre-hour
Portable Traps	Trap-hour
Hooks (long lines, individual hooks etc)	Hook-hour
Dewatering <i>Kuas</i> (fish pits) Hand fishing on floodplains	Site ² Man-hour
Spears	Spearing-hour

¹ Effort units including hours are either soakhours for unattended gears (mostly in Indonesia) or active fishing hours for attended gears (mostly in Bangladesh)

² eg per *katha/ku*a in Bangladesh. This effort measure takes no account of the different water areas fished.

Table 3. Required bi-monthly biological sample sizes for Bangladesh, stratified by fish size class and habitat type for each of the key species.

Species & Size Class (cm)					Habitat Type & Position			
					RIVER		FP/BEEL	
CS	CC	PS	GG	WA	IN	OUT	IN	OUT
0-10	0-10	0-3	0-4	0-10	2	2	2	2
11-20	11-20	4-7	5-9	11-20	2	2	2	2
21-30	21-30	8-11	10-14	21-30	2	2	2	2
31-40	31-40	12-15	15-19	31-40	2	2	2	2
40+	40+	15+	20+	40+	2	2	2	2

Table 4. Required annual fecundity sample sizes for Bangladesh, stratified by fish size class and habitat type for each of the key species.

Species & Size Class (cm)					Habitat Type & Position			
					RIVER		FP/BEEL	
CS	CC	PS	GG	WA	IN	OUT	IN	OUT
0-10	0-10	0-3	0-4	0-10	25	25	25	25
11-20	11-20	4-7	5-9	11-20	25	25	25	25
21-30	21-30	8-11	10-14	21-30	25	25	25	25
31-40	31-40	12-15	15-19	31-40	25	25	25	25
40+	40+	15+	20+	40+	25	25	25	25

Key species codes: CS *Channa striatus*
 CC *Catla catla*
 PS *Puntius sophore*
 GG *Glossogobius giurus*
 WA *Wallago attu*

Data Recording Forms

- Catch & Effort Data Recording Forms, CE1a, CE1b, CE2, CE3
- Length Frequency Data Recording Form
- Mark & Recapture Data Recording Forms, MR1, MR2
- Biological Data Recording Forms, B
- Recording Respondent Catch/Effort Data on form CE2: An Example
- Recording Length Frequency Data: An Example

Recording Respondent Catch/Effort Data on form CE2: An Example

The following CE2 data form is shown as an example of how CE data should be recorded. In this example, three respondents have been interviewed about their catches during the first sampling period of September 1994:

- On the preceding day (recall period '-1'), respondent B1 fished a seine net (code SN) with two colleagues for four hours, and they caught 5.2kg of fish between them. B1 then went on to haul his 400m gill net on his own to catch 2.1kg of fish.
- On the same preceding day, respondent B16 spent 5 hours hauling his line of 500 size 8 hooks, which had been in the water for approximately 12 hours. He then went on to haul his 12 standard-sized bamboo traps (code TB) to catch only 0.2kg of fish. Respondent B16 was also able to accurately recall his catch on the day before yesterday (recall period '-2'), when he did not haul his hooks, but his bamboo traps caught 0.8kg of fish.
- Respondent B23 did not fish any of his own gears on the preceding day, but did work earlier in the week (ie within the preceding 7 days overall; recall period '+7') with a team of 8 labourers to catch 48kg of fish from a brushpile trap (code SNB).

Fishing gear types should be carefully defined in the Gear Type, Size and Mesh/Gape columns. Mesh sizes should be measured as the knot-to-knot distance of one diamond of mesh stretched taught. Sizes are particularly important for gill nets, where the length is part of the effort measure (table 2). The column for CER Hours Fishing is crucial to the effort measure for seines, lift nets, cast nets and spears, but should also be entered for other gears to estimated the daily times spent fishing at each site. The numbers of units of gear are the most essential effort measures for hooks and individual traps. All cells should, however, be filled in whenever possible. Fishing locations should be identified with hypothetical, individual codes, used to distinguish discrete areas of the waterbody. These locations should be determined by interviewing the fishermen, and by reference to a detailed map of the area.

Key points for completing the CE2 data recording form

- *Each respondent should always be interviewed once in each half of each month.*
- Respondents should be interviewed as they are first encountered during travels around the study site, and ticked off on a *checklist* for the sample period once they have been interviewed.
- Respondents should be asked to recall their CEs for each gear they fished during the appropriate *recall period*. The recall period should be the preceding day for gears usually hauled every day, and the preceding 7 days for gears only fished occasionally (eg brushpile seines, dewatering).
- A separate row should be used for the CE data for each different fishing gear used by each respondent, within the appropriate recall periods.
- When the respondent fishes a gear as a *member of a team*, CE data should relate to the full equipment of the team, and the team size should be recorded.
- Suitable *codes* should be developed for the respondents, gear types and locations, and only these codes should be used on the forms.

Recording Length Frequency Data: An Example

The following LF data form is shown as an example of how LF data should be recorded.

In this example of a single day's LF sampling at XYZ market, fish were measured from fisherman's catches from a seine net and a long line (hooks) from a riverine site, and also from a second catch of smaller hooks from a floodplain site. The seine net catch comprised fish of three different key species, A, B and C, while both the hook samples catches contained only key species C.

The capture locations are identified with hypothetical, individual codes, used to distinguish discrete areas of the waterbody. These locations should be determined by interviewing the fishermen, and by reference to a map of the area.

Key points for LF data recording forms

- Samples from different *days* and different *sampling points* (ie different markets) should be recorded on separate *forms*.
- Samples of different *fish species*, *gear types* and *capture locations* should be recorded in separate *columns*.
- Suitable *codes* should be developed for the gear types and locations, and only these codes should be used on the forms.
- The *fork length* of fish should be measured, ie from the snout to the fork of the tail. For round-tailed fish, this will be equivalent to the total length.
- Small fish (maximum lengths up to 25cm) should be measured to the *nearest ½cm below*. Large fish (maximum lengths over 25cm) should be measured to the *nearest 1cm below*, ie:

Small fish in ½cm classes Larger fish in 1cm classes

1.0 - 1.49 = 1	26 - 26.99 = 26
1.5 - 1.99 = 1.5	27 - 27.99 = 27
2.0 - 2.49 = 2	28 - 28.99 = 28
etc	etc

- Measurements should be recorded in the appropriate boxes, by adding ticks in groups of five, thus **||||**. This enables easy tallying during subsequent data entry.