Government of the Peoples Republic of Bangladesh
Flood Action Plan

FAP 17

Fisheries Studies and Pilot Project

FINAL REPORT

(Draft)

JUNE 1994

Supporting Volume No. 7

FISHERIES STUDY

CHALAN BEEL POLDER B

ODA
Overseas Development Administration, U.K.

FAP 17

FINAL REPORT

SUPPORTING VOLUME NO. 7

**** Draft ****

FISHERIES STUDY

Chalan Beel Polder B

FAP 17
FISHERIES STUDIES
AND PILOT PROJECT

June, 1994

Funded by ODA in conjunction with the Government of Bangladesh

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PREFACE

The Fisheries Studies and Pilot Project (FAP 17) was funded by the British Overseas Development Administration (ODA) in conjunction with the Government of Bangladesh. The national implementing agency for the Fisheries Studies was the Department of Fisheries of the Ministry of Fisheries and Livestock. FAP 17 also reported to the Flood Plan Coordination Organisation of the Ministry of Water Resources. The project was one of a number of supporting studies of a broader programme known as the Flood Action Plan (FAP) of Bangladesh. The FAP consisted of a series of eleven major engineering studies, five of which comprised separate regional studies which aimed to identify feasible large-scale flood control and drainage projects through which it would be possible to regulate the extent of flooding during the monsoon. The engineering components were supported by a range of complementary studies, several of which were designed to address various social and environmental impacts which were anticipated to result from large-scale flood control.

FAP 17 was designed to address issues relating to fisheries and aimed to collect, analyse and interpret information on which to make predictions of the impacts of the planned flood control action upon the inland capture fisheries of Bangladesh. To do this, quantitative baseline fisheries and socioeconomic data were collected from inside and outside a range of different types of flood control projects in four regions of the country.

A total of eight FCD/I projects was studied and the results of each study were documented in a series of Supporting Volumes (Fisheries Studies) of the project Draft Final Report (see list of reports on page viii). Three further fisheries studies were completed, one of which described the fisheries of the main rivers Jamuna and Padma (Supporting Volume No. 10). The other two investigated the movements of a) adult and juvenile fish and b) fish hatchlings in regulated and unregulated rivers and assessed the impact of regulators on these movements (Supporting Volume Nos. 5 and 11). A parallel set of socioeconomic studies was carried out and the results documented in seven village study reports (Supporting Volumes 12-18). In addition to the fisheries and village studies, several special studies, mainly desk studies, were completed during the course of the project. These provided background information on fish, the environment and socioeconomics (Supporting Volumes No. 19-28). Several of these studies have been documented previously as annexes to the FAP 17 Interim Report. However, to ensure wider circulation, they were also included as part of the Draft Final Report.

One extremely important output from the FAP 17 study was the establishment of a detailed and comprehensive fisheries database which provides quantitative baseline information on inland fish resources and fisheries in Bangladesh. Fisheries and socioeconomic databases were submitted to the Government of Bangladesh through the Flood Plan Co-ordination Organisation of the Ministry of Water Resources and the Department of Fisheries in the Ministry of Fisheries and Livestock. Documentation of each database was included as Appendices 1 and 2 of the Draft Final Report.

The present report is one of a series of eight fisheries studies which form part of the Supporting Volumes to the Draft Final Report. The principal objectives of the supporting studies are listed below.

1) Evaluation of the effects of different flood control measures on the production of fisheries.
2) Evaluation of the effects of different flood control measures on the movements and populations of fish.
3) Assessment of the feasibility of technical and developmental measures to compensate for or reduce potential losses to fisheries due to flood control.

Descriptions of the methods employed for field data collection, laboratory studies and analyses of data are provided in the FAP 17 Inception and Interim Reports and are presented again with some additions in Appendix 3 of the Draft Final Report.

Two taxonomic guides were used for the identification of fish found during this study. The first was Rahman, A. K. A. 1989, Freshwater Fishes of Bangladesh, published by the Zoological Society of Bangladesh. The second was Talwar, P. K. and Jhingran, A. G. 1991, Inland Fishes of India and Adjacent Countries, Vols. 1 and 2, published by Oxford and IBM Publishing Co. Ltd. The more recent guide was used to provide a systematic listing of the scientific names of fish. However, the guide by Rahman was used more widely by fisheries biologists and all Bengali names of fish used in the present report were derived from this guide. The FAP 17 database also provides comprehensive lists of local names of fish collected in each region studied.

The term "species diversity" was used in this report in its simplest sense to denote the total number of different species of fish recorded at each site. The numbers of species recorded were dependent on the sampling effort deployed. No doubt more species would have been recorded had more sites or gear units been sampled more often using larger sub-samples of catches. All species recorded were divided into three categories of habitat preference: riverine, migratory and floodplain residents based on distributions identified using the complete FAP 17 database. The categorisations should be regarded as provisional only. As more knowledge is gained of the ecology and behaviour of individual fish and prawn species in Bangladesh more accurate revisions to the list will be needed.

Local names of gears were used throughout the report despite considerable geographical differences in names used in Bangladesh. A list of all gears recorded by FAP 17, with local and English names, and a brief description of each, is provided as an appendix to this report.

The source of all tables and figures presented in this report, unless otherwise stated, is from data collected by FAP 17 fisheries surveys.

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ACKNOWLEDGEMENTS

This report is based on the concerted efforts of a large number of people whose responsibilities covered: field data collection; administrative support; entry of data into computers; management of databases; analyses and interpretation of results, and report preparation.

Under the guidance of a senior fisheries supervisor, fisheries biologists, directly recruited by the project or provided through temporary employment by the Department of Fisheries, were responsible for the collection of fisheries, hydrological and limnological data. Field survey schedules required the team to monitor fishing activities from dawn to dusk, 12 hours each day, with additional surveys carried out before dawn to monitor night fishing. That the team accomplished its objectives despite arduous working conditions and long, unsocial hours of work, warrants the highest recognition and is a credit to both the team and the senior fisheries supervisor, Dr Nazrul Islam, who was responsible for maintaining not only discipline and high quality survey work but also team morale. The achievements of the FAP 17 fisheries survey teams demonstrated that it is possible in Bangladesh to obtain detailed quantitative fisheries appraisals based on the direct monitoring of fishermen's activities on water.

Administrative support staff and computer operators both in the field station and in Dhaka headquarters were responsible for the smooth running of the field programme and ensured that data were entered into the database promptly and accurately.

Mr. Asaf Hussain, senior computer programmer, was responsible for database management and programming and worked closely with Drs. James Scullion and Bernadette McCarton on data analyses. Fisheries resource assessment specialists, Professor John Beddington and Dr. Geoffrey Kirkwood of the Marine Resource Assessment Group, Imperial College, London, UK, advised on the statistical methods for the analysis of catch rates of gears which formed the basis of comparisons of fish catches inside and outside the flood control project.

Mr. Goutam Chandra Dhar, computer specialist, together with a small team in Dhaka were responsible for the preparation of the report.

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ABBREVIATIONS AND ACRONYMS

b. aman	Broadcast *aman*
BRRI	Bangladesh Rice Research Institute
BWDB	Bangladesh Water Development Board
°C	Degree(s) Centigrade
cm	centimetre(s)
CPUA	Catch Per Unit Area
CPUE	Catch Per Unit Effort
DO	Dissolved Oxygen
DWR	Deepwater Rice
EIRR	Economic Internal Rate of Return
EUS	Epizootic Ulcerative Syndrome
FAP	Flood Action Plan
FAP 17	Flood Action Plan Study No. 17 (Fisheries Studies and Pilot Project)
FCD	Flood Control and Drainage
FCD/I	Flood Control and Drainage with or without Irrigation
FRI	Fisheries Research Institute
g	Gram(s)
GPS	Geographical Positioning System
ha	hectare(s)
hr	hour(s)
HYV	High Yield Varieties
kg	kilogram(s)
km	kilometre(s)
m	metre(s)
mg/l	milligram(s) per litre
MIKE11	A microcomputer based modelling system for rivers and channels
NWR	North West Region
ODA	Overseas Development Administration
PIRDP	Pabna Irrigation and Rural Development Project
PWD	Public Works Datum (water level)
pH	Measure of acidity and alkalinity of water (log of hydrogen ion concentration)
SWMC	Surface Water Modelling Centre
t	tonne(s)
t. aman	Transplanted *aman*
TDWR	Transplanted deepwater rice
t/ha	Tonne(s) per hectare
WARPO	Water Resources Planning Organisation (previously MPO, Master Plan Organisation)
μS	Measurement of conductivity of water (micro Siemens)

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SUMMARY

1. Chalan *Beel* Polder B is one of a series of four contiguous polders on the right bank of the Atrai River in the North West Region of Bangladesh. The four polders together form part of a larger poldering system throughout the lower Atrai Basin. Construction work on Polder B started in 1973 and was completed in the eighties. The polder covers an area of about 33,00 ha and contains 48 km of flood control embankments along its boundary rivers Atrai and Barnai. The flow of a third boundary river, the Baral Nandakuja, is regulated at its offtake with the Padma River by Charghat regulator.

2. Between October 1992 and February 1994, fisheries catch assessment surveys were conducted at fortnightly intervals on floodplains inside Polder B and on unregulated areas of Chalan *Beel*. The Atrai River and unregulated canals linking it to Chalan *Beel* were also surveyed.

Flooding Patterns

3. Although Polder B was structurally secure and capable of preventing river flooding from its boundary rivers, extensive flooding of low-lying eastern areas still occurred in both the wet and dry years of 1993 and 1992. There were two reasons for this flooding. First, the project could not prevent internal rainfall flooding by gravity drainage when water levels in the Atrai exceeded those on the regulated floodplains. Secondly, local farmers dictated the operations of sluice gates for the production of deepwater rice. This involved opening gates to permit entry of external river water and closing gates to prevent drainage when Atrai levels decreased, so that relatively stable water levels were maintained. The operational practices of flood control differed from the original design objectives of the project which anticipated full protection from external river flooding with a consequent expansion of HYV *t. aman* on increased areas of drier land and a reduction in deepwater rice.

4. Controlled flooding for deepwater rice cultivation on low floodplains in Polder B resulted in the following impacts on flooding patterns.

   i) External river flooding was reduced inside the polder therefore a greater proportion of the monsoon flood was derived from rainfall.

ii) As a result of gate closures, the onset of extensive inundation of floodplains by rising river levels was delayed by about two weeks inside the polder compared with the time of arrival of floods (mid-June) on unregulated floodplains of comparable height on Chalan *Beel*.

iii) The period of complete inundation of floodplains was 11% shorter inside the polder (139 days) than that outside (157 days) due to the delay in the onset of flooding caused by sluice gate closures. However, temporary gate closures in early December prolonged the flooding in a drainage canal and its surrounding depressions inside the polder, which extended the flood season in these habitats by two weeks.

iv) Although there was no difference in peak flood levels recorded in early September inside and outside the polder, several differences were observed through the flood season. Between mid-June and mid-July, water levels inside the polder were 0.3-0.8 m lower than those outside but from mid-July onwards, levels inside were 0.5 - 1.0 m higher than outside. The overall effect of flood control was to provide a more gradual rising and progressively deeper flood between June and October thereby avoiding rapid seasonal fluctuations in water levels ranging from 0.5 m to 1.0 m recorded on unregulated floodplains.

v) Since the depth of flooding was at times up to 1.0 m higher than that outside, then the extent of flooding during these periods was also increased. In an extrapolation area surrounding the sampling site inside the polder, it was estimated that an additional 1,668 ha of floodplain were inundated due to flood control for deepwater rice production.

vi) A flood index based on the integration of depth and duration of flooding was 18% higher inside the polder (153 metre days) than that outside (126 metre days). Assuming other factors determining fish production remained unchanged, a higher flood index would be expected to result in increased fish production.

vii) Inter-annual variations in flood magnitude, extent and duration were substantially reduced inside the polder compared with those on unregulated floodplains.

Water Quality

5. Seasonal variations in water temperature, water colour, pH, dissolved oxygen concentration, total dissolved solids and transparency were monitored on floodplains, canals and rivers. With the exception of water transparency and water colour, no major differences in water quality were detected inside and outside the polder. However, the greater clarity of water observed inside the polder confirmed the stronger influence of rainfall flooding compared to that on unregulated floodplains which received a mix of river and rain waters during the monsoon.

Total Catch

6. The annual catch per unit area (CPUA) between March 1993 and February 1994 from floodplains inside Polder B was 189 kg/ha compared with 51 kg/ha on unregulated floodplain of Chalan *Beel*. Floodplain catch estimates inside the polder included the catch from the main drainage canal of the area which was submerged during the monsoon whereas feeder and drainage canals of unregulated floodplains remained identifiable and were therefore sampled separately. Once the catch from these canals was integrated into floodplain catches from a wider extrapolation area, the yield from unregulated floodplains increased to 68 kg/ha, still considerably lower than that from Polder B. However, statistical analyses indicated that there was no significant difference in fish densities inside and outside the polder (see para 8) and that much of the higher catch resulted from increased fishing effort inside the polder.

7. Other factors relating to hydrology, topography and sluice gate operations were also responsible, in part, for the higher catch per unit area in Polder B. First, an 18% increase in a flood index calculated for the monsoon period on the floodplain site inside the polder, would be expected to result in increased fish production (para 4 vi). That the flood, index was higher inside the polder was due solely to sluice gate closures. Secondly, proportionately more higher ground surrounded the sampled site inside the polder than that on unregulated floodplains. Thus the site probably served as a "sink" during the drawdown into which both floodwaters and fish drained from higher land via the main drainage canal. Thirdly, temporary sluice gate closures in December trapped and concentrated retreating fish, facilitating their subsequent capture. Part of this catch probably originated from areas outside the site.

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8. A survey of 17 months enabled a comparison to be made of catches taken during two flood recessions and winters during which the magnitude, duration and extent of flooding differed considerably. 1992 was a relative drought year while in 1993 there were substantially greater floods. Catches from both regulated and unregulated floodplains/*beel* were lower during the dry year and this was attributed to reduced flooding. The results also revealed a varying degree of impact of changes in flooding between years on the catches of different groups of fish. Greatest reductions in catch in the dry year were those of floodplain resident species, the group most dependent on floodplains. Large reductions in riverine species were also recorded but catches were very small (1 kg or less) and therefore percentage values were sensitive to very small differences in catch between years. Migratory species were less affected by changes in flooding patterns which suggests that at least some of the species concerned could feed and breed successfully in canals and rivers as well as floodplains.

Fish Densities

9. Statistical analyses of seasonally pooled catch rates of dominant gears used inside and outside the polder revealed no clear differences between sites. The results therefore indicated that fish densities were generally similar inside and outside the polder and that the higher catch recorded inside the polder was due principally to increased fishing effort of three of the most important gears, *jhaki jal*, *doiar* traps and *current jal* whose annual effort per hectare was two to fivefold higher inside the polder.

Diversity

10. The total annual number of fish species recorded on floodplains inside the polder (65) was 19% lower than the number (80) found on unregulated floodplains. Examination of the diversity within different groups of fish revealed a serious adverse impact on riverine and migratory fish from flood control. A total of 42 species in these groups was found on the unregulated floodplains of Chalan *Beel* compared with only 30 species within Polder B, a reduction of 29%. In contrast, diversity of floodplain resident species was reduced to a lesser degree (8%) on regulated floodplains.

Catch Composition

11. Riverine and migratory species accounted for 35% of the annual catch from unregulated floodplains compared with only 6% from the polder. These groups included large, high value species such as *boal* and several important smaller species such as *batasi*, *golsha tengra*, *kabashi*, *balichata*, *gang tengra* and *raik* which were considerably more abundant on unregulated floodplains. The differential impact of flood control on different groups of fish could be seen clearly by examination of values of CPUA of each group. The catch of riverine and migratory species inside the polder (11 kg/ha) was 39% lower than that on unregulated floodplains (18 kg/ha). In contrast, floodplains resident species comprised 52% of the catch from unregulated floodplains with a CPUA of 27 kg/ha compared with 77% from Polder B and a CPUA of 145 kg/ha, a fivefold increase in catch.

12. Ten riverine species were absent from Polder B which were found on the unregulated floodplains of Chalan *Beel*. However, all species were uncommon and together accounted for only 0.4% of the annual catch from Chalan *Beel*. Of the ten species, the most abundant included juveniles of *rita*, *shillong* and *baghair* and smaller species such as *piali* and *phasa*. Five migratory species were absent from the polder but present on Chalan *Beel*: *ayre*, *guizza*, *bata*, *boga* and *dari*. Again these were not particularly abundant species and comprised only 0.8% of the annual catch.

13. Of the 15 dominant floodplain resident species occurring on floodplains inside and/or outside the polder, 9 were common to both areas. The most abundant species on unregulated floodplains were *puti* (10%), *guchi baim* (9%), *tara baim* (6%) and *taki* (4%). Inside the polder, *puti* and *taki* dominated catches, each comprising about 20% of the annual catch. Other abundant species included *canchan puti* (7%) and *lal chanda* (6%). Prawns were important inside and outside the polder accounting for 17% and 13% of the annual catch respectively.

Fish Movements

14. Reductions in the diversity and abundance of riverine and migratory species inside Polder B were caused principally by blockage or hindrance to their seasonal movements between the Atrai River and floodplains caused by closures of sluice gates.

15. During May, water levels in the Atrai River increased sharply and connected with *khals* crossing unregulated floodplains and lowest depressions. In this month 11 riverine and migratory species appeared in catches on Chalan *Beel*, the most abundant of which were *balichata*, *gharpoia*, *guizza* and *batasi*. In Polder B, only 5 riverine and migratory species appeared in catches in May and their contribution to the catch (14%) was substantially lower than that from unregulated floodplains (54%). Movements of fish from river to floodplain were blocked after the first week of May by sluice gate closure. The two most important species entering the polder from the river were *balichata* and *batasi*.

16. In late June, river water inundated unregulated floodplains and also entered Polder B during partial, intermittent gate openings. A further 7 migratory/riverine species entered unregulated floodplains and appeared in catches at this time and a similar number (6 species) appeared in catches within the polder. The species composition of migratory fish differed markedly inside and outside the polder. On unregulated floodplains, *boal* and *bhangan* were the dominant migrants in June, whereas *katari* predominated within the polder.

17. From mid-July to the end of September, sluice gates were closed to retain floodwaters for deepwater rice. Only one new migrant species was recorded in catches from the polder in July compared with 5 on Chalan *Beel*. However, a further 10 migratory/riverine species which appeared in catches from the polder in August and September must have entered earlier in the year when gates were opened. During the same period, 11 migratory/riverine species appeared on unregulated floodplains of Chalan *Beel*. Riverine and migratory species migrated more rapidly from Polder B than from unregulated floodplains and almost all species had left by early December when sluice gates were temporarily closed. On unregulated floodplains, riverine species moved out more rapidly than migratory species and most had left by the end of December, while several migratory species remained until January. The reasons for these differences in rates of migration from regulated and unregulated floodplains during the drawdown and early winter remain unclear.

Future Flood Control Proposals

18. As part of the Fourth Flood Control and Drainage Project, recommendations were made for the rehabilitation of Chalan *Beel* Polders A, B, C and D to full flood control capability. Results from the present study indicated that on low-lying floodplains in

the eastern part of Polder B, this would result in a reduction in species diversity of 53%, increased fishing pressure on the fewer floodplain resident species remaining in smaller flooded areas, reduced dry season habitat in years of high river floods, reduced habitat diversity and fewer options for mitigation. There would also be a reduction in fish production but this could not be predicted accurately in the absence of details of quantitative changes in flooded areas in the low-lying floodplains adjacent to the Atrai and Barnai Rivers.

19. Following a detailed study of the lower Atrai basin, which included Chalan *Beel* Polders A, B, C and D, the North West Regional Study (FAP 2) concluded that full flood control on low floodplains was neither a feasible nor acceptable development option. Instead, it recommended a development approach termed the "Green River". The title was selected to emphasise the more "environmentally friendly" aspects of the approach. The Green River approach included a provision for partial flood protection near the Atrai so that peak monsoon river water flows over adjacent low-lying floodplains, including those in the eastern part of Polder B, as it would have done in its natural state. Away from the river, at a distance of 5 to 10 km from the channel and generally on higher ground, greater control of flooding and drainage would be established using fixed weirs.

20. The potential impact of the Green River approach on capture fisheries is dependent upon the degree of partial flood control planned for low floodplains. Although specifications of the method and degrees of flood control were provided for areas set back from the river, they were not clearly defined for low-lying floodplains. If fixed weirs were to be used for the protection of transplanted deepwater rice until 20 July as indicated in general design figures, then the flood return period determining crest heights of such weirs becomes critically important and must be clearly defined. The longer the return period, the greater the degree of river flood prevention. Partial flood protection until the 20 July would delay the entry of at least 20 species of migratory and riverine fish which would result in lost fish production and diversity during this period. The degree to which such losses can be compensated by the later (post 20 July) entry of river flood waters and fish cannot be predicted accurately since it is not known what proportion of the catch from unregulated floodplains of migratory species made after July was dependent on the entry of hatchlings, juveniles or adult fish earlier in the season.

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Mitigation Measures

21. On low-lying floodplains of Polder B and similar areas within the lower Atrai basin, the most effective mitigation measure to reduce losses to capture fisheries caused by flood control is to allow a degree of river flooding necessary for the production of deepwater *aman* rice. To achieve this, the FAP 2 study recommended partial flood control on low floodplains adjacent to the Atrai. However, justification in terms of potential agricultural benefits for even partial flood control, appears questionable. Partial flood control served two possible objectives, either to protect the winter *boro* harvest in May or early June or allow the cultivation of transplanted deepwater *aman* which required shallow flooding (less than 0.3 m) until about 20 July. FAP 2 itself noted that river floods did not normally threaten the harvest of winter rice in the lower Atrai basin because river levels were usually late in rising. Secondly, since the Green River approach is designed to provide more gradual flooding to lower maximum levels, it seems possible that both transplanted deepwater *aman* and *b. aman* could be cultivated without the need for any flood control measures. The re-establishment of a more natural flooding pattern on low floodplains along the lower Atrai basin would provide the most effective fisheries mitigation measure possible.

22. A series of other mitigation measures was recommended to reduce the adverse impact of flood control on capture fisheries of low-lying floodplains in Polder B and similar areas in the lower Atrai basin. The measures included: improved operation of regulators to increase fish and hatchling migrations from the Baral-Nandakuja on to floodplains; reassessment of the need for a second major regulator across the Baral River; improved migrations on the Atrai by the prohibition of seasonal dams; rehabilitation and protection of dry season habitats such as perennial *beel,* and conservation of fish populations during the dry season using *kua* or *beel* as fish sanctuaries. In addition, several measures were recommended which related to institutional improvements mainly within BWDB. The most important of these was the need to establish an effective multidisciplinary technical assessment unit in BWDB or WARPO comprising expertise from fisheries, agriculture, environment, hydrology and hydraulic engineering. The unit should be responsible for the re-evaluation of operating procedures of major existing structures and for the examination of future proposed flood control projects. Proposals for major new road or rail links which may affect flooding and drainage patterns should also be assessed by the unit.

Future Research

23. Several topics which require further research work were identified, most of which follow on from the baseline data provided by the FAP 17 study. The topics cover a mix of basic and adaptive research. Emphasis was placed on the need for detailed long-term studies running for up to ten years to obtain an understanding of the functioning of complex floodplain fisheries in relation to biological, environmental and socioeconomic factors which influence fish populations. The ultimate purpose of the research work is to provide not only a more detailed understanding of the precise mechanisms by which flood control affects different fish stocks but also to collect sufficient information on fisheries and flooding regimes upon which to base the development of a quantitative floodplain fisheries model. This can then be used as a predictive tool to provide future advice on fisheries management and development in Bangladesh.

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CHALAN BEEL POLDER B

1 STUDY AREA: BACKGROUND

Chalan *Beel* is an extensive lowland area located in the lower Atrai River basin in the North West Region of Bangladesh. The area is subject to deep flooding during the monsoon season caused by local rainfall and river flooding from the Atrai and its tributaries. Chalan *Beel* Polder B covers an area of 33,166 ha in Natore and Singra districts and is one of four contiguous FCD Polders, A, B, C and D, situated on the right bank of the Atrai (Figs 1.1 and 1.2). Construction work on Polders A, B and C was begun in 1973 by BWDB and continued in the eighties, under the Food for Work Programme. Construction work on Polder D started in 1981.

Polder B is bounded in the east, north and south by the Atrai and its tributaries, the Barnai and Nandakuja rivers respectively, while road and rail links form the western boundary on predominantly higher land. Under the original design of Polder B, it was intended to construct 86 km of flood control embankments, however only 48 km were constructed by BWDB along the Atrai and Barnai rivers. The left bank of the Nandakuja was not embanked since this was relatively high land already protected by a continuous line of village dwellings and rural roads. In addition, since 1983 the flow of the Nandakuja has been controlled by Charghat regulator on the Baral River at its offtake point with Padma River. The Baral and Nandakuja form a single river system which has been described in detail in a separate FAP 17 report[1]. In the high flood years of 1987 and 1988 there was very little overbank spillage from the left bank of the Nandakuja because of the protection by Charghat regulator and the Padma River embankment.

During the course of the Flood Action Plan, Polder B has been investigated as part of the North West Regional Study (FAP 2)[2] and an independent assessment was made in 1991 of its performance and impact on fisheries and agriculture as part of the Fourth Flood Control and Drainage Project[3]. Both studies proposed various engineering measures for the future development of Polder B. The 1991 assessment concluded that there was a need for rehabilitation of the polder and its neighbours to provide full flood protection and to improve the operation and maintenance of regulatory structures and embankments. The FAP 2 study proposed a different approach based on partial flood protection in low-lying areas and greater protection on higher land. The approach entitled "The Green River" is examined in more detail in Section 6 of this report.

The FAP 17 Fisheries Studies Project selected the Chalan *beel* area for study since it formed an important component of the FAP 2 regional studies which involved proposals for large-scale flood control in the lower Atrai basin. Polder B was selected for study largely through a process of elimination of other possible study areas based on the need to identify an FCD for which there were no engineering works on-going or planned in the immediate future and one which was not breached regularly or stocked with carp by the Third Fisheries Project and Department of Fisheries and for which a comparable free-flooding control area could be found. Only Polder B fulfilled all the requirements listed above.

Figure 1.1 Location of study area

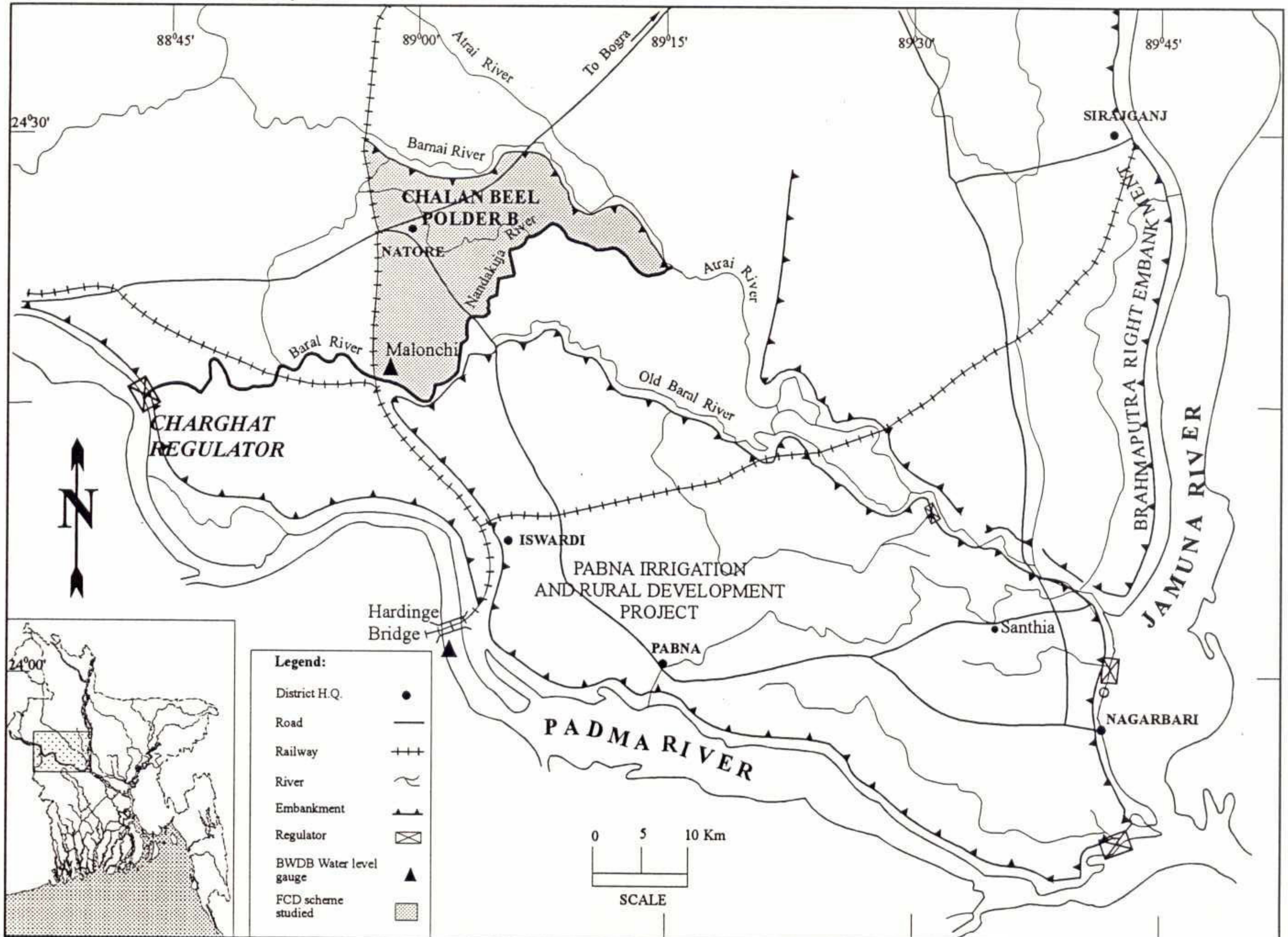
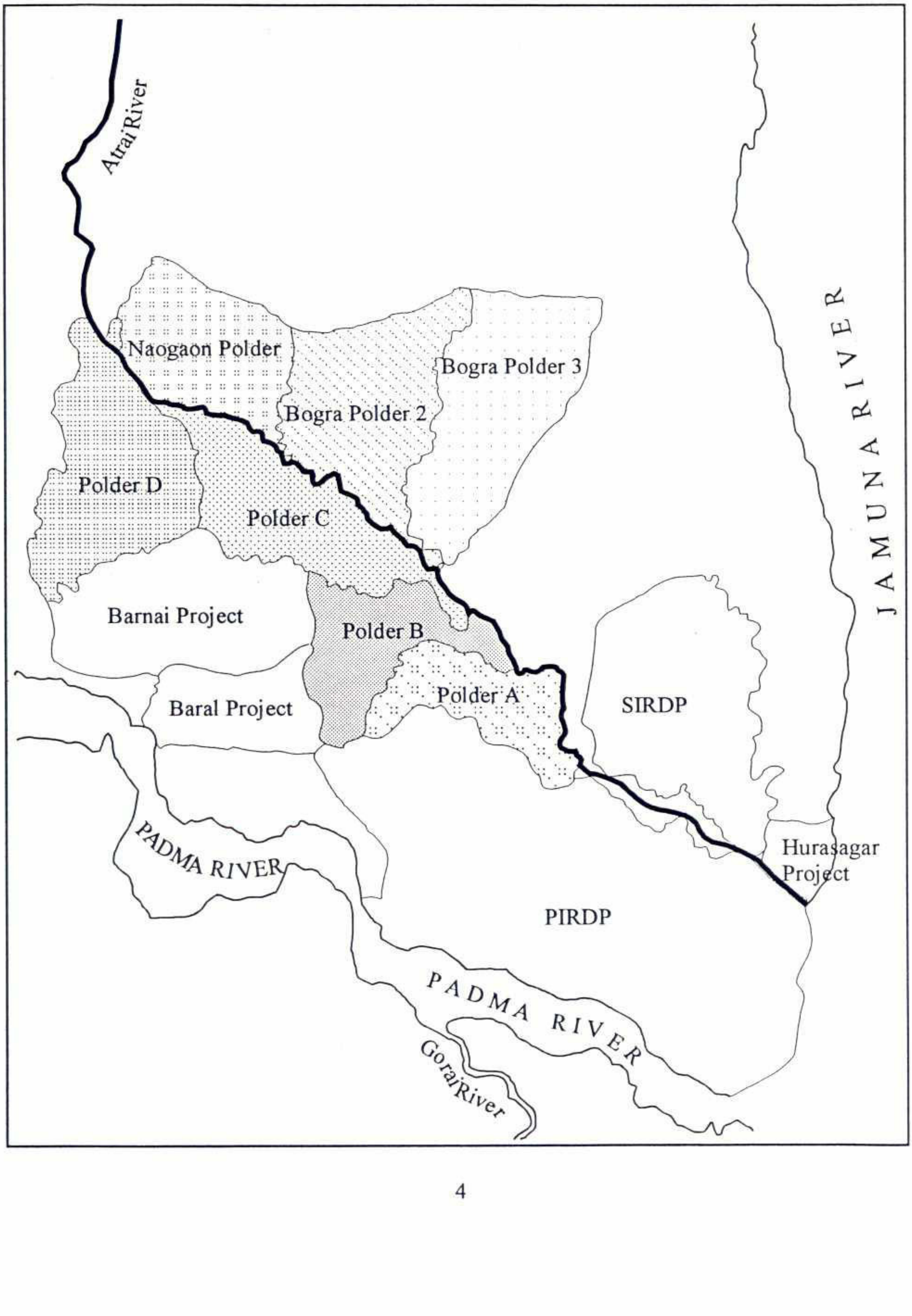


Figure 1.2 Polders in the Lower Atrai basin



2 DESCRIPTION OF SAMPLING SITES

Polder B covers a distance of 30 km from east to west. In outline it narrows considerably towards the east where an isthmus between the Nandakuja and Barnai rivers leads into an eastern "peninsula" of low land which floods fairly deeply during the monsoon. To the west of the isthmus the land progressively increases in height with only one other area of low land situated to the northeast of Natore (Fig. 1.1). For the purpose of the FAP 17 fisheries studies, only the low-lying eastern area was considered. This area was compared with an unregulated control area outside the polder on the opposite bank of the Atrai River in Chalan *Beel* (Fig. 2.1).

One floodplain site (NW30) was selected on Chalan *Beel* covering an area of 555 ha and one site was selected within Polder B (NW28) covering an area of 240 ha (Table 2.1 and Fig. 2.1). This site contained a drainage canal which connected with the Atrai through Haribhanga regulator. Since the canal was totally submerged during the monsoon, it was sampled as part of the floodplain. Similarly on Chalan *Beel* a canal which bisected the site but which was totally submerged during the monsoon was also sampled within the floodplain site. However, this canal drained into the Atrai via Piplagang *Khal* outside the floodplain survey area. A separate canal site was therefore selected (NW29) to monitor catches in reaches supplying and draining floodwaters from the floodplain site. The Atrai River was also surveyed along a 13 km stretch dividing the two floodplain sites.

Table 2.1 Description of sampling sites

Site Code	Site name	Habitat	In/Out FCD	Size	
				Area (ha)	Length (km)
NW28	Haribhanga *Beel*	Floodplain	Inside	240.1	-
NW30	Chalan *Beel*	Floodplain	Outside	554.7	-
NW29	Kubjipur and Piplagang *Khal*	Canal	Outside	24.5	8.9
NW27	Atrai River	River	Outside	87.3	12.7

Area elevation curves of each floodplain site were obtained using electronic planimetry on 8"/mile topographical maps (Fig. 2.2). There was some evidence from water level readings taken during this study that localised changes in land elevation have occurred at both sites due to siltation and, in Polder B, embankment construction (see Section 3). In general however, the sites inside and outside the FCD scheme were similar, with average (50%) land elevations of 9.1 m and 9.2 m respectively. The unregulated site covered a small area (10% of total) of higher ground (range 10-11 m PWD) which was not found inside Polder B.

Broader areas inside and outside Polder B were selected for the purpose of extrapolation of catch estimates from sampled sites and integration of catches from floodplains and canals (Fig. 2.1). Area elevation curves revealed that the extrapolation area on the unregulated Chalan *Beel* was similar in topography to the sampled area. However, the extrapolation area in Polder B contained a relatively larger area of higher ground than the sampled area. The possible effect of this difference between inside and outside areas on estimated annual fish catches is discussed in Section 5.1.2.

A comparison of the area elevation curves in Figures 2.2 and 2.3 of sampled, extrapolation and total areas of Polder B clearly show that most of the unsampled area was predominantly high ground. This is also shown clearly in the estimated areas flooded to different depths inside the polder during the monsoon season (Table 2.2).

Table 2.2 Estimated areas of land in Polder B flooded to different depths in July

Flood Depth in July (m)	Area Flooded (ha)	%
< 0.3	19,686	67.0
0.3 - 0.6	2,800	9.5
0.6 - 1.5	4,500	15.3
> 1.5	2,410	8.2
All depths	29,396	-

Source: Anon 1992[3]

Figure 2.1 Location of sampling sites

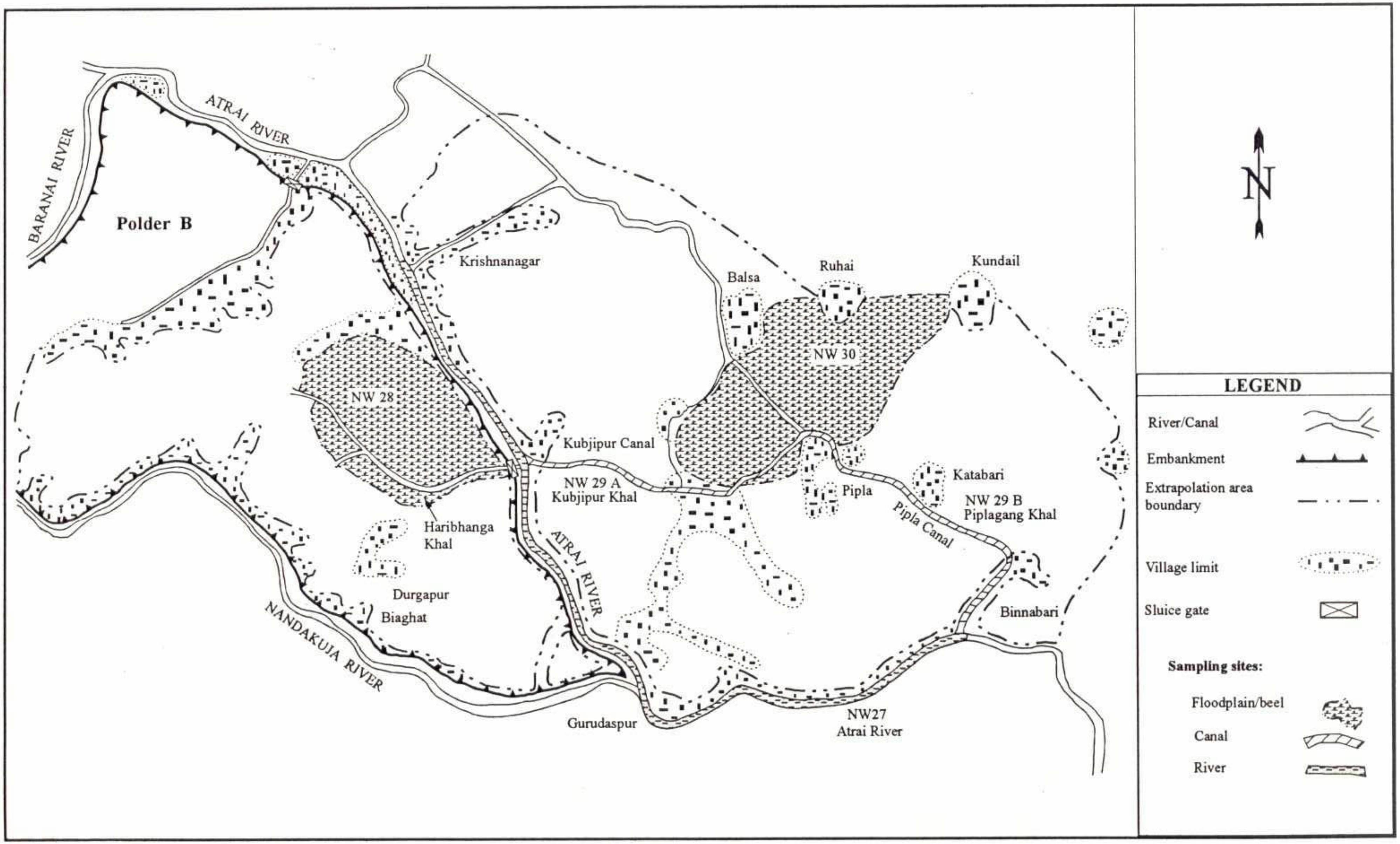
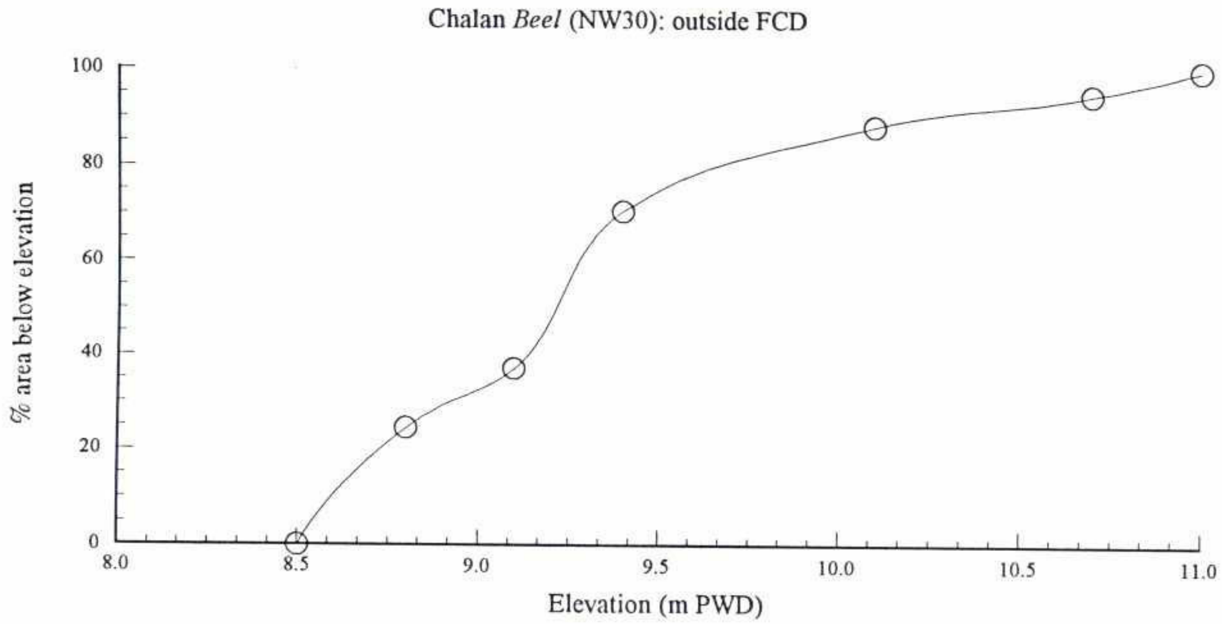


Figure 2.2 Area elevation curves of sites on Haribhanga and Chalan *Beel*



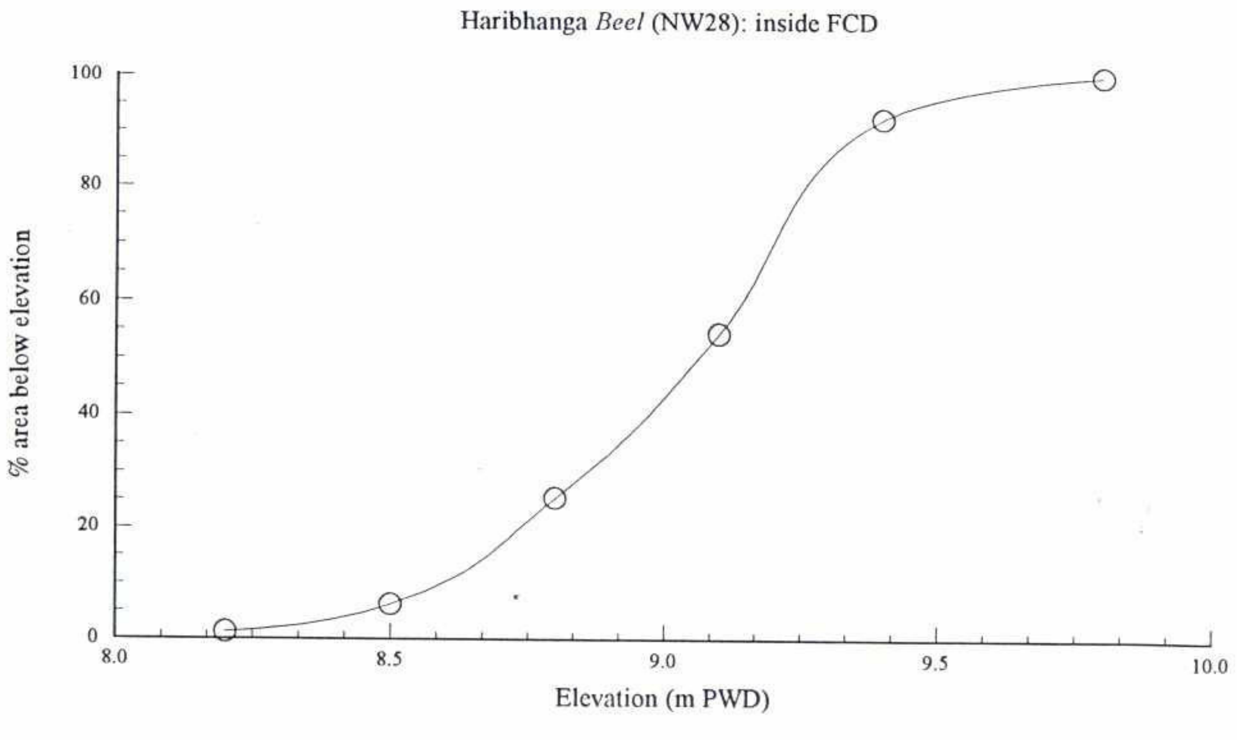
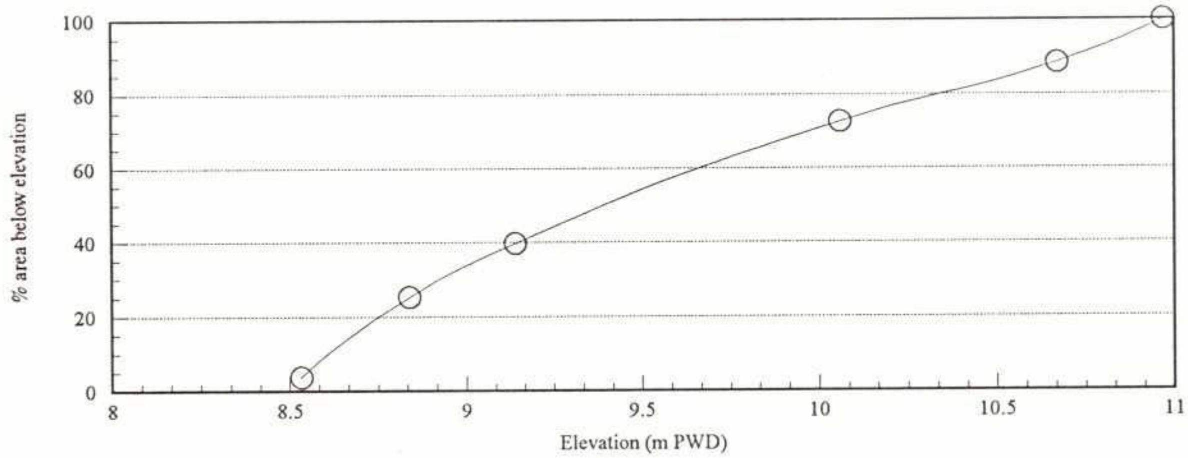
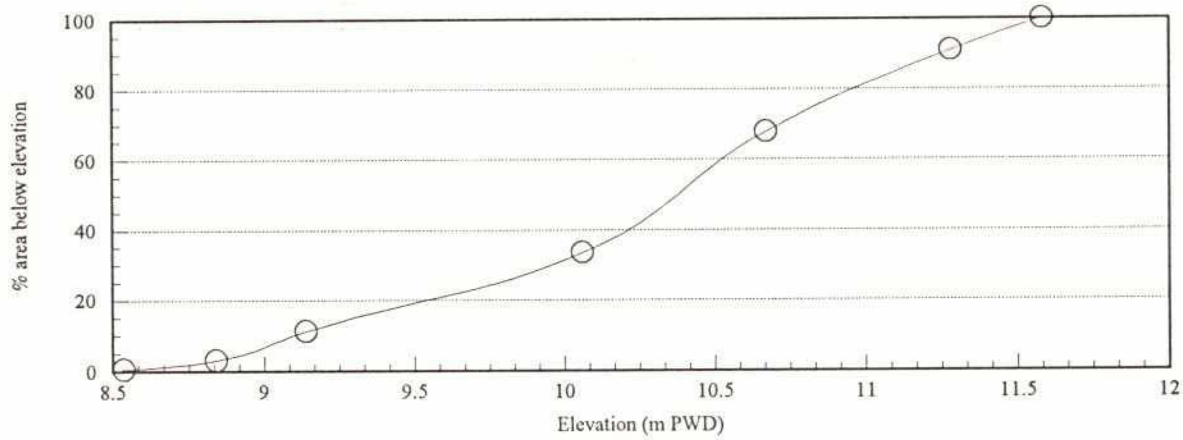


Figure 2.3 Area elevation curves of extrapolation areas on the unregulated Chalan *Beel* and in Polder B

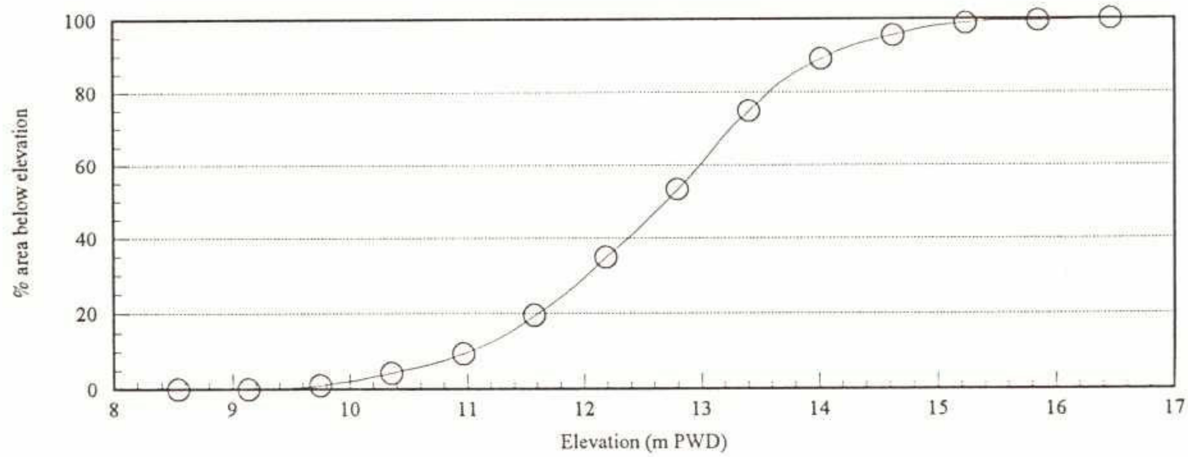
a) Extrapolation area on the unregulated Chalan *Beel* (2,070 ha)



b) Extrapolation area in Polder B (3,878 ha)



c) Total area of Polder B (33,166 ha)



3 HYDROLOGY

Two sources of data were used to provide quantitative and qualitative descriptions of flooding patterns inside and outside the polder. The first was from data collected directly during fisheries surveys. At each floodplain site, water depths were measured every two weeks at fixed points covering a range of land heights. The position of each depth reading was identified from both visual markers in the field and GPS readings. These were then located on topographical maps from which elevations were derived. At the same time, the extent of the flood was recorded on sketch maps and points of entry and exit of floodwaters were noted together with records of directions of flow in canals.

The second source of information was from daily readings of water levels in the Atrai River at Singra, about 25 km upstream from the floodplain sites. These readings were converted to water level readings in the reach bisecting the study area by deducting the difference in elevation at the two points on the river (1.0 m). The river levels derived in this way then provided a continuous record of flooding levels on unregulated areas of Chalan *Beel* which could be compared with direct readings of water depths on known land heights inside and outside the FCD scheme.

Searches were made for water level data from gauges on Haribhanga regulator, the main sluice gate draining the study area of Polder B. Unfortunately, BWDB could provide only fragmentary data (July - September 1991) and none for the period of this study. When data from the outside gauge for 1991 were compared with water level records from the Atrai, there was found to be poor agreement and therefore the data were not used in this study. The lack of accurate continuous records of water levels at an important structure such as Haribhanga regulator makes analyses of the performance of the polder impossible without additional direct measurements such as those made during the fisheries surveys.

3.1 Unregulated Chalan *Beel*

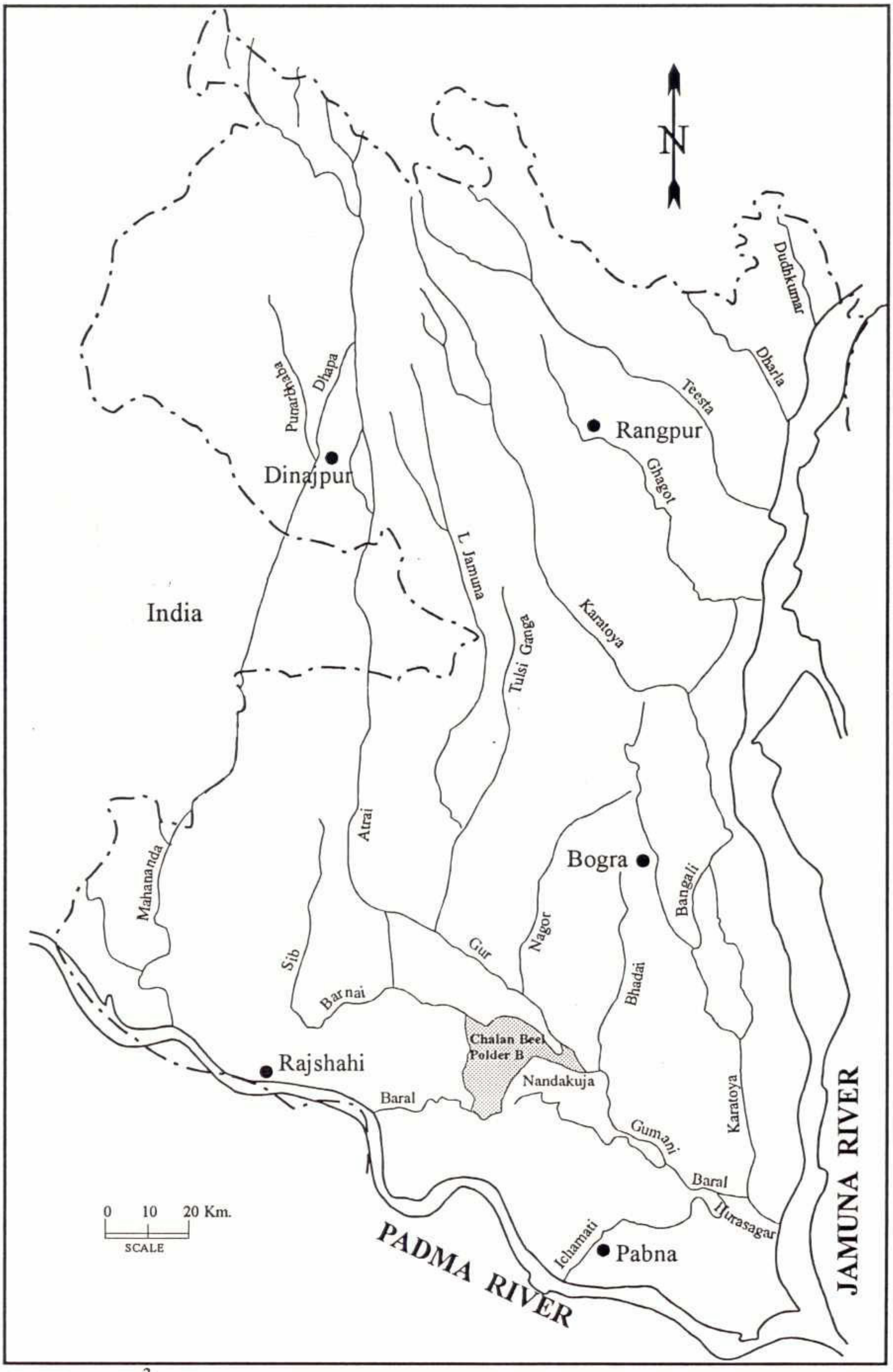
Flooding of Chalan *Beel* originates from local rainfall and from the Atrai River. The river rises in West Bengal, India, where its catchment area is relatively small but is subject to occasional overspills from the Teesta River during exceptionally large floods (Fig. 3.1). The river runs south draining the north west corner of Bangladesh where it subsequently turns to the south east and is joined by several tributaries, notably the Sib-Barnai and Baral-

Nandakuja on its right bank and the little Jamuna, Tulsi Ganga, Nagor and Bhadai on its left bank. All rivers except the Baral-Nandakuja are rainfall fed internal rivers while the Baral is a distributary of the Padma, the flow of which has been controlled by Charghat regulator since 1983. As the river flows southwards its known variously as the Atrai-Gur-Gumani and Baral before picking up the Karatoya-Bangali River and emptying into the Jamuna River as the Hurasagar.

Flooding in the lower Atrai is caused principally by drainage congestion as the Hurasagar meets the Jamuna River. High water levels of the Jamuna during most of the monsoon season prevent drainage of Atrai system and cause backing up of water levels for approximately 100 km upstream as far as Singra which is well beyond Polder B and its selected control area on Chalan *Beel*. The severity of flooding in the lower Atrai is related mainly to rainfall conditions within the region since the total flow from internal rivers must be stored until levels in the Jamuna permit drainage out through the Hurasagar. The degree of flooding is therefore related to conditions both in the main rivers and in the region itself. This means that even in relatively dry years such as 1992, extensive areas of the Atrai basin remained flooded due to drainage congestion. Attempts to prevent flooding by the construction of polders throughout the basin have largely failed, since the construction of a polder in one place exacerbated flooding in other places, resulting in a history of repeated embankment breaches by public cuts. In areas where there are no flood control embankments such as in the study area on Chalan *Beel*, local people report that following the construction of polders in other areas, floods in their area are now deeper and more sudden but that the extent of low-lying areas of perennial water has decreased due to siltation[4].

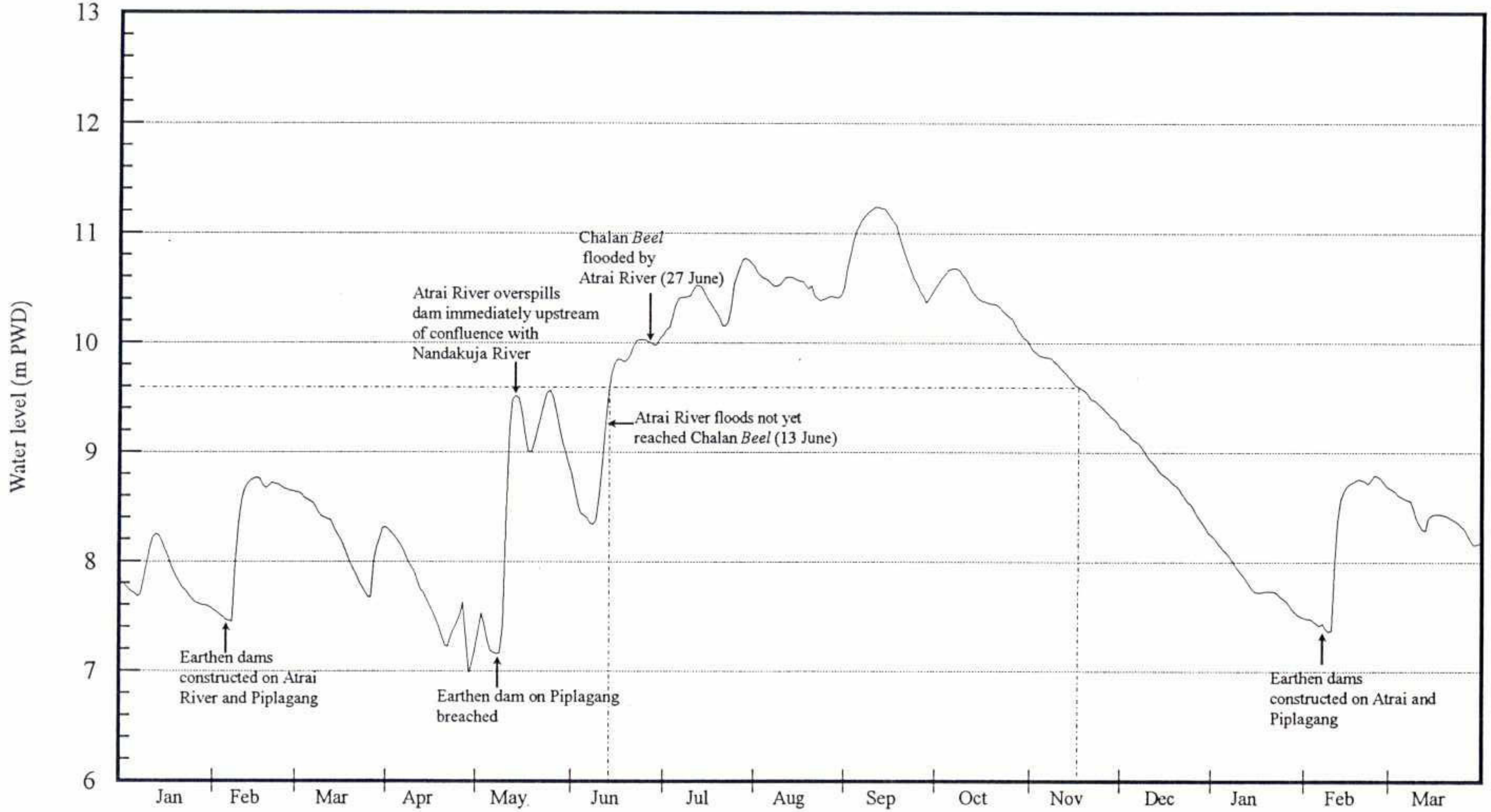
Water level measurements made at various points on the unregulated floodplain site on Chalan *Beel* (NW30), when converted to metres PWD and compared with levels of the adjacent Atrai River, showed reasonable agreement between June and September but differed by 0.4-0.6 m during the flood drawdown in October (Table 3.1). It was therefore considered acceptable to use the Atrai levels as an accurate continuous record of monsoon flooding levels in the unregulated area of Chalan *Beel* (Fig. 3.2). During February each year, earthen dams were constructed on the Atrai River above its confluence with the Nandakuja and on Piplagang *Khal* at Pipla village which served as the principal drainage canal for the study area (Fig 3.2). The dams created a reservoir of water in the feeder channels, Kubjipur and Besani *Khals* for the irrigation of HYV winter rice which covered the floodplain site and most of the surrounding area. Rainfall began in February 1993 but had little impact on floodplains. In March and April, heavy rains continued and caused intermittent shallow

Figure 3.1 Rivers of the North West Region



Source: FAP 2, 1992[2]

Figure 3.2 Seasonal changes in water levels in the Atrai River January 1993 - March 1994



Notes:
——— Denotes Atrai River levels derived from BWDB water level data at Singra minus 1.0 m to allow for differences in elevation
-·-·-·- Denotes water level and date when Atrai floodwaters enter Chalan *Beel* sampling site

flooding in scattered small depressions but did not result in extensive flooding. Further rainfall resulted in a sharp rise in the level of the Atrai during early May which consequently overspilled dry season dams. At about the same time, farmers cut a dam on Piplagang *Khal* to drain increasing rainfall flooding from the rice fields which were to be harvested in this month.

Table 3.1 Comparison of water levels (m PWD) on the unregulated Chalan *Beel* and the Atrai River, June - October 1993

Date	Floodplain levels			Arithmetic mean	Atrai River	Difference between floodplain and Atrai River (m)
	WL05	WL04	WL01			
13 June	0	0	-	0.00	9.72	
27 Jun	9.99	10.08	9.63	9.90	9.98	- 0.08
13 July	10.60	10.66	10.52	10.59	10.50	+ 0.09
26 July	10.68	11.00	10.78	10.82	10.69	+ 0.13
12 Aug	10.39	10.52	10.00	10.30	10.60	- 0.30
27 Aug	10.62	10.77	10.30	10.56	10.42	+ 0.14
12 Sep	11.00	11.30	10.88	11.06	11.23	- 0.17
24 Sep	10.55	10.72	10.42	10.56	10.54	+ 0.02
12 Oct	9.99	10.17	9.80	9.99	10.59	- 0.60
26 Oct	9.70	9.95	9.64	9.76	10.17	- 0.41
12 Nov	0.00	0.00	0.00	0.00	9.74	

By the end of May, the lower-lying areas of floodplain were under 0.3 m to 0.5 m of water but about 30-40% of the sampled area was still dry (Fig. 3.3). Rainfall runoff from floodplain to river continued until mid-June and higher areas of the site still remained dry. Between 13-26 June the Atrai rose sharply and floodwaters completely submerged the floodplain (Figs 3.2 and 3.3). During the monsoon months of July to September water levels fluctuated with the rise and fall of the Atrai and water depths ranged from 1.5 to 2.5 m over most of the site. The flood drawdown started in mid-October and the first dry land appeared in early November. By the end of the month about 50% of the site was dry and by mid-December water remained in small scattered depressions which dried up completely by the end of the month leaving only *kua* and canals as dry season water bodies on the floodplain.

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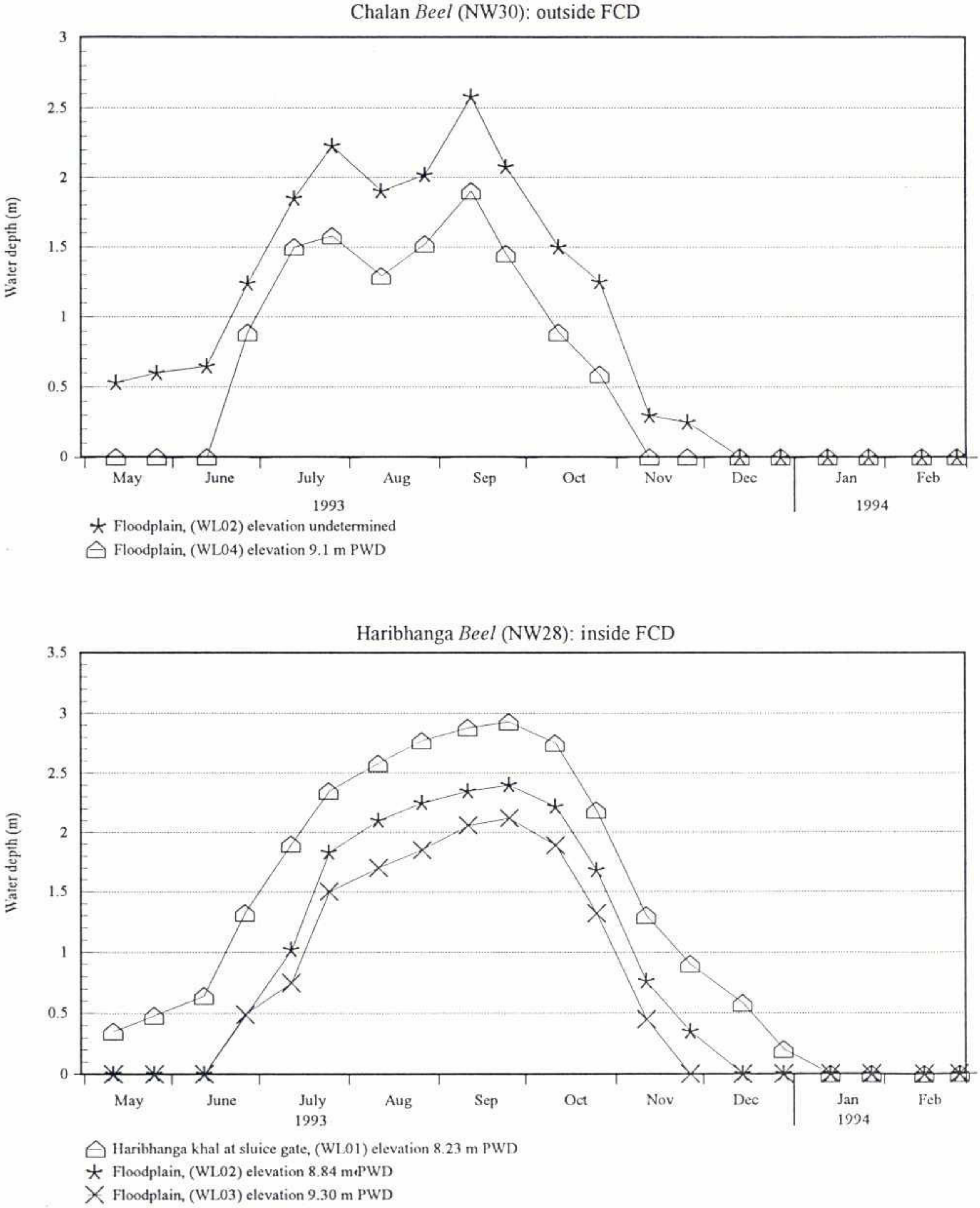
Figure 3.3 Seasonal variation in water depths at different land elevations on Haribhanga and Chalan *Beel*



3.2 Polder B

Prior to the construction of flood control embankments and high village roads, the low-lying areas in the eastern part of the polder received floodwaters from the Atrai, Barnai and Nandakuja rivers. Since 1983 the flow of the Nandakuja has been controlled effectively by Charghat regulator at the offtake of the Baral River from the Padma. Prior to regulation, the confluence of the Nandakuja and Atrai provided the basin's most important meeting point of the Ganges and Atrai systems. The mixing of waters from such large rivers as these has particular importance for fisheries in providing major migration routes not only for adult and juvenile fish but also their spawn and hatchlings[1]. These rivers provide the last remaining route through which the hatchlings of major carp spawned in the Ganges can reach the extensive floodplains of the lower Atrai basin.

Since the construction of flood control embankments along the Atrai and Barnai rivers from 1973 onwards, Polder B has been breached by deliberate public cuts once only in each of 3 years, 1985, 1986 and 1988. These were all related to flooding problems outside and upstream of the project in Polder C. The neighbouring upstream polders have been subject to regular deliberate breaches since their construction and have therefore proved to be ineffective and misconceived as a flood management measure. In contrast, Polder B has caused fewer problems, principally because much of its regulated area comprises relatively high land where regular deep flooding did not occur prior to flood control. In addition its southern boundary along the Nandakuja is controlled effectively by Charghat regulator. During very high floods of 1987, satellite images show that Polder B was flooded deeply by rivers only on the lowest lands in the small eastern part of the project.

Fortnightly water level readings taken in Haribhanga *Khal* immediately inside the main drainage sluice, Haribhanga regulator, and at various points on the floodplain were converted to datum levels (m PWD) and compared with one another (Table 3.2). Since there was generally good agreement between readings, the arithmetic mean was used to compare with water levels in the Atrai immediately outside the sluice gate. These also reflected water levels on the unregulated floodplain (Fig. 3.4).

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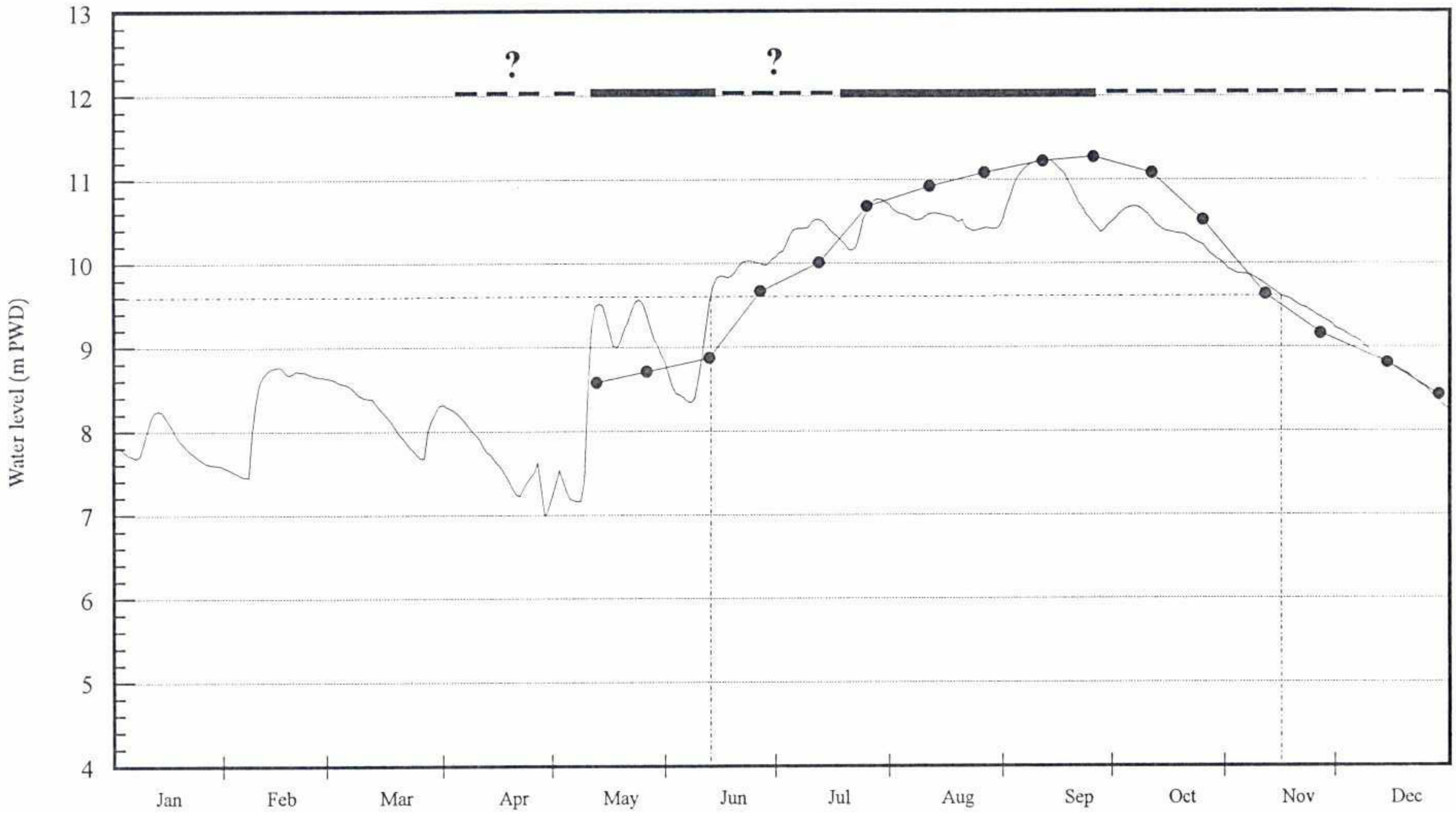
Figure 3.4 Comparison of water levels in Haribhanga *Beel* and the unregulated Chalan *Beel*, January 1993 - December 1993



Notes:
1. Denotes water level in Atrai River and on the unregulated Chalan *Beel* between June and November
2. Denotes water level in Polder B
3. Denotes level and date at which Atrai River flooded the unregulated Chalan *Beel*
4. Solid and dashed lines denote sluice gates closed and open respectively

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Table 3.2 **Comparison of water levels (m PWD) in Haribhanga *Beel*, May - December 1993**

Date	WL01	WL02	WL03	Arithmetic mean
12 May	8.58	0	0	8.58
26 May	8.71	0	0	8.71
12 June	8.87	0	0	8.87
26 June	9.55	-	9.79	9.67
12 July	10.13	9.86	10.05	10.01
25 July	10.58	10.67	10.80	10.68
11 Aug	10.81	10.94	11.00	10.92
26 Aug	11.00	11.09	11.15	11.08
11 Sep	11.11	11.19	11.36	11.22
25 Sep	11.14	11.24	11.42	11.27
11 Oct	10.98	11.06	11.19	11.08
25 Oct	10.42	10.52	10.62	10.52
11 Nov	9.53	9.60	9.75	9.63
26 Nov	9.13	9.19	0.00	9.16
14 Dec	8.81	0.00		8.81

Note: Arithmetic means omit zero or missing values

Early rainfall between February and April 1993 resulted in the flooding of small depressions inside Polder B but most of the floodplain was relatively unaffected and supported an extensive crop of HYV winter rice. There were no obvious differences in the extent of this winter rice crop inside and outside the polder. During May, rainfall continued but resulted in only a slight expansion of flooded area. At this time, the gates of Haribhanga regulator were closed to prevent entry of Atrai waters into Haribhanga *Khal* (Fig. 3.4). Between mid-June and mid-July when the Atrai reached levels higher than the surrounding floodplains, water levels inside the polder increased less swiftly than those on the unregulated floodplains and depths were reduced by 0.3 m to 0.8 m. Consequently, the timing of initial complete inundation of the floodplain site inside the polder was delayed by about two weeks compared with that on unregulated floodplains. This occurred between late June and early July.

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During this period it seems likely from Figure 3.4 that there was intermittent partial opening of sluice gates to allow the controlled entry of Atrai waters for the surrounding fields of deepwater rice which covered about 30-40% of the higher marginal areas of the sampling site and its adjacent floodplains. Once water levels inside the polder exceeded those of the Atrai, gates were closed to maintain levels needed for deepwater rice. Between July and October water levels gradually increased due to rainfall flooding and runoff from higher land, reaching a peak in late September when depths ranged from about 2.0 - 3.5 m across the floodplain. They progressively declined once sluice gates were partially opened in early October and then fully opened later in the month. The regulation of water levels for the benefit of deepwater rice resulted in flood levels exceeding those on the unregulated site by 0.5 m to 1.0 m for most of the monsoon season. The flood drawdown started in October but the first dry land appeared on the site in early November. By mid-December, the first outlines of *kua* appeared but at least 40% of the floodplain was still submerged. Sluice gates were recorded as closed in mid-December but fully open again at the end of the month. At this time floodwaters remained in a narrow low-lying depression extending across the floodplain adjacent to Haribhanga *Khal* and in several *kua* which had fully emerged.

Compared with outside unregulated floodplains, the duration of the flood season inside Polder B was extended by about two weeks during December 1993 due to temporary gate closure in the first half of the month. Between January and February, Haribhanga *Khal* dried out leaving *kua* as the last remaining water bodies on the floodplain which was by then covered with HYV winter rice.

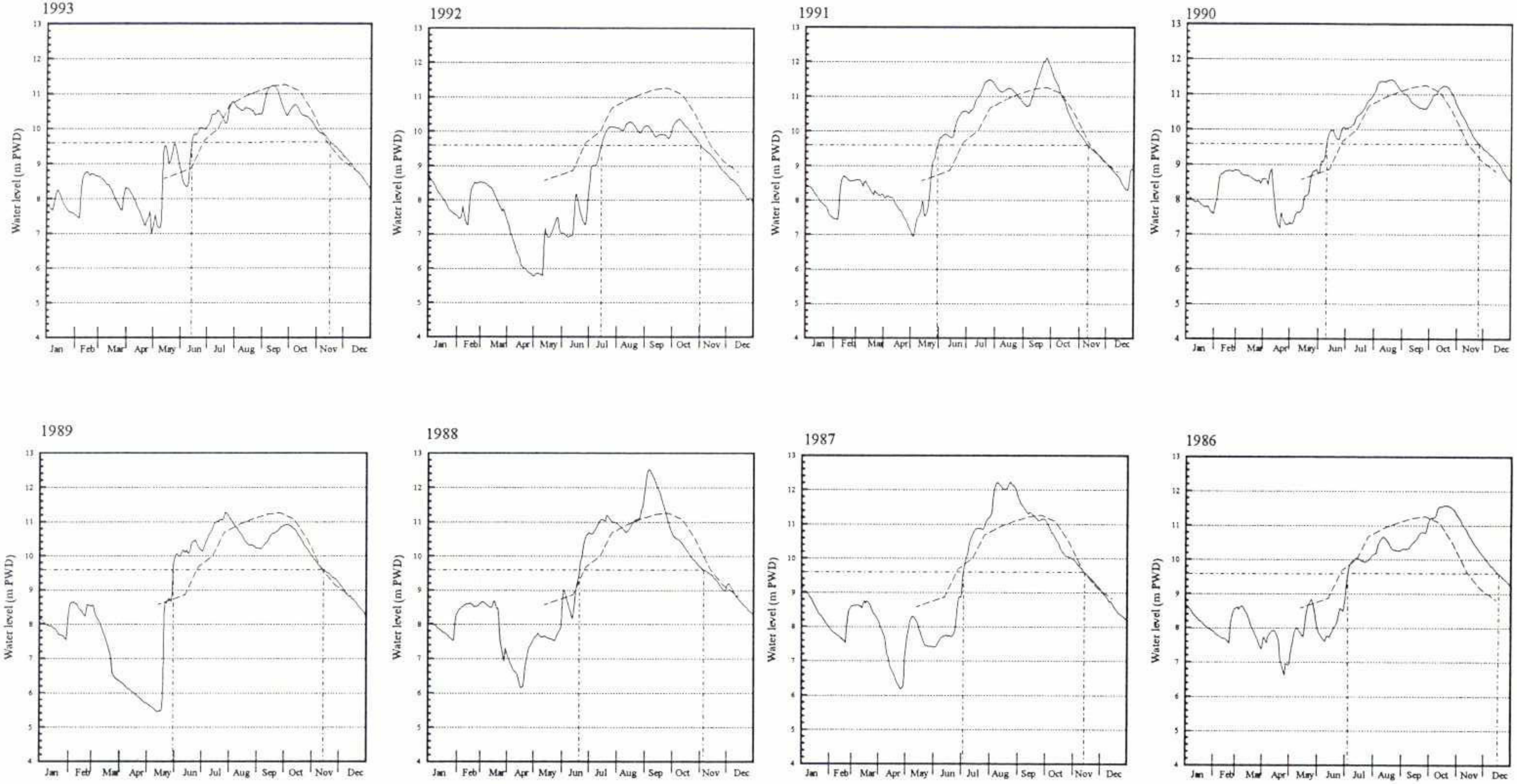
Analyses of flooding patterns shown in Figures 3.4 and 3.6 were used to compare sites inside and outside the polder during 1993 (see Section 3.3 for details of Figure 3.6). The results indicated that the period of complete inundation of floodplains was 11% shorter inside the polder (139 days) than that outside (157 days) due to the delay in the onset of flooding caused by gate closures. Maximum flood levels were similar inside and outside but a flood index based on the integration of depth and duration of flooding was 18% higher inside the polder (153 metre days) than that outside it (126 metre days) which should favour increased fish production inside the polder assuming all other determining factors remained unchanged (see Section 5.1.2).

3.3 Inter-Annual Variations in Flooding Patterns

No data were available to examine directly inter-annual variations in flooding patterns in Polder B. However, during reconnaissance surveys carried out in Haribhanga *Beel* and the unregulated Chalan *Beel* on 27 and 29 September 1992, water depths of between 3.0 m to 3.5 m were recorded from the deepest area of Haribhanga *Beel* in site NW28 while the deepest areas on Chalan *Beel* were 1.0 m lower (2.5 m) with most of floodplain under only 1.0 - 1.5 m of water. Thus, during 1992, a year of severe drought, levels in Haribhanga *Beel* were about 1.0 m to 1.5 m higher than in Chalan *Beel*. This was undoubtedly the result of the conservation of rainfall flooding for the production of deepwater rice in the low-lying areas of Polder B. In this way, flood control substantially reduced the degree of inter-annual variation in flooding levels to meet the needs of rice production. Water levels recorded inside Polder B during 1993 were superimposed on the hydrograph for the Atrai River for 1992. The difference between inside and outside (Atrai) levels in late September 1992 agreed closely with observed differences and therefore the data for Polder B were compared with Atrai levels in other years (Fig. 3.5).

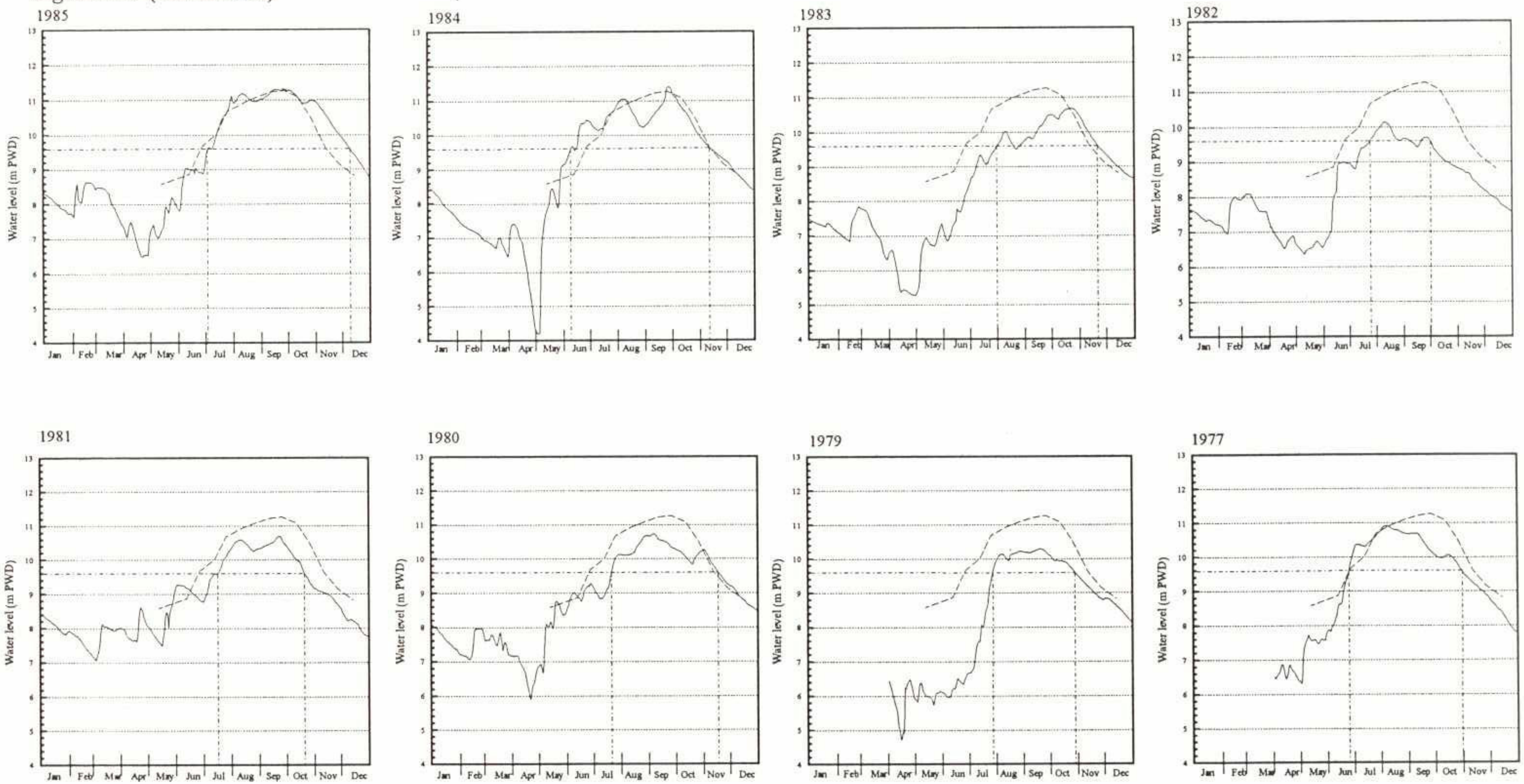
Since breaching of the Barnai embankment was reported in 1985, 1986 and 1988, it is likely that water levels inside Polder B would follow more closely the Atrai levels in these years. In 1990, the flooding in Polder B would also follow the drainage pattern during the late drawdown of that year and not that of 1993, as shown in Figure 3.5. Between June and July in most years, water levels in the polder were lower than in the Atrai. The degree to which gates were opened during this period would have depended upon the amount of local rainfall flooding. If this was sufficient for deepwater rice growth then gates would not have been opened at all. It is also clear that in most years there were extended periods from August onwards when regulated water levels exceeded outside levels by closure of sluice gates. The data also revealed considerable variation in the timing of river flooding on unregulated floodplains, ranging from the beginning of June to the end of July between 1977 and 1993. The timing of entry of river waters on to floodplains was determined by both internal river flooding patterns and levels in the Jamuna River. The high degree of inter-annual variation in the time of arrival of floods has been documented for other regions in Bangladesh. At Habiganj near the lower Meghna River, the time of inundation from 1975 to 1988 averaged 9 June and varied by $\pm$ 35 days[5].

Figure 3.5 Comparison of observed levels of the Atrai River at Haribhanga regulator with estimated levels in Polder B, 1977 - 1993



Notes: 1. ——— Atrai River levels at Haribhanga regulator derived from water level data from Singra gauging station minus 1.0 metre to allow for differences in elevation
2. - - - - - Denotes water levels in Polder B during 1993 (see text for explanation)
3. -.-.-.-. Denotes level and date at which Atrai River flooded unregulated Chalan *Beel*

Figure 3.5 (Continued)



Notes: 1. ——— Atrai River levels at Haribhanga regulator derived from water level data from Singra gauging station minus 1.0 metre to allow for differences in elevation
2. - - - - - Denotes water levels in Polder B during 1993 (see text for explanation)
3. - . - . - . Denotes level and date at which Atrai River flooded unregulated Chalan *Beel*
4. Only 3 months data available in 1978 therefore omitted

Data from Figure 3.5 were used to obtain annual estimates of the duration of the flood season and maximum depths of flooding each year on the unregulated floodplains of Chalan *Beel* (Fig. 3.6 a and b). Another valuable parameter was provided by the integration of duration and depth of flooding to obtain a single index in metre-days of flooding which should, theoretically, show a direct positive relationship to floodplain fish production (Fig. 3.6 c). A similar method of integrating the area under the flood profile has been used previously to assess the impact of proposed flood control projects on fisheries in the North Central Region of Bangladesh[6] and, in a slightly more complex manner, to classify varieties of deepwater rice in terms of their response to different flooding patterns[7].

Data in Figure 3.6 indicated that the duration of inundation of Chalan *Beel* ranged from 69 to 169 days between 1977 and 1993. The duration of the flood in 1992 (111 days), a relative drought year, was 29% lower than in 1993 (157 days). Longest floods were recorded between 1984-86 and 1989-91. The early eighties appeared to be a period of particular drought on Chalan *Beel*. Deepest flooding was seen in 1987 and 1988, years of exceptional floods. These were not however the periods of longest floods. Integration of flood depth and duration revealed that greatest flooding indices occurred between 1984 and 1991 with the highest value recorded in 1991. The flood index of 1992 was 61% lower than in 1993. The implications of such large inter-annual variations in flooding are discussed in more detail in Section 5.1.3.

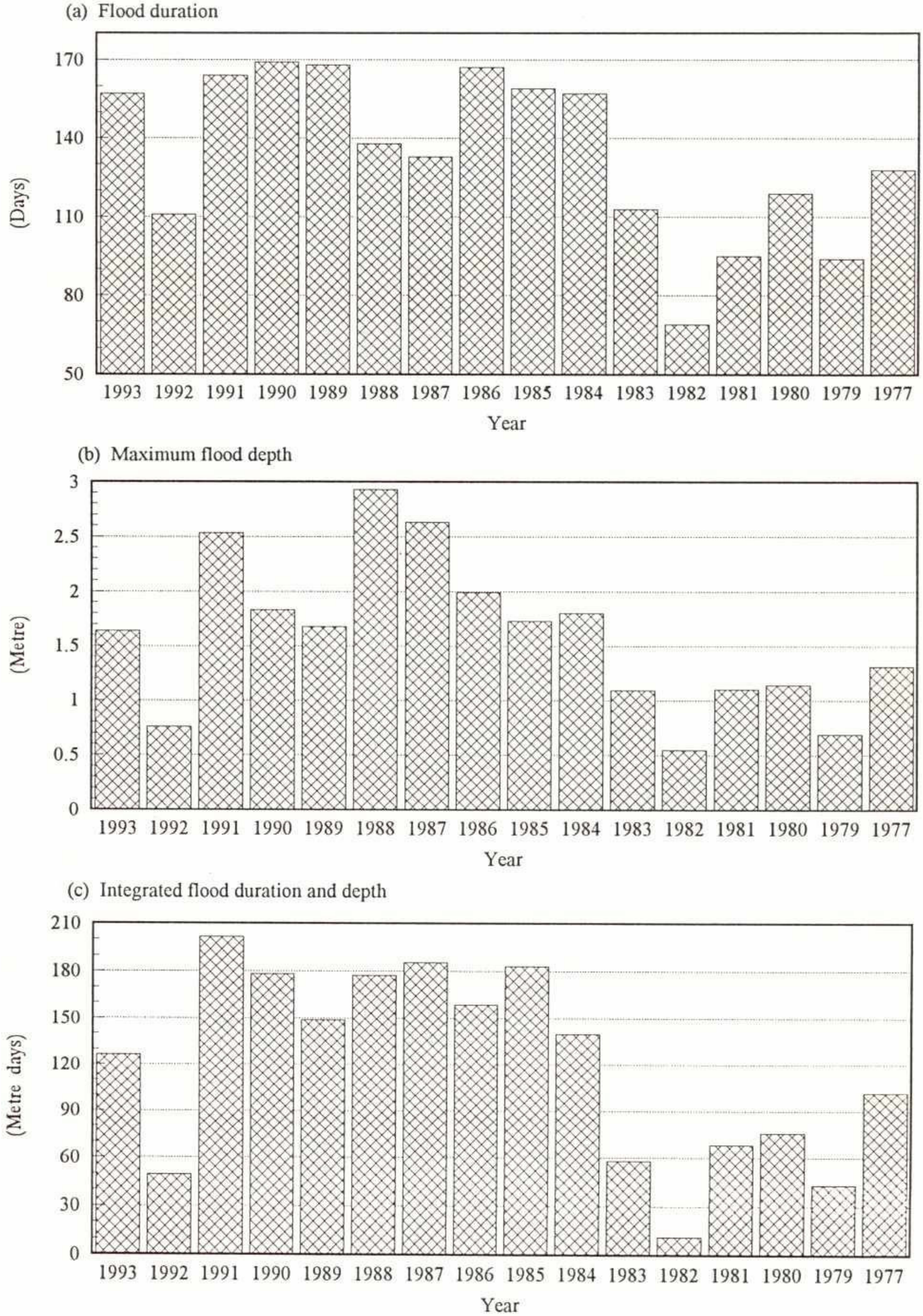
The time series of water level data provided by BWDB for the gauging station at Singra and used in this study was compared with data from gauging stations upstream and downstream on the Atrai. There were some inconsistencies between data sets for the early eighties; the results for this period should therefore be treated with caution.

3.4 Impact of Polder B on Flooding Patterns

3.4.1 Flood source

River flooding inside the polder was greatly reduced therefore a substantially larger proportion of the monsoon flood resulted from internal rainfall compared with that on unregulated floodplains of Chalan *Beel*.

Figure 3.6 Inter-annual variations in flooding patterns on the unregulated floodplains of Chalan *Beel*, 1977-1993



(12)

3.4.2 Flood timing and duration

On lower areas of floodplains inside and outside the polder, shallow rainfall flooding accumulated in May. During the second half of June, rapidly rising river floodwaters resulted in the submergence of unregulated floodplains, while sluice gate closures prevented or slowed the rate of increase and delayed the initial rise in water levels inside the polder by about two weeks. The timing and speed of the flood drawdown on regulated floodplains was delayed and slowed in December by temporary gate closure which prolonged the flooding on lowest land by about two weeks. Thus, while the period of complete inundation of floodplains was about two weeks shorter within the polder, the duration of flooding of *khal* and the lowest areas of floodplain was about two weeks longer than that on unregulated floodplains.

3.4.3 Flood magnitude and extent

Peak flood levels recorded in early September were of the same magnitude inside and outside the polder. However, regulated levels were 0.3 m to 0.8 m lower between mid-June and mid-July and 0.5 m to 1.0 m higher from mid-July onwards. The overall effect of flood control was to provide a smoother rising and progressively deeper flood for the period June to October compared to levels on unregulated floodplains which fluctuated with the rise and fall of the Atrai. Since the depth of flooding inside the polder was at times up to 1.0 m higher than that outside it, the extent of the flood also increased on the low land in the eastern part of the polder. The increased extent of flooding within the surrounding extrapolation area of the sampled site was estimated from the area elevation curve to be 1668 hectares (Fig. 2.3).

3.4.4 Inter-annual variation in flooding patterns

Controlled flooding inside the polder resulted in a considerable reduction in the degree of variation in flood timing, duration, magnitude and extent between years. In drought years, rainfall flooding was retained by gate closures for the production of deepwater rice. In high flood years, significant reductions in flood magnitude could be attained by gate closures since deliberate breaching of embankments by public cuts was not a common occurrence.

3.5 Conclusions

i. The low-lying eastern part of the polder was subject to extensive, deep rainfall flooding which could not be drained during the early monsoon between June and July due to high levels in the Atrai River.

ii. While the polder was capable of preventing river flooding in most years, protection of the harvest of the HYV winter rice crop in May and occasionally early June was not generally needed in the lower Atrai basin. Rather, the polder operated to control water levels for the production of deepwater rice. This necessitated the controlled entry of river water if rainfall flooding was not sufficient in a particular year.

iii. Operational practices of the polder deviated from the original design objectives which anticipated full flood prevention for the expansion of higher yielding *t. aman* to replace deepwater rice on increased areas of drier land. In practice, the flooding levels in the low-lying eastern part of the polder were dictated by the requirements of deepwater rice production.

4 WATER QUALITY

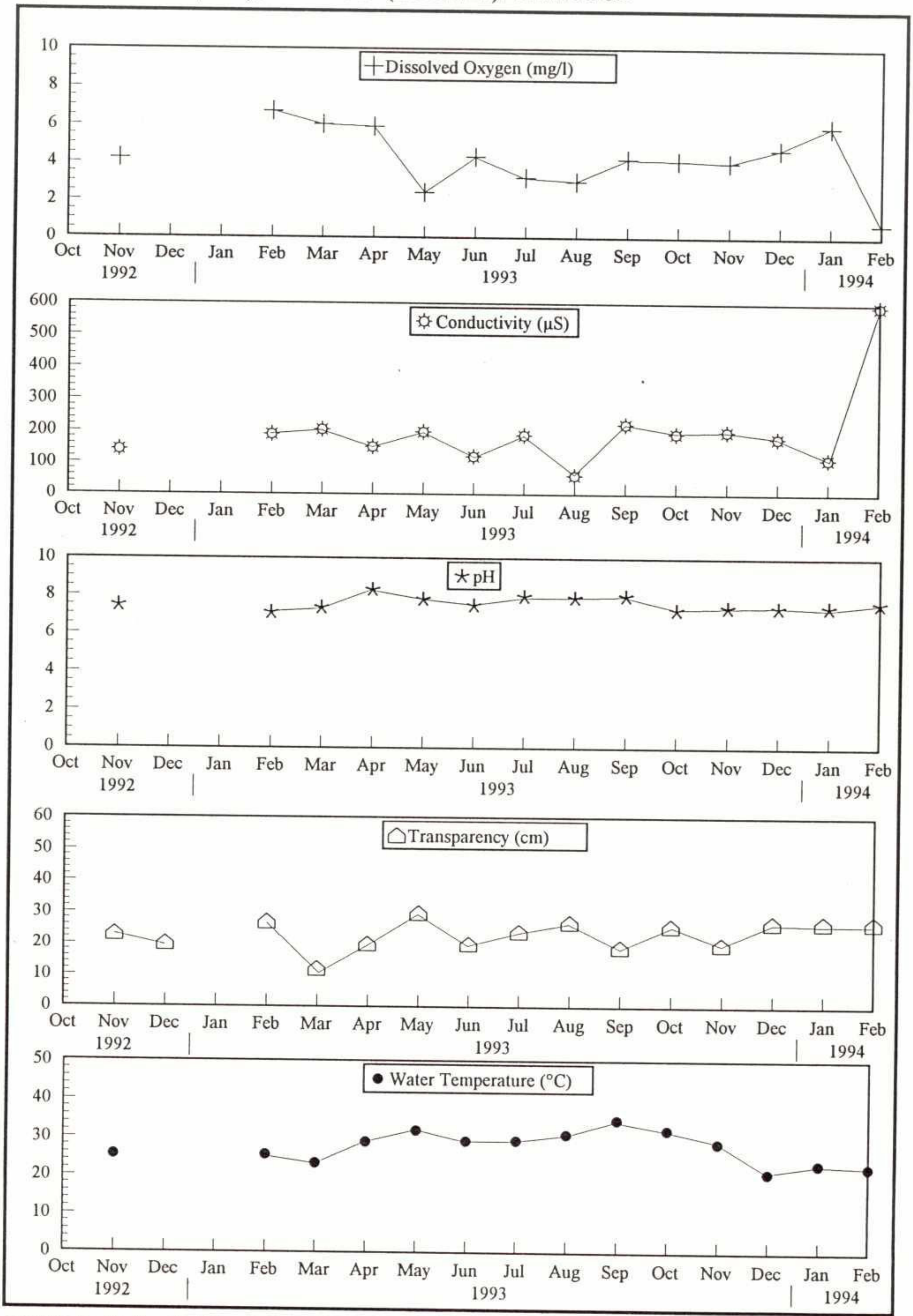
Surface water measurements of temperature, pH, dissolved oxygen (DO), conductivity and total dissolved solids were made at sites on the Atrai River and on Chalan and Haribhanga *Beel* at fortnightly intervals using electronic metering techniques (Figs 4.1 - 4.3). Given that temperature, pH and DO levels on floodplains generally depend on the time of day, attempts were made to standardise times when measurements were taken. However, this was not always achieved and whilst most readings were taken between 11.00-13.00, some were taken outside this range. Therefore data presented in Figures 4.2 and 4.3 also reflect diurnal changes as well as seasonal variations.

Dissolved oxygen concentrations on floodplains inside and outside the polder were very similar with most ranging from 3 to 7 mg/l. A similar range was recorded in their feeder river, the Atrai. Previous more detailed studies carried out in Bangladesh showed that oxygen levels ranged over a 24 hour period from a completely anoxic (zero oxygen) condition near dawn to supersaturation in mid-afternoon in both open flooded fallow land and in deepwater rice fields[8, 9]. The studies also revealed considerable vertical stratification in oxygen levels in rice fields with lowest concentrations (near zero) in the bottom layer whilst surface layers remained near saturation. The effects of stratification were more pronounced towards the end of the monsoon season when amounts of decomposing macrophytic vegetation increased in decreasing volumes of water. The studies suggested that unplanted fields and fallow areas of *beel* may produce more fixed nitrogen than deepwater rice fields because the rich and diverse community of weeds supported more dense growths of epiphytic nitrogen fixing blue-green algae. It was further hypothesized that this nitrogen may be supplied directly to deepwater rice fields, or at a later stage after decomposition and mineralisation of the algal biomass, and could yield to possibly as much as 50 kg N/ha[10].

No seasonal trends in pH levels were detected on floodplains or in the Atrai River. Values ranged from 7.0 to 8.2 which posed no danger to fish health or survival. Conductivities were lowest during the monsoon on both regulated and unregulated floodplains where they averaged about 100 μS. Given the generally higher conductivity of Atrai water (200 μS), the similarity in conductivities inside and outside Polder B during the monsoon suggests that mixing of river water and rainfall on unregulated floodplains of Chalan *Beel* was far from complete and that much of the inundation resulted from the backing up of rainfall flooding as river levels increased. Conductivities increased during the drawdown and winter due to a combination of natural causes such as the decomposition of plant material in smaller volumes of water and, later, to the inflow of ionically-rich groundwaters pumped to the surface for the irrigation of winter rice.

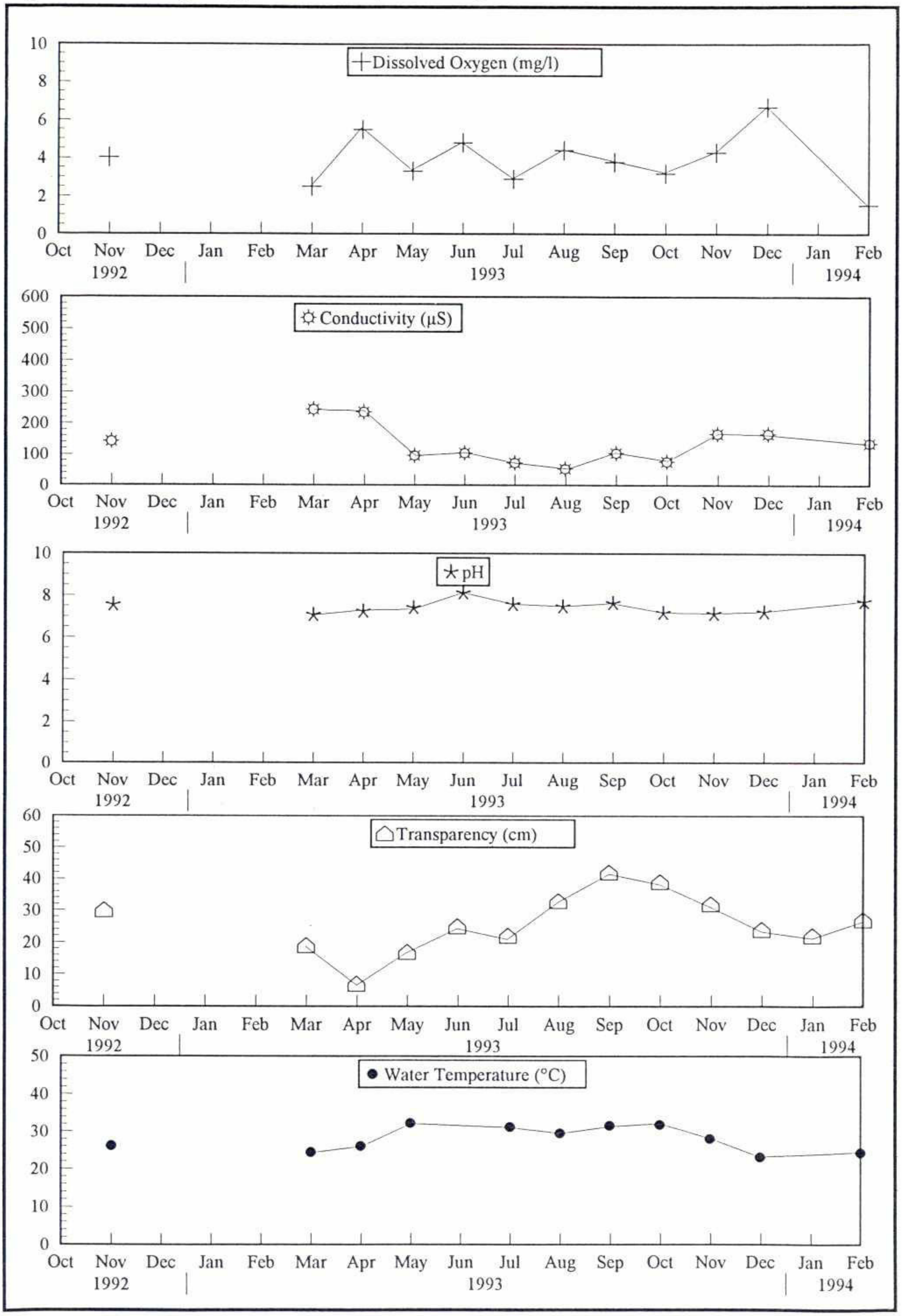
Values of transparency (Secchi disc readings) increased on Chalan *Beel* during the monsoon. Values were similar to those in the Atrai between June and July but were generally higher for the remainder of the monsoon season. This may be interpreted in two ways: increased transparency was due either to the deposition of silt load on the floodplain or to incomplete mixing of river and rainfall floodwaters. The stability of conductivity levels between May and October support the latter interpretation. However, substantially higher values of transparency were recorded inside Polder B due to rainfall flooding during the monsoon which contradicted the interpretation of results based on conductivities alone, and suggested that there was indeed intrusion and mixing of river and rainfall floodwaters on the unregulated floodplains. This was further supported by the fact that water colour on the unregulated Chalan *Beel* was the same as that in the Atrai during the monsoon whereas that inside the polder was clear. The increased clarity of floodwaters inside the polder would be expected to encourage macrophytic and algal growth and increased phytoplankton and zooplankton populations which serve as food for many juvenile and some adult fish, and thus result in increased fish production.

Figure 4.1 Water quality, Atrai River (site NW27): outside FCD



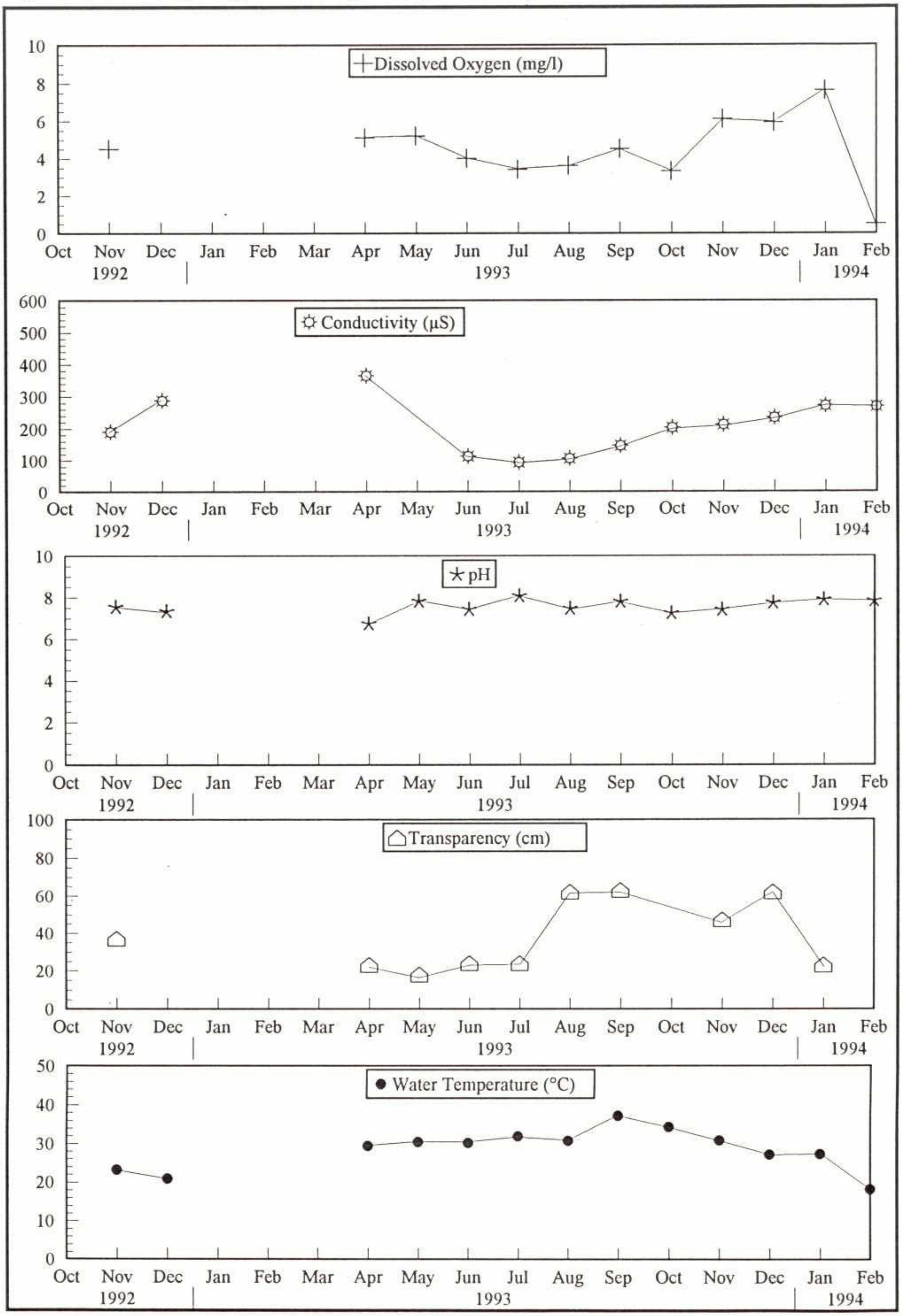
Note: Data absent for December 1992 and January 1993

Figure 4.2 Water quality, Chalan *Beel* (site NW30): outside FCD



Note: Data absent for December 1992 and January to February 1993

Figure 4.3 Water quality, Haribhanga *Beel* (site NW28) : inside FCD



Note: Data absent for January to March 1993

5 FLOODPLAIN FISHERIES

In the analyses and interpretations of data which follow, the results from one unregulated canal site and one river site are also presented, to compare changes in fishing activities and catches with those from unregulated and regulated floodplains on Chalan *Beel* and Haribhanga *Beel*.

5.1 Total Catch

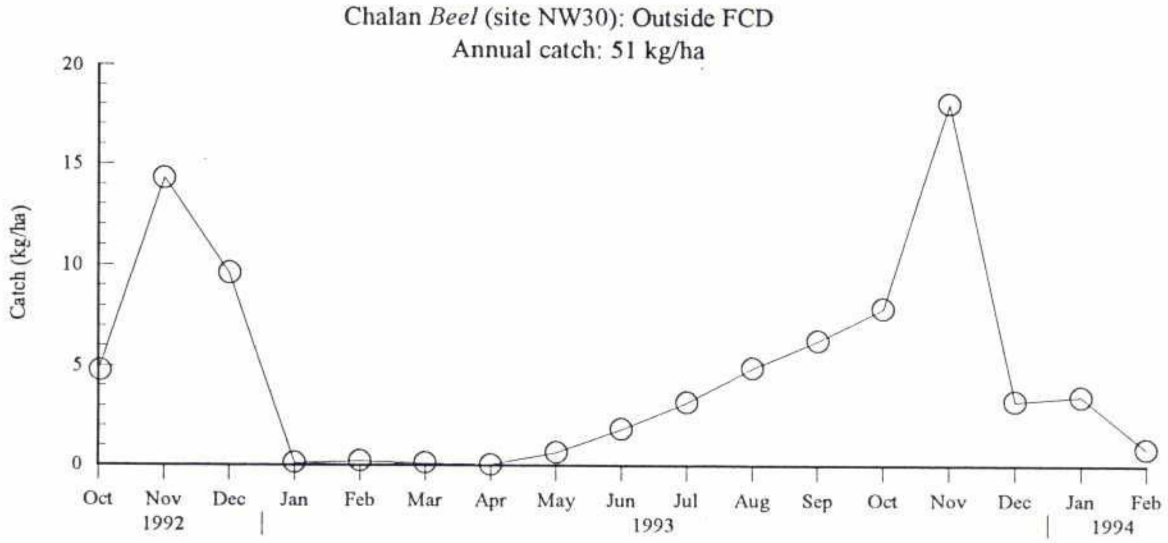
5.1.1 Pattern of catch

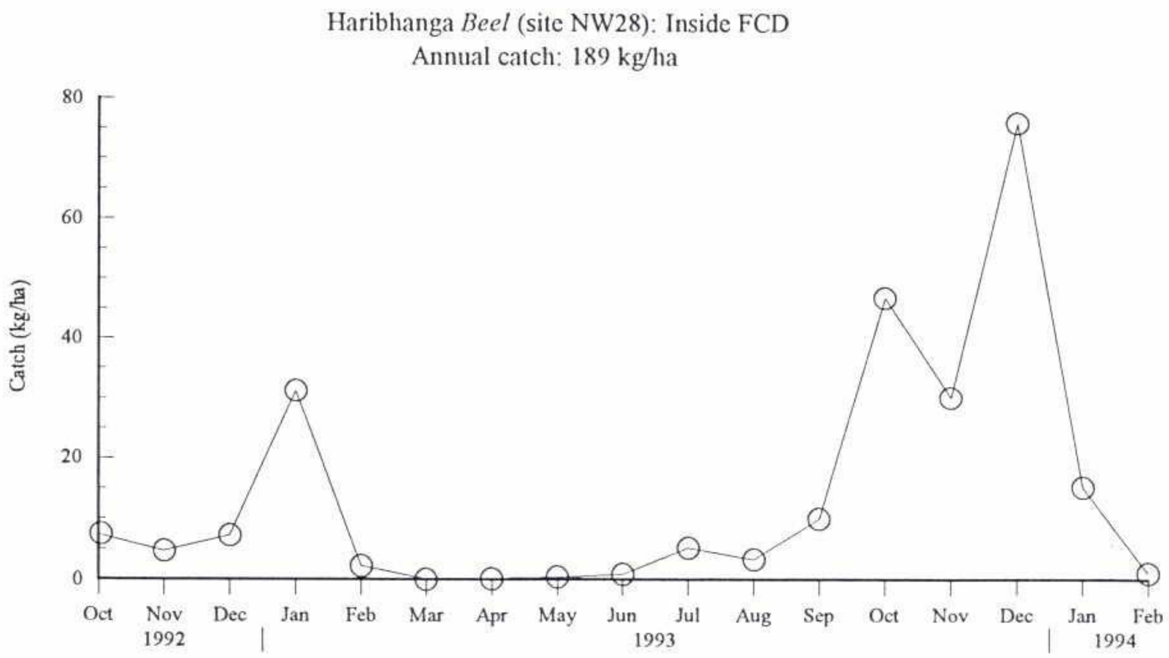
Variations in the size of the catch from Chalan and Haribhanga *Beel* followed different seasonal patterns (Fig. 5.1). In both, catches were at their lowest (< 1 kg/ha) between February and May despite fairly heavy rainfall during this period which resulted in the flooding of small scattered depressions during May. This localised flooding was not sufficient to make any detectable impact on catches. As flooding increased in June and submerged most of the unregulated area of Chalan *Beel*, catches rose slightly and continued to increase progressively until the start of the drawdown in October. In November, catches increased sharply to a peak of 18 kg/ha coinciding with the concentration of fish in small areas of residual water within depressions on the floodplains and in canals which were submerged during the monsoon but reappeared during the drawdown. Catches declined equally sharply in December and decreased further in February 1994.

Inside Polder B, catches remained relatively low until September, although absolute values of catch (3-5 kg/ha) were similar to those on Chalan *Beel* in July and August. During September catches rose slightly followed by a substantial increase in October when a yield of 47 kg/ha was recorded. The catch temporarily declined in November only to rise again to a peak level of 76 kg/ha in December after which catches dropped rapidly to low levels in January and February 1994.

The major difference between patterns of catch seen on regulated and unregulated floodplains was the substantially greater share of the annual catch taken during the drawdown and early winter (October - December) in Polder B. During this period, catches of 153 kg/ha and 29 kg/ha were recorded inside and outside the polder accounting for 81% and 58% of total annual catches respectively. Much of the difference was related to sluice gate closure in early December which enabled large-scale intensive village fishing operations to be undertaken

Figure 5.1 Seasonal variation in the catch per unit area from floodplains/ *beel* inside and outside Polder B, October 1992 - February 1994





within the polder. Consequently, the December catch alone (76 kg/ha) accounted for 40% of the annual total from the poldered site whereas in the same month on unregulated floodplains, which had by then dried out almost completely, the catch (3 kg/ha) was comparatively insignificant (6% of annual).

On the main drainage canal of Chalan *Beel*, catches remained negligible until the late drawdown in November when they increased sharply before falling again in December (Fig. 5.2). Here, the share of the catch taken in winter (December - February) was 28% of the annual catch while 57% of the catch was taken during the drawdown in October and November. On the Atrai River, lowest catches were recorded between February and June and highest catches between October and December 1993 when 54% of the annual catch was taken. A marked difference was seen between different years. In November 1992, catches rose precipitously due mainly to high catch rates of *suti jal* whereas in the following year no large, sudden increase was observed.

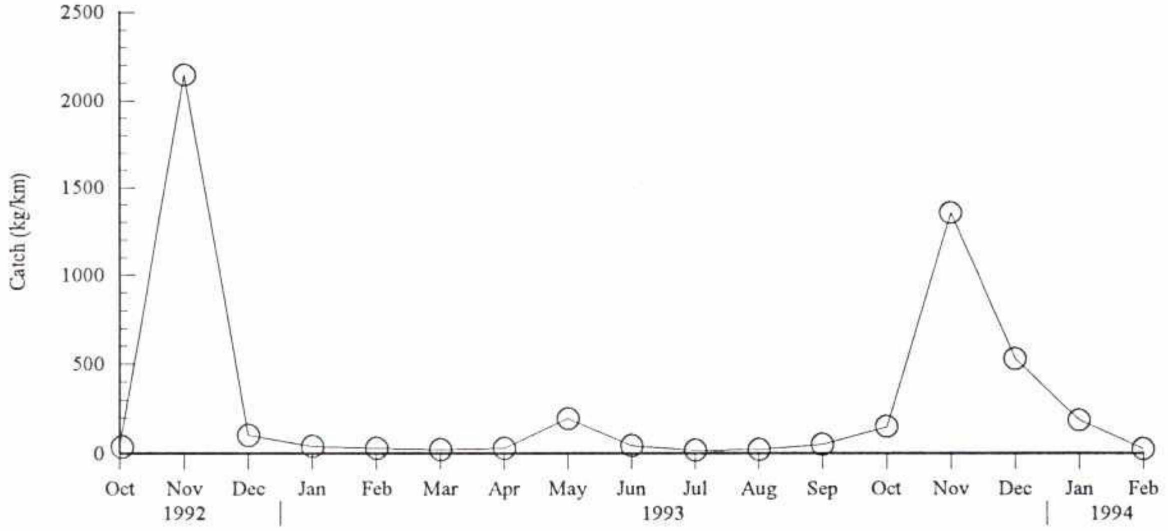
5.1.2 Size of catch

An annual catch per hectare (CPUA) of 189 kg was recorded at the regulated floodplain site inside Polder B between March 1993 and February 1994. This was 3.7 times higher than that (51 kg/ha) from the free-flooding site on Chalan *Beel* (Table 5.1). The difference between sites was partly due to the fact that the estimated catch from Polder B also contained the catch from the main drainage canal, Haribhanga *Khal*, which submerged completely during the monsoon. In contrast, the main drainage canal of the sampled area on Chalan *Beel* was surveyed separately. To make therefore, a more accurate comparison of catches inside and outside the polder, catches from unregulated floodplains and canals had to be combined. This was achieved by extrapolation of the catch rate (kg/ha) from floodplain site to the larger selected area (Fig. 2.1). The total length of canals inside the unregulated extrapolation area was then estimated from topographical maps and field surveys and its catch was estimated by using the catch rate (kg/km) from the sampled length. In Polder B, the only major canal in the extrapolation area was sampled as part of floodplain and its catch was already incorporated in the estimated yield of 189 kg/ha from floodplains.

The results are presented in Table 5.2. Total annual catches of 391 and 266 tonnes from Polder B and Chalan *Beel*, when divided by their respective areas, resulted in yields of 189 kg/ha from Polder B and 68 kg from Chalan *Beel*.

Figure 5.2 Seasonal variation in catch per unit length from unregulated canal and river sites, October 1992 - February 1994

Kubjipur and Piplagang *Khal* (site NW29): Outside FCD
Annual catch: 2634 kg/km



Atrai River (site NW27): Outside FCD
Annual catch: 2009 kg/km

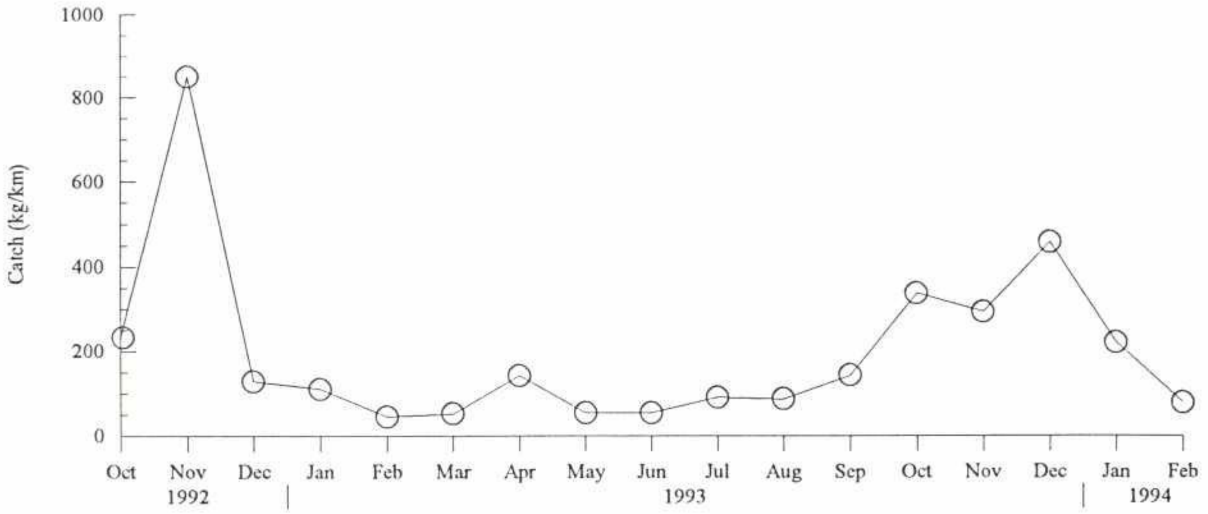


Table 5.1 Annual catch from sites inside and outside Polder B, March 1993 - February 1994

Site Code	Name	Inside/ Outside FCD	Total catch (kg)	Area		Catch per unit area	
				ha	km	kg/ha	kg/km
NW28	Haribhanga *Beel*	Inside	45,465	240	-	189	-
NW30	Chalan *Beel*	Outside	28,067	555	-	51	-
NW29	Kubjipur and Piplagang *Khal*	Outside	23,440	25	9	958	2,634
NW27	Atrai River	Outside	25,418	87	13	291	2,009

Note: Values of catch are rounded to nearest whole number

Table 5.2 Total annual catch from extrapolation areas in Polder B and the unregulated Chalan *Beel*

Area	Habitat	Area (ha) or Length (km)	Catch rate	Total catch (tonnes)	Total CPUA kg/ha
Polder B	Floodplain/canal	2,070 ha	189 kg/ha	391.2	-
	Total			391.2	189
Chalan *beel*	Floodplain	3,878 ha	51 kg/ha	197.8	-
	Canal	25.7 km	2,634 kg/km	67.7	-
	Total			265.5	68

Statistical analyses of catch rates of dominant gears revealed no clear significant differences between sites (see Section 5.3). The results therefore indicated that the densities of fish inside and outside the polder were similar. However, examination of fishing effort showed that for three of the most important gears used inside the polder, *jhaki jal*, *doiar* traps and *current jal*, the annual effort deployed per hectare of floodplain was 2 to 5 times higher inside the polder than that on the unregulated area of Chalan *Beel* (Section 5.3). It is clear therefore that much of the difference in CPUA between sites can be explained in terms of increased fishing effort by certain dominant gears. The same conclusion was reached in a study of the PIRDP in the lower reaches of the Atrai basin where a higher value of CPUA was also recorded inside the polder (139 kg/ha) compared to outside it (84 kg/ha)[11].

In Polder B, it seems likely that other factors relating to hydrology, topography and sluice gate operation, were also responsible, in part, for the higher fish catch. In Section 3.2, it was shown that by integration of flood magnitude and duration a simple flood index could be obtained which should be directly positively related to fish catch. This assumption is based partly on studies from other parts of the world which have demonstrated a direct relationship between flood magnitude and extent and floodplain fish catches[12, 13]. The flood index inside the polder was 18% higher than that outside and higher catches might therefore be expected. That the index was higher inside the polder was due solely to gate closures during the monsoon period which retained floodwater at higher levels than those on unregulated floodplains, thus providing a greater volume and probably greater diversity of habitats for fish.

A second possible determining factor relates to the topography of Polder B. Data from area elevation curves presented in Section 2 showed that the area for extrapolation of site catch data, which immediately surrounded the site, contained a larger proportion of higher land than did the equivalent area on unregulated floodplains. This suggests that the main drainage canal, Haribhanga *Khal*, running through the sampled site, served as a "sink" during the drawdown for the larger areas of higher ground located outside the site itself. As floodwaters drained from these higher areas into Haribhanga *Khal*, their dependent fish populations would also move into the sampled area. Thus substantially larger values of CPUA would be expected since the site area alone underestimated the actual "productive area" of the fishery. With the benefit of hindsight, the study required an additional sampling site on the higher land within the extrapolation area to obtain a more accurate integrated estimate of CPUA.

A third factor which undoubtedly raised catches from the polder was the temporary closure of sluice gates for two weeks in early December. This had the effect of blocking fish on their migration to the Atrai River; many of these fish could have originated outside the sampled area. Once the gates were reopened and water levels dropped in late December, a *suti jal* was placed in the *khal* to trap escaping fish and an intensive village "fish-out" of the floodplain took place using *jhaki jal* (see Section 5.2.2).

5.1.3 Catch differences between years

A survey period of 17 months from October 1992 to February 1994 provided the opportunity to examine catches made during two flood recessions and winters in consecutive years. Catches made between October and February 1992/93 were compared with those made during the same months in 1993/94. Catches from *katha* and *kua* fishing were excluded from analyses since these gears required more intensive sampling which was provided in 1993/94 but not at all sites in 1992/93.

The two years differed greatly in terms of flood magnitude, duration and extent (see Section 3.3). In 1992, a relative drought year, the duration of inundation of floodplains was 29% shorter than in 1993 and an index of flooding, based an depth and duration, was 61% lower in 1992. Studies from other parts of the world have shown that floodplain fish catches are directly related to the size and extent of flooding, therefore higher catches would be expected in 1993/94[12, 13].

Results in Table 5.3 revealed, as predicted, higher catches from floodplains in the year of highest floods. However, catches from Piplagang *Khal* and the Atrai River varied little between years. This differential impact of inter-annual variation in flood magnitude on catches from different habitats was observed in other FAP 17 studies in the North West and North Central Regions[11, 14]. To examine the differences between habitats, catches were divided into different categories of fish based on habitat preference: riverine, migratory and floodplain resident species (see Section 5.4.1 for definitions). The results are shown in Table 5.4. Of the three categories of fish, largest reductions in floodplain catches during the dry year of 1992/93 were recorded for floodplain residents, the group most likely to be dependent on floodplains and therefore most affected by inter-annual changes in flooding patterns. Large reductions in catches of riverine species were also observed but total catches in both years were very small (1 kg or less) and therefore percentage values were sensitive to very small differences in catches. Migratory species were less affected by changes in flooding patterns between years which suggests that the species concerned could also feed and breed successfully in canals or rivers as well as floodplains. On unregulated floodplains catches of migratory species were slightly higher in the dry year of 1992/93 (14 kg/ha) than in the wetter year of 1993/94 (10 kg/ha), while on regulated floodplains inside Polder B catches were slightly lower in the dry year (7 kg) than in the following year (8 kg).

Table 5.3 Comparison of the total catch from floodplains, canal and river between different years

Site code	Name	Inside/ Outside FCD	Catch (kg/ha)		% change in catch in 92/93
			1992-1993	1993-1994	
NW28	Haribhanga *Beel*	Inside	32	156	- 79
NW30	Chalan *Beel*	Outside	21	31	- 32
NW29	Piplagang *Khal*	Outside	2,321	2,247	+ 3
NW27	Atrai River	Outside	1,330	1,314	+ 1

Notes: 1. *Katha* and *kua* catches were excluded from analyses (see text)
2. + and - denote increase and decrease in catch respectively

Table 5.4 Comparison of the total catch[1] (kg/ha) of riverine, migratory and floodplain resident fish between different years

Site code	Inside/ Outside FCD	Riverine CPUA			Migratory CPUA			Floodplain Resident CPUA		
		1992-1993	1993-1994	% change in 92/93	1992-1993	1993-1994	% change in 92/93	1992-1993	1993-1994	% change in 92/93
NW28	Inside	0.44	1.03	- 58	7.18	8.46	- 15	22.03	120.85	- 82
NW30	Outside	0.71	1.57	- 55	13.97	10.17	+ 37	5.64	15.53	- 64
NW29	Outside	42.45	105.53	- 60	769.25	1209.79	- 36	1474.04	827.37	+ 78
NW27	Outside	101.06	156.87	- 36	945.22	608.35	+ 55	257.85	485.80	- 47

Notes: 1. *Katha* and *kua* catches were excluded from analyses (see text)
2. + and - denote increase and decrease in catch respectively

On the Atrai River, the catch of floodplain resident species was 47% lower in the dry year while the catch of migratory species was 55% higher in this year due mainly to the particular abundance of juveniles of the large catfish, *boal*. Riverine species were also less abundant during the dry year in both the Atrai and the connecting Piplagang *Khal*. This result differs from the expected trend as does the recorded higher catch of floodplain residents in the canal during the drier year.

5.2 Pattern of Fishing

5.2.1 Catch by gear

Percentage contributions made by dominant gears to the total annual catch at each site are presented in Table 5.5. More detailed data on percentage monthly catches of all observed gears are provided in Tables 5.6 - 5.9.

A total of 26 different types of gear was recorded on unregulated floodplains of Chalan *Beel* compared with 24 types on floodplains inside Polder B. On the Atrai River, 27 gear types were recorded compared with 20 on the connecting Piplagang *Khal*.

Suti jal, *doiar* traps and *current jal* predominated on both regulated and unregulated floodplains while small seine nets such as *baoli jal*, *kachitana* and *dhor jal* captured a larger share (25%) of the catch from unregulated floodplains than from inside Polder B where they accounted for only 4% of the catch. Other differences in gear use between floodplains included the substantially higher contribution to the catch made by *jhaki jal* inside the polder (19%) compared with that outside (4%) and the lower contribution made by daun inside the scheme (< 1%) than outside (6%). The share of the catch taken by *thella jal* inside (3%) and outside (< 1%) the polder was surprisingly small compared with results from other low-lying floodplains in the North West and North Central Regions. Reasons for its relative unimportance in this study remain unclear, particularly since regulated water levels within Polder B favoured the use of this gear along shallower, shoreline areas of the floodplain.

Table 5.5 Percentage contribution (by weight) to the total annual catch made by dominant[1] gears inside and outside Polder B

	Inside FCD	Outside FCD		
	Floodplain	Floodplain	Canal	River
Gear name	NW28	NW30	NW29	NW27
Suti jal	25.1	20.6	53.8	12.3
Jhaki jal	18.6	4.4	10.5	28.5
Doiar trap	18.2	15.4	7.4	7.1
Current jal (Stationary)	12.5	11.0	-	-
Kua	7.1	5.4	-	-
Dhor jal	3.7	6.6	5.1	2.5
Veshal	3.5	-	-	7.4
Thella jal	3.1	-	-	-
Hand fishing	-	-	3.1	-
Akra	-	-	3.1	-
Katha	-	-	-	8.1
Sip	-	-	-	7.8
Deal trap	-	-	-	5.1
Dharma jal	-	-	-	3.4
Baoli jal	-	13.3	10.4	8.0
Ber jal	-	3.0	-	-
Kachitana	-	4.9	-	-
Daun	-	5.8	-	-

Note 1: Dominant gears are defined as those gears which when ranked in order of magnitude of percentage values, formed at least 90% of the annual catch

Table 5.6 Percentage monthly catch from floodplains by gear type: inside FCD (site NW28)

Gear		Year: 1992			Year: 1993												Year: 1994		Total annual catch (Mar'93 – Feb'94)	
Code	Gear name	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Kg	%
271	*Suti jal*	–	–	–	–	–	–	–	–	12.150	–	–	–	56.295	10.707	23.367	–	–	11414.586	25.106
164	*Jhaki jal*	7.397	0.681	44.425	31.066	10.090	–	–	9.229	–	0.433	–	1.773	7.025	4.471	37.851	6.805	53.121	8460.651	18.609
95	*Doiar trap*	24.270	34.845	21.901	2.590	0.532	–	–	90.138	48.229	27.575	45.875	50.492	9.080	42.733	10.225	4.402	–	8257.991	18.163
88	*Current jal (Stationary)*	7.851	36.080	5.932	1.995	–	–	–	0.633	15.203	31.678	47.335	26.517	3.376	13.945	15.676	0.360	–	5702.216	12.542
302	*Kua*	–	–	–	56.267	66.391	–	–	–	–	–	–	–	–	–	–	86.031	26.257	3203.200	7.045
89	*Dhor jal*	–	–	–	–	–	–	–	–	24.417	39.028	–	1.009	8.851	–	0.720	–	–	1688.938	3.715
266	*Veshal*	5.850	–	–	–	–	–	–	–	–	–	–	1.862	2.165	4.735	5.326	–	–	1604.048	3.528
255	*Thella jal*	–	–	–	–	–	–	–	–	–	0.224	1.289	0.397	2.275	7.336	3.158	–	8.605	1406.785	3.094
272	*Daun*	21.631	4.632	–	–	–	–	–	–	–	–	–	17.504	4.341	2.818	–	–	–	1114.386	2.451
307	Hand fishing	–	–	–	–	–	–	14.816	–	–	–	–	–	1.695	0.488	3.343	0.764	–	870.698	1.915
310	*Kakila bana*	–	–	–	–	–	–	–	–	–	–	–	–	–	4.922	–	–	–	356.039	0.783
278	*Nol barsi*	–	–	–	–	–	–	–	–	–	1.061	–	0.362	0.152	4.215	–	–	–	343.916	0.756
276	*Hat panch*	–	23.139	22.844	0.886	–	–	–	–	–	–	–	–	–	3.507	–	–	–	253.710	0.558
45	*Ber jal*	30.628	–	–	–	–	–	–	–	–	–	5.501	–	1.699	–	–	–	–	234.980	0.517
298	*Akra*	–	–	0.522	0.121	22.987	100.000	55.080	–	–	–	–	–	–	–	0.143	1.639	–	122.827	0.270
291	*Urani*	–	0.623	0.332	0.335	–	–	–	–	–	–	–	–	0.903	–	0.010	–	–	103.656	0.228
286	*Deal trap*	–	–	–	0.671	–	–	–	–	–	–	–	0.084	0.768	–	–	–	–	88.571	0.195
170	*Juti*	–	–	–	–	–	–	–	–	–	–	–	–	0.631	0.123	–	–	–	80.086	0.176
311	*Kadum trap*	–	–	–	–	–	–	–	–	–	–	–	–	0.709	–	–	–	–	79.893	0.176
306	*Baoli jal*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.182	–	–	33.166	0.073
202	*Moi jal*	–	–	4.044	2.253	–	–	–	–	–	–	–	–	–	–	–	–	12.018	28.560	0.063
97	By hand/Dewatering	–	–	–	–	–	–	30.104	–	–	–	–	–	–	–	–	–	–	12.024	0.026
301	*Chunga*	2.373	–	–	–	–	–	–	–	–	–	–	–	0.038	–	–	–	–	4.249	0.009
270	*Katha*	–	–	–	3.817	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	45465.176	100

Note – denotes zero catch

Table 5.7 Percentage monthly catch from floodplains by gear type: outside FCD (site NW30)

Gear		Year: 1992			Year: 1993												Year: 1994		Total annual catch (Mar'93 – Feb'94)	
Code	Gear name	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Kg	%
271	*Suti jal*	56.269	80.520	1.922	–	–	–	–	2.878	–	–	–	–	–	55.529	11.292	–	–	5790.707	20.632
95	*Doiar trap*	3.476	2.877	–	–	–	–	–	67.041	62.479	25.933	19.232	23.325	12.740	6.987	7.494	–	54.690	4330.989	15.431
306	*Baoli jal*	–	–	–	–	–	–	–	–	7.197	3.065	10.157	15.546	16.772	11.687	25.888	19.405	6.629	3723.354	13.266
88	*Current jal (Stationary)*	1.051	0.260	–	–	–	–	–	–	4.625	39.882	11.254	11.381	15.400	9.596	–	–	–	3091.207	11.014
89	*Dhor jal*	3.676	3.333	0.601	–	–	67.979	–	29.708	6.034	4.781	43.925	2.262	5.715	–	–	–	3.336	1841.546	6.561
272	*Daun*	5.611	0.011	–	–	–	–	–	–	–	3.759	7.919	22.427	9.378	1.506	–	–	–	1622.170	5.780
302	*Kua*	–	–	67.602	–	–	–	–	–	–	–	–	–	–	–	–	78.704	–	1522.500	5.424
277	*Kachitana*	–	–	–	–	–	–	–	–	–	–	–	1.251	30.402	–	0.317	–	–	1377.662	4.908
164	*Jhaki jal*	1.473	6.324	2.327	65.607	–	14.827	15.993	–	0.059	0.666	5.107	2.513	–	6.269	16.027	1.892	6.138	1236.022	4.404
45	*Ber jal*	0.628	0.270	–	–	–	–	–	–	–	–	1.143	15.021	6.811	–	–	–	–	850.472	3.030
255	*Thella jal*	–	–	0.471	34.393	–	–	–	–	0.117	0.386	–	1.324	2.467	3.754	6.226	–	–	650.757	2.319
278	*Nol barsi*	–	–	–	–	–	–	–	–	–	20.937	1.263	3.390	0.315	–	–	–	–	536.129	1.910
298	*Akra*	–	–	–	–	16.098	–	–	–	–	–	–	–	–	–	24.452	–	4.738	461.918	1.646
276	*Hat panch*	–	–	1.722	–	–	–	–	–	–	–	–	–	–	2.430	3.303	–	–	303.453	1.081
307	Hand fishing	–	0.600	1.790	–	83.902	–	4.696	–	–	–	–	–	–	0.755	4.444	–	24.469	273.144	0.973
266	*Veshal*	–	–	–	–	–	–	–	–	–	–	–	–	–	1.476	–	–	–	148.200	0.528
170	*Juti*	–	–	–	–	–	–	–	–	8.206	–	–	1.559	–	–	–	–	–	138.187	0.492
296	*Tukri*	–	0.032	0.149	–	–	–	–	–	11.283	–	–	–	–	–	0.558	–	–	125.597	0.447
202	*Moi jal*	27.305	5.772	11.097	–	–	16.997	54.580	–	–	–	–	–	–	–	–	–	–	24.363	0.087
282	*Current jal (Drifting)*	–	–	–	–	–	–	–	–	–	0.591	–	–	–	–	–	–	–	10.443	0.037
97	By hand/Dewatering	–	–	–	–	–	–	24.730	–	–	–	–	–	–	–	–	–	–	5.845	0.021
30	*Sip*	–	–	–	–	–	–	–	0.373	–	–	–	–	–	–	–	–	–	1.364	0.005
317	*Thushi*	–	–	–	–	–	–	–	–	–	–	–	–	–	0.011	–	–	–	1.120	0.004
314	*Boat Katha*	–	–	–	–	–	0.197	–	–	–	–	–	–	–	–	–	–	–	0.133	0.0005
270	*Katha*	–	–	12.320	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
286	*Deal trap*	0.511	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	28067.281	100

Note: – dentoes zero catch

Table 5.8 Percentage monthly catch from canals by gear type: outside FCD (site NW29)

Gear Code	Gear name	Year: 1992 Oct	Nov	Dec	Year: 1993 Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year: 1994 Jan	Feb	Total annual catch (Mar'93–Feb'94) Kg	%
271	*Suti jal*	–	88.164	14.787	–	–	–	–	7.933	–	–	–	–	4.665	84.143	45.523	–	–	12535.574	53.479
164	*Jhaki jal*	7.134	4.620	5.340	0.830	3.404	14.289	1.180	1.163	0.031	10.023	–	6.476	26.987	9.404	13.027	11.713	25.264	2463.184	10.508
306	*Baoli jal*	–	–	–	–	–	–	–	32.450	22.021	–	–	1.188	5.836	1.532	21.072	23.926	54.987	2435.153	10.389
95	*Doiar trap*	0.082	0.008	–	–	–	4.954	86.522	24.034	69.110	52.020	21.988	12.656	6.967	0.047	2.684	23.786	–	1725.819	7.363
89	*Dhor jal*	20.465	2.294	6.460	13.921	–	19.824	2.001	22.791	7.892	17.554	1.261	26.996	0.876	2.256	5.028	1.817	5.604	1184.742	5.054
307	Hand fishing	–	1.298	8.956	0.242	–	8.079	9.707	–	–	–	–	–	8.117	0.897	6.996	8.774	–	735.633	3.138
298	*Akra*	–	–	1.848	0.933	84.492	–	–	–	–	–	–	–	–	–	5.671	25.787	14.145	731.154	3.119
272	*Daun*	41.081	0.057	–	–	–	–	–	–	–	–	39.777	26.255	36.179	–	–	–	–	677.637	2.891
30	*Sip*	9.637	0.035	–	–	–	–	–	11.629	–	20.403	30.811	24.228	4.963	0.254	–	–	–	500.261	2.134
255	*Thella jal*	18.553	2.383	26.082	–	–	–	–	–	0.946	–	1.845	–	4.380	1.122	–	–	–	201.393	0.859
202	*Moi jal*	3.048	1.077	23.284	39.892	11.359	51.755	–	–	–	–	–	–	–	–	–	–	–	102.138	0.436
270	*Katha*	–	–	13.242	44.181	–	–	–	–	–	–	–	–	–	–	–	3.640	–	60.800	0.259
266	*Veshal*	–	0.065	–	–	–	–	–	–	–	–	–	–	–	0.325	–	–	–	39.344	0.168
286	*Deal trap*	–	–	–	–	–	–	–	–	–	–	4.318	2.011	0.667	–	–	–	–	26.454	0.113
97	By hand/Dewatering	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.557	–	9.300	0.040
88	*Current jal (Stationary)*	–	–	–	–	–	–	–	–	–	–	–	–	0.364	–	–	–	–	4.842	0.021
296	*Tukri*	–	–	–	–	–	1.100	0.590	–	–	–	–	–	–	0.008	–	–	–	4.630	0.020
263	*Ucha*	–	–	–	–	–	–	–	–	–	–	–	–	–	0.012	–	–	–	1.480	0.006
170	*Juti*	–	–	–	–	–	–	–	–	–	–	–	0.190	–	–	–	–	–	0.840	0.004
314	*Boat Katha*	–	–	–	–	0.745	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	23440.382	100.00

Note: – denotes zero catch

Table 5.9 Percentage monthly catch from the Atrai River by gear type: outside FCD (site NW27)

Gear Code	Gear name	Year: 1992			Year: 1993												Year: 1994		Total annual catch (Mar'93 – Feb'94)	
		Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Kg	%
164	*Jhaki jal*	28.180	21.805	60.354	25.647	8.547	8.787	0.190	2.786	15.911	6.114	28.582	14.647	33.829	44.417	36.398	43.439	-	7246.045	28.507
271	*Suti jal*	10.391	67.461	-	-	-	-	-	-	-	-	-	-	29.937	18.595	19.981	-	-	3123.413	12.288
270	*Katha*	-	-	-	23.049	23.475	-	63.472	-	-	-	-	-	-	-	-	11.977	59.007	2061.707	8.111
306	*Baoli jal*	-	-	-	-	-	43.520	24.230	8.174	-	-	-	-	-	4.921	4.385	23.462	15.549	2023.105	7.959
30	*Sip*	12.450	4.637	1.310	0.131	-	3.259	2.407	18.617	1.159	0.830	6.747	3.126	2.709	10.945	17.450	3.826	0.323	1984.046	7.806
266	*Veshal*	17.445	1.095	-	-	11.248	8.019	3.403	-	11.175	60.251	1.817	3.038	4.039	6.842	7.580	-	5.161	1869.607	7.355
95	*Doiar trap*	2.409	0.036	0.130	-	1.126	0.181	1.884	53.569	67.809	15.283	26.950	19.121	0.631	0.192	-	0.516	6.463	1794.306	7.059
286	*Deal trap*	1.517	0.053	-	-	-	-	-	-	-	5.884	15.216	32.350	8.206	0.590	0.007	-	9.800	1287.454	5.065
105	*Dharma jal*	14.725	0.073	-	-	-	-	-	-	0.062	0.086	0.065	6.923	17.385	0.100	-	-	-	871.356	3.428
89	*Dhor jal*	7.546	4.116	1.093	0.639	0.562	7.562	0.268	12.291	-	1.900	-	-	0.483	8.816	0.301	4.152	-	641.497	2.524
282	*Current jal (Drifting)*	-	-	0.544	0.905	-	-	-	-	1.003	5.439	4.212	10.918	1.463	0.475	-	2.548	-	463.396	1.823
317	*Thushi*	-	-	0.517	7.579	2.884	-	-	-	-	-	-	-	-	0.068	3.902	6.558	-	411.653	1.620
123	*Koi jal*	-	-	-	1.108	-	-	-	-	-	-	-	-	-	0.721	4.573	1.120	-	323.186	1.271
234	*Shangla jal*	-	-	-	-	-	-	-	-	2.799	3.751	10.514	3.628	0.559	-	-	-	-	266.532	1.049
298	*Akra*	-	-	14.739	-	-	-	-	-	-	-	-	-	-	0.665	2.158	1.896	-	202.634	0.797
202	*Moi jal*	-	-	19.358	40.943	50.155	25.742	-	-	-	-	-	-	-	0.044	-	-	-	170.467	0.671
272	*Daun*	1.481	0.045	-	-	-	-	0.163	-	0.083	0.109	4.394	2.736	0.759	-	-	0.314	2.633	169.482	0.667
126	*Ferra jal*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.405	-	-	139.500	0.549
255	*Thella jal*	0.304	0.516	-	-	-	-	0.995	4.563	-	0.354	0.068	-	-	1.486	0.295	-	-	126.342	0.497
88	*Current jal (Stationary)*	3.553	0.161	-	-	1.416	1.842	0.168	-	-	-	0.860	1.979	-	-	-	-	1.065	70.842	0.279
296	*Tukri*	-	-	-	-	0.587	1.089	2.608	-	-	-	-	-	-	0.097	0.128	-	-	65.162	0.256
307	Hand fishing	-	-	1.954	-	-	-	-	-	-	-	-	-	-	0.942	0.360	0.193	-	61.189	0.241
321	*Afa/Hat bauli*	-	-	-	-	-	-	-	-	-	-	-	1.119	-	-	-	-	-	20.218	0.080
278	*Nol barsi*	-	-	-	-	-	-	-	-	-	-	0.574	0.413	-	-	-	-	-	13.764	0.054
301	*Chunga*	-	0.002	-	-	-	-	-	-	-	-	-	-	-	0.029	0.061	-	-	4.605	0.018
45	*Ber jal*	-	-	-	-	-	-	0.213	-	-	-	-	-	-	-	-	-	-	3.840	0.015
170	*Juti*	-	-	-	-	-	-	-	-	-	-	-	-	-	0.057	0.017	-	-	3.088	0.012
		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	25418.436	100

Note: – denotes zero catch

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5.2.2 Catch by gear by month

Inside Polder B very little fishing occurred during March and April, when floodplains were used for the production of HYV *boro* rice. The only fishing activities observed during this period were fishing by hand and dragging the muddy sediments with *akra* in search of *baim*. Pre-monsoon rainfall flooding of small depressions and Haribhanga *Khal* in May had little impact on the size of catches but stimulated the activities of *doiar* traps, *jhaki jal* and *current jal* (Fig. 5.3). At this time of year, water levels in the Atrai were higher than those inside the polder and regulator gates were closed to prevent entry of river waters into Haribhanga *Khal*. Water levels in the Atrai rose sharply in June and towards the end of the month were sufficiently high to flood unregulated floodplains. Hydrological data suggested that gates of Haribhanga regulator were partially opened for short intervals during June and July. This is supported by the fact that a *suti jal* was temporarily set on Haribhanga *Khal* in late June, before the *khal* became completely submerged, and captured 12% of the monthly catch. Only three other gears were recorded during June, *doiar* traps which took 48% of the catch, *dhor jal* (24%) and *current jal* (15%). Between July and September, when sluice gates were closed and water levels progressively increased due to local rainfall and drainage into the area from higher lands, two gears, *doiar* traps and *current jal*, dominated catches.

During the flood drawdown between October and December, when sluice gates were opened, *suti jal* reappeared to capture fish as they moved off the floodplains towards the Atrai River. This gear took more than half the catch in October and between 11-23% of the catch during the next two months. In December it operated only during the second part of the month since sluice gates were temporarily closed for 2 weeks in the first half of December. The number of different types of fishing gears used on the floodplain increased sharply from 4 in August to 16 in October, falling slightly to between 11 and 12 in November and December. In November, *doiar* traps provided the greatest proportion (43%) of the catch while in December, unprecedented levels of fishing by *jhaki jal* in the second half of the month accounted for 38% of a peak total monthly catch of 76 kg/ha. Within a single two hour observation period of fishing effort, a maximum of 102 *jhaki jal* were counted operating in the remaining flooded depression and *khal*, an area of about 60 hectares. This is the highest concentration of *jhaki jal* recorded on any site sampled by FAP 17 in four FAP regions of Bangladesh. The same increase in fishing effort by *jhaki jal* was observed during the previous winter (early January 1993) when a maximum of 44 nets was counted in a 2 hourly survey period (Fig. 5.4). This intensive fishing activity during early winter, following both a relative drought year and a reasonable flood year, was rendered possible only by regulation

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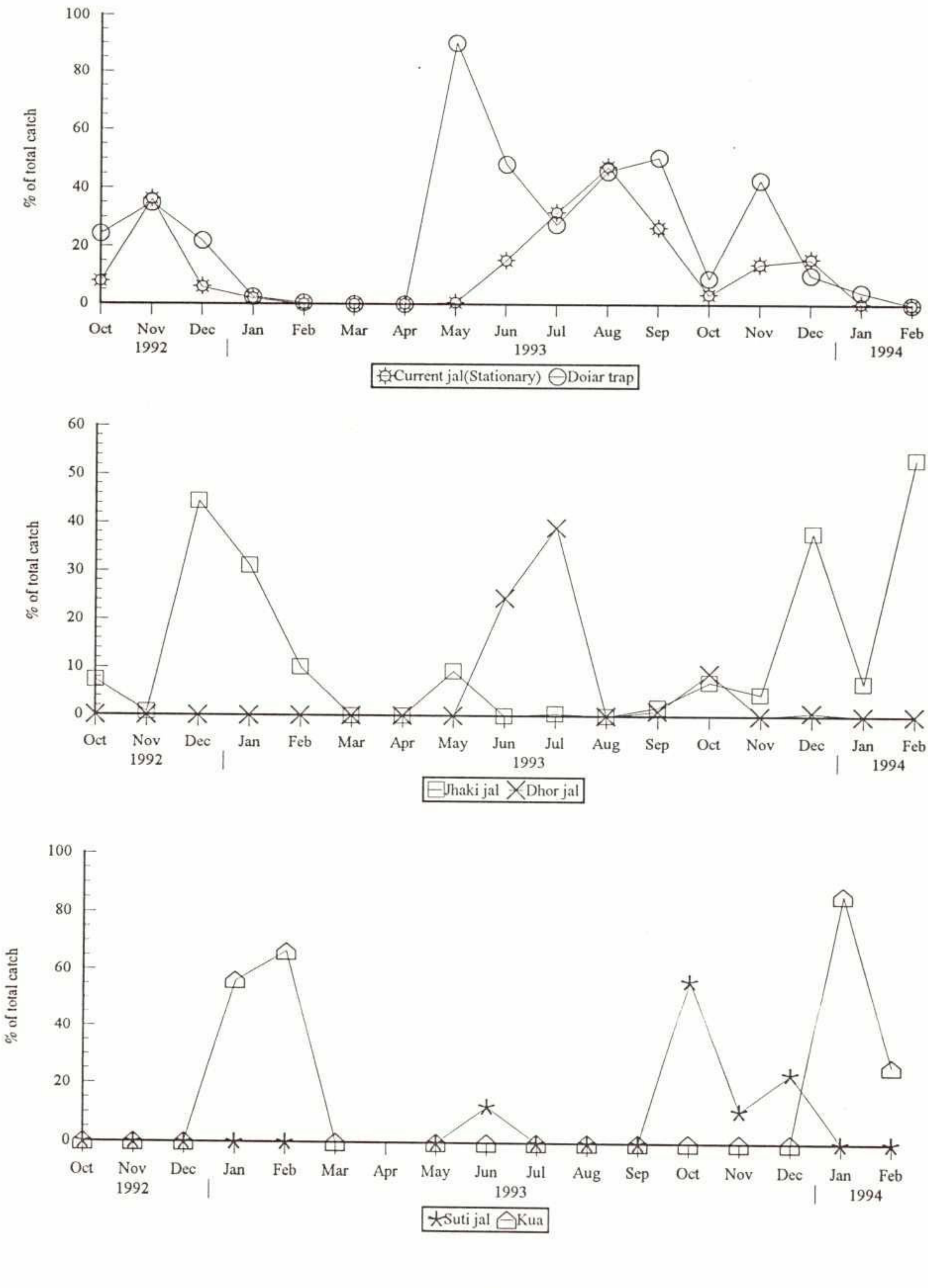
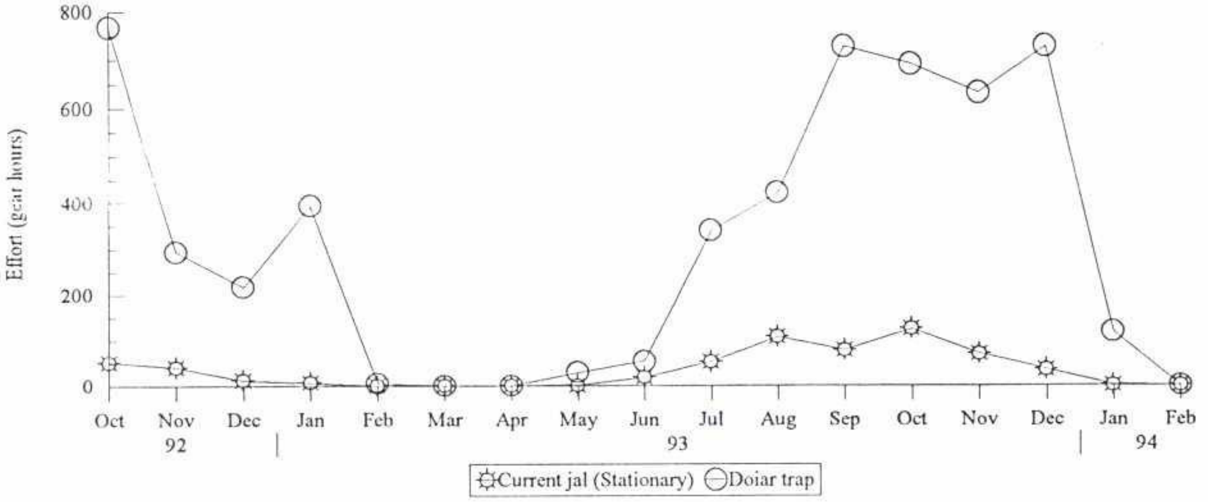
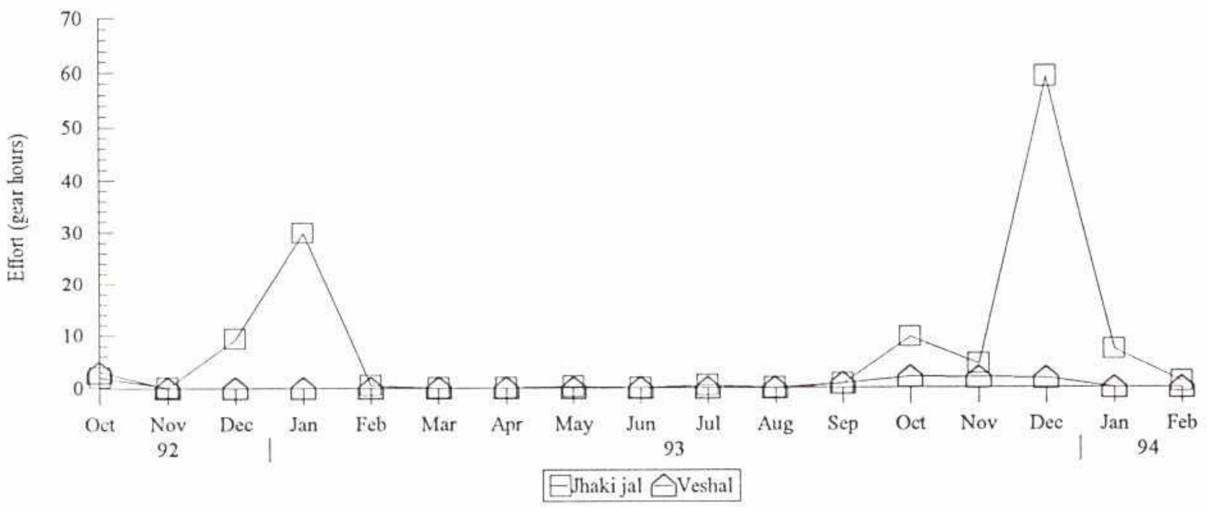
Figure 5.3 Percentage of total monthly catch taken by dominant gears: site NW28 (inside FCD)

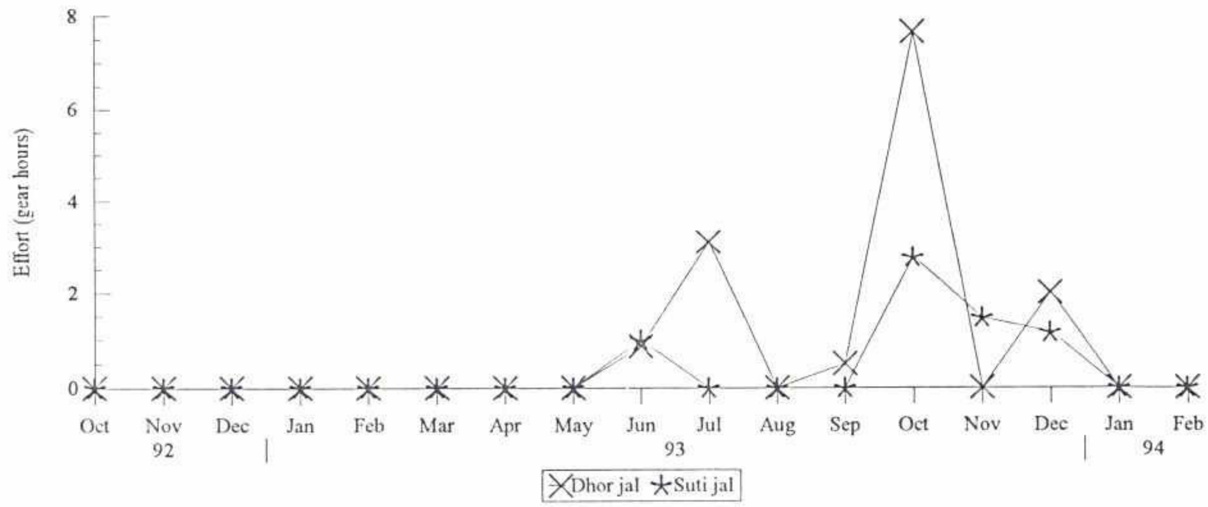


98

Figure 5.4 Total monthly fishing effort per hectare of floodplain by dominant gears: site NW28 (inside FCD)







of the rate of drawdown using Haribhanga sluice gates to extend the flood seasons within the polder. Whether the retention of water was primarily for agricultural purposes on adjacent higher land or to provide the opportunity for a village "fish-out" or *nimbaich*, is not known. The second most important gear contributing to the high catch in December was a single *suti jal* set on Haribhanga *Khal* in the second half of the month, coinciding with the reopening of the sluice gates. The *suti jal* captured a total annual catch of 11.4 tonnes of fish and prawns (Table 5.6) most of which was taken between October and December. At the same time, a *veshal* operated in the *khal* but was less successful and accounted for an annual catch of only 1.6 tonnes. The *khal* was fished under a one year lease and during the previous year the *suti jal* was not used and the *veshal* operated only up to October 1992. Reasons for the inter-annual differences in fishing pattern remain unclear.

The high total monthly catches recorded between October and December were a function of both high, often peak, fishing effort by dominant gears (Fig. 5.4) and peak catch rates (Fig. 5.5). The higher catch rates at this time of year resulted from the concentration of fish and prawns in decreasing areas of water. As a consequence of the higher catch rates, both fishing effort and the diversity of gears employed also increased.

During the winter months of January and February, *kua* fishing provided most of the catch together with *jhaki jal*. Following the dry year of 1992, *kua* contributed between 56% and 66% of the monthly catches in January and February 1993. In the following year they provided 86% of the catch in January but only 26% in February.

On unregulated floodplains of Chalan *Beel*, little fishing activity was recorded in January and February 1993 when HYV winter rice covered the area. Only two types of gear were observed in each month, *thella jal* and *jhaki jal* in January and fishing by hand and with *akra* during February. Fishing activity increased slightly and diversified during March and April but total monthly catches remained very low. New gears such as *moi jal* and *dhor jal* appeared and were used to fish small *khal* on the floodplain which received an artificial supply of water by the construction of dams on the Atrai and Piplagang *Khal* to divert water into *khals* of the floodplain for the irrigation of winter rice. In May, water levels in the Atrai increased rapidly and overspilled cross dams. At the same time, the cross dam on Piplagang *Khal* was breached by farmers to drain rainfall runoff which accumulated progressively in the lowest depressions. The ingress of Atrai waters through canal systems on the floodplain and the ponding of rainfall on the floodplain stimulated the start of *doiar* trap fishing, which

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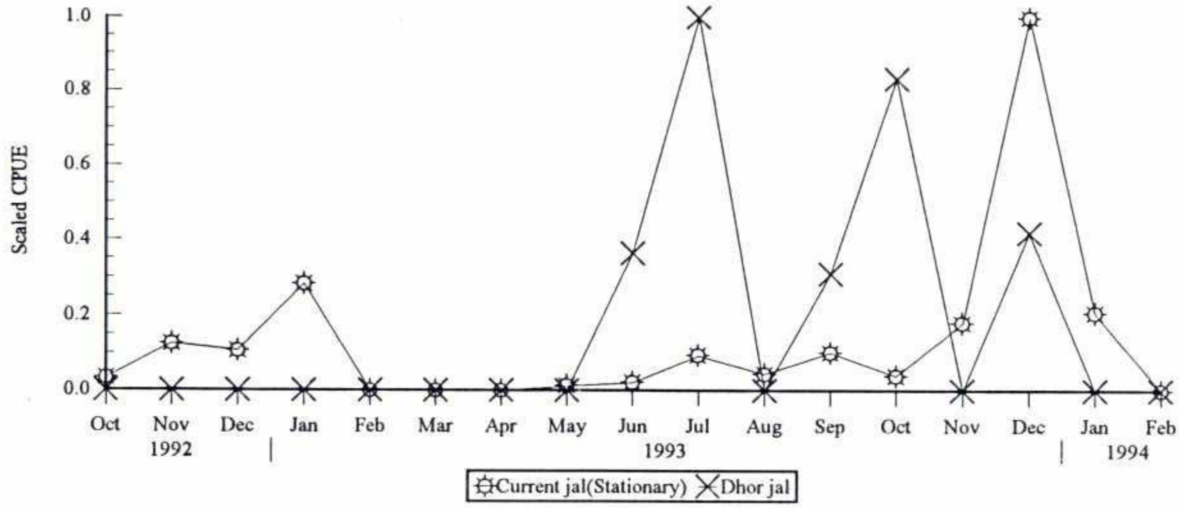
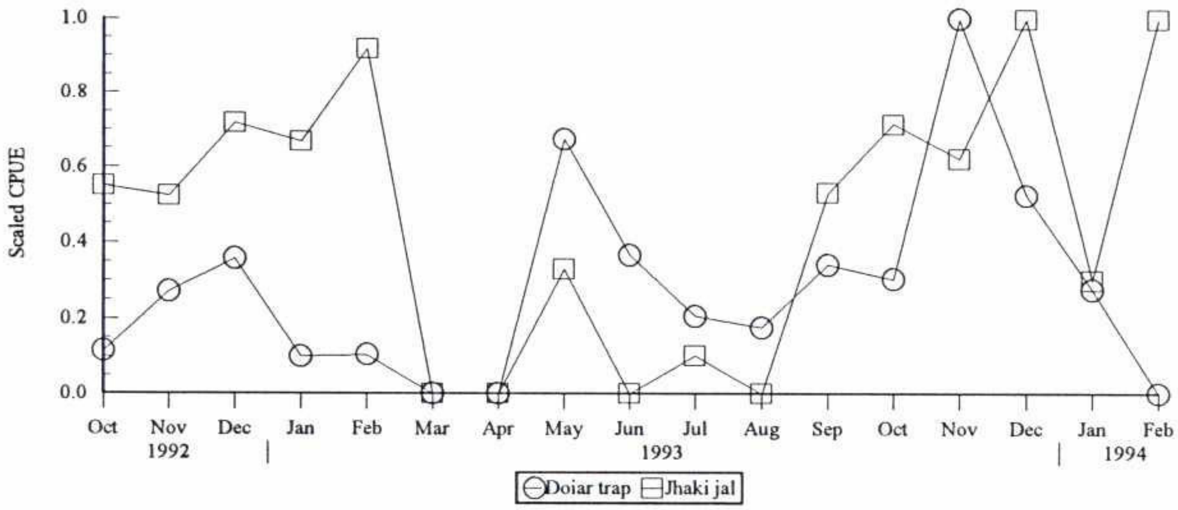
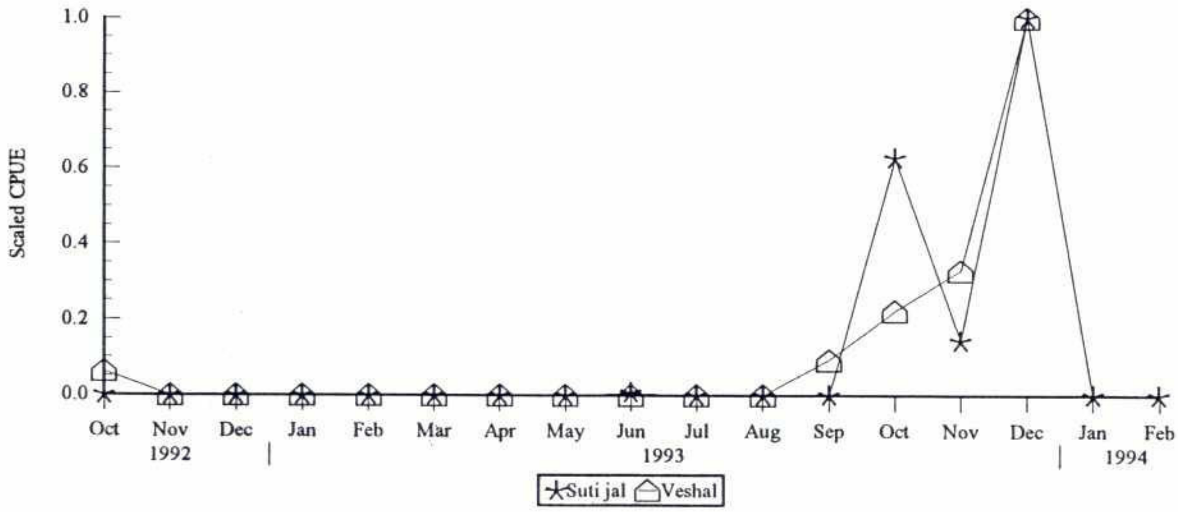
Figure 5.5 Scaled CPUE of dominant gears: site NW28 (inside FCD)







Note: Scaled CPUE are values of CPUE expressed as a proportation (decimal) of the maximum monthly value recorded.

accounted for 67% of the catch, and the temporary setting of a *suti jal* which took much less (3%) while *dhor jal* provided the rest (30%) of the catch (Fig. 5.6).

During the second half of June, Atrai River levels increased sharply and totally inundated the floodplains. This resulted in increased fishing activity by a larger number of gear types. At this time, only four gears; *suti jal*, *doiar* traps, *current jal* and *dhor jal* were recorded in use inside Polder B where controlled water levels were lower than those on unregulated floodplains. In contrast, eight different gears were used here; in addition to those listed above there were also small-scale gears such as *sip*, *juti* and *thella jal* and more expensive gears such as *jhaki jal* and *baoli*. Of the eight gears, *doiar* traps provided most (62%) of the catch.

The diversity of gears used on the floodplains remained higher than that inside Polder B throughout the full flood season from July to September. During this period, *doiar* traps consistently accounted for between 19% and 26% of monthly catches while other gears predominated in different months: *current jal* and *nol barsi* in July (40% and 21% respectively), *dhor jal* in August (44%) and *daun* in September (22%).

During the early part of the drawdown in October, small seine nets such as *baoli jal*, *dhor jal* and *kachitana* together accounted for 53% of the catch. In the following month, when peak monthly catches were recorded, a khal on the floodplain reappeared after being submerged since June and this was fished by *suti jal* which captured more than half (56%) the total monthly catch of 10 tonnes. The remainder of the catch was taken mainly by *baoli jal*, *current jal*, *doiar* traps and *jhaki jal*. In December the *suti jal* continued operations but its share of the monthly catch was lower (11%) than in November and the total monthly catch also declined. The most prominent gears in this month were again *baoli jal*, *akra* and *jhaki jal*. Peak catches during the drawdown in November were largely a function of increased fishing effort and peak catch rate of the *suti jal* (Figs 5.7 and 5.8). High fishing effort by other dominant gears such as *baoli jal* and *doiar* traps, and high catch rates of *dhor jal* and *current jal*, also contributed to the peak catch.

Fishing activities and patterns of catch during the drawdown and early winter differed markedly from those inside Polder B. On unregulated floodplains, most activity and highest catches occurred in November and floodplains quickly dried out in December, at least two weeks earlier than in Polder B where sluice gates were closed temporarily in early December to retain water. The subsequent heavy community fishing using *jhaki jal* seen in Polder B in late December, which resulted in a peak monthly catch, was not seen on the unregulated

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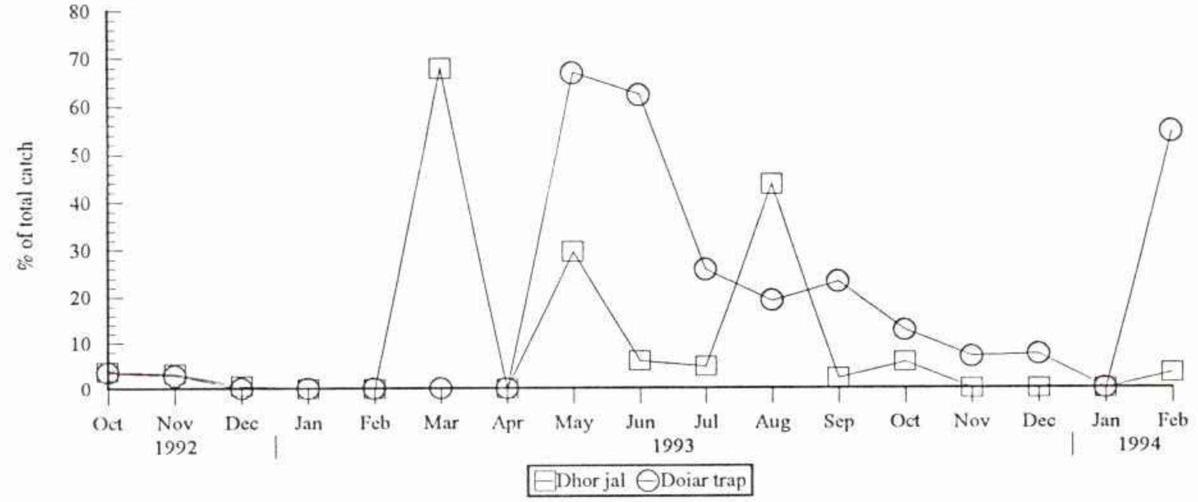
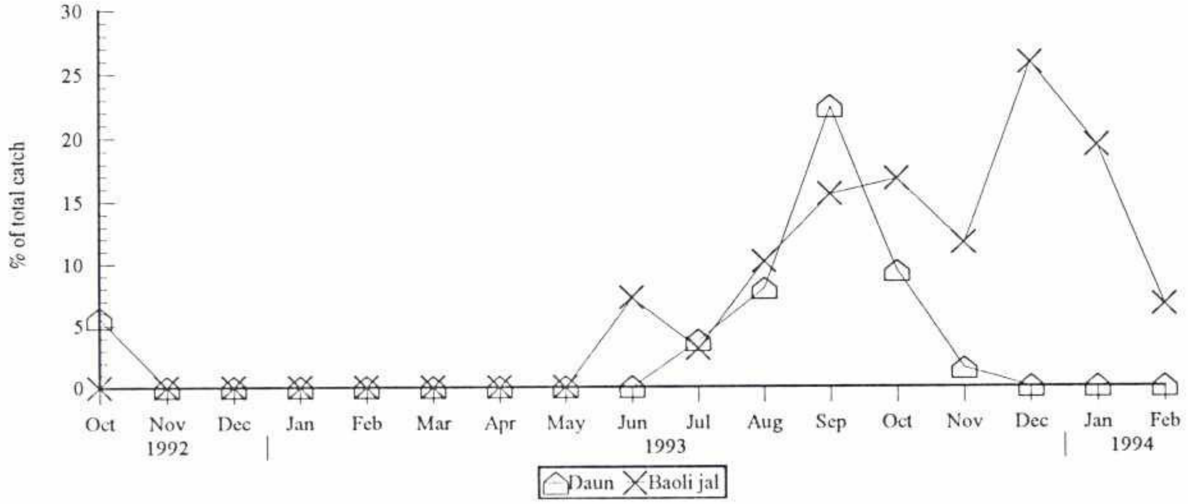
Figure 5.6 Percentage of total monthly catch taken by dominant gears: site NW30 (outside FCD)





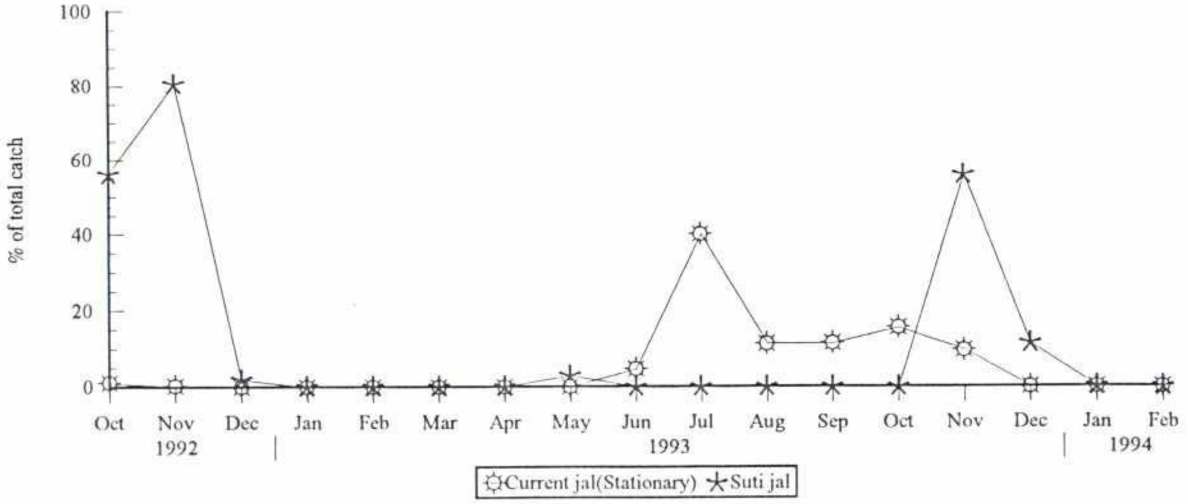


Figure 5.7 Total monthly fishing effort per hectare of floodplain by dominant gears: site NW30 (outside FCD)

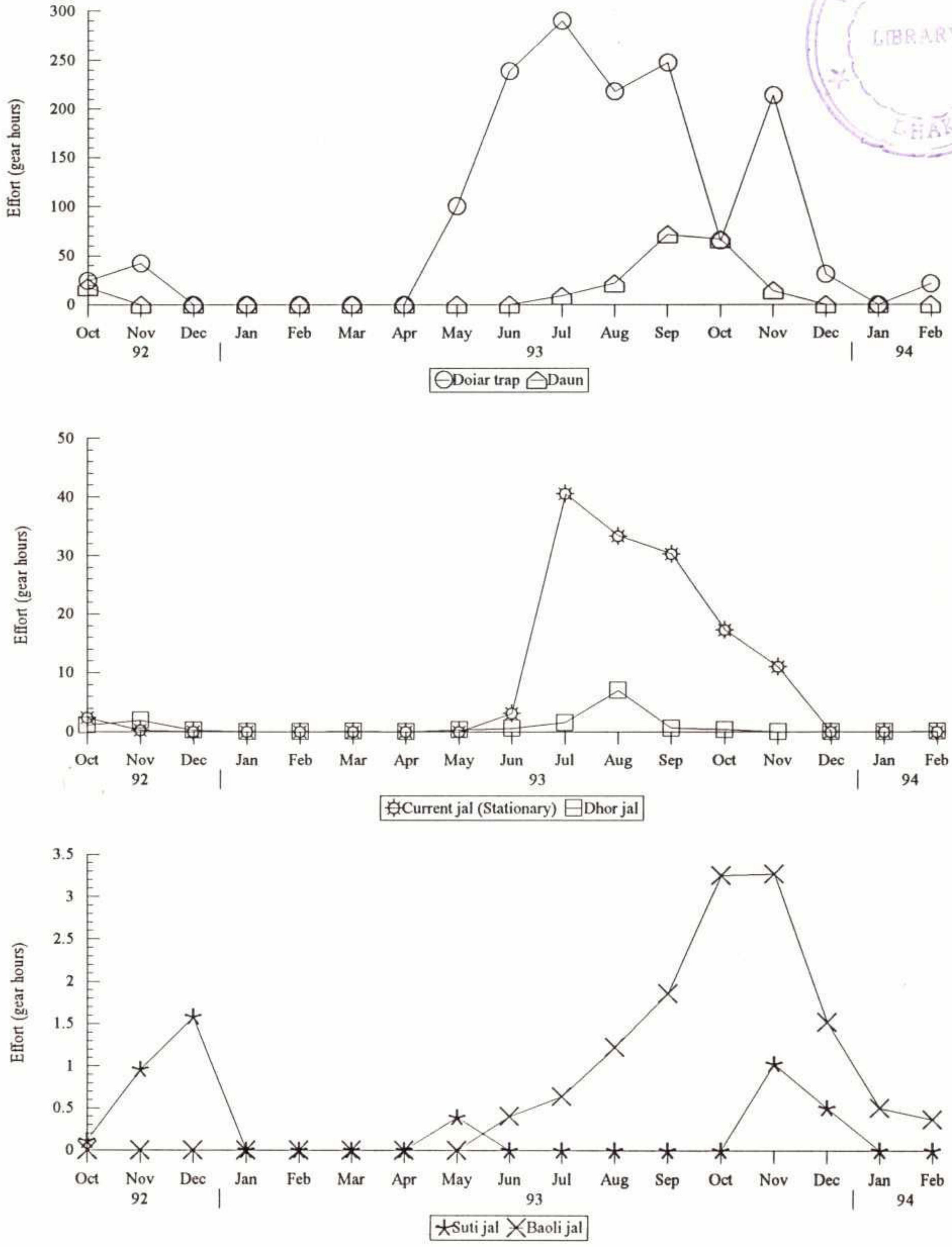
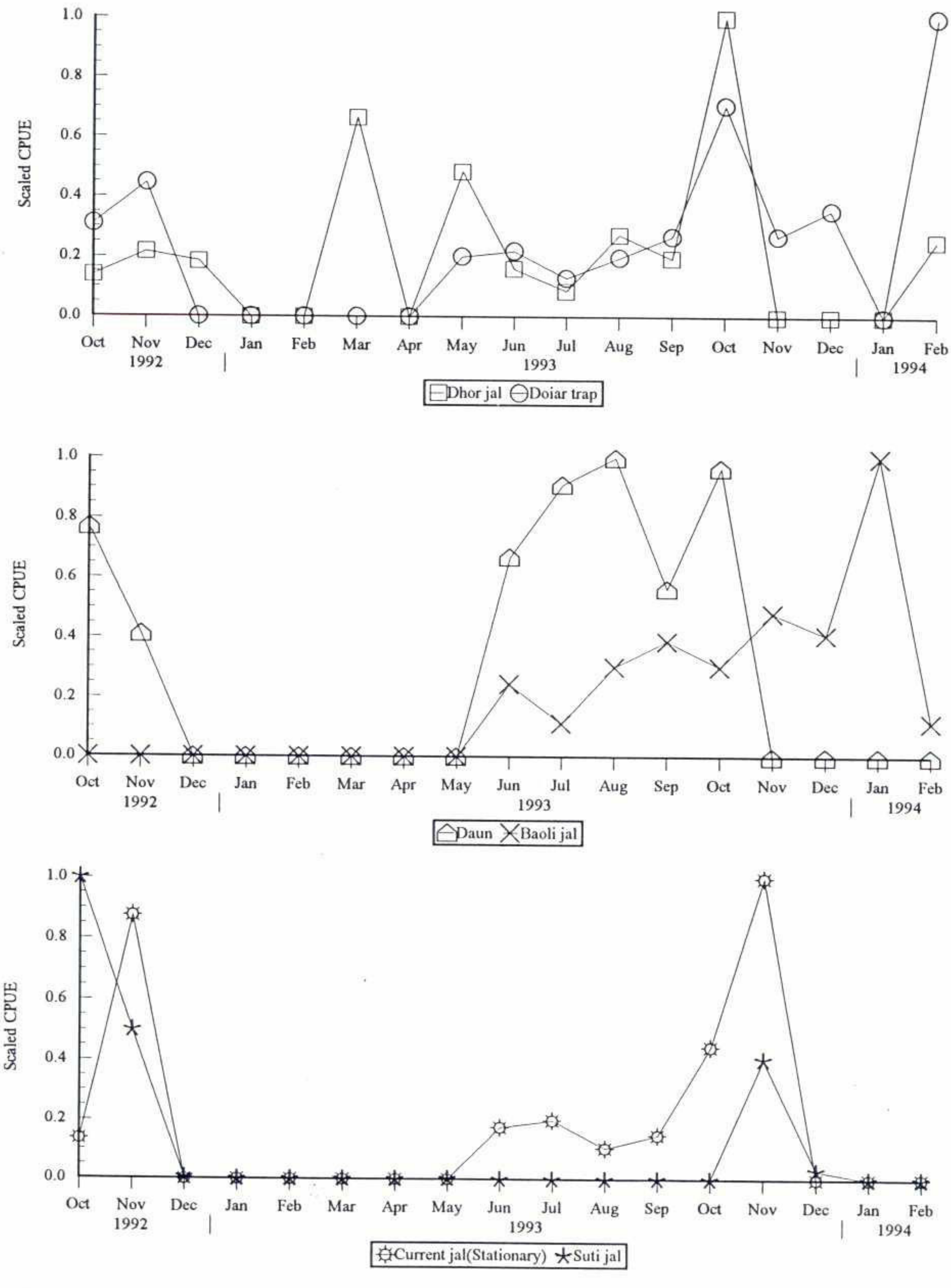


Figure 5.8 Scaled CPUE of dominant gears: site NW30 (outside FCD)



Note: Scaled CPUE are values of CPUE expressed as a proportation (decimal) of the maximum monthly value recorded.

Chalan *Beel*, where it would have required the construction of a dam on Piplagang *Khal* to achieve the same hydrological effect.

A notable feature of winter fishing activities was the harvesting of *kua* which occurred over a much shorter interval of two months on Chalan *Beel* compared with four months on Haribhanga *Beel*. Not only was there less fishing effort by *kua* on Chalan *Beel* compared with Haribhanga but *kua* density was also less outside (0.03 *kua*/ha) than inside (0.08 *kua*/ha) the polder. The lower level of *kua* development on Chalan *Beel* can be explained, in part, by differences in patterns of land ownership between the two areas. Land ownership on Chalan *Beel* was dominated by large landholdings whose landlords were more interested in the large-scale production of HYV winter rice than in diversifying earnings through *kua* excavation. In contrast, small farmers in Polder B complained about the rising costs of HYV *boro* cultivation. For these smaller landholdings, diversification into capture fisheries through *kua* excavation and harvesting was more economically attractive[4].

On the unregulated Kubjipur and Piplagang *Khal*, very low pre-monsoon monthly catches were taken principally by *moi jal* and *dhor jal* in March, *doiar* traps in April and a combination of these together with *baoli jal* in May (Fig. 5.9). Small *suti jal* were set temporarily in May to exploit fish moving from the river on to the floodplains via a feeder canal, Kubjipur *Khal*, and in the opposite direction via a drainage canal, Piplagang *Khal*. As water levels continued to rise, *doiar* traps contributed most to the prevailing low catches of June and July while hook fisheries, *sip* and *daun* predominated during the monsoon, accounting for 71% of the catch in August, 50% in September and 41% during the drawdown of October when total catches still remained low. In November, catches rose precipitously due mainly to *suti jal* which captured 84% of the peak catch. The high catch was a function of increased effort by *suti jal* but, more importantly, increased catch rate of this gear (Figs 5.10 and 5.11). Higher levels of effort were deployed by *suti jal* in December but because of lower catch rates, the total monthly catch declined considerably. However, this gear still provided 46% of the monthly catch before being dismantled in January. Predominant gears during the winter months included *jhaki jal*, *baoli jal*, *doiar* traps and *akra*.

On the Atrai River, the low pre-monsoon catches of March and April were taken by *moi jal* and *katha*. As water levels rose sharply in May and June, *doiar* traps took most of the catches together with *jhaki jal*, *dhor jal*, *sip* and *veshal* (Fig. 5.12). During the full flood season from July to September gear diversity increased and catches were dominated by traps, *doiar* and *deal* which together accounted for 21% of the catch in July, 42% in August and

Figure 5.9 Percentage of total monthly catch taken by dominant gears: site NW29 (outside FCD)

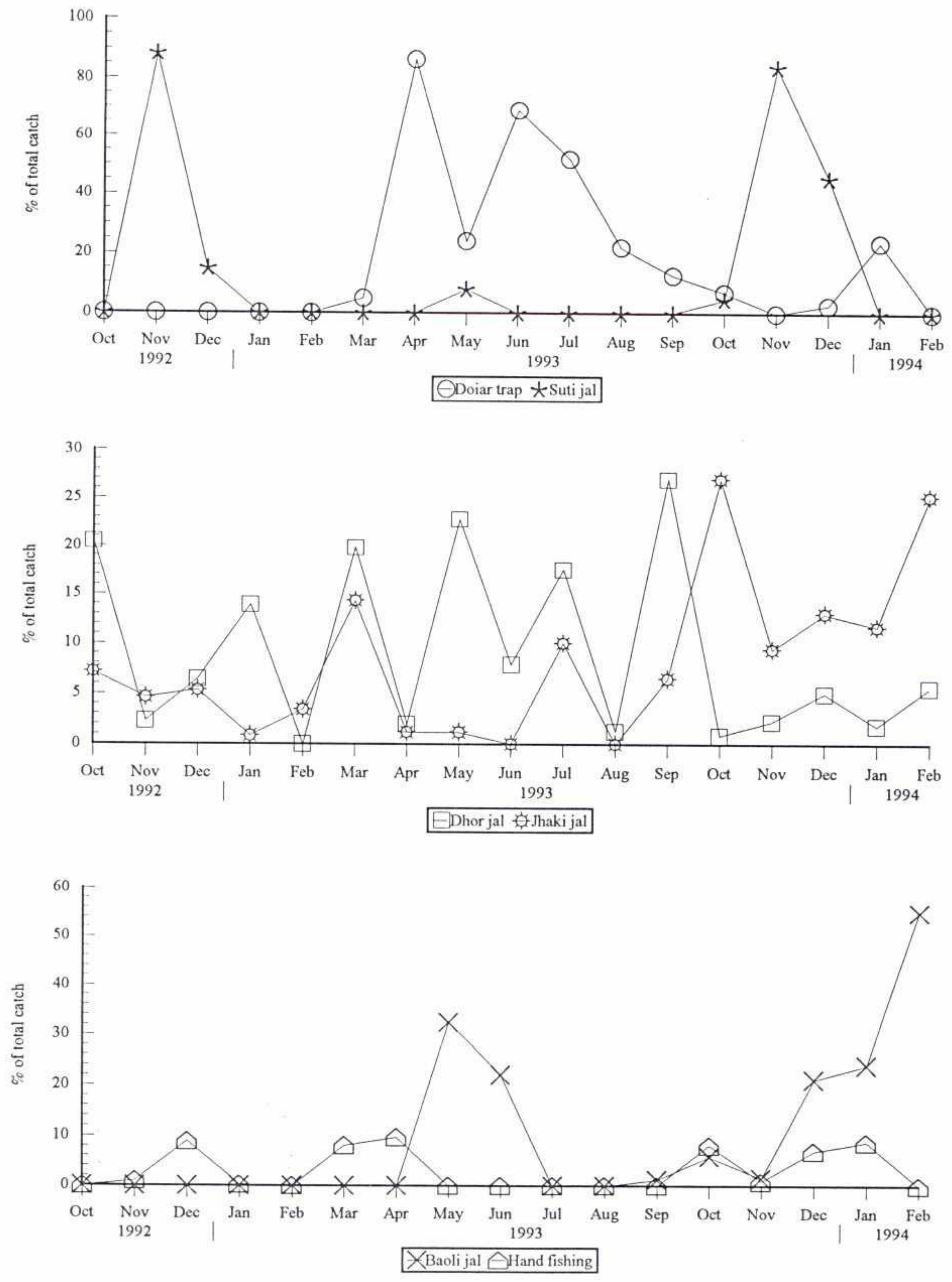


Figure 5.10 Total monthly fishing effort per kilometre of canal by dominant gears: site NW29 (outside FCD)

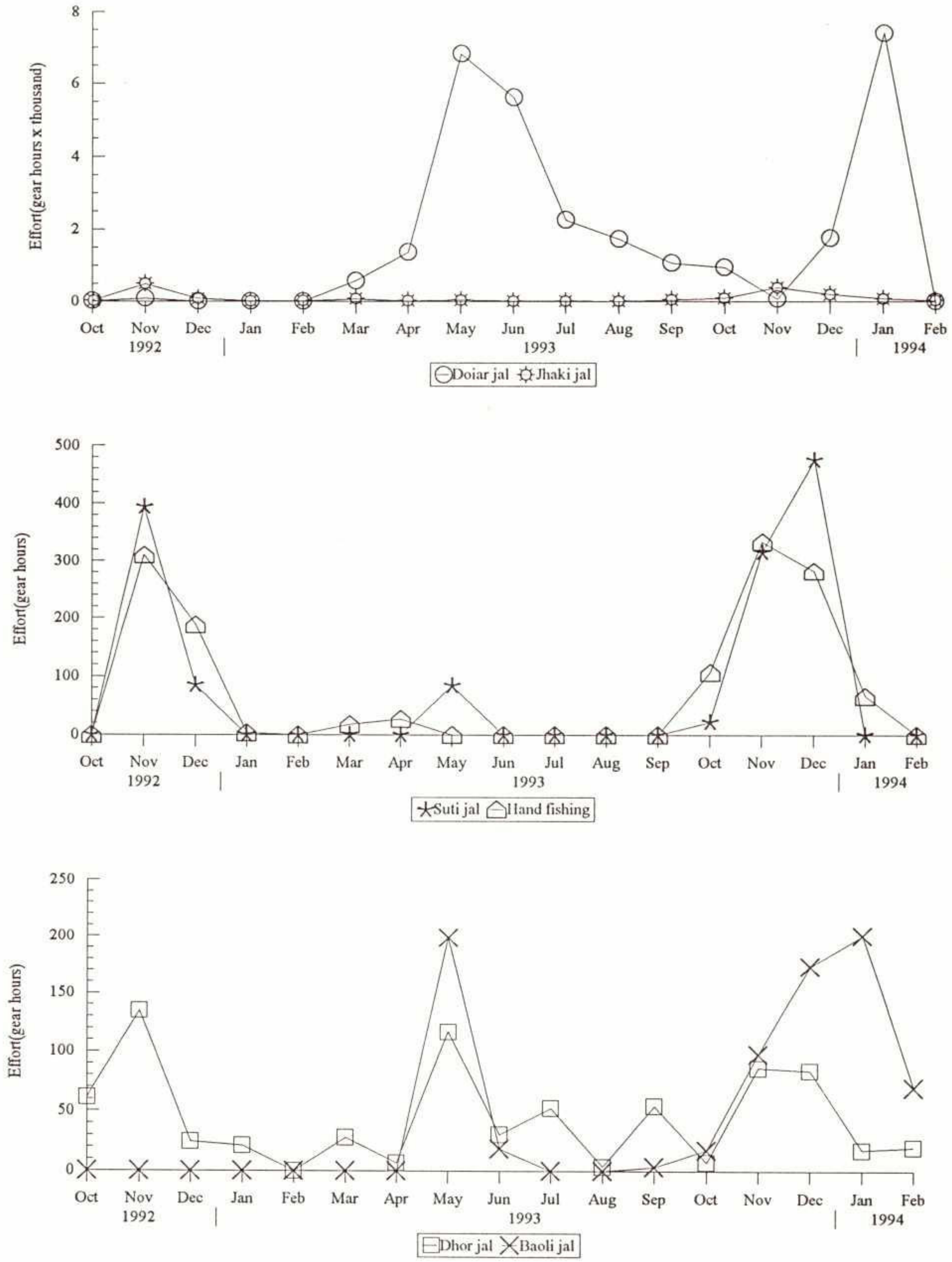
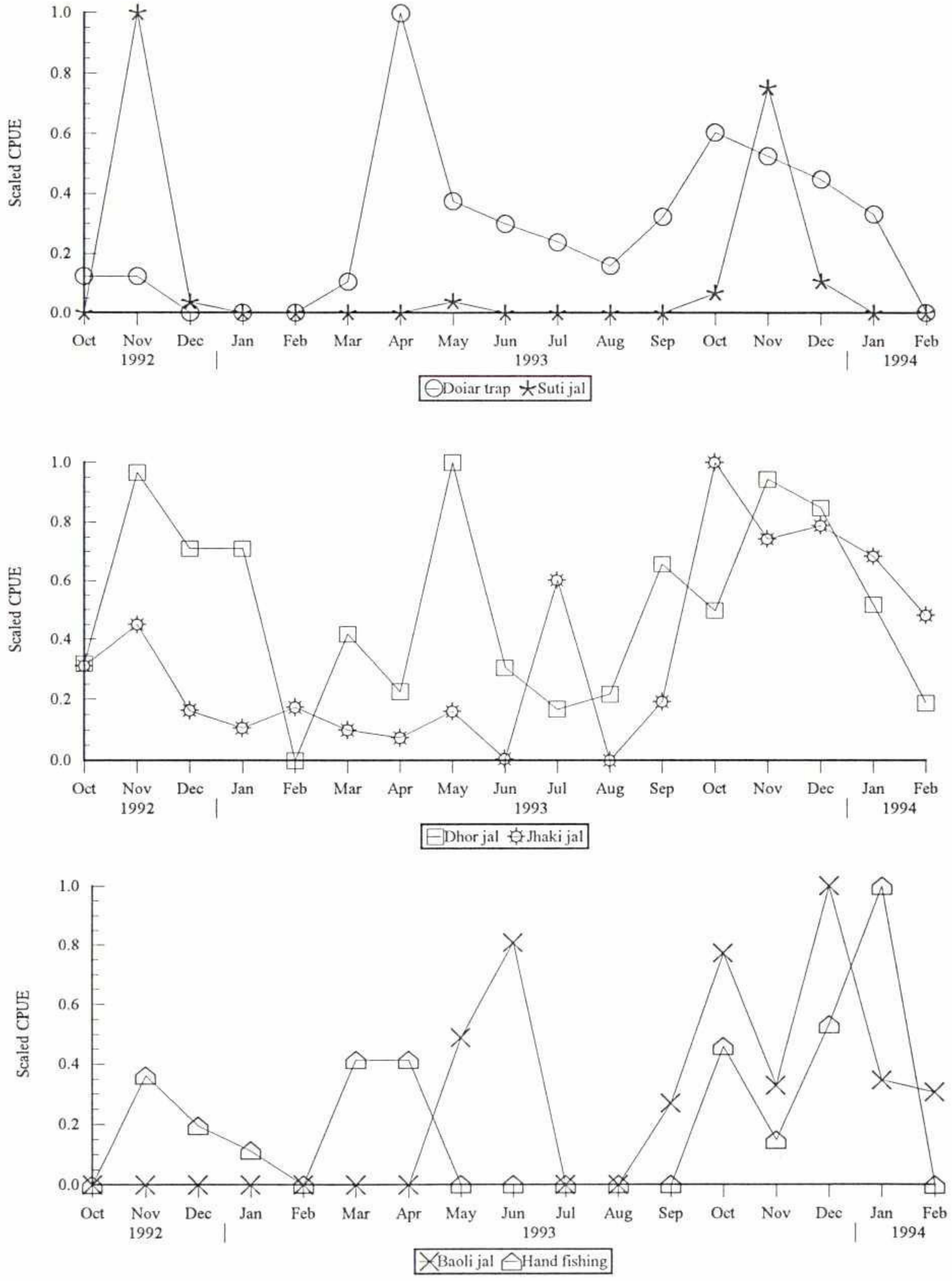


Figure 5.11 Scaled CPUE of dominant gears: site NW29 (outside FCD)



Note: Scaled CPUE are values of CPUE expressed as a proportation (decimal) of the maximum monthly value recorded.

Figure 5.12 Percentage of total monthly catch taken by dominant gears: site NW27 (outside FCD)

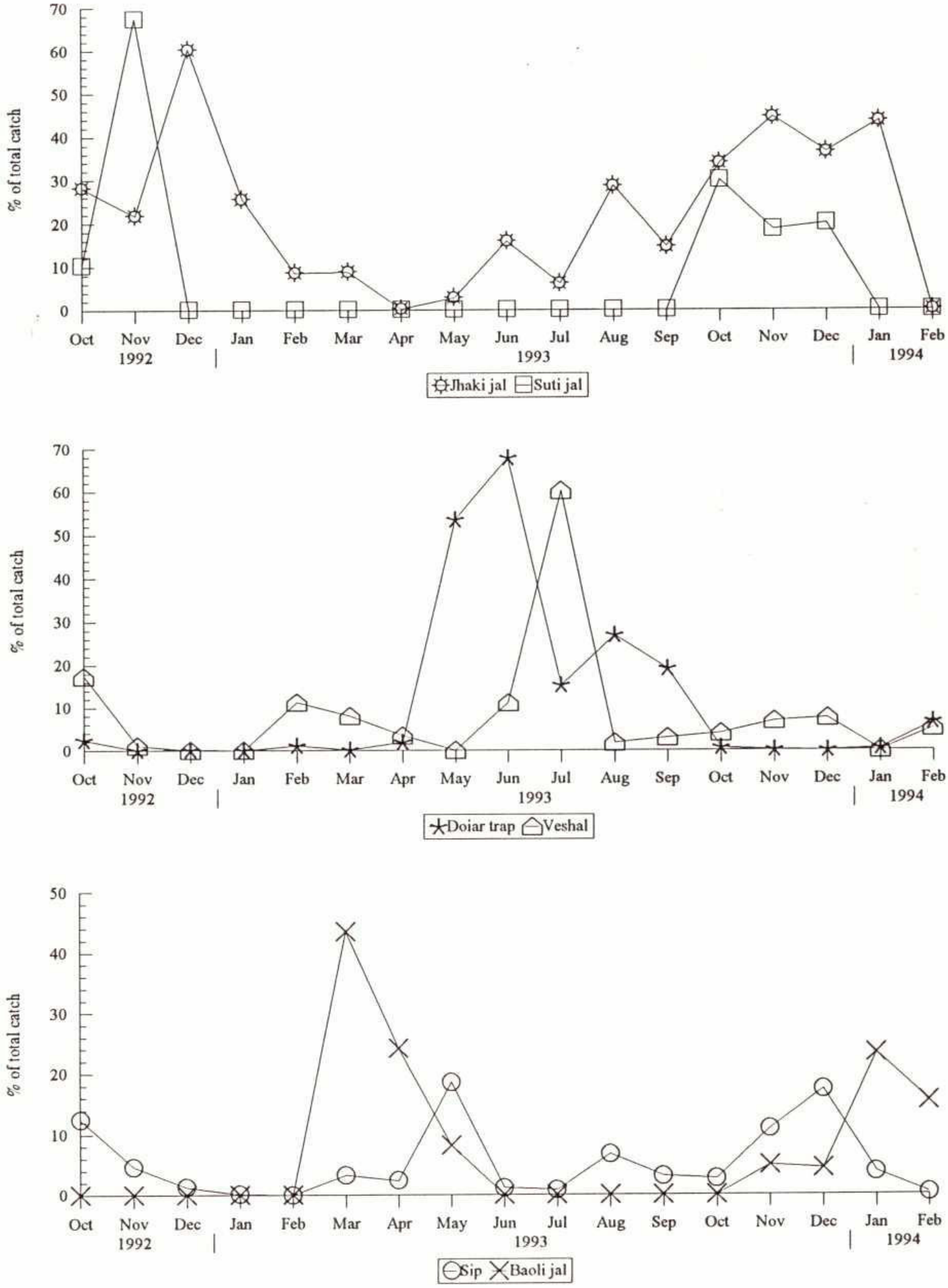


Figure 5.13 Total monthly fishing effort per kilometre of river by dominant gears: site NW27 (outside FCD)

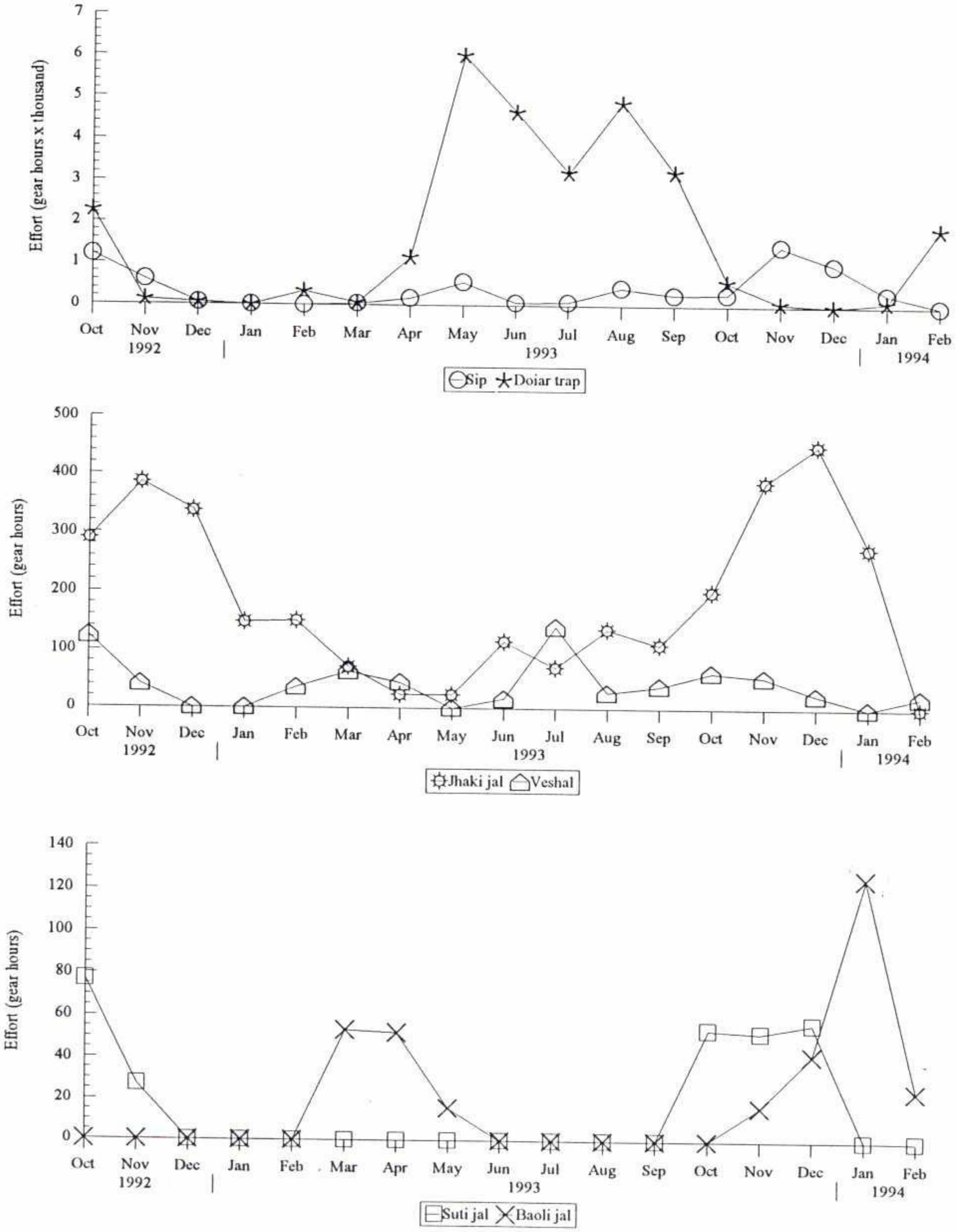
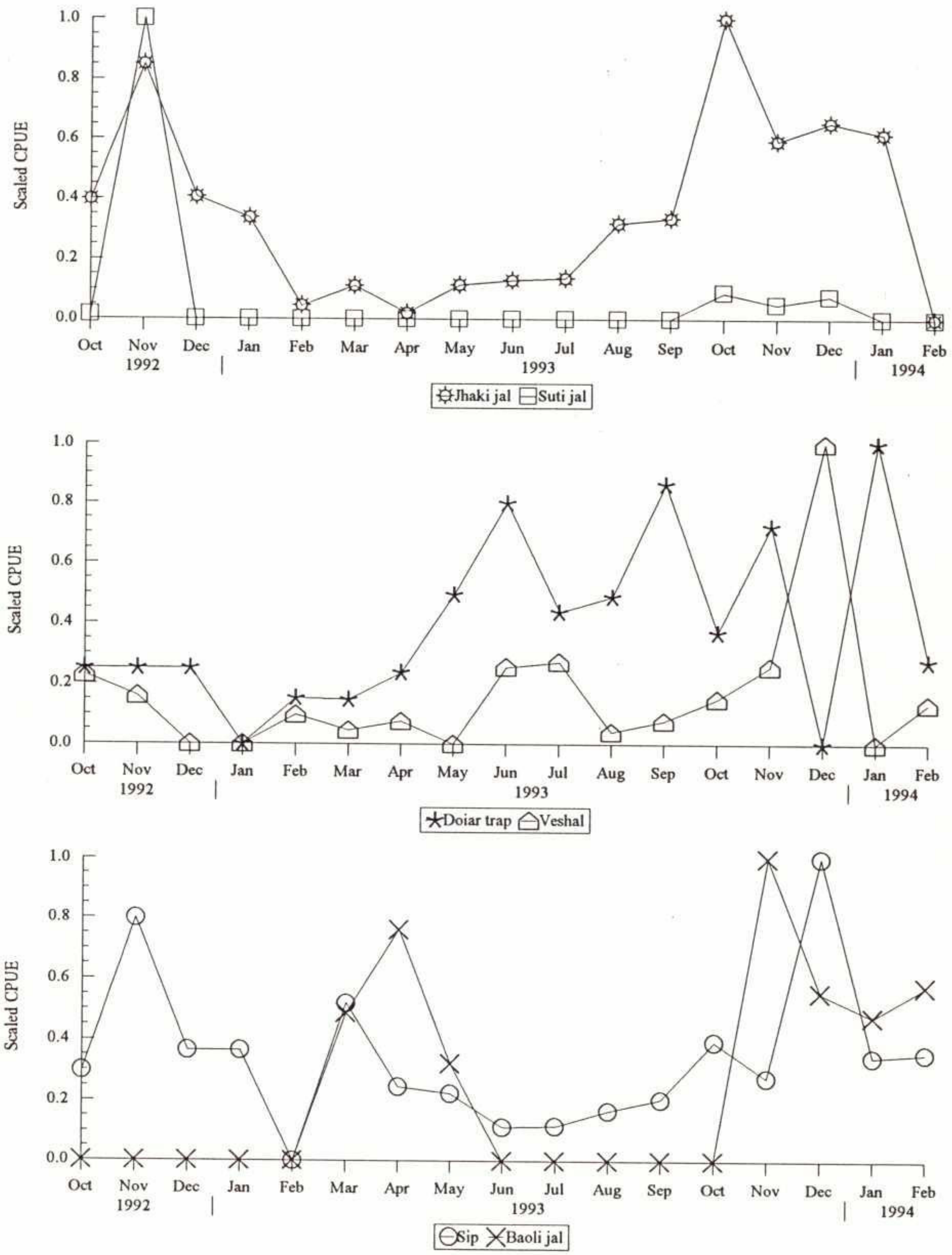


Figure 5.14 Scaled CPUE of dominant gears: site NW27 (outside FCD)



Note: Scaled CPUE are values of CPUE expressed as a proportion (decimal) of the maximum monthly value recorded.

51% in September. Other important gears included *veshal* which took 60% of the July catch and *jhaki jal* which accounted for 29% of the catch in August. During the flood drawdown, between October and December, *suti jal* were set and caught between 19% and 30% of the monthly catches. *Jhaki jal* were also very important during this period, accounting for 34% to 44% of catches. The high catches during the drawdown were a function of both increased fishing effort and peak catch rates of dominant gears (Figs 5.13 and 5.14). In the winter months of January and February, *katha* harvesting provided 12% to 59% of the catch and *baoli jal* between 16% and 23% of the catch.

5.3 Statistical Comparison of Catch Rates Inside and Outside Polder B

Statistical analyses of seasonally pooled catch rates of gears used inside and outside the polder were attempted following the method outlined in the Draft Final Report, Appendix 3. The underlying assumption of this method was that once differences in catchabilities between gears were accounted for, then any further differences in catch rates inside and outside the polder were due solely to differences in fish densities.

Catch rates of dominant gears used on floodplains inside Polder B were compared with those of dominant gears used on both the unregulated floodplain of Chalan *Beel* and in the canals connecting it with the Atrai River. The unregulated canal site was included since the floodplain site inside Polder B also included catches from the main feeder and drainage canal, Haribhanga *Khal*.

At the inside site, over 91% of the catch per hectare for the period March 1993 to February 1994, excluding *katha* and *kua*, was taken by 7 gears. In descending order of catch per hectare, they were; *suti jal*, *jhaki jal*, *doiar* traps, *current jal*, *dhor jal*, *veshal* and *thella jal*. At the outside site, more than 89% of the total catch per hectare over the same period was also taken by 9 gears. These were; *suti jal*, *baoli jal*, *doiar* traps, *jhaki jal*, *current jal*, *dhor jal*, *daun*, *kachitana* and *akra*. Five gears appeared in both lists; *suti jal*, *jhaki jal*, *doiar* traps, *current jal* and *dhor jal*. Of these, however, seasonal patterns of gear usage and catch rates were very different at inside and outside sites for *suti jal* and *dhor jal*, and inclusion of these in the statistical comparisons would clearly violate the assumptions of the statistical model.

Of the remaining three common gears, seasonal patterns of catch rates were very similar between inside and outside sites for *jhaki jal* and *doiar* traps, at least where the number of catch rate observations was large. The same was true for *current jal* except for season 4, when the seasonally pooled catch rate at the inside site was much lower than at the outside site.

Despite this, statistical comparisons were attempted, but inspection of observed and predicted catch rates revealed that the discrepancy in catch rates in season 4 for *current jal* caused severe lack of fit in the statistical model. With three of the five common gears showing differences in gear usage and seasonal catch rate patterns, no valid statistical comparisons using the model could be made between fish densities at inside and outside sites.

An alternative method was therefore applied which involved separate analyses of catch rates of five dominant gears (Fig. 5.15). Mean catch rates of each gear inside and outside the polder were compared for each of five seasons and for all seasons combined between March 1993 and February 1994 (Table 5.10). The non-parametric Mann-Whitney U-test was used since initial tests showed that the catch rate data were not normally distributed. However, the parametric student t-test on logarithmic transformed catch rates produced essentially the same results as those presented in Table 5.10. Of the 23 gear/season combinations examined statistically, significant ($p < 0.05$) differences were found in only 5 cases.

Catch rates of *suti jal* were significantly higher inside Polder B during season 5. However the sample size was very small with just two catch rates and both were taken in late December immediately following temporary sluice gate closures which artificially concentrated trapped fish in Haribhanga *Khal*. When catch rates were compared over the year, no statistical difference between inside and outside sites was detected.

There was no significant difference in the catch rates of *jhaki jal* in any one season but when combined for the year, catch rates were found to be significantly higher inside the polder. No significant difference was found between the catch rates of *doiar* traps either for individual seasons or annually. For *current jal*, a significantly higher catch rate was found at the outside site during the drawdown but not in other seasons nor when seasons were pooled. *Dhor jal* catch rates were significantly higher inside the polder during the full flood season but not in other seasons. When data from all seasons were combined, a significantly higher catch rate was found inside the polder.

Thus, of the five dominant gears examined: one showed no difference between catch rates seasonally or annually; one showed significantly higher catch rates in one season on unregulated floodplains, and three showed significantly higher catch rates in one season only

Figure 5.15 Comparison of mean monthly catch rates (kg/hr) of dominant gears from floodplains/*beel* and connected *khal* inside and outside Polder B, October 1992 - February 1994

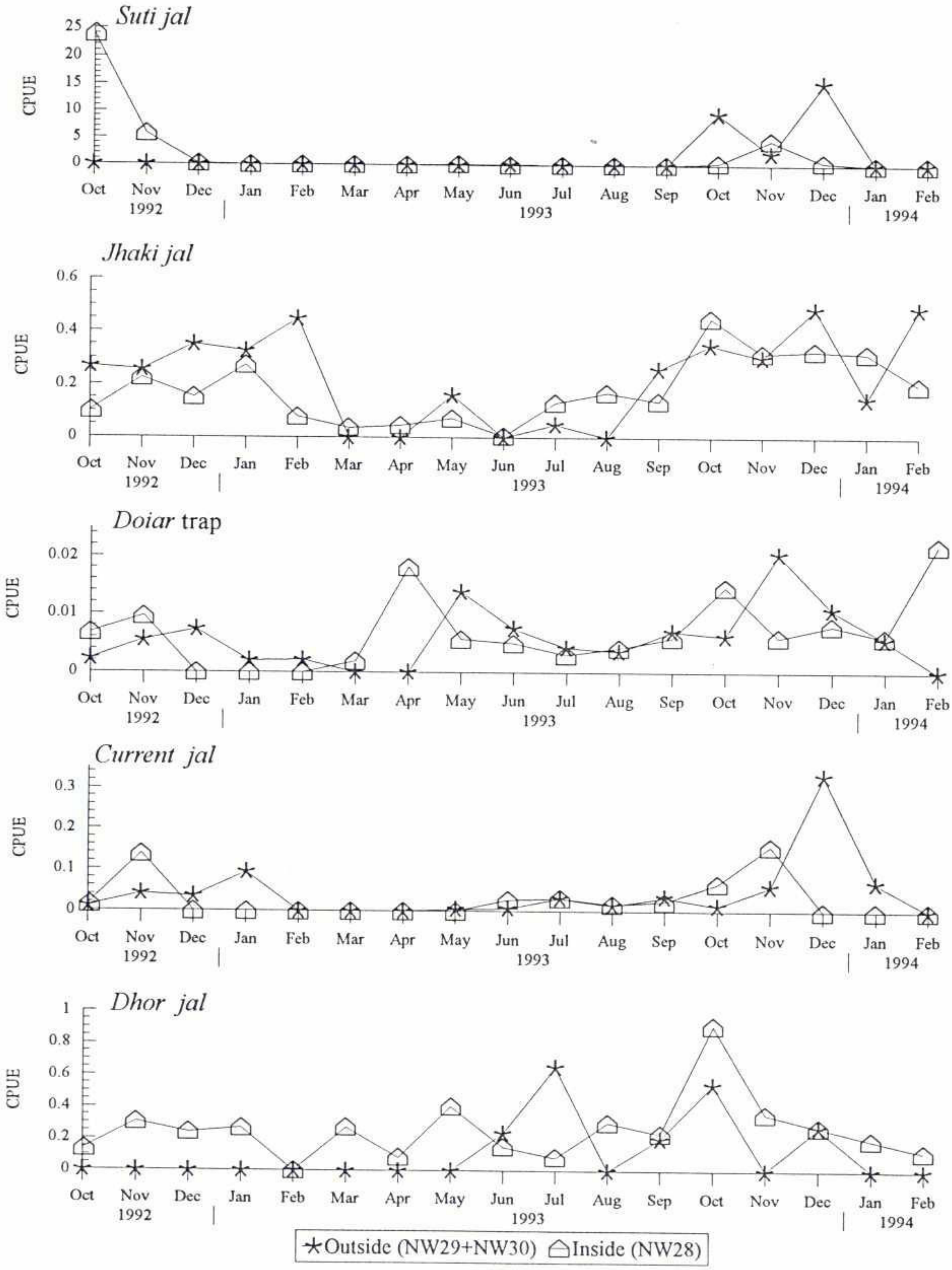


Table 5.10 Statistical comparison of catch rates (kg/hr) of dominant gears used inside and outside Polder B, March 1993 - February 1994

Gear	Season	NW28: Inside FCD		NW29+30: Outside FCD		Non-parametric Mann-Whitney U-test on CPUE			
		Sample size	Mean CPUE	Sample size	Mean CPUE	U-value	Z-value	P-value	Comment
Suti jal	1	-	-	-	-	-	-	-	-
	2	2	0.128	2	0.116	1.0	-0.77	0.437	NS
	3	-	-	-	-	-	-	-	-
	4	5	5.184	12	4.527	26.0	-0.42	0.673	NS
	5	2	10.757	8	0.617	-	-2.09	0.037	SIG
	All seasons	9	5.299	22	2.704	78.0	-0.914	0.361	NS
Jhaki jal	1	-	-	6	0.045	-	-	-	-
	2	1	0.161	5	0.068	1.0	-0.87	0.380	NS
	3	4	0.138	9	0.167	13.0	-0.77	0.440	NS
	4	10	0.381	15	0.321	62.0	-0.72	0.471	NS
	5	18	0.375	20	0.265	144.5	-1.04	0.299	NS
	All seasons	33	0.342	55	0.222	639.5	-2.31	0.021	SIG
Doiar trap	1	-	-	3	-0.007	-	-	-	-
	2	4	0.010	20	0.006	22.0	-1.39	0.163	NS
	3	21	0.006	12	0.006	125.0	-0.02	0.985	NS
	4	6	0.011	9	0.010	25.0	-0.24	0.814	NS
	5	6	0.014	8	0.008	15.0	-1.16	0.245	NS
	All seasons	37	0.008	52	0.007	860.5	-0.84	0.398	NS
Current jal	1	-	-	-	-	-	-	-	-
	2	3	0.006	4	0.015	4.0	-0.71	0.480	NS
	3	27	0.043	15	0.036	192.0	-0.28	0.783	NS
	4	14	0.045	12	0.230	39.0	-2.31	0.021	SIG
	5	7	0.254	-	-	-	-	-	-
	All seasons	51	0.070	31	0.109	733.0	-0.55	0.582	NS
Dhor jal	1	-	-	4	0.522	-	-	-	-
	2	2	0.199	13	0.191	11.0	-0.34	0.734	NS
	3	8	0.537	15	0.207	28.5	-2.03	0.042	SIG
	4	5	0.455	7	0.443	17.0	-0.08	0.935	NS
	5	3	0.261	13	0.179	10.0	-1.20	0.194	NS
	All seasons	18	0.431	52	0.252	316.0	-2.04	0.041	SIG

Notes:
1. NS - Not significant, SIG - Significant at 5% level
2. - denotes no data
3. Seasons: 1. March-April, 2. May-June, 3. July-September, 4. October-November and 5. December-February

inside the polder. It is concluded, therefore, that there is no clear statistical evidence for differences in catch rates inside and outside Polder B. The substantially higher catch recorded inside the polder was therefore due largely to a greater amount of fishing effort by dominant gears (Table 5.11). Most of this increased fishing effort resulted from the activities of *jhaki jal*, *doiar* traps and *current jal* for which the annual fishing effort per hectare of floodplain/khal was 2.5 to 5 times higher inside the polder.

Table 5.11 Comparison of the amount of annual fishing effort per hectare by dominant gears used inside and outside Polder B

Gear	Effort (gear hr/ha)			% change at NW28 compared with NW29+NW30
	Inside FCD	Outside FCD		
	NW28	NW30	NW29+NW30	
Suti jal	6	2	8	- 25
Jhaki jal	83	10	16	+ 419
Doiar trap	3,739	1,422	1,617	+ 131
Current jal (Stationary)	495	136	136	+ 264
Dhor jal	14	11	14	0

Note: + and - denote increase and decrease in effort respectively

5.4 Biodiversity and Catch Composition

5.4.1 Species richness

Between March 1993 and February 1994, 80 species of fish were recorded from the unregulated floodplains of Chalan *Beel*. This compares with 65 species found inside Polder B during the same period, a reduction in species diversity of 19% (Table 5.12). On unregulated canals slightly fewer species (72) were recorded than on adjacent floodplains while more (96) were recorded from the Atrai River.

Table 5.12 Comparison of the total number of fish species found on sites inside and outside Polder B

Site Code	Name	In/Out FCD	Number of species	
			Total (October 1992 - February 1994)	Annual (March 1993 - February 1994
NW28	Haribhanga *Beel*	In	68	65
NW30	Chalan *Beel*	Out	84	80
NW29	Kubjipur and Piplagang *Khal*	Out	79	72
NW27	Atrai River	Out	105	96

In Table 5.13 species have been divided into three categories of habitat preference based on spatial distributions derived from the FAP 17 fisheries database covering four FAP regions. The categories are defined below.

a) Riverine
Species which are usually confined to rivers and estuaries (or sea in the case of *ilish*) throughout their life cycle with no direct dependence on floodplains, although some species can be found on more extensive floodplains, particularly in the North East Region.

b) Migratory
Species which move between river and floodplain during different stages of their life cycle and therefore have some dependence on floodplains for growth and/or reproduction.

c) Floodplain resident
Species which are capable of surviving in perennial waters of the floodplain throughout the year and are largely dependent upon them for growth and reproduction. Many of these species inhabit a variety of habitats, including large rivers.

Table 5.13 Total annual number of fish species, classified by habitat preference, recorded from sites inside and outside Polder B, March 1993 - February 1994

Site Code	Name	In/out FCD	Number of species			Total
			Riverine	Migratory	Floodplain resident	
NW28	Haribhanga *Beel*	In	15	15	35	65
NW30	Chalan *Beel*	Out	22	20	38	80
NW29	Kubjipur and Piplagang *Khal*	Out	17	17	38	72
NW27	Atrai River	Out	31	22	43	96

The results in Table 5.13 reveal that there were 29% fewer riverine and migratory species on floodplains inside the polder than on those outside. There was also a slight reduction (8%) in the number of floodplain resident species recorded from regulated floodplains. It is clear from these results that there were major changes in catch composition and community structure of fish populations resulting from the controlled flooding of Polder B. These are discussed in more detail in Sections 5.4.2 and 5.5 where seasonal movements of individual species between river and floodplains are examined in detail.

5.4.2 Catch composition

Percentage contributions made by riverine, migratory and floodplain resident species to annual catches from each site are summarised in Table 5.14.

Table 5.14 Percentage contribution of riverine, migratory and floodplain resident fish species to the total annual catches from sites inside and outside Polder B, March 1993 - February 1994

Site code	Name	In/Out FCD	% Total annual catch		
			Riverine	Migratory	Floodplain resident
NW28	Haribhanga *Beel*	In	<1	5.8	76.6
NW30	Chalan *Beel*	Out	4.6	30.8	52.0
NW29	Kubjipur and Piplagang *Khals*	Out	4.9	52.0	37.5
NW27	Atrai River	Out	17.1	41.2	34.1

On unregulated floodplains of Chalan *Beel*, riverine and migratory species accounted for 35% of the annual catch, most of which (31%) was from migratory species. In contrast, on the regulated floodplains inside Polder B, riverine and migratory species provided only 6% of the catch, almost all of which (5.8%) was from migratory species.

In terms of catch per unit area (CPUA), riverine and migratory species provided 18 kg/ha on Chalan *Beel* compared with 11 kg/ha in Polder B, a reduction of 39%. Floodplain resident species comprised 52% of the catch from Chalan *Beel* with a CPUA of 27 kg/ha compared with 77% from Polder B and a CPUA of 145 kg/ha, fivefold higher than that on unregulated floodplains.

It is clear from results given in Tables 5.13 and 5.14 that for those species which move seasonally between rivers and floodplains, not only are they reduced substantially in terms of diversity but also in terms of catch per unit area on regulated floodplains compared with fish populations on free flooding areas of Chalan *Beel*.

On the Atrai River, as might be expected, the relative abundance of riverine and migratory species was considerably higher (58% of catch) than on floodplains. The relative abundance of migratory species was also particularly high (52%) on the unregulated canals leading to floodplains.

The percentage contribution of dominant species to annual catches from each site are presented in Table 5.15. Dominant species are defined here as those species comprising 1% or more of the annual catch. More detailed information on monthly catch compositions is provided in Tables 5.16 to 5.19.

On the Atrai River, four dominant riverine species; *kajuli*, *ilish*, *ghaura* and *gang tengra* together accounted for 11% of the annual catch. Of these, *kajuli* had the highest relative abundance, comprising almost 6% of the catch. None of the four species was particularly abundant in the connecting canals of Chalan *Beel*. Instead, two small riverine loaches, *balichata* and *gharpoia* predominated, forming about 3% of the catch.

Seven dominant migratory species comprised 36% of the annual catch of the Atrai, the most abundant of which were the large catfish, *boal* (13%) and two smaller species *golsha tengra* (10%) and *kabashi* (5%). Other dominant species included another catfish, *batasi* and three carps; *rui*, *kalbaus* and *raik*. On the connecting unregulated canals, basically the same species

Table 5.15 Percentage contribution (by weight) to the total annual catch by dominant species from sites inside and outside Polder B, March 1993 – February 1994

Habitat Preference	Species name: Scientific	Species name: Bengali	Inside FCD Floodplain NW28	Outside FCD Floodplain NW30	Outside FCD Canal NW29	Outside FCD River NW27
Riverine	*Nemacheilus botia*	*Balichata*	–	1.5	1.2	–
	Somileptes gongota	*Gharpoia*	–	–	1.4	–
	Hilsa ilisha	*Ilish*	–	–	–	2.5
	Ailia coila	*Kajuli*	–	–	–	5.6
	Clupisoma garua	*Ghaura*	–	–	–	1.3
	Gagata youssoufi	*Gang tengra*	–	1.0	–	1.7
Subtotal			–	2.6	2.6	11.0
Migratory	*Aorichthys aor*	*Ayre*	–	–	1.3	–
	Mystus bleekeri	*Golsha tengra*	–	4.1	16.0	9.5
	Mystus cavasius	*Kabashi*	–	2.5	7.2	5.4
	Cirrhinus reba	*Raik*	1.4	2.3	4.2	1.3
	Labeo calbasu	*Kalbaus*	–	–	–	1.8
	Labeo rohita	*Rui*	–	–	–	3.0
	Salmostoma bacaila	*Katari*	–	–	2.3	–
	Pseudeutropius atherinoides	*Batasi*	–	9.8	5.4	2.1
	Wallagu attu	*Boal*	1.3	8.5	13.2	13.0
Subtotal			2.7	27.2	49.7	36.0
Floodplain Resident	*Mystus vittatus*	*Tengra*	1.3	3.4	3.2	2.7
	Colisa fasciatus	*Khalisha*	2.7	–	1.1	–
	Xenentodon cancila	*Kaikka*	3.1	–	–	–
	Puntius conchonius	*Canchan puti*	6.8	2.6	3.0	5.9
	Puntius sophore	*Puti*	20.1	9.5	6.3	3.0
	Glossogobius giurus	*Bailla*	3.6	1.6	2.0	1.9
	Lepidocephalus guntea	*Gutum*	1.1	2.0	2.1	–
	Channa punctatus	*Taki*	20.7	4.0	3.7	2.0
	Heteropneustes fossilis	*Shingi*	1.1	1.9	–	–
	Macrognathus aculeatus	*Tara baim*	–	5.8	–	–
	Macrognathus pancalus	*Guchi*	2.8	9.3	5.4	3.2
	Mastacembelus armatus	*Baral baim*	1.5	2.2	4.3	9.0
	Chanda baculis	*Chanda*	–	2.9	1.0	–
	Chanda nama	*Nama Chanda*	1.5	–	–	–
	Chanda ranga	*Lal chanda*	6.3	–	–	–
Subtotal			72.4	45.1	32.1	27.8
Other	Prawn spp.	*Chingri/Icha*	16.7	12.6	5.6	7.6
Grand total			91.7	87.4	90.0	82.4

Notes:
1. Dominant species are those species contributing 1% or more by weight to the total annual catch
2. Shaded values highlight the most important species (>4%)
3. See text for definitions of habitat preference categories.

Table 5.16 Monthly catch composition from floodplains (% by weight): inside FCD (site NW28)

Species Code	Habitat Preference	Species name: Scientific	Species name: Bengali	Year: 1992 Oct	Nov	Dec	Year: 1993 Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year: 1994 Jan	Feb	Total annual catch (Mar'93 – Feb'94) Kg	%
59	Riverine	*Crossocheilus latius*	*Kalabata*	–	–	–	–	–	–	–	–	–	0.007	–	0.023	–	–	–	–	–	0.634	0.001
139		*Nemacheilus botia*	*Balichata*	0.062	–	–	–	–	–	–	5.888	–	2.784	–	–	0.041	0.017	–	–	–	46.784	0.103
198		*Somileptes gongota*	*Gharpoia*	–	–	0.057	0.064	0.397	–	5.428	–	–	–	0.413	0.496	0.900	–	–	–	–	118.886	0.261
28		*Botia dario*	*Rani*	5.184	–	0.143	–	–	–	–	–	–	–	–	–	0.580	–	–	–	–	65.420	0.144
29		*Botia lohachata*	*Putul*	–	–	–	–	–	–	–	–	–	–	–	0.024	–	–	–	–	–	0.585	0.001
89		*Hilsa ilisha*	*Ilish*	–	–	–	–	–	–	–	–	–	–	0.051	0.544	0.144	–	–	–	–	29.768	0.065
85		*Gonialosa manmina*	*Goni chapila*	–	–	–	–	–	–	–	–	–	–	–	–	0.189	–	–	–	–	21.268	0.047
58		*Corica soborna*	*Kachki*	–	0.195	–	–	–	–	–	–	0.039	3.881	2.139	–	0.268	0.043	–	–	–	98.568	0.217
185		*Rhinomugil corsula*	*Khorsula*	–	–	–	–	–	–	–	–	–	–	–	0.002	–	–	–	–	–	0.049	0.0001
923		*Sicamugil cascasia*	*Bata*	–	–	–	–	–	–	–	–	–	–	0.153	–	–	–	–	–	–	1.209	0.003
2		*Ailia coila*	*Kajuli*	–	–	–	–	–	–	–	–	–	–	0.447	0.022	–	–	–	–	–	4.064	0.009
51		*Clupisoma garua*	*Ghaura*	–	–	–	–	–	–	–	–	–	–	–	–	–	0.003	–	–	–	0.186	0.0004
74		*Erethistes pussilus*	*Kutakanti*	–	–	–	–	–	–	–	1.357	–	–	–	–	–	–	–	–	–	1.463	0.003
81		*Gagata youssoufi*	*Gang tengra*	–	–	–	–	–	–	–	–	–	–	–	–	–	0.009	–	–	–	0.648	0.001
955		*Amblyceps mangois*	*Magur*	–	–	–	–	–	–	–	–	–	–	–	–	0.029	–	–	–	–	3.315	0.007
	Subtotal			5.246	0.195	0.200	0.064	0.397	–	5.428	7.245	0.039	6.672	3.203	1.111	2.152	0.071	–	–	–	392.847	0.864
131	Migratory	*Mystus bleekeri*	*Golsha tengra*	–	–	–	0.072	–	–	–	2.301	0.235	1.337	0.310	1.052	0.102	0.757	–	–	–	113.674	0.250
132		*Mystus cavasius*	*Kabashi*	0.581	–	–	0.476	–	–	–	–	0.255	3.065	0.294	0.330	0.289	–	–	–	–	81.463	0.179
32		*Catla catla*	*Catla*	–	–	–	7.087	–	–	–	–	–	–	–	–	0.798	0.132	–	–	–	99.561	0.219
47		*Cirrhinus mrigala*	*Mrigel*	0.365	–	–	2.514	–	–	–	–	–	–	–	–	0.237	–	–	–	–	26.752	0.059
48		*Cirrhinus reba*	*Raik*	14.724	0.317	0.081	0.894	0.341	–	0.180	–	–	–	4.222	5.353	4.119	0.110	–	–	–	634.566	1.396
102		*Labeo calbasu*	*Kalbaus*	–	–	–	4.091	–	–	–	–	–	–	0.175	1.025	0.204	–	–	–	–	49.027	0.108
107		*Labeo rohita*	*Rui*	1.148	0.977	–	3.395	–	–	–	–	–	–	–	0.178	0.742	0.386	–	–	1.448	119.290	0.262
188		*Salmostoma bacaila*	*Katari*	2.860	0.002	–	0.011	–	–	–	–	1.576	0.096	0.076	2.324	0.384	0.044	–	–	–	107.461	0.236
189		*Salmostoma phulo*	*Fulchela*	5.965	0.002	–	–	0.163	–	–	0.904	–	2.561	0.891	0.051	2.473	1.417	–	–	–	422.411	0.929
154		*Securicula gora*	*Chora chela*	–	–	–	–	–	–	–	–	0.137	–	9.149	3.030	0.587	–	–	–	–	211.576	0.465
86		*Gudusia chapra*	*Chapila*	3.375	0.968	0.203	0.640	0.008	–	–	–	0.313	–	2.149	0.073	0.907	0.617	–	–	–	166.267	0.366
76		*Eutropiichthys vacha*	*Bacha*	–	–	–	–	–	–	–	–	–	–	–	0.014	–	–	–	–	–	0.342	0.001
169		*Pseudeutropius atherinoides*	*Batasi*	0.375	–	–	0.054	0.728	–	–	3.174	0.218	0.510	0.469	0.702	0.168	–	–	–	–	49.773	0.109
209		*Wallagu attu*	*Boal*	21.501	24.895	19.068	13.272	5.368	–	–	–	–	–	–	–	4.789	–	–	0.789	–	568.843	1.251
216		*Nemacheilus zonalternans*		–	–	–	–	–	–	–	–	0.049	–	–	–	–	–	–	–	–	0.100	0.0002
	Subtotal			50.893	27.161	19.353	32.507	6.608	–	0.180	6.379	2.784	7.569	17.736	14.132	15.799	3.463	–	0.789	1.448	2651.106	5.831
136	Floodplain	*Mystus tengara*	*Bajari tengra*	–	–	0.400	0.090	1.888	–	–	5.435	0.789	–	–	–	0.501	–	–	0.200	–	71.322	0.157
137	Resident	*Mystus vittatus*	*Tengra*	–	0.104	2.692	3.517	4.311	–	0.601	4.237	0.206	4.458	5.121	1.990	2.397	0.307	0.285	2.366	–	579.929	1.276
55		*Colisa fasciatus*	*Khalisha*	0.749	0.390	–	0.547	0.983	–	–	–	1.435	3.050	1.341	0.176	0.004	11.397	1.250	2.518	5.288	1213.343	2.669
211		*Colisa labiosus*	*Khalisha*	–	–	–	–	–	–	–	–	2.279	0.682	0.418	0.243	–	3.022	0.0002	–	–	240.909	0.530
56		*Colisa lalia*	*Lal Khalisha*	0.010	0.126	–	–	–	–	0.180	–	–	–	–	–	0.020	–	–	–	–	2.347	0.005
57		*Colisa sota*	*Khalisha*	–	2.857	1.065	0.180	0.063	–	–	–	–	0.007	0.090	0.080	0.016	1.939	0.021	0.458	0.171	165.760	0.365
210		*Xenentodon cancila*	*Kaikka*	4.241	0.141	0.645	0.156	0.862	–	–	–	0.039	0.875	–	3.658	4.104	9.859	0.527	1.000	1.899	1412.218	3.106
187		*Osteobrama cotio cotio*	*Keti*	–	–	–	–	–	–	–	–	–	–	0.073	–	0.053	0.073	–	–	–	11.755	0.026
175		*Puntius conchonius*	*Canchan puti*	–	0.097	0.991	1.160	0.887	–	0.601	0.086	0.451	2.837	0.818	3.168	5.836	7.928	9.118	1.226	7.500	3078.461	6.771
176		*Puntius gelius*	*Giliputi*	–	0.013	–	–	–	–	–	0.453	0.524	0.034	–	0.060	0.010	0.055	0.164	0.052	–	40.254	0.089
178		*Puntius phutunio*	*Phutani puti*	–	0.013	–	0.018	0.004	–	–	–	0.123	0.158	0.051	0.043	0.125	1.145	0.418	0.246	–	185.901	0.409
179		*Puntius sarana*	*Sarputi*	–	0.024	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	

Note: – denotes zero catch

(Cont.)

Table 5.16 Monthly catch composition from floodplains (% by weight): inside FCD (site NW28)

Species Code	Habitat Preference	Species name: Scientific	Species name: Bengali	Year: 1992 Oct	Nov	Dec	Year: 1993 Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year: 1994 Jan	Feb	Total annual catch (Mar'93 – Feb'94) Kg	%
180		*Puntius sophore*	*Puti*	1.459	23.685	8.425	12.931	13.547	–	12.115	7.012	21.033	22.414	24.098	4.855	28.124	10.972	22.235	11.817	14.401	9132.283	20.086
212		*Puntius ticto*	*Tit puti*	1.760	0.114	0.343	0.181	0.033	–	0.060	1.357	0.657	0.046	0.359	0.020	0.477	0.300	0.185	–	–	115.968	0.255
4		*Amblypharygodon microlepis*	*Mola*	–	–	–	0.058	0.012	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5		*Amblypharygodon mola*	*Mola*	–	–	–	0.054	–	–	–	–	0.029	–	0.051	0.001	0.018	0.013	–	–	0.149	3.833	0.008
69		*Brachydanio rerio*	*Anju*	–	–	–	–	–	–	–	–	0.646	–	–	–	0.009	–	–	–	–	2.312	0.005
68		*Danio devario*	*Chebli*	–	–	–	–	–	–	–	–	0.039	0.072	–	–	–	–	–	–	–	0.977	0.002
75		*Esomus danricus*	*Darkina*	0.010	0.050	0.218	0.145	0.550	–	0.120	2.262	14.754	2.416	0.110	0.158	0.078	0.782	0.320	0.168	0.830	199.143	0.438
83		*Glossogobius giurus*	*Bailla*	3.795	3.072	9.955	7.515	13.028	1.551	1.898	1.472	6.320	1.889	1.564	1.119	1.042	3.870	5.987	1.203	0.410	1613.956	3.550
110		*Lepidocephalus guntea*	*Gutum*	1.069	2.409	2.457	1.466	3.490	9.784	10.616	4.531	1.784	3.000	2.108	0.503	1.498	1.127	0.631	0.470	14.269	497.091	1.093
9		*Aplocheilus panchax*	*Kanpona*	0.010	0.680	–	–	–	–	0.060	–	0.088	0.026	–	0.025	–	0.095	0.016	–	–	10.909	0.024
40		*Channa orientalis*	*Cheng*	–	–	–	–	–	–	–	–	–	0.489	0.589	–	–	–	–	–	–	10.734	0.024
41		*Channa punctatus*	*Taki*	2.170	9.289	29.252	17.599	12.898	5.587	4.927	–	22.879	9.155	0.932	15.905	12.804	11.035	28.421	37.011	27.524	9402.320	20.680
42		*Channa striatus*	*Shol*	–	2.701	3.865	7.341	–	–	–	–	–	–	–	–	–	–	–	2.791	–	101.878	0.224
49		*Clarias batrachus*	*Magur*	–	–	–	0.289	–	–	–	–	–	–	–	–	–	–	–	2.934	–	107.121	0.236
88		*Heteropneustes fossilis*	*Shingi*	0.083	0.920	2.015	1.986	10.494	–	20.678	–	0.098	2.329	0.537	–	0.201	0.014	–	12.267	1.452	516.593	1.136
121		*Macrognathus aculeatus*	*Tara baim*	0.447	3.780	3.249	1.553	12.019	69.879	28.720	6.793	1.399	0.528	2.062	1.386	0.117	0.046	0.015	4.923	0.683	288.890	0.635
123		*Macrognathus pancalus*	*Guchi*	0.260	0.537	3.857	4.562	15.388	13.199	13.372	24.414	1.655	1.043	0.850	3.780	4.066	0.906	1.432	8.112	9.212	1251.270	2.752
122		*Mastacembelus armatus*	*Baral baim*	10.615	0.912	–	2.869	0.038	–	–	4.314	–	–	–	6.876	2.325	0.335	–	6.390	–	689.818	1.517
15		*Badis badis*	*Napit koi*	–	0.516	0.030	0.084	0.102	–	–	1.357	1.670	0.178	0.115	0.109	0.025	1.927	0.307	0.024	0.117	210.104	0.462
147		*Ompok bimaculatus*	*Kani pabda*	–	–	–	0.037	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
148		*Ompok pabda*	*Madhu pabda*	–	–	–	1.052	–	–	–	–	–	0.519	–	–	–	–	–	–	–	6.455	0.014
203		*Tetraodon cutcutia*	*Potka*	4.838	–	–	0.522	–	–	–	–	–	–	–	–	0.778	0.124	–	0.333	–	108.862	0.239
33		*Chaca chaca*	*Cheka*	–	–	–	–	0.983	–	–	–	–	–	–	–	0.040	–	–	0.020	–	5.195	0.011
35		*Chanda baculis*	*Chanda*	1.869	0.001	0.038	0.243	–	–	0.060	–	0.052	0.289	0.115	–	0.225	0.030	–	–	–	32.167	0.071
36		*Chanda nama*	*Nama Chanda*	4.868	0.063	0.029	0.260	–	–	–	13.592	5.019	2.518	1.851	1.432	2.030	4.260	0.054	0.216	0.085	660.305	1.452
37		*Chanda ranga*	*Lalchanda*	0.087	0.321	0.512	0.153	0.165	–	0.120	0.904	1.650	15.096	0.403	1.154	10.577	5.570	5.535	0.698	7.596	2873.000	6.319
	Subtotal			38.340	52.813	70.036	66.565	91.745	100.000	94.128	78.218	85.615	74.108	43.655	46.740	77.501	77.129	76.921	97.441	91.587	34843.383	76.636
931	Others	Prawn spp.	*Chingri/Icha*	5.520	19.831	10.411	0.862	1.249	–	0.263	8.157	11.561	11.650	35.406	38.015	4.478	19.336	23.079	1.770	6.965	7570.894	16.652
207		*Trionyx gangeticus*	*Kachhim*	–	–	–	–	–	–	–	–	–	–	–	–	0.068	–	–	–	–	7.632	0.017
	Subtotal			5.520	19.831	10.411	0.862	1.249	–	0.263	8.157	11.561	11.650	35.406	38.015	4.546	19.336	23.079	1.770	6.965	7578.526	16.669
	Grand total			100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	45465.862	100

Note: – denotes zero catch

Table 5.17 Monthly catch composition from floodplains (% by weight): outside FCD (site NW30)

Species	Habitat	Species name		Year: 1992			Year: 1993												Year: 1994		Total annual catch (Mar'93 – Feb'94)	
Code	Preference	Scientific	Bengali	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Dec	Kg	%
186	Riverine	*Rita rita*	*Rita*	-	-	-	-	-	-	-	-	-	0.104	-	0.114	-	-	-	-	-	5.801	0.021
13		*Aspidoparia morar*	*Piali*	0.001	0.001	-	-	-	-	-	-		-		-	-	0.119	-	-	-	11.967	0.043
59		*Crossocheilus latius*	*Kalabata*	0.006	0.040	-	-	-	-	-	-		-	-	0.087	0.094	1.210	-	-	-	128.631	0.458
139		*Nemacheilus botia*	*Balichata*	0.421	0.455	0.774	-	-	-	-	2.879	15.728	0.259	1.339	0.697	2.773	0.665	0.398	-	-	432.030	1.539
198		*Somileptes gongota*	*Gharpoia*	0.422	0.631	0.022	1.362	0.755	-	-	3.728	0.545	-	0.220	0.290	0.485	0.772	2.246	0.912	0.042	192.209	0.685
28		*Botia dario*	*Rani*	1.939	0.001	-	-	-	-	-	-	-	-	0.155	0.007	-	0.060	-	-	-	10.505	0.037
29		*Botia lohachata*	*Putul*	-	-	-	-	-	-	-	-	-	-	0.340				-	-	-	9.251	0.033
89		*Hilsa ilisha*	*Ilish*		-	-	-	-	-	-	-	-	-	-	-	0.060	-	-	-	-	2.603	0.009
58		*Corica soborna*	*Kachki*	0.001	0.001	-	-	-	-	-	-	0.007	-	0.003	0.095	0.456	0.220	-	-	0.011	45.573	0.162
193		*Setipinna phasa*	*Phasa*	-	0.001	-	-	-	-	-	-	-	-	-	0.047	-	-	-	-	-	1.649	0.006
185		*Rhinomugil corsula*	*Khorsula*	0.158	0.230	-	-	-	-	-	-	-	0.049	0.059	0.117	-	-	-	-	0.282	7.867	0.028
923		*Sicamugil cascasia*	*Bata*	-	-	-	-	-	-	-	-	-	-	0.212	0.047	-	-	-	-	-	7.410	0.026
2		*Ailia coila*	*Kajuli*	0.301	0.346	0.237	-	-	-	-	-	-	-	0.035	0.261	0.034	0.010	0.085	-	-	14.049	0.050
51		*Clupisoma garua*	*Ghaura*	0.597	0.419	-	-	-	-	-	-	-	1.114	0.061	-	-	-	-	-	-	21.359	0.076
52		*Clupisoma naziri*	*Muri bacha*	0.163	0.233	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
196		*Silonia silondia*	*Shillong*	0.008	-	-	-	-	-	-	-	-	-	0.051	0.178	0.078	-	-	-	-	10.976	0.039
16		*Bagarius bagarius*	*Baghair*	-	-	-	-	-	-	-	-	-	-	-	-	-	0.011	-	-	-	1.064	0.004
74		*Erethistes pussilus*	*Kutakanti*	-	-	-	-	-	-	-	0.379	2.219	-	-	-	-	0.115	-	-	-	35.626	0.127
80		*Gagata viridescens*	*Gang tengra*	-	-	-	-	-	-	-	-	-	-	-	-	0.060	-	-	-	-	2.608	0.009
81		*Gagata youssoufi*	*Gang tengra*	0.017	0.023	-	-	-	-	-	0.047	0.187	0.007	0.153	1.118	1.802	1.622	-	-	-	286.807	1.022
87		*Hara hara*	*Kutakanti*	1.409	0.021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
93		*Ichthyocampus carce*	*Kumirer khil*	-	-	-	-	-	-	-	-	-	-	-	-	1.194	-	-	-	-	52.152	0.186
171		*Psilorhynchus balitora*	*Balitora*	-	-	-	-	-	-	-	-	-	-	-	-	0.067	0.095	-	-	-	12.430	0.044
955		*Amblyceps mangois*	*Magur*	-	-	0.012	0.851	-	-	0.127	-	0.774	-	-	-	-	0.003	-	-	-	8.259	0.029
	Subtotal			5.441	2.401	1.045	2.213	0.755	-	0.127	7.032	19.461	1.532	2.628	3.059	7.100	4.901	2.728	0.912	0.335	1300.826	4.635
130	Migratory	*Aorichthys aor*	*Ayre*	1.170	1.677	3.494	-	-	-	-	-	0.048	0.052	-	-	0.534	0.271	0.226	-	-	56.042	0.200
135		*Aorichthys seenghala*	*Guizza*	-	-	-	-	-	-	-	29.698	-	-	-	-	-	-	-	-	-	108.635	0.387
131		*Mystus bleekeri*	*Golsha tengra*	0.310	0.829	0.477	-	0.090	0.012	1.015	0.963	8.939	4.269	8.163	1.838	6.706	3.594	0.352	2.044	-	1156.951	4.122
132		*Mystus cavasius*	*Kabashi*	3.479	0.588	0.264	-	-	-	-	0.319	6.058	2.476	2.082	2.344	2.948	3.116	-	0.142	-	689.689	2.457
32		*Catla catla*	*Catla*	0.022	-	-	-	-	-	-	-	-	-	-	0.608	-	-	-	-	-	21.118	0.075
47		*Cirrhinus mrigala*	*Mrigel*	0.473	0.045	-	-	-	-	-	-	-	-	-	0.831	-	-	-	-	-	28.865	0.103
48		*Cirrhinus reba*	*Raik*	3.256	3.309	-	-	-	-	-	-	0.146	0.155	0.216	1.766	6.666	2.666	0.463	-	-	638.839	2.276
100		*Labeo bata*	*Bata*	1.035	1.509	-	0.681	-	-	-	-	-	0.055	-	0.475	0.397	-	-	-	-	34.811	0.124
101		*Labeo boga*	*Bhangan*	0.017	-	-	-	-	-	-	-	1.819	0.027	-	-	-	-	-	-	-	19.111	0.068
102		*Labeo calbasu*	*Kalbaus*	-	0.001	2.529	-	-	-	-	-	0.013	0.381	-	2.612	1.330	-	-	2.799	-	209.858	0.748
107		*Labeo rohita*	*Rui*	0.080	-	-	-	-	-	-	-	-	-	0.075	1.366	-	-	-	-	-	49.498	0.176
188		*Salmostoma bacaila*	*Katari*	0.377	0.613	0.846	6.584	-	-	-	1.318	0.408	0.073	0.059	0.059	-	1.272	-	-	-	141.703	0.505
189		*Salmostoma phulo*	*Fulchela*	0.145	-	0.091	-	0.061	-	-	0.318	0.035	0.070	0.153	0.306	0.675	0.560	0.017	0.021	0.732	107.483	0.383
154		*Securicula gora*	*Chora chela*	0.169	0.238	-	-	-	-	-	0.288	0.280	-	0.032	0.882	0.043	0.291	0.067	-	-	67.719	0.241
86		*Gudusia chapra*	*Chapila*	0.099	0.090	-	-	-	-	-	-	-	-	0.024	0.137	1.044	1.012	0.053	-	-	153.603	0.547
76		*Eutropiichthys vacha*	*Bacha*	-	-	-	-	-	-	-	0.178	-	0.361	0.007	-	-	-	-	-	-	7.213	0.026
169		*Pseudeutropius atherinoides*	*Batasi*	0.297	0.531	0.426	1.362	-	-	-	13.986	8.040	0.593	0.419	2.362	0.148	24.535	2.939	0.018	-	2761.434	9.838
209		*Wallagu attu*	*Boal*	47.984	64.132	17.154	-	-	-	-	-	8.206	3.879	7.919	22.448	8.862	4.444	3.303	17.035	-	2370.548	8.446
142		*Nemacheilus scaturigina*	*Dari*	-	-	-	-	-	-	-	-	-	0.221	-	-	-	0.153	-	-	-	19.247	0.069
216		*Nemacheilus zonalternans*		-	-	-	-	-	-	-	-	0.040	-	0.030	-	-	-	-	-	-	1.216	0.004
	Subtotal			58.912	73.562	25.280	8.627	0.150	0.012	1.015	47.068	34.031	12.610	19.177	38.034	29.355	41.913	7.420	22.058	0.732	8643.583	30.795

Note: - denotes zero catch

(Cont.)

200

Table 5.17 Monthly catch composition from floodplains (% by weight): outside FCD (site NW30)

Species	Habitat	Species name		Year: 1992			Year: 1993												Year: 1994		Total annual catch (Mar'93 – Feb'94)	
Code	Preference	Scientific	Bengali	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Dec	Kg	%
6	Floodplain	*Anabas testudineus*	*Koi*	-	-	0.412	-	-	-	-	-	-	-	-	0.317	-	-	-	-	-	11.007	0.039
136	Resident	*Mystus tengara*	*Bajari tengra*	1.357	0.046	2.667	-	0.090	-	-	-	-	-	-	0.017	0.246	-	0.467	-	-	19.719	0.070
137		*Mystus vittatus*	*Tengra*	0.368	1.833	3.620	13.507	0.423	11.141	20.434	0.337	2.501	5.863	2.744	1.537	2.464	3.657	7.350	2.072	8.547	958.805	3.416
55		*Colisa fasciatus*	*Khalisha*	0.169	0.333	1.207	-	-	0.918	-	0.273	1.359	0.454	0.049	0.977	1.951	0.312	2.461	2.738	0.218	273.649	0.975
211		*Colisa labiosus*	*Khalisha*	-	-	-	-	-	-	-	0.455	2.288	0.227	0.168	0.083	0.472	-	-	-	-	57.209	0.204
56		*Colisa lalia*	*Lal khalisha*	-	-	-	-	-	1.914	-	0.651	-	-	-	-	0.560	0.109	-	-	-	39.088	0.139
57		*Colisa sota*	*Khalisha*	0.282	0.211	0.401	0.511	-	0.176	-	0.379	4.475	-	-	-	2.595	0.571	0.014	0.024	-	218.829	0.780
210		*Xenentodon cancila*	*Kaikka*	-	0.026	0.618	-	-	3.308	-	-	0.084	0.054	0.052	-	0.166	0.117	0.334	0.578	0.544	44.238	0.158
62		*Cyprinus carpio*	*Karfu*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.609	-	108.500	0.387
129		*Mylopharyngodon pisceus*	*Kalo carp*	-	-	-	-	-	-	-	-	-	-	-	0.169	-	-	-	-	-	5.884	0.021
187		*Osteobrama cotio cotio*	*Keti*	0.023	0.033	-	-	-	-	-	-	0.193	-	0.100	0.340	-	1.426	0.116	0.064	-	163.047	0.581
174		*Puntius chola*	*Chala puti*	0.041	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
175		*Puntius conchonius*	*Canchan puti*	0.174	0.513	0.455	7.548	-	16.191	2.974	1.255	1.107	0.655	0.732	0.645	2.779	4.288	2.623	1.786	3.053	729.805	2.600
176		*Puntius gelius*	*Giliputi*	0.017	0.023	-	-	-	-	-	0.182	0.065	-	-	0.012	-	0.191	-	-	-	20.921	0.075
178		*Puntius phutunio*	*Phutani puti*	0.006	0.011	-	-	-	-	-	-	0.013	-	-	0.007	0.108	0.153	0.254	-	-	25.024	0.089
179		*Puntius sarana*	*Sarputi*	-	0.024	3.188	-	-	-	-	-	-	-	-	-	-	-	-	0.045	-	0.875	0.003
180		*Puntius sophore*	*Puti*	6.418	4.407	5.876	0.511	0.302	3.184	2.538	6.455	3.959	7.791	1.448	5.380	9.140	14.446	11.061	7.568	9.355	2671.011	9.516
212		*Puntius ticto*	*Tit puti*	0.106	0.193	-	-	-	-	-	0.182	0.426	-	-	-	-	-	0.108	-	0.012	7.017	0.025
5		*Amblypharyngodon mola*	*Mola*	0.072	0.001	-	-	-	-	-	0.182	0.213	0.045	0.062	0.071	0.007	0.192	0.025	0.026	-	28.349	0.101
68		*Danio devario*	*Chebli*	-	0.006	-	-	-	-	-	0.515	0.710	-	0.075	0.036	0.494	0.107	0.027	-	-	45.286	0.161
75		*Esomus danricus*	*Darkina*	0.208	0.021	0.117	-	-	1.023	1.015	3.455	1.928	0.748	0.354	0.320	0.797	0.184	0.185	0.037	0.053	124.932	0.445
83		*Glossogobius giurus*	*Bailla*	2.303	1.540	2.170	17.026	0.846	5.168	20.815	4.061	3.019	1.334	0.999	1.363	0.894	0.864	5.958	2.595	1.635	443.218	1.579
110		*Lepidocephalus guntea*	*Gutum*	1.577	2.633	1.934	16.799	24.227	17.711	11.571	8.455	4.020	2.033	1.591	2.088	0.569	0.797	3.061	6.199	8.951	561.023	1.999
9		*Aplocheilus panchax*	*Kanpona*	-	0.021	-	-	-	-	-	0.258	0.193	0.173	0.038	0.173	0.071	0.076	0.035	-	-	24.434	0.087
40		*Channa orientalis*	*Cheng*	-	-	-	-	-	-	-	-	-	1.190	-	-	-	-	-	-	-	21.040	0.075
41		*Channa punctatus*	*Taki*	0.850	1.643	10.034	5.448	-	3.317	6.101	-	1.456	5.797	1.141	5.125	1.260	0.942	13.080	15.426	19.734	1107.171	3.945
42		*Channa striatus*	*Shol*	0.062	0.489	7.712	-	-	-	-	-	-	-	-	-	-	-	-	1.176	-	22.750	0.081
49		*Clarias batrachus*	*Magur*	-	-	2.108	-	-	-	-	-	-	0.439	0.013	-	-	-	-	0.289	-	13.730	0.049
88		*Heteropneustes fossilis*	*Shingi*	0.390	0.657	7.560	8.854	0.795	0.007	15.036	-	0.576	19.527	0.533	-	0.124	0.328	1.955	4.137	-	522.822	1.863
121		*Macrognathus aculeatus*	*Tara baim*	1.316	1.286	8.017	-	14.969	-	-	4.410	2.288	27.875	18.927	7.165	2.499	0.302	4.208	5.234	0.294	1614.777	5.753
123		*Macrognathus pancalus*	*Guchi*	4.997	1.820	4.358	0.511	57.112	22.922	4.556	5.410	6.358	3.868	23.922	7.485	15.805	1.089	24.480	7.252	33.700	2622.020	9.342
122		*Mastacembelus armatus*	*Baral baim*	0.903	0.876	4.214	2.894	0.241	-	-	-	0.646	1.831	3.625	0.816	5.330	1.311	2.126	0.126	8.305	610.866	2.176
15		*Badis badis*	*Napit koi*	0.091	0.136	0.116	1.703	-	0.520	-	0.197	0.490	0.099	0.118	0.175	0.291	0.220	0.038	0.024	0.034	53.271	0.190
147		*Ompok bimaculatus*	*Kani pabda*	0.985	1.407	1.137	2.043	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
148		*Ompok pabda*	*Madhu pabda*	0.152	0.160	1.294	-	-	-	-	-	0.860	0.205	-	-	0.120	-	-	2.126	-	58.824	0.210
145		*Notopterus notopterus*	*Foli*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.084	-	117.693	0.419
203		*Tetraodon cutcutia*	*Potka*	0.023	0.041	0.007	-	-	-	-	-	-	-	-	-	-	0.440	0.086	-	-	45.701	0.163
35		*Chanda baculis*	*Chanda*	0.140	0.189	0.268	-	-	1.041	-	0.182	-	0.018	0.013	0.604	0.482	7.647	-	-	0.041	812.340	2.894
36		*Chanda nama*	*Nama chanda*	2.560	0.149	0.252	1.192	-	-	0.254	0.576	1.526	0.352	0.755	1.163	0.455	0.511	0.047	0.298	0.076	163.131	0.581
37		*Chanda ranga*	*Lal chanda*	0.157	0.043	0.021	0.625	-	2.435	0.508	2.485	0.658	0.282	0.442	0.958	1.073	0.961	0.269	0.578	0.076	227.688	0.811
	Subtotal			25.744	20.767	69.760	79.170	99.005	90.977	85.802	40.353	41.408	80.858	57.903	37.026	50.752	41.240	80.367	72.092	94.627	14595.694	52.001
998	Others	Unidentified fish		0.378	0.093	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
114		*Machrobrachium lammariei*	*Kunchu icha*	6.014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
931		*Prawn spp.*	*Chingri/Icha*	3.509	3.176	3.914	9.989	0.090	9.011	13.056	5.546	5.100	4.999	20.291	21.880	12.792	11.944	9.484	4.938	4.306	3527.909	12.569
	Subtotal			9.901	3.269	3.914	9.989	0.090	9.011	13.056	5.546	5.100	4.999	20.291	21.880	12.792	11.944	9.484	4.938	4.306	3527.909	12.569
	Grand total			100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	28068.012	100

Note: – denotes zero catch

Table 5.18 Monthly catch compositon from canals (% by weight): outside FCD (site NW29)

Species Code	Habitat Preference	Species name: Scientific	Species name: Bengali	Year: 1992 Oct	Nov	Dec	Year: 1993 Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year: 1994 Jan	Feb	Total annual catch (Mar'93 – Feb'94) Kg	%
13	Riverine	*Aspidoparia morar*	*Piali*	-	-	-	-	-	0.584	-	-	-	-	0.092	-	-	-	-	-	-	1.339	0.006
59		*Crossocheilus latius*	*Kalabata*	-	0.074	-	-	-	0.308	-	-	-	-	-	0.069	0.228	0.663	-	-	-	84.110	0.359
139		*Nemacheilus botia*	*Balichata*	0.074	0.640	0.192	-	-	0.231	-	2.855	3.756	-	-	0.407	0.374	1.184	1.280	0.101	1.445	279.988	1.195
198		*Somileptes gongota*	*Gharpoia*	0.011	0.194	-	-	-	-	-	3.089	8.953	2.411	-	0.326	0.294	1.611	0.802	-	-	330.624	1.411
28		*Botia dario*	*Rani*	0.016	0.096	-	-	-	-	-	-	-	0.168	-	-	-	-	-	-	-	0.281	0.001
29		*Botia lohachata*	*Putul*	-	-	-	-	-	-	-	-	-	-	-	0.240	-	0.001	-	-	-	1.192	0.005
58		*Corica soborna*	*Kachki*	0.033	0.141	0.043	-	-	-	-	-	0.038	-	-	-	0.073	0.247	0.057	0.038	0.237	34.853	0.149
185		*Rhinomugil corsula*	*Khorsula*	-	-	0.081	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
923		*Sicamugil cascasia*	*Bata*	-	-	-	-	-	-	-	-	0.020	-	-	0.097	-	-	-	-	-	0.507	0.002
2		*Ailia coila*	*Kajuli*	0.104	0.641	-	-	-	-	-	-	-	0.562	1.929	1.432	1.071	0.336	0.340	-	-	82.140	0.350
51		*Clupisoma garua*	*Ghaura*	2.108	0.002	-	-	-	-	-	-	-	0.326	0.157	1.881	0.590	1.258	-	-	-	169.182	0.722
52		*Clupisoma naziri*	*Muri Bacha*	-	-	-	-	-	-	-	-	-	-	0.037	-	-	0.009	-	-	-	1.172	0.005
196		*Silonia silondia*	*Shillong*	0.280	-	-	-	-	-	-	-	-	-	0.240	0.943	0.247	-	-	-	-	7.935	0.034
74		*Erethistes pussilus*	*Kutakanti*	-	-	-	-	-	-	-	0.144	0.346	-	0.092	-	0.103	0.122	-	-	-	20.214	0.086
77		*Gagata cenia*	*Kauwa*	-	-	-	5.497	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80		*Gagata viridescens*	*Gang tengra*	-	-	-	-	-	-	-	-	-	-	-	-	0.006	-	-	-	-	0.074	0.0003
81		*Gagata youssoufi*	*Gang tengra*	0.133	0.114	-	-	-	-	-	0.368	0.009	0.133	0.037	1.090	0.068	0.896	0.137	-	-	127.255	0.543
171		*Psilorhynchus balitora*	*Balitora*	-	-	-	-	-	-	-	-	-	-	-	0.043	-	-	-	-	-	0.188	0.001
26		*Batrachocephalus mino*	*Kata bukha*	0.029	0.010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
955		*Amblyceps mangois*	*Magur*	-	-	0.043	-	0.176	-	-	0.128	-	-	-	-	-	-	0.067	-	-	5.389	0.023
	Subtotal			2.787	1.912	0.358	5.497	0.176	1.123	-	6.583	13.122	3.600	2.582	6.528	3.054	6.328	2.682	0.140	1.682	1146.443	4.891
130	Migratory	*Aorichthys aor*	*Ayre*	-	-	-	-	-	-	-	-	-	-	-	-	-	2.597	-	-	-	313.982	1.340
135		*Aorichthys seenghala*	*Guizza*	-	-	-	-	-	-	-	0.544	-	-	-	-	-	-	0.191	0.035	-	19.020	0.081
131		*Mystus bleekeri*	*Golsha tengra*	2.516	5.577	0.231	0.624	1.513	0.946	-	22.421	36.230	5.653	22.433	21.076	3.199	18.990	14.840	1.432	-	3745.063	15.979
132		*Mystus cavasius*	*Kabashi*	0.084	1.121	0.332	1.603	-	-	-	9.958	11.660	4.680	6.131	2.173	0.578	11.714	0.148	0.115	-	1680.266	7.169
47		*Cirrhinus mrigala*	*Mrigel*	1.617	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48		*Cirrhinus reba*	*Raik*	0.423	4.967	-	-	-	-	-	-	0.076	0.423	0.111	1.197	0.046	8.093	0.118	-	-	991.349	4.230
100		*Labeo bata*	*Bata*	-	2.359	-	-	-	-	-	-	0.158	-	-	-	-	-	-	-	-	0.623	0.003
101		*Labeo boga*	*Bhangan*	-	-	-	-	-	-	-	-	0.372	-	-	-	-	-	-	-	-	1.463	0.006
102		*Labeo calbasu*	*Kalbaus*	-	1.841	-	2.170	0.012	-	-	2.823	2.820	-	-	0.598	-	0.437	0.312	0.669	-	141.107	0.602
107		*Labeo rohita*	*Rui*	-	0.133	-	-	-	-	-	-	0.121	-	-	-	-	-	-	-	-	0.474	0.002
188		*Salmostoma bacaila*	*Katari*	0.127	0.793	0.816	32.012	-	0.452	-	-	0.214	0.846	-	-	0.011	4.422	0.194	0.124	-	549.287	2.344
189		*Salmostoma phulo*	*Fulchela*	0.476	0.036	0.305	0.270	-	1.263	-	0.295	2.731	0.370	0.055	0.249	0.034	0.001	0.131	0.268	0.553	32.636	0.139
154		*Securicula gora*	*Chora chela*	-	-	-	-	-	-	-	-	-	-	-	0.491	-	0.923	-	-	-	113.750	0.485
86		*Gudusia chapra*	*Chapila*	0.049	1.359	-	-	-	-	-	-	0.060	-	-	-	0.066	1.318	0.090	0.124	-	166.820	0.712
76		*Eutropiichthys vacha*	*Bacha*	-	-	-	-	-	-	-	-	-	-	-	-	0.281	0.023	-	-	-	6.466	0.028
169		*Pseudeutropius atherinoides*	*Batasi*	1.797	3.166	2.286	0.314	0.077	-	-	5.266	0.976	1.871	0.092	0.272	0.354	8.342	3.127	0.613	0.611	1272.409	5.429
209		*Wallagu attu*	*Boal*	53.624	12.333	7.905	32.161	-	-	-	-	-	-	36.949	26.256	42.672	15.779	4.837	11.682	-	3091.024	13.188
144		*Notopterus chitala*	*Chital*	-	0.101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
142		*Nemacheilus scaturigina*	*Dari*	-	-	-	-	-	-	-	3.918	-	-	-	-	-	-	-	-	-	67.479	0.288
	Subtotal			60.712	33.785	11.875	69.155	1.602	2.660	-	45.224	55.418	13.844	65.771	52.311	47.241	72.637	23.988	15.062	1.164	12193.218	52.024

Note: – denotes zero catch

(Cont.)

Table 5.18 Monthly catch compositon from canals (% by weight): outside FCD (site NW29)

Species	Habitat	Species name		Year: 1992			Year: 1993												Year: 1994		Total annual catch (Mar'93 – Feb'94)	
Code	Preference	Scientific	Bengali	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Kg	%
6	Floodplain	*Anabas testudineus*	*Koi*	–	–	–	–	–	–	8.431	–	–	–	–	–	–	–	–	–	–	21.440	0.091
136	Resident	*Mystus tengara*	*Bajari tengra*	5.195	0.087	4.308	3.204	1.008	–	–	–	–	–	–	–	–	0.130	0.073	–	–	19.143	0.082
137		*Mystus vittatus*	*Tengra*	1.503	0.365	1.455	2.251	0.837	9.618	0.425	0.341	–	8.185	–	0.192	1.607	0.866	11.534	1.858	2.081	749.556	3.198
55		*Colisa fasciatus*	*Khalisha*	1.611	0.798	3.152	0.074	–	1.194	0.321	0.720	0.881	0.336	0.438	0.836	7.026	0.169	1.629	2.199	0.083	252.317	1.077
211		*Colisa labiosus*	*Khalisha*	–	–	–	–	–	–	–	0.363	0.635	–	–	0.026	0.474	0.002	–	–	–	15.371	0.066
56		*Colisa lalia*	*Lal Khalisha*	–	–	–	–	–	0.157	–	–	–	–	–	–	–	0.061	–	–	–	7.677	0.033
57		*Colisa sota*	*Khalisha*	0.295	0.176	0.450	–	0.043	0.298	4.766	–	0.317	–	–	0.294	4.064	0.0001	0.034	–	0.444	71.970	0.307
210		*Xenentodon cancila*	*Kaikka*	0.415	0.014	0.080	–	–	0.346	–	–	0.328	–	–	0.190	1.472	0.812	0.470	0.223	–	146.647	0.626
187		*Osteobrama cotio cotio*	*Keti*	0.074	–	0.004	0.487	0.018	–	–	–	–	–	–	–	0.116	0.157	0.058	–	–	23.334	0.100
174		*Puntius chola*	*Chala puti*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.014	–	0.231	0.001
175		*Puntius conchonius*	*Canchan puti*	0.113	3.775	3.044	1.083	0.411	5.468	17.229	2.936	0.738	0.516	–	0.795	2.188	2.258	4.092	4.898	4.147	699.740	2.986
176		*Puntius gelius*	*Giliputi*	–	–	–	–	–	–	–	–	0.020	–	–	–	–	–	0.039	–	–	1.948	0.008
177		*Puntius guganio*	*Mola puti*	–	–	–	–	–	–	–	–	0.036	–	–	–	–	–	–	–	–	0.140	0.001
178		*Puntius phutunio*	*Phutani puti*	–	0.074	–	–	–	–	–	0.081	–	–	–	0.086	0.022	0.203	0.079	–	–	30.352	0.130
180		*Puntius sophore*	*Puti*	4.490	18.385	21.343	1.121	0.173	4.281	0.118	0.907	1.992	5.613	0.346	1.333	3.774	4.840	13.366	8.527	9.751	1481.872	6.323
181		*Puntius terio*	*Teri punti*	–	–	–	–	–	–	–	–	0.492	–	–	–	–	–	–	–	–	1.936	0.008
212		*Puntius ticto*	*Tit puti*	0.452	0.003	–	–	–	–	6.234	–	0.533	–	–	0.129	–	–	–	0.194	–	21.750	0.093
5		*Amblypharygodon mola*	*Mola*	0.065	0.568	0.123	–	0.074	0.308	–	0.098	0.281	0.317	–	0.097	–	0.041	0.085	–	–	13.350	0.057
69		*Brachydanio rerio*	*Anju*	–	–	–	–	–	–	–	–	0.018	–	–	–	–	–	–	–	–	0.070	0.0003
68		*Danio devario*	*Chebli*	0.891	–	–	–	–	–	–	–	–	–	–	0.342	0.052	0.013	–	–	–	3.749	0.016
75		*Esomus danricus*	*Darkina*	0.238	0.029	0.406	0.122	0.025	–	–	0.397	5.296	3.322	0.237	–	0.975	0.025	0.027	0.181	0.221	54.465	0.232
83		*Glossogobius giurus*	*Bailla*	2.858	1.669	4.326	0.292	1.058	9.730	0.283	3.969	2.725	4.614	3.282	2.600	1.052	0.175	3.706	6.437	6.097	456.852	1.949
110		*Lepidocephalus guntea*	*Gutum*	0.311	8.942	4.866	0.545	4.567	15.968	22.208	4.838	1.125	7.617	1.907	0.582	2.468	0.272	3.814	1.924	12.799	502.169	2.143
9		*Aplocheilus panchax*	*Kanpona*	0.217	0.031	0.385	–	–	0.063	–	0.292	0.892	1.543	–	–	0.051	0.023	0.008	–	–	15.124	0.065
41		*Channa punctatus*	*Taki*	2.825	3.181	13.304	3.341	0.197	6.520	0.448	1.528	1.024	9.944	3.028	0.326	5.749	1.145	5.805	17.925	7.054	874.003	3.729
42		*Channa striatus*	*Shol*	–	0.425	–	–	–	–	–	–	–	–	–	–	–	0.534	–	–	–	64.515	0.275
49		*Clarias batrachus*	*Magur*	–	0.004	0.055	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
88		*Heteropneustes fossilis*	*Shingi*	0.509	1.102	1.402	0.588	6.219	4.112	0.566	0.936	1.685	0.509	–	0.125	–	0.066	–	2.741	–	87.457	0.373
121		*Macrognathus aculeatus*	*Tara baim*	0.113	1.604	0.672	0.286	16.811	2.609	–	2.235	1.167	0.444	–	1.299	0.891	–	0.787	3.534	7.119	178.702	0.762
123		*Macrognathus pancalus*	*Guchi*	3.150	8.592	7.803	2.137	55.695	17.206	8.124	13.816	2.293	0.660	–	6.998	6.211	0.519	10.214	14.068	32.160	1269.979	5.419
122		*Mastacembelus armatus*	*Baral baim*	1.496	6.960	6.451	2.873	4.018	2.157	–	3.623	2.088	1.066	0.276	0.211	2.300	4.426	5.910	4.395	4.807	1008.458	4.303
15		*Badis badis*	*Napit koi*	0.282	0.425	0.431	0.108	0.028	0.330	–	1.160	0.547	0.665	–	0.125	0.709	0.163	0.163	0.094	–	62.876	0.268
147		*Ompok bimaculatus*	*Kani pabda*	–	0.199	–	–	–	–	–	0.518	–	–	–	–	–	–	0.423	–	–	28.967	0.124
148		*Ompok pabda*	*Madhu pabda*	1.402	1.778	2.140	2.281	0.048	–	–	1.524	–	–	–	–	–	0.016	–	0.731	0.158	40.804	0.174
145		*Notopterus notopterus*	*Foli*	–	–	0.047	–	–	–	–	–	–	–	–	–	–	0.016	–	–	–	1.978	0.008
203		*Tetraodon cutcutia*	*Potka*	–	0.709	–	–	–	–	–	–	–	–	–	–	0.764	0.991	0.006	–	–	130.313	0.556
33		*Chaca chaca*	*Cheka*	–	–	–	–	0.210	–	–	–	–	–	–	–	–	–	–	–	–	–	–
35		*Chanda baculis*	*Chanda*	3.278	1.915	5.387	0.275	0.025	0.231	–	0.056	0.149	0.108	–	0.183	0.371	1.860	–	0.094	–	234.366	1.000
36		*Chanda nama*	*Nama Chanda*	1.464	1.225	0.800	2.136	0.268	0.360	–	0.352	1.467	3.833	–	0.638	0.539	0.136	0.436	0.646	0.055	76.936	0.328
37		*Chanda ranga*	*Lal chanda*	0.552	0.001	0.113	–	0.316	0.868	0.038	0.197	1.529	4.982	4.050	12.715	0.559	0.176	0.544	0.068	–	139.442	0.595
	Subtotal			33.796	63.037	82.547	23.203	92.046	81.823	69.191	40.885	28.257	54.273	13.563	30.122	43.432	20.092	63.300	70.751	86.976	8789.999	37.504
998	Others	Unidentified fish		–	–	0.066	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
931		Prawn spp.	*Chingri/Icha*	2.705	1.265	5.153	2.145	6.175	14.393	30.808	7.306	3.203	28.282	18.084	11.039	6.272	0.942	10.029	14.047	10.179	1308.149	5.581
	Subtotal			2.705	1.265	5.219	2.145	6.175	14.393	30.808	7.306	3.203	28.282	18.084	11.039	6.272	0.942	10.029	14.047	10.179	1308.149	5.581
	Grand total			100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	23437.809	100

Note: – denotes zero catch

Table 5.19 Monthly catch composition from the Atrai River (% by weight): outside FCD (site NW27)

Species Code	Habitat Preference	Species name		Year: 1992			Year: 1993												Year: 1994		Total annual catch (Mar'93 – Feb'94)	
		Scientific	Bengali	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Kg	%
957	Riverine	*Mystus punctatus*	*Gagur*	–	–	4.183	1.317	2.580	–	9.539	–	–	–	–	–	–	–	–	–	–	171.845	0.676
186		*Rita rita*	*Rita*	0.812	0.006	0.217	–	0.400	–	–	–	–	0.898	6.415	1.295	1.244	1.253	0.237	–	–	217.176	0.854
12		*Aspidoparia jaya*	*Piali*	0.294	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
13		*Aspidoparia morar*	*Piali*	–	0.004	–	–	–	0.005	–	–	–	–	–	–	–	0.028	0.010	0.092	0.101	5.212	0.021
67		*Danio dangila*	*Nipati*	–	–	–	–	–	–	–	–	0.250	–	–	–	–	–	0.003	–	–	1.900	0.007
20		*Raiamas bola*	*Bhol*	0.403	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
59		*Crossocheilus latius*	*Kalabata*	0.105	0.163	0.431	6.395	1.640	0.783	0.004	–	0.201	0.038	–	0.016	0.008	0.070	0.358	0.899	1.903	74.906	0.295
139		*Nemacheilus botia*	*Balichata*	0.179	0.017	0.069	0.118	1.180	2.859	2.752	2.448	0.181	0.212	–	0.004	0.244	0.218	0.245	0.593	0.336	141.506	0.557
198		*Somileptes gongota*	*Gharpoia*	–	0.026	0.121	0.239	12.800	1.606	0.206	1.934	–	2.581	0.089	–	0.109	0.236	0.332	0.459	2.338	126.652	0.498
28		*Botia dario*	*Rani*	0.384	0.083	–	–	–	–	–	–	–	0.060	0.044	0.125	0.087	0.659	0.081	0.057	–	37.835	0.149
29		*Botia lohachata*	*Putul*	–	–	–	–	–	–	–	–	–	–	0.089	–	0.032	0.126	0.012	–	–	7.716	0.030
89		*Hilsa ilisha*	*Ilish*	2.859	0.016	–	–	–	–	–	–	3.655	8.394	14.797	14.310	1.778	0.166	–	–	–	623.465	2.453
58		*Corica soborna*	*Kachki*	0.339	0.034	–	0.010	–	0.980	0.006	0.166	0.283	0.736	0.222	0.068	0.288	2.460	0.003	–	1.134	136.581	0.537
193		*Setipinna phasa*	*Phasa*	0.690	0.013	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
30		*Brachygobius nunus*	*Nunabailla*	–	–	–	–	0.012	–	–	–	–	–	–	–	–	–	–	–	–	–	–
128		*Liza parsia*	*Bata*	–	–	–	–	–	0.007	–	–	–	–	–	–	–	–	–	–	–	0.048	0.0002
922		*Liza sp*	*Bata*	–	–	–	0.020	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
185		*Rhinomugil corsula*	*Khorsula*	0.109	0.005	–	–	0.066	–	–	–	–	–	0.001	–	0.001	–	–	–	–	0.047	0.0002
923		*Sicamugil cascasia*	*Bata*	–	–	–	–	–	–	–	–	–	–	–	0.011	0.046	0.004	–	–	–	2.282	0.009
163		*Pisodonophis boro*	*Kharu*	–	–	–	–	–	–	–	–	0.259	–	–	–	–	–	–	–	–	1.765	0.007
2		*Ailia coila*	*Kajuli*	3.029	0.108	0.822	0.035	0.162	–	–	–	9.439	18.685	9.471	27.033	9.956	2.805	0.264	–	–	1413.500	5.561
51		*Clupisoma garua*	*Ghaura*	5.140	3.439	0.850	1.185	0.054	–	–	–	0.320	1.539	5.485	2.825	2.005	1.916	0.631	0.177	–	328.829	1.294
52		*Clupisoma naziri*	*Muri bacha*	–	–	–	–	–	–	–	–	–	–	–	–	–	0.179	0.142	–	–	14.896	0.059
196		*Silonia silondia*	*Shillong*	0.124	–	–	–	–	–	–	–	–	–	0.642	0.226	0.124	0.063	–	–	–	18.743	0.074
16		*Bagarius bagarius*	*Baghair*	0.114	0.056	3.221	–	1.735	–	0.478	–	–	–	0.044	–	–	–	0.302	0.774	0.940	57.504	0.226
74		*Erethistes pussilus*	*Kutakanti*	–	–	–	–	0.006	–	0.141	–	0.734	–	0.018	–	–	–	0.049	0.012	–	10.915	0.043
77		*Gagata cenia*	*Kauwa*	–	0.006	0.032	3.895	–	–	–	–	–	–	–	–	0.118	–	–	0.168	–	9.710	0.038
80		*Gagata viridescens*	*Gang tengra*	0.239	–	–	–	–	–	–	–	0.156	0.015	2.326	2.799	0.713	0.812	1.517	0.706	–	245.449	0.966
81		*Gagata youssoufi*	*Gang tengra*	0.234	0.107	0.105	0.194	0.010	1.463	–	–	1.692	0.403	1.172	7.061	2.227	1.730	1.270	0.745	0.044	420.004	1.652
84		*Glyptothorax telchitta*	*Telchitta*	–	–	–	–	–	–	–	–	–	0.565	2.610	1.004	0.310	1.024	2.058	0.544	–	238.888	0.940
958		*Glyptothorax sp*	*Lal moina*	0.111	0.056	0.0002	–	0.048	–	–	–	–	–	–	–	–	–	–	–	–	–	–
87		*Hara hara*	*Kutakanti*	0.033	0.011	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
95		*Johnius coitor*	*Koitor*	–	–	–	–	–	–	–	–	–	–	–	0.023	–	–	–	–	–	0.417	0.002
155		*Pama pama*	*Poa*	–	–	–	–	–	–	–	–	–	0.074	–	–	–	–	–	–	–	0.843	0.003
195		*Sillaginopsis panijus*	*Tular dandi*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.554	5.488	0.022
45		*Chelonodon fluviatilis*	*Potka*	0.018	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
171		*Psilorhynchus balitora*	*Balitora*	–	–	–	–	0.037	–	0.002	–	–	–	–	0.003	0.076	0.006	–	0.074	–	5.602	0.022
158		*Pangasius pangasius*	*Pangas*	0.033	–	–	–	–	–	–	–	–	–	–	–	0.030	–	–	–	–	1.284	0.005
955		*Amblyceps mangois*	*Magur*	–	–	–	–	–	0.641	–	0.088	0.604	0.673	–	–	–	–	0.022	–	–	17.886	0.070
	Subtotal			15.249	4.151	10.052	13.406	20.729	8.344	13.128	4.636	17.774	34.873	43.425	56.802	19.394	13.756	7.536	5.299	7.349	4338.894	17.070
130	Migratory	*Aorichthys aor*	*Ayre*	–	–	0.322	2.438	–	–	–	–	–	–	3.128	0.494	–	0.721	–	1.503	–	111.836	0.440
135		*Aorichthys seenghala*	*Guizza*	–	–	–	–	–	–	–	–	–	0.133	5.490	–	–	–	2.120	2.293	–	248.573	0.978
24		*Batasio batasio*	*Tengra*	–	–	–	–	–	–	–	–	–	0.029	–	–	–	–	0.022	–	0.194	3.542	0.014
131		*Mystus bleekeri*	*Golsha tengra*	10.005	0.704	8.568	11.764	9.771	32.844	18.793	12.255	2.623	3.643	5.169	0.806	3.417	9.963	10.480	16.387	6.788	2415.997	9.505

Note: – denotes zero catch

(Cont.)

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Table 5.19 Monthly catch composition from the Atrai River (% by weight): outside FCD (site NW27)

Species Code	Habitat Preference	Species name: Scientific	Species name: Bengali	Year: 1992 Oct	Nov	Dec	Year: 1993 Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year: 1994 Jan	Feb	Total annual catch (Mar'93 – Feb'94) Kg	%
132		*Mystus cavasius*	*Kabashi*	2.102	1.998	15.588	9.689	8.139	19.570	20.553	7.193	0.469	0.954	1.982	2.158	2.078	2.267	4.306	8.024	10.803	1376.027	5.413
32		*Catla catla*	*Catla*	0.213	–	–	–	–	–	–	–	–	–	–	2.579	–		–			46.609	0.183
47		*Cirrhinus mrigala*	*Mrigel*	0.817	0.487	–	–	0.302	–	–	–	–	0.201	–	–	3.525	1.985	0.136	–	–	233.950	0.920
48		*Cirrhinus reba*	*Raik*	3.229	2.217	1.119	1.875	0.766	–	0.495	–	–	1.960	0.362	1.494	4.674	1.174	0.336	–	0.037	324.746	1.278
100		*Labeo bata*	*Bata*	2.249	0.821	0.768	–	–		–	–	–	0.043	–	–	–	0.341	0.088	1.276	–	53.794	0.212
101		*Labeo boga*	*Bhangan*	–	–	–	0.539	–	0.112	0.010	–	–	–	0.447	–	–	–	–	–	–	5.817	0.023
102		*Labeo calbasu*	*Kalbaus*	6.092	9.299	2.293	1.505	2.892	0.440	5.878	–	–	0.417	1.182	3.735	0.634	1.270	0.104	3.336	8.882	455.072	1.790
107		*Labeo rohita*	*Rui*	3.531	–	–	–	–	–	–	–	–	–	–	4.411	15.470	0.450	–	–	–	755.278	2.971
188		*Salmostoma bacaila*	*Katari*	3.302	0.724	1.004	0.120	0.319	1.962	0.058	–	–	0.894	–	0.007	0.262	0.403	0.233	–	–	63.903	0.251
189		*Salmostoma phulo*	*Fulchela*	0.190	0.277	0.744	0.402	0.123	0.208	0.084	0.215	0.354	0.699	0.065	0.142	0.303	0.688	0.130	0.025	0.259	67.266	0.265
154		*Securicula gora*	*Chora chela*	–	–	–	0.400	–	–	–	–	–	0.569	0.001	0.221	0.341	0.024	1.244	–	–	98.062	0.386
86		*Gudusia chapra*	*Chapila*	6.992	0.318	–	–	–	0.029	–	–	0.354	2.079	0.012	0.716	3.491	1.006	0.335	–	0.022	245.032	0.964
76		*Eutropiichthys vacha*	*Bacha*	1.412	0.665	–	–	–	–	–	0.055	0.084	0.076	0.195	0.336	1.438	1.120	0.074	–	–	117.096	0.461
169		*Pseudeutropius atherinoides*	*Batasi*	0.867	0.322	0.570	0.379	1.765	0.381	4.659	5.555	4.498	0.430	1.471	–	0.489	5.762	1.170	0.411	3.693	526.749	2.072
209		*Wallagu attu*	*Boal*	13.689	67.837	8.761	9.544	5.015	–	7.170	–	–	0.652	–	–	0.147	25.681	33.107	6.722	9.479	3296.585	12.969
144		*Notopterus chitala*	*Chital*	–	–	–	1.447	–	–	–	–	–	0.222	–	–	–	–	–	0.054	–	4.031	0.016
140		*Nemacheilus corica*	*Koirka*	–	–	0.016	0.032	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
142		*Nemacheilus scaturigina*	*Dari*	–	–	–	–	–	–	–	–	–	0.500	–	–	–	–	–	0.092	–	8.271	0.033
216		*Nemacheilus zonalternans*		–	–	–	–	–	–	–	1.362	–	–	–	0.002	–	0.020	–	0.028	–	10.949	0.043
	Subtotal			54.690	85.668	39.753	40.134	29.092	55.546	57.700	26.635	8.380	13.501	19.503	17.102	36.270	52.875	53.885	40.151	40.158	10469.185	41.187
136	Floodplain	*Mystus tengara*	*Bajari tengra*	3.264	0.001	1.058	2.317	–	–	0.197	1.181	0.682	0.108	–	–	0.405	0.009	–	–	–	35.148	0.138
137	Resident	*Mystus vittatus*	*Tengra*	0.071	0.421	6.278	4.709	3.481	0.603	1.609	0.097	–	0.443	0.013	0.029	1.453	0.965	7.295	3.626	2.101	681.992	2.683
55		*Colisa fasciatus*	*Khalisha*	–	–	0.009	–	0.097	–	0.099	–	–	0.181	–	2.579	0.081	0.214	0.047	0.199	1.086	80.848	0.318
211		*Colisa labiosus*	*Khalisha*	–	–	–	–	–	–	–	–	–	0.157	–	–	–	–	–	–	–	1.788	0.007
56		*Colisa lalia*	*Lal khalisha*	–	–	–	–	0.027	0.004	0.043	–	–	–	–				–	–	–	0.801	0.003
57		*Colisa sota*	*Khalisha*	–	–	0.060	–	0.011	0.005	–	–	0.009	–	–	–	0.002	0.014	–	0.368	–	10.932	0.043
210		*Xenentodon cancila*	*Kaikka*	0.429	0.102	0.174	0.157	0.099	0.331	0.301	–	1.132	0.222	0.026	0.146	1.868	1.786	0.873	0.008	0.981	227.144	0.894
62		*Cyprinus carpio*	*Karfu*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.197	–	5.505	0.022
64		*Cyprinus nudus*	*Leather carp*	–	–	–	–	–	–	–	–	–	–	2.024	–	–	–	–	–	–	22.186	0.087
187		*Osteobrama cotio cotio*	*Keti*	0.094	0.001	0.159	–	0.018	0.220	0.001	0.044	–	–	–	–		–	0.035	0.002	–	3.824	0.015
174		*Puntius chola*	*Chala puti*	–	–	–	–	–	0.060	0.006	–	–	–	–	–	–	–	–	–	–	0.494	0.002
175		*Puntius conchonius*	*Canchan puti*	0.098	1.175	2.004	2.443	3.223	1.407	2.607	10.317	14.324	17.449	0.013	0.186	8.726	5.546	7.357	2.621	0.248	1507.279	5.930
176		*Puntius gelius*	*Gilputi*	–	–	–	0.050	–	–	0.023	0.028	–	0.038	0.001	–	0.014	–	0.003	–	–	1.850	0.007
177		*Puntius guganio*	*Mola puti*	–	–	–	–	–	–	0.043	–	–	–	–	–	–	0.007	–	–	–	1.031	0.004
178		*Puntius phutunio*	*Phutani puti*	–	–	–	–	–	–	0.001	–	–	0.039	–	–	0.017	0.099	0.030	–	–	6.602	0.026
179		*Puntius sarana*	*Sarputi*	–	–	–	–	0.034	–	–	–	–	–	–	–	–	–	–	0.017	–	0.473	0.002
180		*Puntius sophore*	*Puti*	2.748	1.062	5.772	3.200	5.739	1.631	0.391	0.519	0.261	2.873	0.054	2.179	2.290	3.578	4.784	4.751	2.473	760.468	2.992
212		*Puntius ticto*	*Tit puti*	0.927	0.021	0.005	–	–	–	–	–	0.316	0.074	–	–	0.926	0.642	0.016	0.019	–	67.682	0.266
5		*Amblypharyngodon mola*	*Mola*	0.083	–	–	–	–	0.025	0.035	–	–	0.046	–	–	0.105	0.007	0.002	–	0.048	6.632	0.026
69		*Brachydanio rerio*	*Anju*	–	–	–	–	0.006	–	–	–	–	0.074	–	–	0.008	–	–	–	–	1.175	0.005
68		*Danio devario*	*Chebli*	–	–	–	–	–	–	–	0.035	–	0.074	–	0.056	–	0.018	0.040	–	–	5.049	0.020
75		*Esomus danricus*	*Darkina*	0.008	0.023	0.0004	–	–	0.025	0.191	0.273	2.332	1.235	–	0.656	0.414	–	–	–	–	64.970	0.256
83		*Glossogobius giurus*	*Bailla*	0.035	0.186	1.923	0.849	4.190	1.959	0.384	4.998	3.526	10.731	2.085	3.023	0.843	0.417	1.794	1.838	0.278	487.724	1.919

Note: – denotes zero catch

(Cont.)

Table 5.19 Monthly catch composition from the Atrai River (% by weight): outside FCD (site NW27)

Species Code	Habitat Preference	Species name: Scientific	Species name: Bengali	Year: 1992 Oct	Year: 1992 Nov	Year: 1992 Dec	Year: 1993 Jan	Year: 1993 Feb	Year: 1993 Mar	Year: 1993 April	Year: 1993 May	Year: 1993 June	Year: 1993 July	Year: 1993 Aug	Year: 1993 Sep	Year: 1993 Oct	Year: 1993 Nov	Year: 1993 Dec	Year: 1994 Jan	Year: 1994 Feb	Total annual catch (Mar'93 – Feb'94) Kg	Total annual catch (Mar'93 – Feb'94) %
91		*Hypophthalmichthys molitrix*	*Silver carp*	2.997	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
43		*Chela cachius*	*Chep chela*	–	–	–	–	–	–	0.002	–	–	0.026	–	–	–	–	–	–	–	0.331	0.001
110		*Lepidocephalus guntea*	*Gutum*	0.408	0.149	1.193	1.096	3.685	3.610	1.422	1.928	4.447	0.894	0.065	0.040	0.654	0.632	0.148	0.496	0.079	178.984	0.704
9		*Aplocheilus panchax*	*Kanpona*	–	0.002	–	–	0.133	–	0.027	0.177	–	0.189	–	0.214	0.018	–	–	–	–	8.490	0.033
40		*Channa orientalis*	*Cheng*	–	–	–	–	–	–	–	–	–	–	–	–	–	0.093	–	–	–	3.443	0.014
41		*Channa punctatus*	*Taki*	0.248	0.054	0.137	2.128	1.694	0.307	2.368	–	0.990	1.911	–	1.847	2.781	1.897	0.257	6.150	3.887	520.252	2.047
42		*Channa striatus*	*Shol*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.195	–	–	11.335	0.045
49		*Clarias batrachus*	*Magur*	–	0.002	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
88		*Heteropneustes fossilis*	*Shingi*	0.104	0.135	0.028	0.238	0.622	0.314	–	–	0.078	0.389	–	–	–	–	0.019	0.025	0.566	14.431	0.057
121		*Macrognathus aculeatus*	*Tara baim*	–	–	0.082	–	0.734	–	–	0.513	–	0.318	0.462	1.505	–	0.319	–	0.238	–	57.878	0.228
123		*Macrognathus pancalus*	*Guchi*	1.110	0.249	2.913	2.459	6.628	4.609	4.680	23.756	14.691	1.228	0.195	0.113	4.162	1.896	0.640	2.919	5.751	819.635	3.225
122		*Mastacembelus armatus*	*Baral baim*	4.076	4.884	21.940	21.091	7.557	7.741	2.788	0.264	4.701	0.285	3.496	2.781	6.814	9.550	11.472	21.618	16.124	2298.587	9.043
138		*Nandus nandus*	*Bheda*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.599	0.168	74.109	0.292
15		*Badis badis*	*Napit koi*	0.080	0.020	–	–	0.136	0.096	0.352	1.588	0.311	0.630	–	0.220	0.040	0.032	0.032	0.012	–	36.305	0.143
147		*Ompok bimaculatus*	*Kani pabda*	2.056	0.115	0.136	–	0.125	–	0.456	–	–	–	–	0.033	0.005	–	–	–	–	9.032	0.036
148		*Ompok pabda*	*Madhu pabda*	0.237	0.231	–	0.991	2.928	–	0.473	–	–	–	–	–	–	0.030	–	0.523	4.992	73.658	0.290
145		*Notopterus notopterus*	*Foli*	–	–	–	–	0.165	–	–	–	–	–	–	–	–	0.584	–	0.402	–	32.873	0.129
203		*Tetraodon cutcutia*	*Potka*	0.149	–	–	–	–	–	–	–	–	–	–	–	0.007	0.078	0.006	0.017	–	4.009	0.016
33		*Chaca chaca*	*Cheka*	–	–	0.145	–	–	0.045	–	–	–	–	–	–	–	–	–	–	–	0.296	0.001
35		*Chanda baculis*	*Chanda*	4.467	0.084	0.576	0.118	1.574	0.356	0.231	0.009	0.026	0.424	0.018	0.024	0.723	0.117	0.317	0.425	0.892	86.392	0.340
36		*Chanda nama*	*Nama chanda*	1.240	0.562	1.948	1.837	2.085	0.255	0.454	0.219	0.844	4.410	0.092	0.070	2.501	0.476	0.140	0.481	0.249	217.925	0.857
37		*Chanda ranga*	*Lal chanda*	0.115	0.007	0.079	0.020	0.167	0.100	0.671	0.257	0.815	2.867	0.015	0.271	2.983	0.503	0.283	0.014	0.521	225.545	0.887
	Subtotal			25.043	9.483	46.618	43.702	45.156	23.702	19.852	46.202	49.483	47.312	8.559	15.971	37.839	29.507	35.784	49.564	40.443	8655.107	34.050
998	Others	Unidentified fish		–	–	0.002	0.292	–	–	–	–	–	–	–	–	0.572	–	–	–	0.067	25.016	0.098
931		Prawn spp.	*Chingri/Icha*	5.017	0.695	3.573	2.465	5.021	12.407	9.319	22.527	24.362	4.311	28.511	10.124	5.924	3.860	2.794	4.985	11.983	1930.358	7.594
	Subtotal			5.017	0.695	3.575	2.758	5.021	12.407	9.319	22.527	24.362	4.311	28.511	10.124	6.495	3.860	2.794	4.985	12.050	1955.374	7.693
	Grand total			100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	25418.560	100

Note: – denotes zero catch

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dominated catches with the exception of the two major carps each of which comprised less than 1% of the canal catch.

On the unregulated floodplains of Chalan *Beel*, two dominant riverine species, *balichata* and *gang tengra* together comprised 3% of the catch while five dominant migratory species accounted for a further 27% of the catch. The most abundant migratory species included *boal*, *batasi* and *golsha tengra*. The two remaining species were *kabashi* and *raik*, each accounting for a little more than 2% of the annual catch. In contrast, on the regulated floodplains of Polder B, no riverine species comprised over 1% of the catch and while two dominant migratory species were recorded, they each provided less than 2% of the catch.

Dominant floodplain resident species formed an important component of the catch from the Atrai River and unregulated canals where between 7 and 10 species accounted for 28% to 32% of the catch respectively. The most important species on the river included *baral baim* and *canchan puti* while on the canals, *baral baim*, *guchi baim* and *puti* predominated. On the floodplain, 10 dominant species comprised 45% of the catch from Chalan *Beel* compared with 13 species comprising 72% of the catch from Polder B. The most abundant species on Chalan *Beel* included *guchi baim* and *tara baim*, which together accounted for 15% of the catch, and *puti* (10%). Inside the polder, *puti* provided a greater share (20%) of the annual catch which was exceeded only by *taki* (21%). Two other species that were relatively more abundant within the polder included *lal chanda* and *canchan puti*.

Prawns formed an important component of the catch from both regulated and unregulated floodplains where they comprised 17% and 13% of the annual catch respectively. On the Atrai River and unregulated canals they were relatively less abundant in the catch but still provided important contributions of 8% and 6% by weight respectively. Because of taxonomic difficulties prawns were rarely identified in the field, however, sub-samples were sent regularly to the University of Chittagong for identification. Results provided so far indicate that all species belong to the genus *Macrobrachium*. This genus is regarded as an estuarine spawner which makes migrations into freshwaters at the juvenile stage in its life cycle. However, FAP 17 studies using drift nets (savar nets) at Charghat regulator on the River Baral, and in other areas of Bangladesh, revealed that newly-hatched prawns form an extremely important component of the catch which indicates that there is widespread spawning inland by some species[15].

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5.5 Fish Migrations

In the following discussion, seasonal movements of fish between floodplains/*beel* and river were identified from changes in catch compositions, temporal changes in distributions of important individual species and changes in monthly species numbers and catch contributions of groups of riverine, migratory and floodplain resident fish. Where available, additional information on the average size of fish and their reproductive state was used to determine at what stage in their life cycles migrations were made and whether these were primarily for breeding and/or growth.

Atrai River

The numbers of fish species recorded on the Atrai gradually declined through the winter and pre-monsoon to reach a minimum in May (Fig. 5.16). Similar trends were observed for riverine and migratory species while numbers of floodplain resident species fluctuated rather more and remained relatively higher than the other fish groups. In June, the numbers of riverine species increased as did their contribution to the monthly catch (Fig. 5.17) but numbers of migratory species remained unchanged. The two most important species appearing in June were *kajuli* and *ilish*. Both species arrived as adults (mean indiv wts: 4.5 g and 440 g respectively) on spawning migrations which for *ilish* commenced in the Bay of Bengal. Other species arriving in June included *ghaura* and *gang tengra* (*Gagata viridescens* and *G.youssoufi*). Since waters from the Padma River did not cross Charghat regulator into the Baral-Nandakuja River until early July, all riverine species appearing in June must have originated from the lower Atrai and Jamuna rivers[1]. In July, small (3 g) juvenile *rita* were captured indicating possible upstream spawning grounds on the Atrai system. Juveniles (3-8 g) of this riverine catfish were recorded from July to December but no adults were observed in the sampled catches. Two smaller riverine species, *rani* and *telchitta*, also arrived in July. Species appearing from July onwards may have originated from the Jamuna and/or Padma. A separate FAP 17 study[15] of the impact of Charghat regulator on the downstream movements of fish hatchlings showed that a very high diversity of species (135 species) entered the Baral-Nandakuja from the Padma River between July and September 1993 and many of these probably reached the Atrai River system.

Several migratory species appeared in relatively low abundance in July and made little contribution to the catch. Prominent among these were juveniles of two major carps, *mrigel* and *kalbaus* averaging 10 g and 3-8 g per individual fish respectively. Since no spawning grounds of major carp are known to exist in the Atrai system, the origin of these juveniles

Figure 5.16 Seasonal variation in the number of riverine, migratory and floodplain resident fish species on the Atrai River (site NW27)

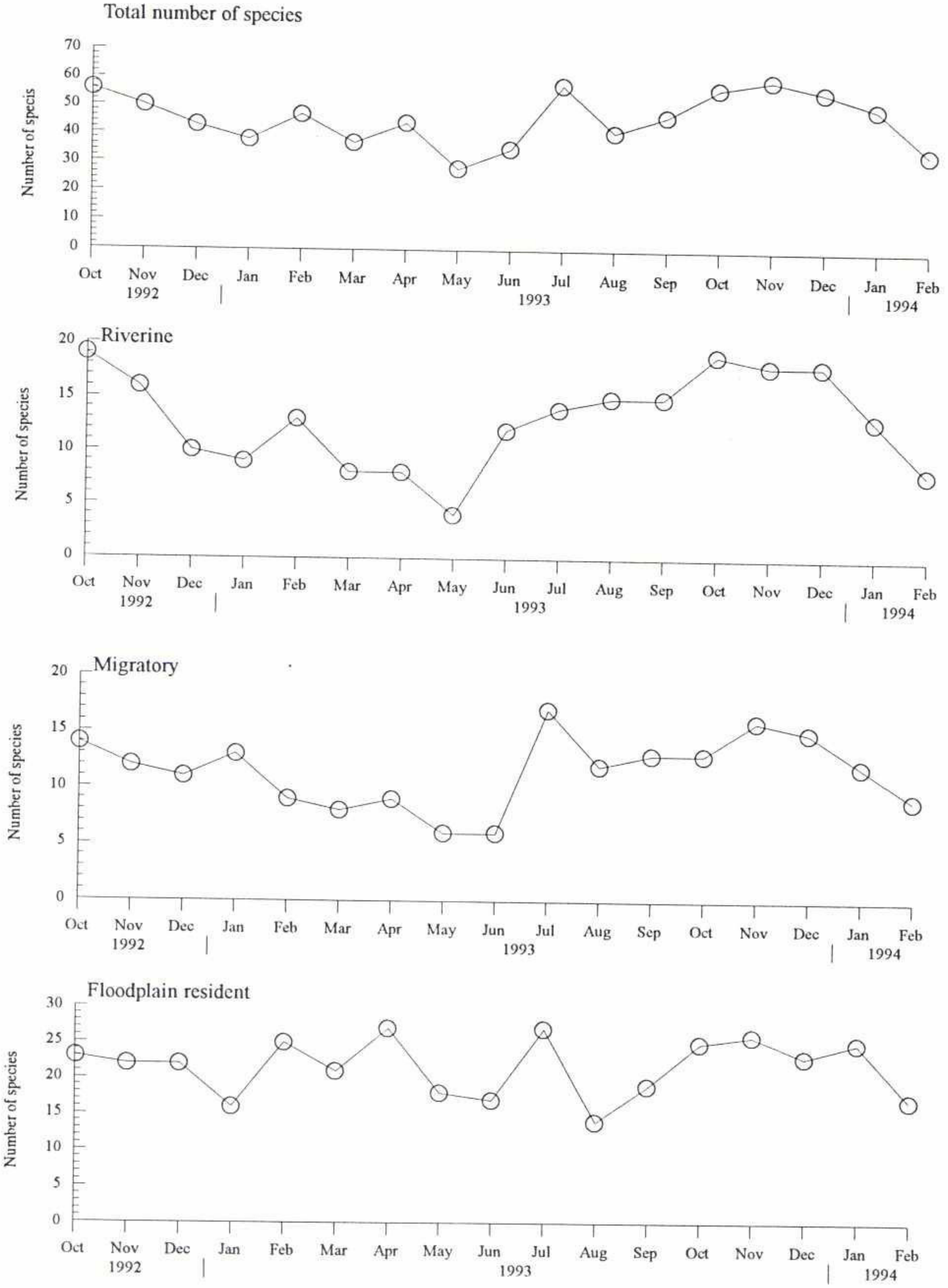
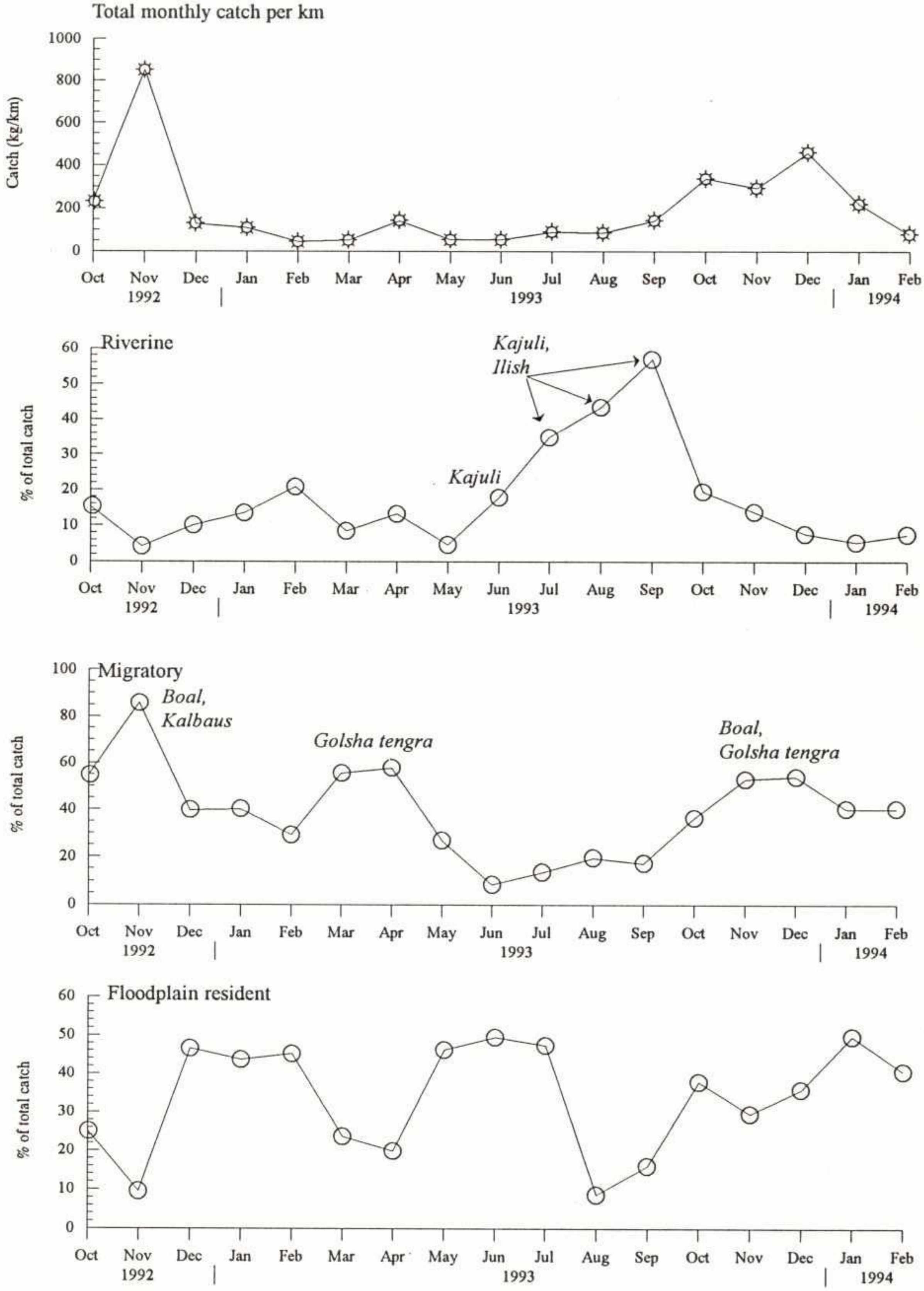


Figure 5.17 Percentage total monthly catch of riverine, migratory and floodplain resident groups of fish from the Atrai River, (site NW27)



Notes: 1. See text for definition of different categories of fish based on habitat preference (Section 5.3.2)
2. Dominant species are shown for peak relative abundances of riverine and migratory fish; less abundant species are not shown

remains unclear. It is possible that they entered from the Padma River via the Baral-Nandakuja but they were rather large for this time of the year since July is the time when major carp hatchlings usually first appear[15]. A third carp species, *raik*, was also captured in July as both adult and juveniles (<1 g). This carp probably breeds in the Atrai and other small rivers. Another species captured as juveniles was *boal* which averaged 140 g per individual. Earlier in the year, during May, very small (1-2 g) juvenile *boal* were caught in the river presumably after migrating or being swept downstream in rainfall runoff from nearby spawning grounds on the floodplains. The advantages of such movements remain unclear since the usual habitat for such young *boal* is newly inundated floodplain. Other migratory species arriving in July included *chapila*, *katari* and *chora chela*.

Between August and September, the total number of riverine species stabilised but catch contributions increased considerably due principally to the arrival of more adult *ilish* on a spawning migration and to *kajuli* which commenced spawning in July (Table 5.20) and was subsequently captured as adults (6 g/indiv.) and juveniles (<1 g in July; 3 g in August). During this period of peak river flow, juveniles of other riverine species such as *ghaura*, *shillong* and *baghair* were captured but no adults were recorded in catches at this time. These may have originated from upstream spawning grounds in the Atrai system, or from the Padma by downstream drift of hatchlings and migration of fry along the Baral-Nandakuja. A third possibility is that spawning grounds were located in the Jamuna and lower Atrai and that they moved into the sampled reach by upstream migration.

The number of migratory species decreased in August compared to the peak number recorded in July and numbers remained steady during September while catch contributions by this group of fish continued to be low. Juveniles of two large catfish species, *ayre* and *guizza* were captured for the first time in August, their weights per individual averaging 118 g and 97 g respectively; again, no adults were captured at this time. Juveniles of *raik* and *kalbaus* were captured throughout August and September together with *rui* (144 g/indiv.). It is possible that the two major carp species, *kalbaus* and *rui*, were escapees from a large-scale carp stocking programme carried out by the Third Fisheries Project on Halti *Beel* about 25 km upstream from the sampling site.

During the flood drawdown and early winter (October - December), the numbers of riverine species reached a peak, stable level throughout this period (Fig. 5.16) but their contribution to monthly catches declined sharply (Fig. 5.17). *Ilish* migrated out of the area as both adult and young *jatka* (4-15 g/indiv.) during November when it returned to the main river system.

Table 5.20 Breeding seasons of selected fish, inside and outside Polder B, October 1992 – February 1994

Legend

Peak season >50% fish ripe, ripe running, spent	(dark shading)
20–50% fish ripe, ripe running, spent	(medium shading)
<20% fish ripe, ripe running, spent	(light shading)
0% fish ripe, ripe running, spent	(blank box)
No data	

Note: Numbers quoted are numbers of fish examined

Habitat Preference	Species name: Scientific	Species name: Bengali	Habitat	Inside/ Outside FCD	Site	Year: 1992 Oct	Nov	Dec	Year: 1993 Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year: 1994 Jan	Feb
Riverine species	*Ailia coila*	*Kajuli*	Canal	Outside	NW29										1	2			3	7		
			River	Outside	NW27										27	4	2	14	16	5		
	Corica soborna	*Kachki*	Floodplain	Inside	NW28		40							7	67	119		121	1			
				Outside	NW30												4	1	3			
			Canal	Outside	NW29		1							1			1	2	5	2		
			River	Outside	NW27		24				374	6	4	3	35	21	21	53	224			12
Migratory species	*Gudusia chapra*	*Chapila*	Floodplain	Inside	NW28		3	8	5									8	9			
				Outside	NW30											1		1	4	1		
			Canal	Outside	NW29	2	2												9		2	
			River	Outside	NW27		1				1				4		1	27	11	3		
	Mystus bleekeri	*Golsha tengra*	Floodplain	Inside	NW28				6			1	1	1	3		2		3			
				Outside	NW30			5					9	33	18	37	26	68	37	2	7	
			Canal	Outside	NW29			5	5	7			25	18	19		1	24	61	58	4	
			River	Outside	NW27			22	62	106	56	66	8	4	3	4		11	54	60	129	18
	Salmostoma bacaila	*Katari*	Floodplain	Inside	NW28									1								
				Outside	NW30		4	15					1	3								
			Canal	Outside	NW29	13	1				1											
			River	Outside	NW27	1	1	2	1	9	1											
	Salmostoma phulo	*Fulchela*	Floodplain	Inside	NW28					2			1			1	3	210	5			
				Outside	NW30								1	2	22		1	19			1	12
			Canal	Outside	NW29			2	3				3							15	1	
			River	Outside	NW27				2	3	7	1	2	2	24			44	6			
	Wallagu attu	*Boal*	Floodplain	Inside	NW28	1		1	3	1												
				Outside	NW30		22	5														
			Canal	Outside	NW29	1	1		8													
			River	Outside	NW27		3	3	1	3												

(Contd.)

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Table 5.20 Breeding seasons of selected fish, inside and outside Polder B, October 1992 – February 1994

Legend

- Peak season >50% fish ripe, ripe running, spent
- 20 – 50% fish ripe, ripe running, spent
- <20% fish ripe, ripe running, spent
- 0% fish ripe, ripe running, spent
- No data

Note: Numbers quoted are numbers of fish examined

Habitat Preference	Species name: Scientific	Species name: Bengali	Habitat	Inside/ Outside FCD	Site	1992 Oct	1992 Nov	1992 Dec	1993 Jan	1993 Feb	1993 Mar	1993 April	1993 May	1993 June	1993 July	1993 Aug	1993 Sep	1993 Oct	1993 Nov	1993 Dec	1994 Jan	1994 Feb
Floodplain resident species	*Chanda nama*	*Nama chanda*	Floodplain	Inside	NW28				12				1	10	8	21	131	141	18	5		
				Outside	NW30		1	22				1	1	15	1	6	17	9	9		21	2
			Canal	Outside	NW29	4	3	10	26		3		8	19			5	6	5	14	8	
			River	Outside	NW27		4		1	46	31	56	10	8	49	19	39	55	11	8	4	1
	Chanda ranga	*Lal chanda*	Floodplain	Inside	NW28										149	16	59	105	48	219		
				Outside	NW30										2	6	30	72	12	4	17	1
			Canal	Outside	NW29										2	96	79	11	7	24		
			River	Outside	NW27										73	25	48	111	12	46	2	
	Channa punctatus	*Taki*	Floodplain	Inside	NW28		7	10	72	9	1	5		14	9			1	10	30	32	
				Outside	NW30			9					1	5	5	1				3	1	
			Canal	Outside	NW29			6	2				1	1				3	3	6	7	
			River	Outside	NW27				2	2		1		1	2				3	2	3	
	Colisa fasciatus	*Khalisha*	Floodplain	Inside	NW28				4					25	121	4		2	28	13	6	
				Outside	NW30		1	18					5	138	6	1	7	49	21	14		
			Canal	Outside	NW29		2	3	4					5			3	144	11	14		
			River	Outside	NW27					1					1			1			6	
	Glossogobius giurus	*Baila*	Floodplain	Inside	NW28	2	6	29	218	158	3	18	2	9	8	1	7	13	21	41	6	
				Outside	NW30		10	47			1	21	30	28	3	14	10	9	2	35	33	
			Canal	Outside	NW29	1	6	29	5	1	132		45	18	7	1	18	4	4	45	14	
			River	Outside	NW27	7	1	3	3	41	30	11	28	19	6		1	3	12	8	9	5
	Heteropneustes fossilis	*Shingi*	Floodplain	Inside	NW28		9	8	20	35		11			1							
				Outside	NW30		1	9			1				3					3		
			Canal	Outside	NW29			1	1	3	3										2	
			River	Outside	NW27				1	2					1							
	Lepidocephalus guntea	*Gutum*	Floodplain	Inside	NW28	1		4	53	93	21	37	2	2	6		3	9	7	1	2	
				Outside	NW30		2	6			13	9	15	12	28	9	10	13	9	3	73	
			Canal	Outside	NW29		1	3	7	1	53		11		2	4		7	3	30	13	
			River	Outside	NW27			1	5	15	5	13	15	19	3			2			4	
	Macrognathus pancalus	*Guchi*	Floodplain	Inside	NW28		1		26	198	22	24	16		6	1	8	10	25	4	2	
				Outside	NW30		1	7				1	14	16	10	105	109	109	3	12	5	3
			Canal	Outside	NW29		5	5	2		15		103	10			4	9	3	25	6	
			River	Outside	NW27		5	1	4	23	19	71	231	24	11	2		12	6	4	17	12
	Mystus vittatus	*Tengra*	Floodplain	Inside	NW28		1	27	120	40		1	2		22		2	13	1	2	6	
				Outside	NW30		5	51			5	7	6	1	43	2	15	10	13	51	14	
			Canal	Outside	NW29	1	2	27	17	6	29		2	1			4	7	4	86	16	
			River	Outside	NW27			8	35	33	6	1	1					2	3	40	37	7
	Puntius sophore	*Puti*	Floodplain	Inside	NW28		102	308	338	114		22	1	61	121	2	17	55	63	454	28	
				Outside	NW30		1	48			1	1	54	19	22	10	43	4	97	46	14	
			Canal	Outside	NW29		1	27	9		15		5		3		16	34	56	170	33	
			River	Outside	NW27			2	8	12	17	3	2	2	8	1	2	7	1	63	40	1

It was not recorded from December onwards whereas *kajuli* and *ghaura* migrated out of the sampled area in December and January respectively as both adults and juveniles. Large catfish species such as *shillong* and *pangas* were captured as juveniles between October and November as they moved downstream to seek the shelter of the large rivers Jamuna and Padma during the winter. Juveniles of a third large catfish species, *baghair*, were captured a little later, between December and January, and young adults (1.2 kg/indiv.) were captured in February when dams were constructed across the Atrai for rice irrigation.

The numbers of migratory species increased slightly in November before declining steadily from December onwards. Their catch contribution followed a different pattern with increases in October and November, levelling off in December before decreasing in January. During the drawdown in 1992, juvenile *boal* (30-35 cm total length) were captured in large numbers by *suti jal* set across the river. In November 1992, the time of peak catch, *boal* comprised 74% of the *suti jal* catch which in turn formed 67% of the total monthly catch. In the following year, juvenile *boal*, appeared to be less abundant and peak catches were taken by *suti jal* one month later, in December probably due to the later flood drawdown in 1993. However, the juvenile fish captured in December 1993 were considerably larger (50-55 cm total length) than those caught in November 1992 which suggests that there was a faster growth rate and/or a longer growth season in 1993. Flooding patterns of the Atrai (Fig. 3.5) confirmed that the flood season due to river flooding in 1993 was substantially longer (157 days) than that in 1992 (111 days) thereby providing the opportunity for increased growth. Lower catches of juvenile *boal* were made during winter months of January and February in both 1992 and 1993. By this time most fish had migrated downstream towards the Jamuna. Juveniles of the major carps, *rui* and *mrigel*, were captured as they migrated downstream in October and November and none was recorded after December. In contrast, juveniles of a third major carp, *kalbaus*, were caught in low numbers from October 1993 to February 1994. Juveniles of another carp species, *raik* were also present from October to February but no adults were captured during this period. Two large catfish species, *ayre* and *guizza* were caught during the drawdown and in January, again as juveniles only (350 - 700 g) and no adults were seen in catches.

Several riverine and migratory species remained within the sampled reach on the Atrai throughout the year despite the construction of dams between February and May. Notable among these species were riverine types such as *kalabata*, *balichata*, *gharpoia*, *gang tengra* and *kachki* and migratory species such as *golsha tengra*, *kabashi* and *fulchela*. Information on the reproductive state of selected species indicated that the peak breeding period of *golsha* *tengra* was between May and July and that of *fulchela* between April and May (Table 5.20).

The total numbers of floodplain resident species recorded each month fluctuated frequently and showed no clear seasonal peak even during the drawdown when increased numbers might be expected as fish moved off the drying floodplains. Several floodplain resident species formed an important component of the catch and were present throughout the year. These included *tengra*, *kaikka*, *canchan puti*, *puti*, *bailla*, *gutum*, *taki*, *guchi baim*, *baral baim* and three species of *chanda*. Many of these species were found in peak breeding condition during the pre-monsoon and monsoon period but it is not clear whether they actually spawned in the river or moved on to the floodplains to do so.

Unregulated canals

During the dry season, between January and April, very few riverine species were found in unregulated canals and catch contributions remained very low (Figs 5.18 and 5.19). In May species numbers increased moderately and stabilised until July, after which they increased again to reach a stable peak between September and November then declined rapidly to a low winter level. Catch contributions by riverine species fluctuated frequently without clear seasonal trends apart from lowest catches during winter and pre-monsoon periods.

The numbers of migratory species decreased progressively from January to April followed by a sharp increase in May and June. Numbers dropped in July then gradually increased through the full flood season to reach a peak in November after which numbers declined slowly until January then sharply in February. Monthly catch contributions fluctuated quite widely but, as with riverine species, were lowest during the winter and pre-monsoon periods. There was also a noticeable peak during November when fish moved off floodplains into canals and rivers.

Numbers of floodplain resident species decreased temporarily in April and August, otherwise they remained relatively stable for most of the year. A small peak was evident in November with a gradual decrease in numbers from December 1993 to February 1994. Catch contributions were highest in the winter and pre-monsoon.

In May, five riverine species were recorded and of these *gharpoia* and *balichata* were the most abundant. In the same month seven migratory species were found, four of which *golsha tengra*, *kabashi*, *batasi* and *fulchela* resided in the canals for most of the year. Juvenile *kalbaus* (28 g/indiv.) were also found in May but these were too large to be wild spawned

Figure 5.18 Seasonal variation in the number of riverine, migratory and floodplain resident fish species in unregulated canals, (site NW29)

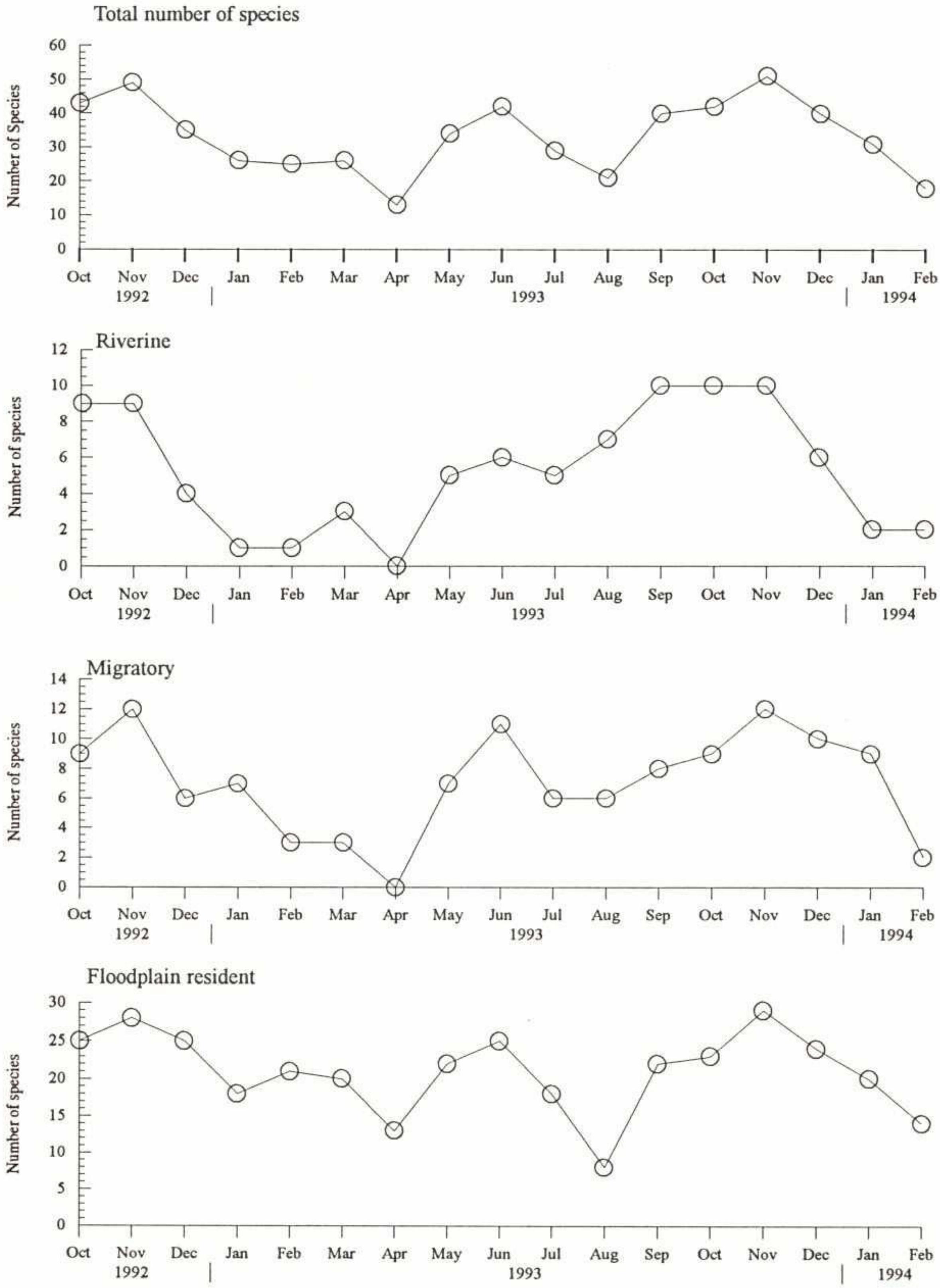

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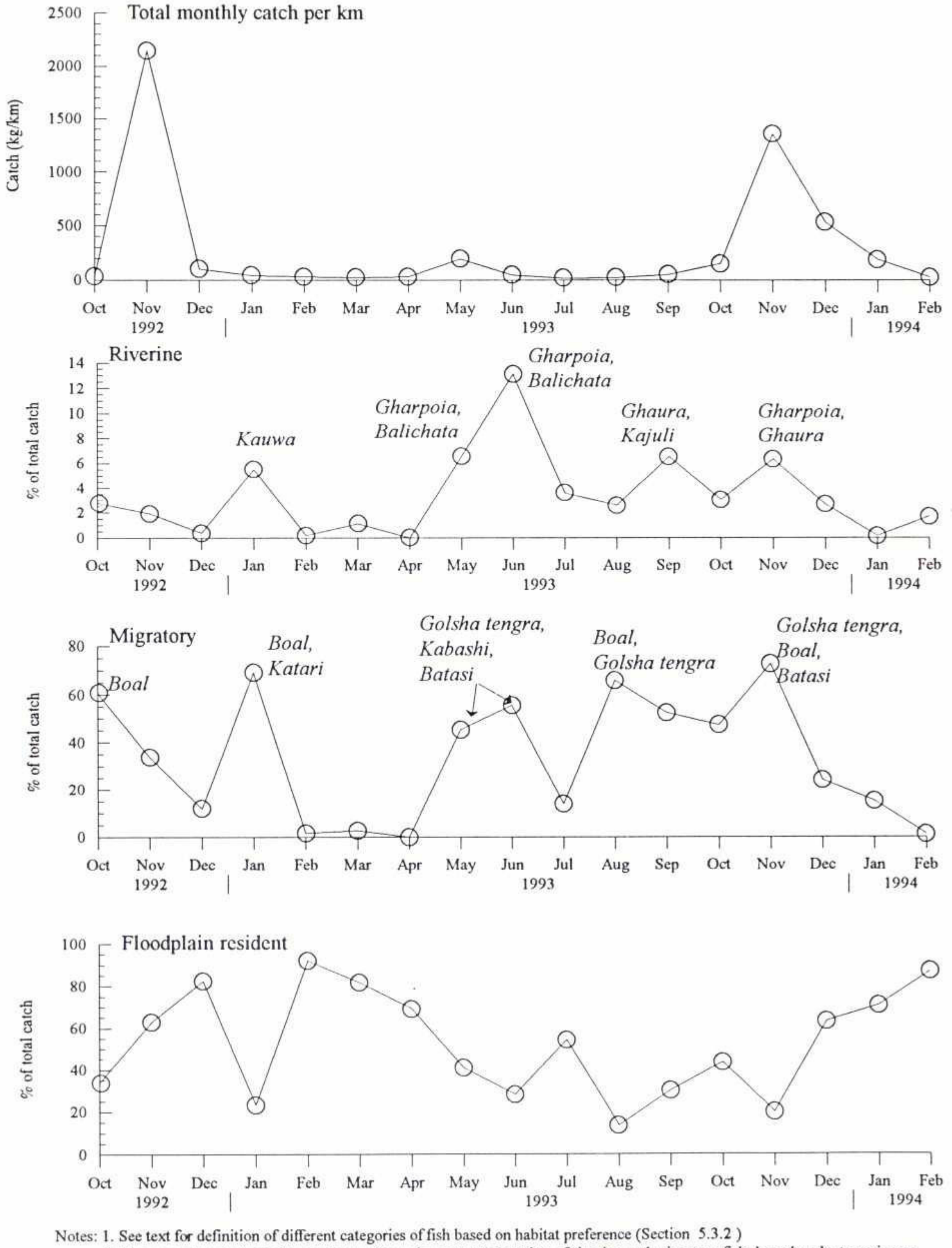
Figure 5.19 Percentage total monthly catch of riverine, migratory and floodplain resident groups of fish from unregulated canals, (site NW29)



Notes: 1. See text for definition of different categories of fish based on habitat preference (Section 5.3.2)
2. The most abundant species are shown for peak percentage catches of riverine and migratory fish; less abundant species are not shown

fish at this time of year. In June, *gharpoia* and *balichata* dominated the catch of riverine species; these were joined by rarer species such as *kachki*, the mullet *bata*, *kutakanti* and *gang tengra*. Dominant migratory species included *golsha tengra*, *kabashi* and *batasi* while others arriving in June floodwaters from the Atrai comprised the minor carps, *bhangan*, *bata* and *raik*, and juvenile *kalbaus* were joined by small (1 g) juvenile *rui*. Again, it seems unlikely that *rui* were wild spawned since at this time of year they could have only originated from the Jamuna River which would therefore require a long upstream migration to reach the sampled area.

In July, two important riverine species arrived: *kajuli*, as adults in peak breeding condition (Table 5.20), and *ghaura* as juveniles (6 g/indiv.). No new migratory species were recorded in this month. During the full flood period of August and September, riverine species *shillong* and *kalabata* appeared in catches as juveniles and adults respectively. Juvenile *boal* (500 g/indiv.) appeared in August when they accounted for 37% of the monthly catch. Most riverine species migrated from the canal site during the drawdown in October and November whereas several migratory species remained until January. Large catfish species such as *boal* and *ayre* were captured only as juveniles while catches of smaller species such as *katari*, *chapila* and *bacha* were adult or mixed adult and juveniles.

Unregulated floodplains

Between January and April 1993, sporadic low catches of a small number of riverine and migratory species were made (Figs 5.20 and 5.21). The numbers of riverine species increased moderately in May and June as the Atrai waters connected with floodplains initially via canals which later became submerged under the totally inundated floodplains by the end of June. Riverine species numbers declined slightly in July before rising sharply in August and stabilizing until November after which numbers dropped very rapidly to low winter levels between December and February. Seasonal variation in catch contribution by riverine species followed an unusual pattern with a prominent peak in June and a secondary peak during the early drawdown in October but for the rest of the year monthly values remained below 10% (Fig. 5.21).

The numbers of migratory species followed a smooth seasonal pattern in 1993/94. Numbers were lowest between January and April, rising sharply in May and June then stabilising from July to November before declining from December onwards. The rate of decline in numbers from November to January was more gradual than that of riverine species. Most species at this time year were caught in the residual waters of previously submerged canals on the

Figure 5.20 Seasonal variation in the number of riverine, migratory and floodplain resident fish species on the unregulated Chalan *Beel*, (site NW30)

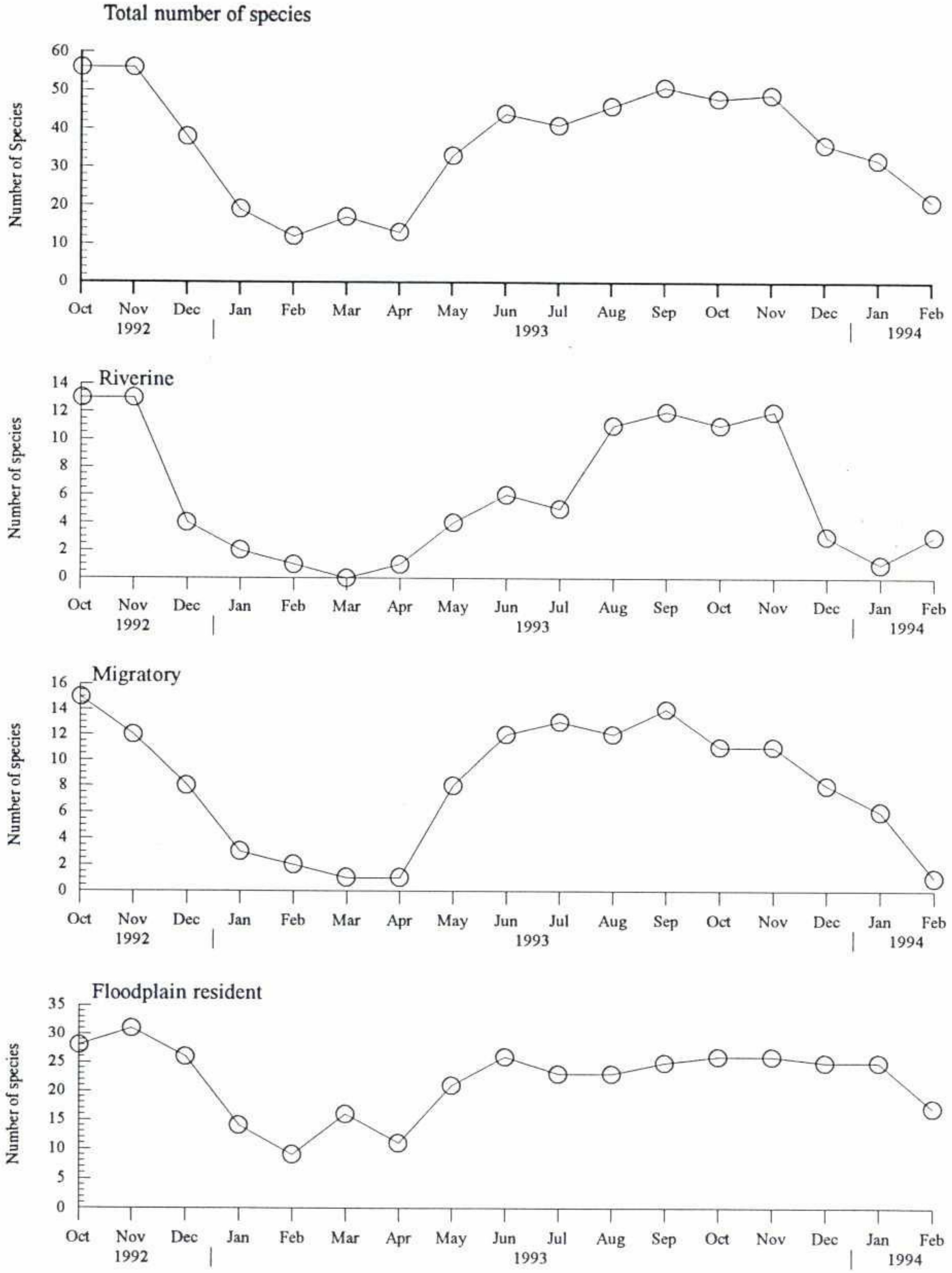


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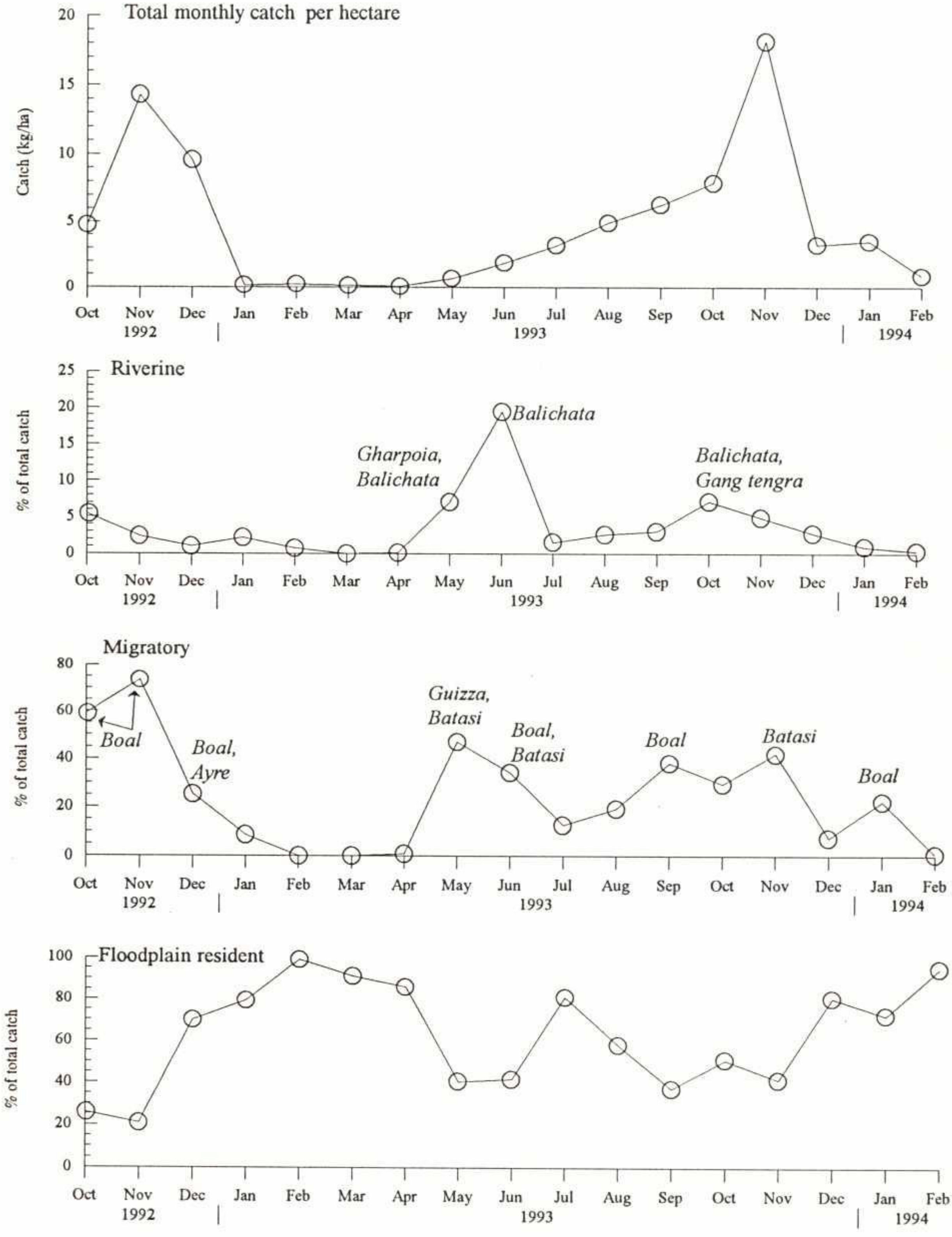
Figure 5.21 Percentage total monthly catch of riverine, migratory and floodplain resident groups of fish from the unregulated Chalan *Beel*, (site NW30)



Notes: 1. See text for definition of different categories of fish based on habitat preference (Section 5.3.2)
2. The most abundant species are shown for peak percentage catches of riverine and migratory fish; less abundant species are not shown

floodplain. Catch contributions made by migratory species during 1993/94 peaked sharply initially, in May and June, but decreased in July before rising again through the full flood period and drawdown. Percentage catches reached a minimum during the winter and pre-monsoon periods.

Numbers of floodplain resident species were lowest between January and April, increased rapidly in May and June and thereafter remained very stable until February 1994 when they declined sharply (Fig. 5.20). In contrast their contributions to monthly catches fluctuated during the flood season and reached a peak during the winter and pre-monsoon (Fig. 5.21).

During May, four riverine species appeared in catches, *balichata*, *gharpoia*, *kutakanti* and *gang tengra*. Of these *balichata* and *gharpoia* were most abundant and were captured as juveniles (3-4 g/indiv.) by *suti jal* set in a canal on the floodplain before submergence in June. Seven migratory species appeared in May, the most notable of which was *guizza* which accounted for 30% of the monthly catch. This species was captured as adults and this was the only record during the study of adult fish in the catch. Other smaller species included *batasi*, *kabashi*, *katari*, *bacha* and *chora chela* which migrated as adults and *fulchela* as juveniles.

In June, a high catch (16%) of juvenile *balichata* by *doiar* traps resulted in a monthly peak catch of riverine species (Fig. 5.21). Only one new riverine species, *kachki*, appeared in June as very small (1 g/indiv.) juveniles, probably transported by floodwaters from spawning grounds on the Atrai River. Six migratory species entered the floodplains in June. The most abundant was *boal* which was caught as juveniles (250 g). Juveniles of a second large catfish, *ayre*, were also caught together with juvenile carps, *kalbaus* (1 g), *raik* (1-3 g) and *bhangan* (3 g). In the case of *kalbaus*, these were probably not wild spawned fish. Two other migratory species, *golsha tengra* and *kabashi*, which were already well established on the floodplains by June, were present as both adults and juveniles. Data on reproductive state of fish showed that for *golsha tengra* the peak breeding season started early in May and continued until July (Table 5.20).

Although the total number of riverine species decreased slightly in July, three new arrivals appeared, juvenile *rita* and *khorsula* and adult *ghaura*. Two migratory species, juvenile *bata* and *dari*, also appeared at this time. As flood levels increased in August, the number of riverine species increased sharply. These mainly comprised newly hatched (1 g), *shillong*, *kajuli* and the *mullet*, *bata* together with adult *rani* and *putul*. The peak breeding season of *kajuli* on the Atrai occurred between July and August. Two new migratory species appeared in August, *chapila* and juvenile (5 g) *rui*. In September, two major carp species were recorded for the first time on the floodplains: *catla* as one year old fish (1.7 kg) and *mrigel* as juveniles of the year (70 g). It seems likely, in view of the size of *mrigel*, that they originated from upstream floodplain stocking programmes. *Boal* were particularly abundant in September, providing 22% of the catch. Again, only juvenile fish were captured. Indeed, although *boal* formed an important component of the catch every month up to February 1994, no adults were ever recorded.

During the drawdown in October and November, most riverine species migrated from the floodplain to the shelter of rivers followed by most migratory species about one or two months later.

Movements of floodplain resident species were more difficult to identify using temporal changes in catch compositions within and between linked sites in different habitats. This was because many dominant species were ubiquitous and were recorded on floodplains in several months of the year. For these species, there would undoubtedly exist lateral movements on to expanding floodplains by overwintering adults and/or immature fish from *beel*, canals and rivers. For some species such movements were identified from the appearance in catches in May and June following an absence of three or more months. These included *khalisha* (*Colisa labiosus*), *giliputi*, *mola*, *chebli*, *keti*, *kanpona* and *madhu pabda*, most of which were found in the Atrai River during the pre-monsoon and from where they probably moved on to the floodplains. Dominant species recorded in every month on the floodplains included *tengra*, *puti*, *bailla*, *gutum* and *guchi baim*. Most of these species or other closely related species exhibited an extended breeding season from May to September. Hatchlings and fry of late spawners would be carried off the floodplains by the receding waters and continue their development in perennial canals and rivers. Other FAP 17 studies on hatchling movements in rivers identified considerable increases in numbers and diversity of hatchlings coinciding with the occurrence of the flood recession[15].

Inside Polder B

Results presented in Section 3.2 indicated that sluice gates of Haribhanga regulator were closed after the first week in May when river levels exceeded those in Haribhanga *Khal* inside the gates (Fig. 3.4). No information on gate operations was available for April 1993 but it seems probable that gates were opened to drain rainfall runoff.

Figure 5.22 Seasonal variation in the number of riverine, migratory and floodplain resident fish species in Polder B, (site NW28)

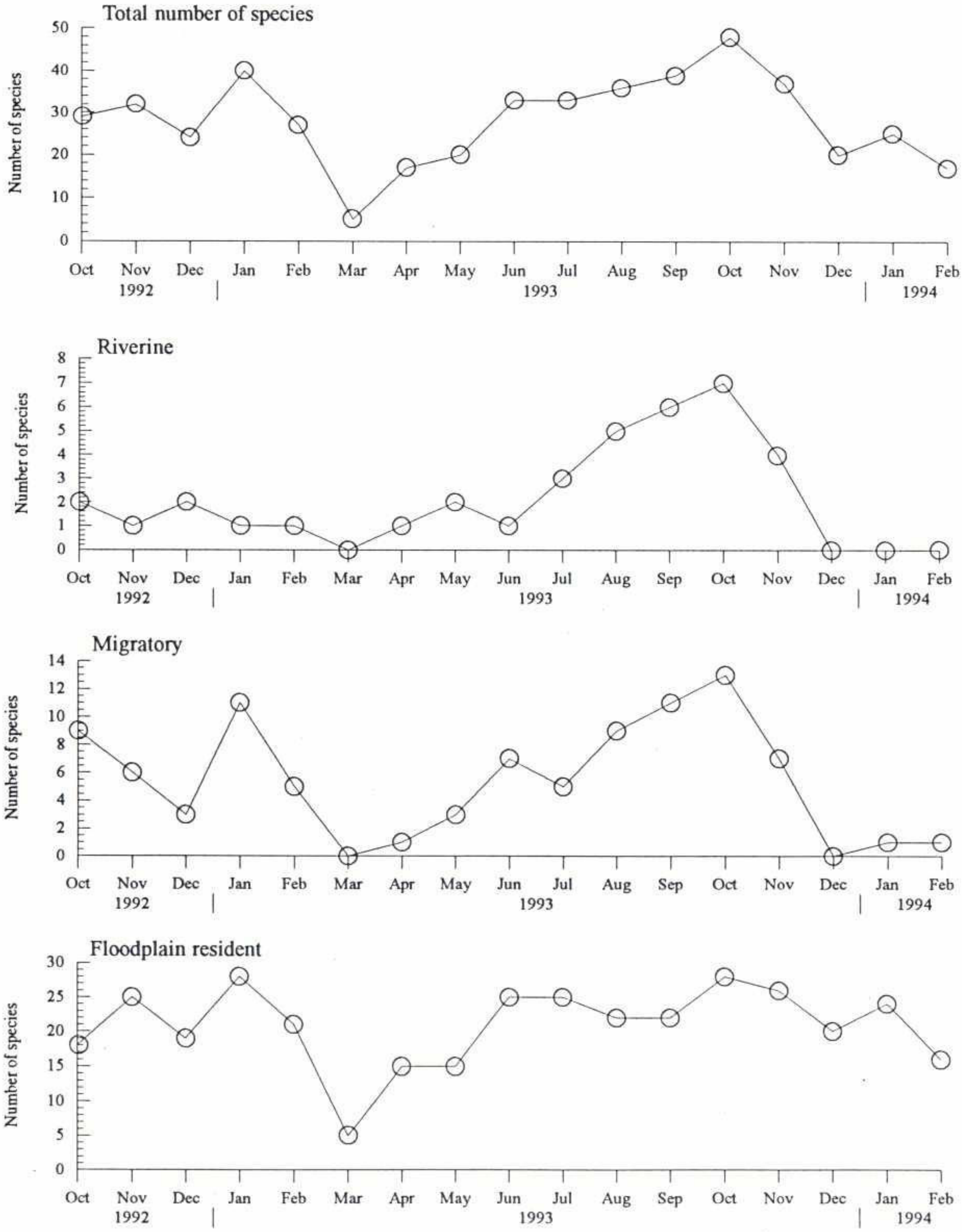
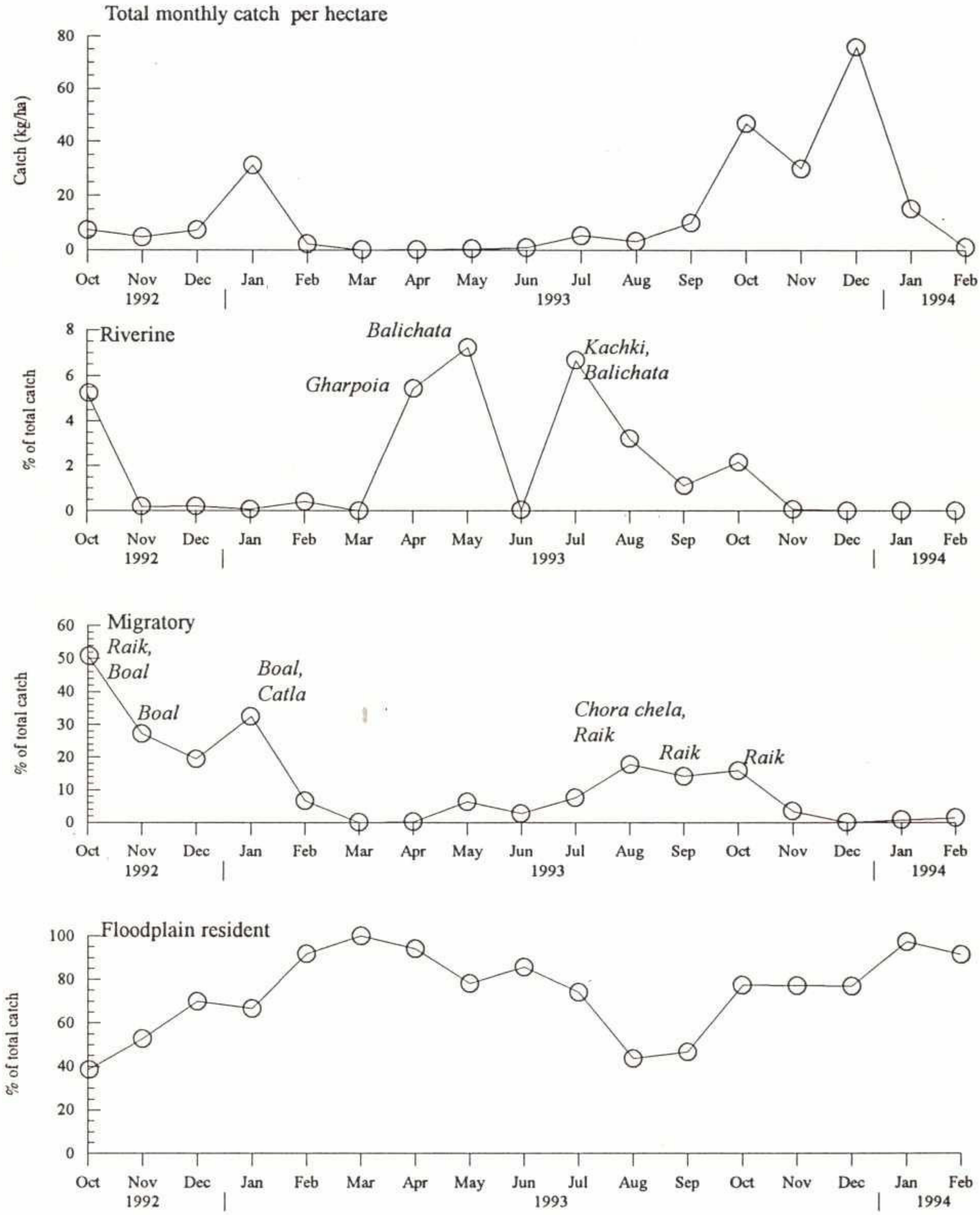


Figure 5.23 Percentage total monthly catch of riverine, migratory and floodplain resident groups of fish from Polder B, (site NW28)



Notes: 1. See text for definition of different categories of fish based on habitat preference (Section 5.3.2)
2. The most abundant species are shown for peak percentage catches of riverine and migratory fish; less abundant species are not shown

Very few riverine and migratory species were found inside the polder between April and May (Figs 5.22 and 5.23) and their contribution to the catch in May (14%) was substantially lower than that recorded from unregulated floodplains (54%). In June, when gates were probably opened partially and intermittently, only one new riverine species, *kachki*, appeared in catches but the number of migratory species increased from 3 to 8. Numbers of riverine species gradually increased through the full flood period at a rate of one or two species per month to reach a monthly maximum of seven species in October. Sluice gates remained closed from mid-July until late September; these species must therefore have entered earlier in June or July but in such low numbers that they were not detected simultaneously in catches. Of the 15 riverine species recorded in 1993/94, 11 comprised less than 1% of individual monthly catches, 8 were found in only one month and 2 more in only two months. All species migrated out of the polder in November and none was found from December onwards. Most species entered the polder as juveniles; these included *balichata* in May, *kachki* in June and species such as *ilish*, *bata* and *kajuli* which were first seen in August. Ten riverine species were found on unregulated floodplains which were absent from Polder B. These included *rita*, *shillong* and *baghair* and smaller species such as *piali* and *phasa*. However, all species were uncommon on Chalan *Beel* and together accounted for 0.4% of the annual catch. Of those riverine species which were most abundant on Chalan *Beel* i.e *balichata*, *gang tengra*, *kalabata* and *gharpoia*, their entry into Polder B, although not necessarily delayed, was nevertheless so highly restricted by gate closures that their contributions to the annual catch were considerably reduced.

The first migratory species to appear in May were *golsha tengra*, *fulchela* and *batasi*. The first two species are capable of surviving on floodplains throughout the year and may not therefore have migrated into the polder at this time but rather have spent the winter in very low numbers in *kua* or in residual pools and *khal* remaining on the floodplain. These two species were found in peak breeding condition between May and June and in August respectively. In June, *katari*, *chora chela* and *kabashi* entered the polder as adults and *chapila* as juveniles (1 g). The most abundant of these was *katari* which comprised 1.6% of the monthly catch and was found in peak breeding condition; the rest comprised less than 0.5%. No new species were recorded in July but in the following month juvenile *raik* (1-10 g) and *kalbaus* (12 g) were caught. Both carps probably entered the polder between late June and early July as fry or, in the case of *raik*, as hatchlings. The only other notable appearances in the catch by new species were the major carps, *rui* in September, *catla* and *mrigel* in October and the catfish *boal* also in October. All were taken in low numbers as juveniles. In the case of *rui* and *mrigel*, these were young of the year (29-66 g) whereas *catla* were possibly one year old (855 g). The origin of the carps is unclear but stocking programmes cannot be ruled out.

During November there was a mass migration out of the polder by all migratory species. This contrasts with the more gradual migration from unregulated floodplains in December and January. Reasons for this distinct difference in fish movements inside and outside the polder remain unclear. It might be expected that gate closures in early December and the longer retention of flooding inside the polder in December would also encourage the retention of migratory species but clearly this was not the case.

In comparison with unregulated floodplains, five migratory species were absent from the polder: *ayre*, *guizza*, *bata* (*L. bata*), *boga* and *dari*. These species were not particularly common on unregulated floodplains where together they formed only 0.8% of the annual catch.

The number of floodplain resident species remained unchanged between April and May but rose sharply in June indicating ingress of several species from the Atrai River (Fig. 5.22). Those species which appeared in June but which were absent from catches during the previous three months included *khalisha* (2 species), *kaikka*, *phutani puti*, *mola*, *chebli* and *ayre*. Three of these, *khalisha* (*C. labiosus*), *mola* and *chebli* also moved on to unregulated floodplains from the Atrai River during the same month.

From June until November, the number of floodplain species remained relatively stable but decreased somewhat between December and February 1994. Contributions to monthly catches were highest between February and April and gradually declined until September principally due to the increasing relative abundance of prawns. Comparison of the timing of breeding seasons of selected floodplain resident species on floodplains inside and outside the polder showed no clear impact from flood control (Table 5.20).

6 FUTURE FLOOD CONTROL PROPOSALS IN POLDER B

6.1 The Fourth Flood Control and Drainage Project

As part of the Fourth Flood Control and Drainage Project, a draft final report[3] on Chalan *Beel* Polders A B C and D presented in February 1992 to BWDB, recommended rehabilitation of all polders to full flood control capability. The report noted that the ineffectiveness of Polders C and D in particular was caused by repeated public cuts in embankments. It added that the breaching problem should be solved at a "social level" rather than at an engineering level. The report suggested that there should be no further embanking on the left side of the Atrai. High EIRRs were reported for the four polders.

6.2 North West Regional Study (FAP 2)

As part of the Flood Action Plan, the North West Regional Study (FAP 2) examined the Atrai basin in detail and took into account the findings of the above study and other relevant FAP studies e.g. FAPs 12[16] and FAP 13[17] in the formulation of its own recommended development programme[2]. Planning for the region was based on three broad objectives. The main objective was to create, as far as possible, a stable flooding regime which would give people the ability to plan their lives with confidence. The second aim was to create a sustainable pattern of development which balanced the requirements of agriculture, fisheries, navigation, groundwater and the environment. The third objective was to safeguard lives and property at the time of major floods.

Within these broad objectives a number of other principles were applied. The most significant of these was the full recognition and account taken of the impacts of flood protection measures on adjacent and downstream areas. This point is particularly important in the Atrai basin where flood control in one area has invariably resulted in increased water depths or discharges and consequent adverse effects elsewhere. On many occasions this has led to the cutting of flood control embankments by people in an attempt to reduce water level differences between protected and unprotected areas. In the ten years since 1982, there have been over one hundred public cuts in the embankments of Chalan *Beel* Polders B, C and D, the great majority of which were in Polders C and D.

The FAP 2 and FAP 12 studies concluded that the extensive full flood control works along the lower Atrai had not performed well because of increased water levels, public cuts in embankments and consequent damage. Continued full flood protection along lower Atrai was therefore considered by FAP 2 to be an unfeasible solution and an unacceptable development scenario. This contradicted the recommendations made by the Fourth Flood Control and Drainage Project on the grounds that continued public cutting of embankments was an inevitable reaction to inequities of expected benefits and real harm caused between people inside and outside the embankments. The issue of relative gains and losses was considered by FAP 2 as crucial to the effectiveness and acceptability of any large FCD project and therefore one which had to be addressed clearly and directly. FAP 2 further noted that the high EIRR values reported for Polders A, B, C and D were dependent on full and effective flood control and that for these returns to be achieved, absolute effectiveness of flood control operations and full farmer confidence were required. Experience in Chalan *Beel* indicated that neither could be guaranteed.

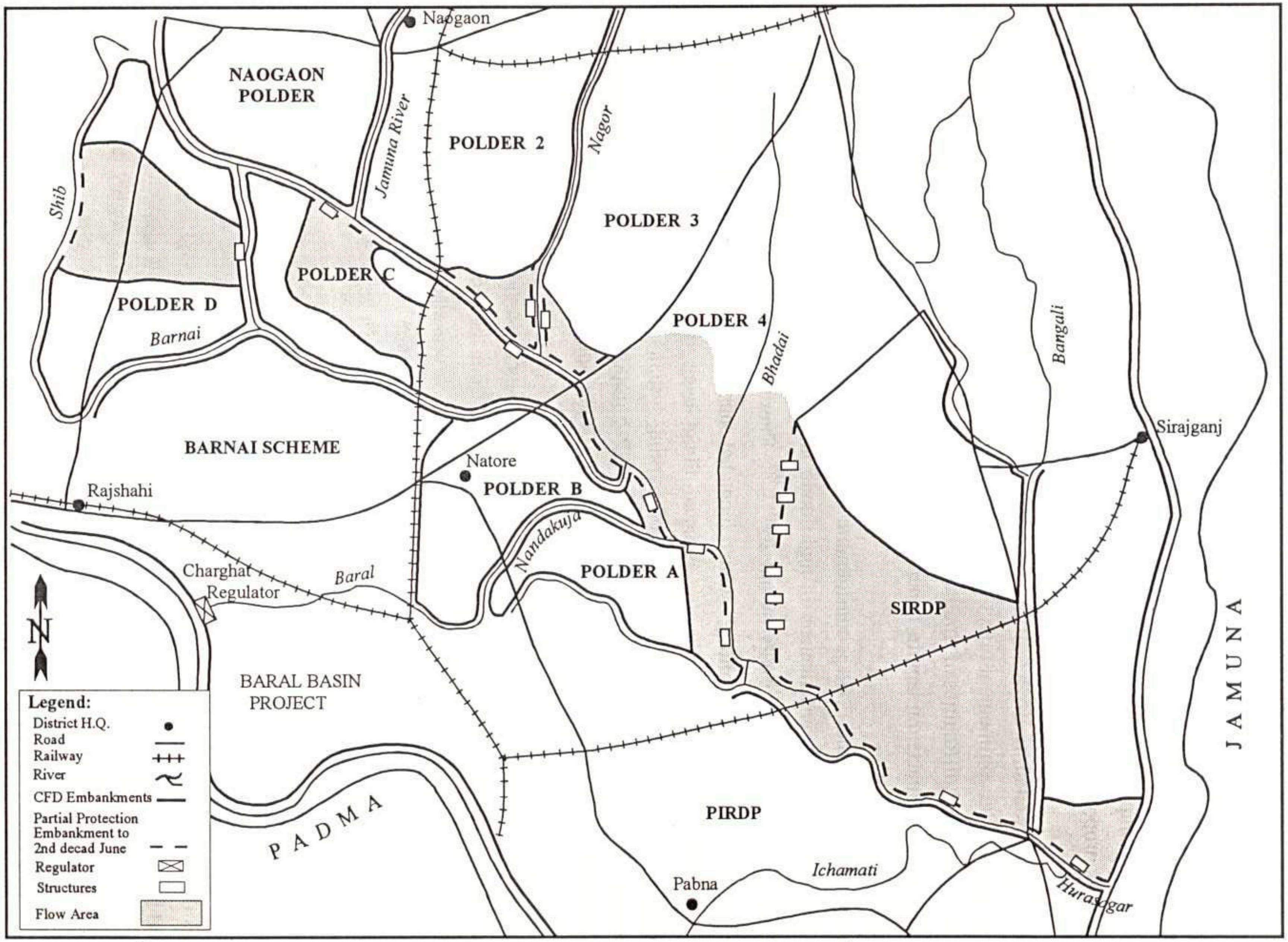
Several alternative developments were investigated by FAP 2, including major drains to divert water entering the lower Atrai and channel it to the main rivers, thus considerably reducing the amount of water in the Atrai. These were found to be unfeasible. Another engineering solution suggested was a large regulator at the Hurasagar outfall. However, FAP 2 recognised that the problem at the outfall was the constraint set by the level in the Jamuna rather than backflow from the Jamuna to the Atrai, and concluded that this solution would prove ineffective.

6.3 The Green River Approach

The development approach finally recommended by FAP 2 was termed the "Green River". The title was selected to emphasise the more "environmentally friendly" aspects of the approach compared with previous attempts at full flood control by poldering the lower Atrai basin.

The Green River approach includes provision for partial flood protection near the Atrai, so that the peak monsoon river water flows over the adjacent low-lying floodplain, as it would have done in its natural state (Fig. 6.1). Away from the river, at a distance of 5 to 10 km from the channel and on generally higher ground, existing infrastructure, particularly village roads, would be used to provide controlled flooding and drainage. By providing a combination of partial and greater flood control on low and high grounds respectively, it was anticipated that a more predictable and stable flooding regime would be provided than that obtained by previous attempts to exclude completely peak floods from all areas.

Figure 6.1 The Green River with partial protection



Source: FAP 2, 1993[2]

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In Polder B, two engineering options were proposed. The first involved partial protection by submersible weirs for low-lying areas (approx 3,500 ha) adjacent to the Atrai and Barnai rivers and controlled flooding and drainage measures for the remaining area of generally higher land. The second option depended on whether sufficient flow width and storage area were made available on Chalan *Beel* on the left bank of the Atrai opposite Polder B. If so, then "more comprehensive" flood control for the whole of Polder B, including the low-lying areas, was proposed. The FAP 17 study area in Polder B was located in this low-lying zone.

The advantages cited by FAP 2 of the new approach over historical FCD attempts included a reduction in the confinement effect on the Atrai and lower river levels which would also reduce operational difficulties of flood control. In addition, the project anticipated reductions in the negative impacts on capture fisheries and increased groundwater recharge.

During the course of the FAP, a considerable number of non-structural measures to reduce or avoid the damaging consequences of high floods have been identified and studied in detail by two supporting projects, FAPs 14 and 23 [18, 19]. These were collectively grouped under the general term "flood proofing" which included such measures as raising important infrastructure on platforms above the expected flood level, providing secure stores for emergency relief and grain and instituting flood warning systems. In areas of the lower Atrai where partial flood protection was recommended, FAP 2 proposed that such measures should be established as an integral component of the Green River approach.

The FAP 2 study reported that there had been a remarkable increase in the production of rice from the Chalan *Beel* area, but this was mostly derived from the introduction of irrigated HYV *boro* rice which was not dependent on flood control. It was also reported that farmers would be satisfied if they could obtain a reliable crop of *b. aman* in most years rather than attempt growing the higher yielding *t. aman* which was subject to greater risk by flood damage especially when public cuts in embankments were made.

Historically, flood control and drainage projects in the area were designed to exclude completely external river flooding and thereby convert low-lying seasonal wetlands to drier areas on which *b. aman* could be replaced by HYV *t. aman*. Indeed, cost-benefit analyses relied heavily on the increased returns from this crop conversion for their apparent economic viabilities. FAP 2 recognised, with hindsight, that such an approach was highly ambitious and unrealistic. Instead, the Green River approach was designed to allow considerable agricultural production through the provision of more gradual flooding on low land for the production of *b. aman* or transplanted deepwater rice (and fish) and greater flood control and drainage on higher land where HYV *t. aman* could be produced.

In low-lying areas, partial flood control was recommended by FAP 2 not primarily for the protection of the *boro* rice harvest which is its usual function in other parts of Bangladesh, particularly the North East Region, but for controlled rate of rise of monsoon water levels so that transplanted deepwater *aman* (TDWR) could be grown. The need for pre-monsoon protection of *boro* was not seen as critical in the Lower Atrai basin because of the generally late rise in river levels. This conclusion is supported by data in Figure 3.5 which show that only once (1993) in the past 16 years have river levels increased sufficiently in May to pose a threat to the *boro* harvest, and that even in that year, the crop was successfully harvested from unregulated floodplains of Chalan *Beel*.

Transplanted deepwater aman is reported to be a fairly recent innovation in the North West Region but one which is spreading[2]. This method of planting arose from the difficulty in double-cropping. HYV *boro* rice and *b. aman* because of the overlap in times of harvesting the former (May - June) and preparing the land and planting *b. aman* (March - May). As HYV *boro* rice increased during the eighties, the area planted and production of *b. aman* declined both regionally and nationally (Fig. 6.2). However, on low-lying lands which flooded deeply during the monsoon, farmers sought ways of obtaining two rice crops, the most important cash crop being the HYV winter rice where reliable irrigation facilities were available. By transplanting DWR in these areas in early June, immediately following the harvest of HYV *boro*, farmers succeeded in obtaining a second rice crop. Unfortunately, this important shift in agricultural practices has not been recorded in the Government agricultural statistics since transplanted deepwater rice is not recorded separately from local varieties of transplanted rice which require shallower flooding. Qualitative observations from the FAP 17 study suggest that this practice is now widespread in Bangladesh since both HYV *boro* rice and deepwater rice were present on most sampled floodplains. An earlier, very detailed study of cropping patterns in deepwater rice fields in four districts of Bangladesh revealed that 23% of farmers in Tangail district had already adopted a double-cropping system of HYV *boro*-TDWR by 1983[20].

On low-lying floodplains immediately bordering the Atrai where partial flood control was recommended, the method by which this control would be achieved was not specified in detail by FAP 2. Without such specification, it is not possible to anticipate potential adverse

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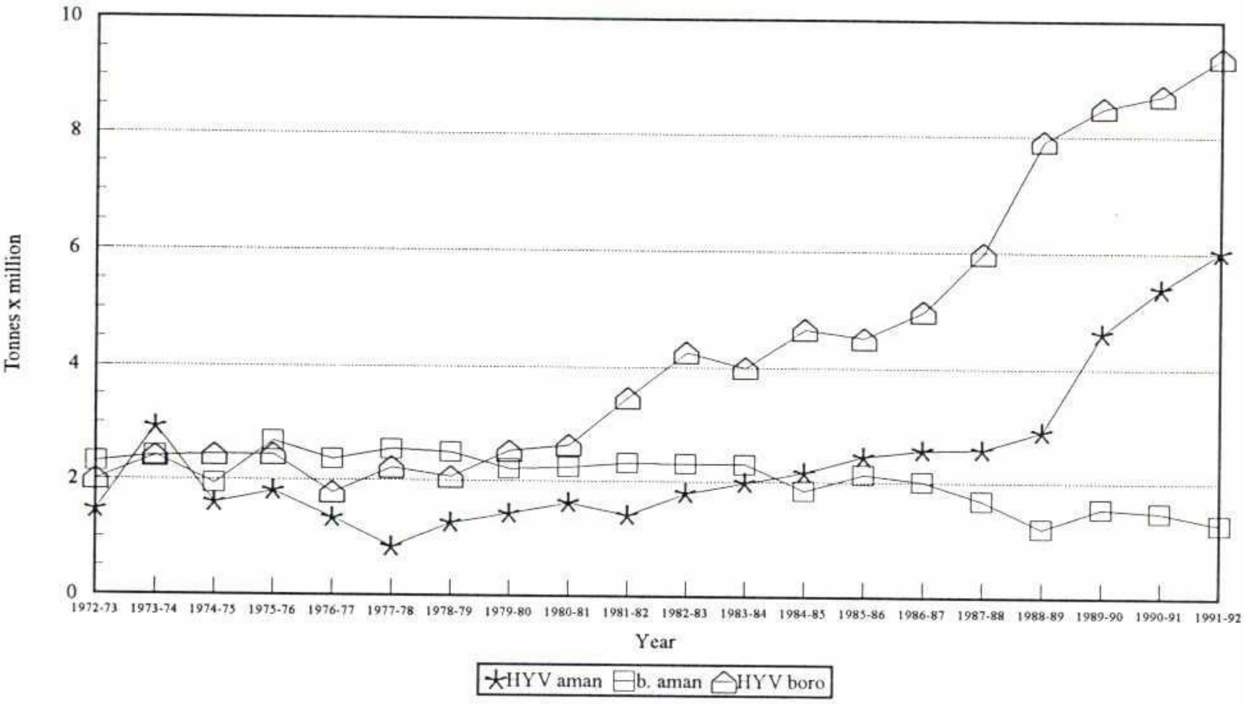
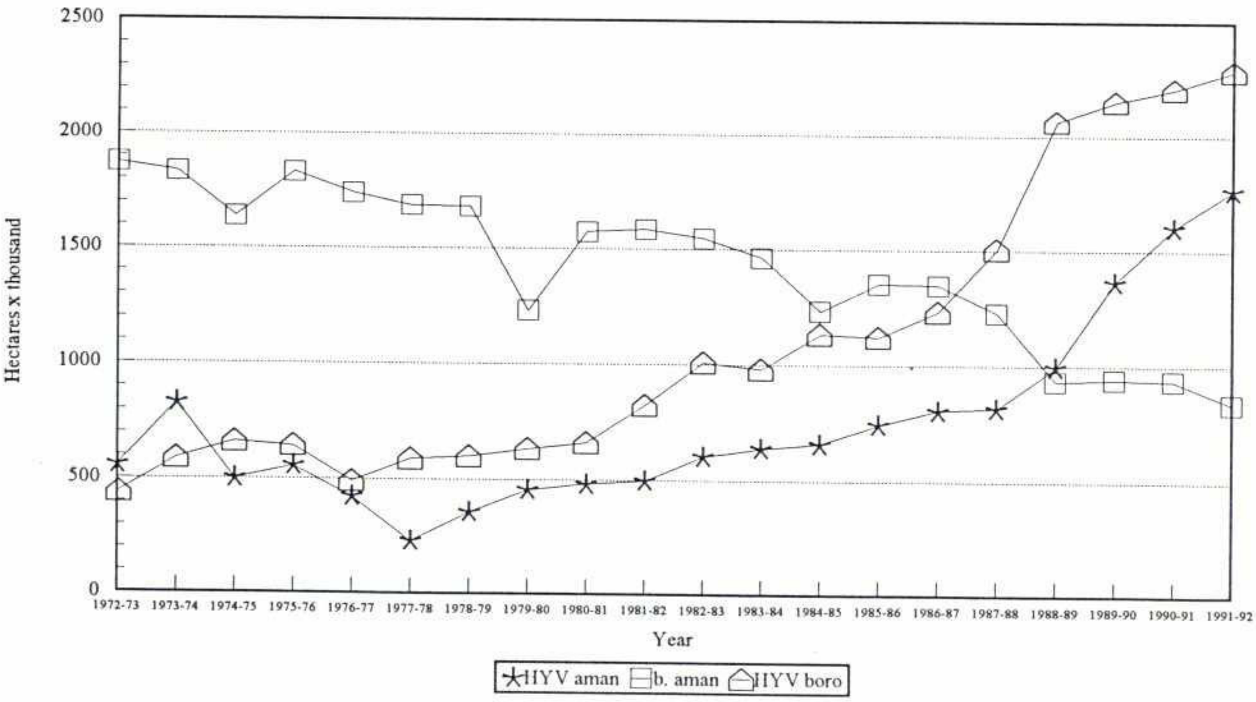
Figure 6.2 Trends in national rice production

(a) Rice Production



(b) Area Planted



Source: BBS (1985-1992)[21]

impacts on fisheries. On areas set back from the river where controlled flooding and drainage was recommended, FAP 2 proposed that this should be achieved using fixed weirs whose crest heights would be set at a suitable level to provide protection for a 1 in 20 year flood level up to 10 June to protect the HYV *boro* harvest, or at a 1 in 20 year level up to 20 July to provide protection for transplanted deepwater *aman*.

The need to protect the *boro* harvest was already reported by FAP 2 not to be critical in the lower Atrai basin; the inclusion of this objective for flood control cannot therefore be justified. The need for the stated level of protection of TDWR was based on the assumption that this crop is planted in early June and cannot tolerate flooding at depths greater than 0.3 m for the first 6-8 weeks after transplantation[22]. Further investigations on the early water tolerances of different varieties of TDWR should be undertaken before the establishment of such severe flood control measures.

In low-lying areas of partial flood control, FAP 2 again anticipated protection of TDWR until 20 July (Fig. 6.1). The level of protection would obviously depend on the flood return period. For instance, a 1 in 20 year level of protection can hardly be described as partial flood control; instead this would be very similar to the worst case of full flood control seen in several polders on the right bank of the Atrai that have a history of repeated public cuts. A return period of a 1 in 2 year flood, would, on the other hand, result in far less change to the natural flooding pattern of the river which is reported to be the prime objective of the Green River approach.

6.4 Impact of Green River Project on Fisheries

6.4.1 Partial flood control

In the absence of detailed specifications of the method and degree of partial flood control in Polder B it is not possible to predict, other than in general terms, potential impacts on fisheries. Figure 6.1 indicates that partial flood control would prevent river flooding in the lower areas of Polder B until 20 July. If regulator gates are used to achieve flood control, then adjustments are possible each year. If fixed weirs are used, then crest heights must be set for a certain flood return period. The lower this is, the less change will occur in natural flooding patterns.

Both methods would result in a delay in entry of adult and juvenile fish. For these species, the duration of growth season within the polder would therefore be shortened, resulting in lower production. Species diversity would also be reduced up to 20 July or longer depending on the flood return period for which weirs would be designed. During May and June, 11 migratory and riverine species entered the polder compared with 20 species which entered the unregulated floodplains of Chalan *Beel*. It therefore seems likely that at least 20 species would be prevented from entering the polder until 20 July under partial flood control.

The temporary loss in fish production and diversity caused by delayed entry of fish on to regulated floodplains may be compensated by the later (post 20 July) entry of river floodwaters and fish. The degree to which compensation is possible cannot be predicted accurately since it is not known what proportion of the catch of riverine and migratory species made after July on unregulated floodplains was dependant on the entry of hatchlings, juveniles or adult fish earlier in the season.

Assuming the Green River approach achieves its objective of providing a more gradual flood with a lower maximum level, there may be no strong agricultural justification for partial flood control on low-lying floodplains. A situation whereby the low floodplains are allowed to flood freely, unhindered by partial flood control measures, would improve fisheries in the long-term through increased diversity, productivity and sustainability of fish populations. The introduction of several fisheries management and development strategies within these free flooding areas would increase the likelihood of successful, sustainable improvements. These are outlined in Section 7.

6.4.2 Controlled flooding and drainage

Low Floodplains

Rehabilitation of Polders A, B, C and D to full flood control capability was recommended in a recent study undertaken as part of the Fourth Flood Control and Drainage Project[3]. Although FAP 2 rejected this recommendation in its own proposals for the development of the lower Atrai basin, it included the option of more comprehensive controlled flooding and drainage measures for the whole of Polder B, including low-lying areas adjacent to the Atrai and Barnai rivers.

Listed below are the potential impacts on fisheries of these low-lying floodplains in Polder B, assuming full flood control was established as recommended in the first study mentioned above.

1. Loss of fish production

Decreases in flood magnitude, area and duration would result in a reduction in fish production from regulated low-lying floodplains. Without details of quantitative changes in flooded areas it is not possible to predict the magnitude of fisheries losses. However, if the low floodplains on Polder B could be converted into drier land suitable for the cultivation of HYV *t. aman*, a task which seems impossible given the drainage problems of the area, then there would be a reduction from the current rate of 189 kg/ha to approximately 14 kg/ha which is the average production from regulated floodplains used for HYV *t. aman* cultivation in the PIRDP[11]. The loss of 175 kg/ha of fish from about 2500 ha of lowland represents an annual loss of 438 tonnes of fish with an on-site value of 11 million taka (at 25 tk/kg). This amount of fish is equivalent to the average consumption (using per capita 20 g/day) of about 60,000 people within this part of the polder.

2. Reduced biodiversity

Complete closure of sluice gates to prevent river flooding of *t. aman* fields would result in a loss of riverine and migratory species. These groups together totalled 42 species on the unregulated floodplains opposite Polder B and accounted for 53% of the total species found in this area. Thus full flood control would lead to a reduction in species diversity of at least 53%, possibly more, since the number of floodplain resident species may also be reduced.

3. Increased fishing pressure

Resident fish species remaining on fully protected floodplains would be subjected to increased fishing pressure on a considerably reduced flooded area. The long term impact of such high fishing pressure on a significantly modified fish community is likely to be highly damaging. It is also probable that the reduction in species heterogeneity would result in a less stable fish community, since there would be fewer species but possibly high numbers of a few dominant ones. Under these conditions disease outbreaks may be more frequent and damaging. This may account for the perception in some studies that the incidence and severity of the disease known as epizootic ulcerative syndrome (EUS) are greater within flood controlled areas[23].

Unfortunately, no quantitative studies have been carried out in Bangladesh to investigate either the impact of increased fishing effort on floodplain fisheries or the impact of EUS on fish populations inside and outside flood control projects. These are areas which require further research.

4. Reduced dry season habitat

A reduction in the areal extent and duration of the monsoon flood which is essential for the production of HYV *t. aman* on lowland may result in a reduction in groundwater recharge. This is an issue of some contention for which an independent, detailed and comprehensive hydrological investigation is needed. It has been reported that surface waters and groundwaters in Bangladesh comprise a single conjunctive resource and that any major change in the rate of abstraction from either would directly affect availability of supplies from the other[24]. Reduced areas of flooding on low-lying land resulting from flood control could be viewed as one form of abstraction from these floodplains.

A reduction in groundwater has several potential adverse impacts during the dry season. First, the numbers and size of perennial water bodies are likely to decline. This means that there would be a reduction in habitat at a critical period for many overwintering fish. As a result, there would be a reduction in the broodstock of many species which would in turn lead to a reduction in fish production during the monsoon caused by a lowering in recruitment rates of juveniles.

Secondly, with fewer perennial waters to fish, there would be increased fishing pressure on those remaining. Any reductions in size and depth of water bodies would also result in increased ease of capture of fish. The two effects, when combined, would probably lead to the elimination of the overwintering population. If water bodies are reduced sufficiently in size to enable further abstraction by pumping, this too would result in the elimination of the broodstock fish.

Thirdly, reduced groundwater levels during the dry season would seriously hinder the production of HYV *boro* rice and encourage pumped abstraction from any remaining residual surface waters, again with the consequent elimination of the overwintering fish populations which they support.

2of

5. Reduced habitat diversity

Under HYV *t. aman*, most of the floodplain receives only shallow flooding during the monsoon season and the only areas of deeper water would be scattered small depressions. In contrast, under deepwater *aman*, depths range from more than 3 m in the centre of *beel*, where fields generally remain fallow because of excessive water depths, and thus provide an opportunity for the growth of dense and diverse stands of rooted aquatic vegetation which in turn provide numerous niches for different types and life stages of fish. At the same time these areas provide a habitat which supports open access fisheries. In the rice fields themselves, water depths generally range from 1.5 to 3.0 m and not only provide a heterogeneous environment but also offer substantial protection from many types of fishing gears which are prohibited by farmers because of damage to their crops e.g. gears such as *ber jal*. Thus there is a form of regulation of fishing effort in DWR fields which is not found in open waters. This mix of two contiguous environments whereby one provides shelter, protection and food while the other allows open access fisheries to exploit fish stocks, cannot be matched by the restricted environment provided by HYV *t. aman*.

A further incidental but potentially important benefit to fisheries provided by deepwater rice production is the removal of dense blankets of water hyacinth which can smother *beel* unless removed manually and also damage rice fields. The removal of water hyacinth should increase phytoplankton and zooplankton populations which form the food of many juvenile and some adult fish and increase epiphytic algal growth which also provides food for many fish and should therefore result in increased fish production.

6. Reduced mitigation options

Since full flood control designed for the production of HYV *t. aman* on low-lying floodplains necessitates exclusions of river flooding by complete gate closure, there remains no scope for the establishment of mitigating measures based on integrated river water management. In contrast, the production of deepwater rice with partial flood control allows the possibility of further mitigating measures since there is a high degree of compatibility between the water requirements of deepwater *aman* and fish.

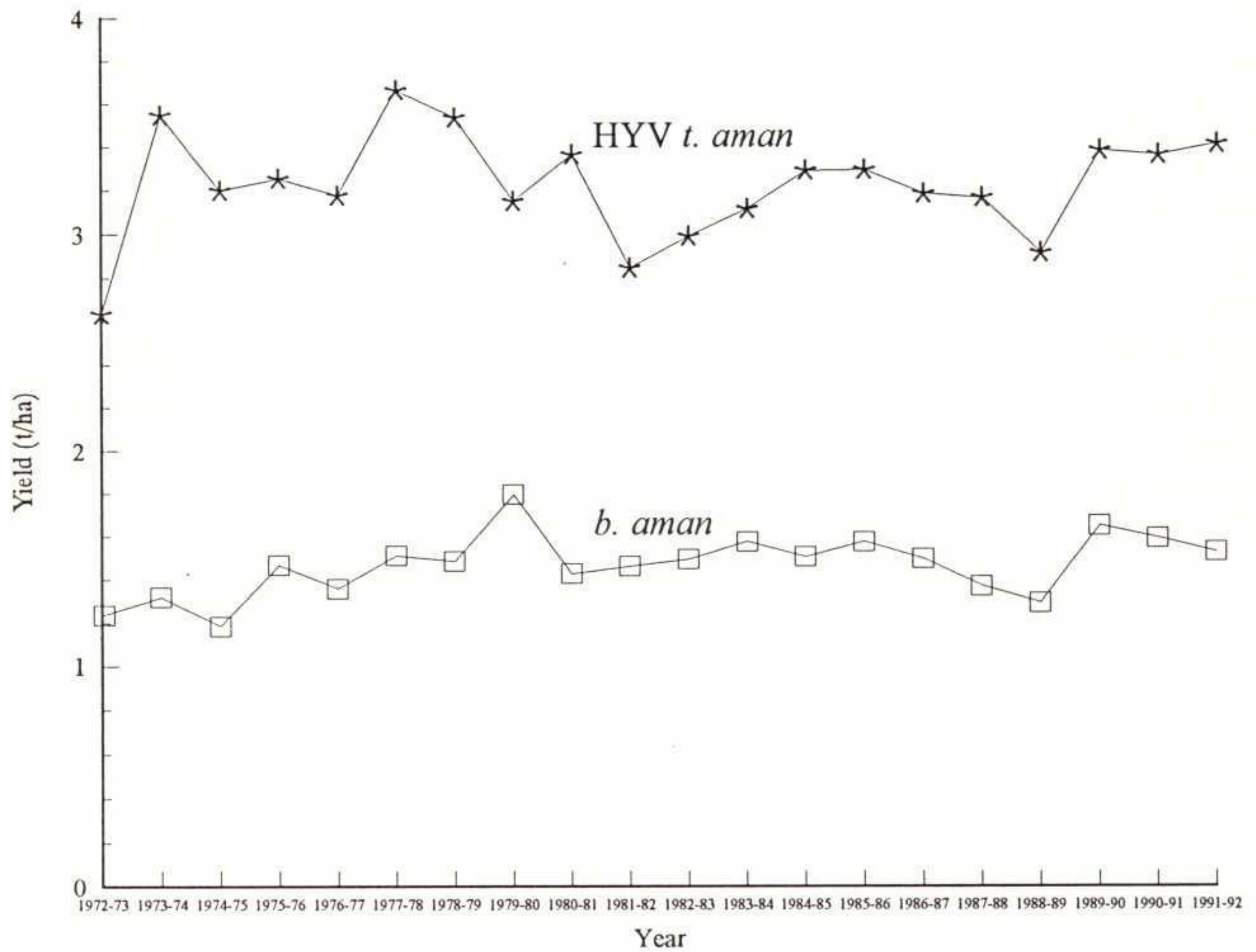
High Floodplains

Under the proposed Green River Project, flood control embankments and fixed weirs would be constructed some distance from the Atrai River to protect generally higher land but in some cases lowland, from severe, less frequent flooding (Fig. 6.1). The route taken by these embankments would generally follow existing infrastructure, particularly village roads. While this is obviously the most practical and cheapest approach to embankment construction, a more accurate siting of such embankments should be determined broadly by land type. The majority of low land (F2-F4) should be allowed to flood freely for the production of deepwater rice and fish whilst controlled flooding on higher land (F0-F1) would facilitate the production of HYV *t. aman*. In Polder B, all low-lying areas east of the isthmus of the Nandakuja and Barnai rivers should be allowed to flood freely. The fisheries on higher land in Polder B were not surveyed by FAP 17; it was therefore not possible to assess the impact of the proposed flood control measures.

6.5 Comparison of HYV *t. aman* and Deepwater *aman* Rice on Low Floodplains

In addition to the harmful effects on fisheries of growing HYV *t. aman* rather than deepwater *aman* on low wetlands, there are several agricultural advantages in the continued production and development of deepwater rice. In a detailed and comprehensive review, Catling[5] dispelled certain myths surrounding deepwater rice. The most important of these was that yields of DWR are low and usually less than 1 t/ha. Using the most complete data available for Bangladesh, Catling showed that between 1977 and 1979 yields of unmilled paddy from several districts averaged 2.3 t/ha. This study was based on crop cuts from 291 fields of which 13% yielded between 3 to 4 t/ha. The average yield was about 50% higher than those reported in annual government statistics which indicated an average yield of about 1.5 t/ha (Fig. 6.3). National statistics indicated that recent average yields of HYV *t. aman* and *b. aman* were 3.4 t/ha and 1.5 t/ha respectively, a difference of 1.9 t/ha. In contrast, a survey of 423 farmers in the North West Region carried out in 1991 by FAP 2, indicated that yields of HYV *t. aman* and *b. aman* were 3.2 and 2.0 t/ha respectively, a difference of only 1.2 t/ha[22]. In a survey of Chalan *Beel* Polders A, B, C and D, yields of 2.34 t/ha and 1.46 t/ha of HYV *t. aman* and *b. aman* were reported in 1991, a difference of only 0.9 t/ha between the two crops[3]. Yields of 3.2 and 1.9 t/ha of HYV *t. aman* and *b. aman* were reported from a survey carried out in 1991 in the lower Atrai basin as part of a study of the Pabna Irrigation and Rural Development Project[25]. It is clear from these results that the differences between the yields of HYV *t. aman* and *b. aman* are not as large as the values derived from national statistics which may often be applied in economic analyses of the performance of flood control projects. It is also clear that the yield of just over 3 tonnes/ha of HYV *t. aman* reported by farmers in the North West Region is well within the upper range of yields of *b. aman* recorded in various regions of the country. Catling[5] concluded that the yield potential

Figure 6.3 Mean annual yields (t/ha unmilled paddy) of HYV transplanted *aman* and broadcast *aman* rice, 1972 - 1991



Source: Derived from data in BBS, (1985-1992)[21] for the best traditional varieties of *b. aman* in Bangladesh was about 4 tonnes/ha. However, in areas of flood control he believed that the development of new varieties of deepwater rice may produce 5 tonnes/ha. The reduced differential between yields of *t. aman* and *b. aman* has considerable implications for the economic viability of many flood control projects, especially when the value of high fish losses associated with HYV *t. aman* production are also taken into consideration. Under these circumstances it seems probable that many projects would fail to produce viable levels of EIRR.

Deepwater *aman* rice is produced principally on small farms ranging in size from 0.6 to 1.3 ha [20, 26]. It is a highly versatile and diverse crop with a staggering 2000 cultivars (varieties) grown in the varied agroecological niches of Bangladesh. Such diversity facilitates a complex and rich variety of cropping patterns which farmers rely on to adjust to changes in flooding patterns between years. Deepwater rice is a valuable crop for the small subsistence farmer since it requires only a small cash input and, although a labour intensive crop, much of the labour can be supplied by the family and the crop mixed with others to spread the risk of loss or damage. Other increased benefits obtained from deepwater *aman*, as opposed to HYV *t. aman*, include a valuable supply of fresh cattle fodder which can be cut from the rice plant during its growth period without affecting rice yield. The crop also provides higher yields of good quality straw used for cattle fodder or thatching, while the stubble is a major source of fuel in rural areas and serves also as a mulch for dry season crops.

7 RECOMMENDED MITIGATION MEASURES

Several mitigation measures are listed below. The first six are directly relevant to Polder B and other areas of the lower Atrai basin and are recommended for implementation in the short or near term. The others involve broad institutional development, mainly within BWDB/WARPO, and are therefore of a longer term nature.

The proposed mitigation measures and the results upon which they are based question a principal rationale of flood control: to convert low-lying wetlands to drier land where deepwater rice can be replaced with HYV *t. aman*. Experience in Bangladesh has shown that most flood control projects have failed, for one reason or another, to achieve this objective. An alternative approach advocated by the North West Regional Study (FAP 2) for partial flood control on lowlands, to allow the production of *b. aman* or transplanted deepwater *aman*, would cause considerably less damage to fisheries providing that the degree of flood control does not substantially alter normal flooding patterns, especially during the early monsoon.

Formulation of the mitigation measures listed below drew a distinction between mitigation, i.e. measures to reduce losses to capture fisheries caused by flood control, and compensation, i.e. measures to replace such losses by culture-based techniques. Only mitigation measures are listed below. This does not imply, however, that aquaculture developments should not be encouraged. Indeed, the ODA has supported work in various aspects of fish culture in Bangladesh for many years, covering activities such as pond culture, cage culture, rice-fish culture and open-water stocking of floodplains. Many of these techniques could be developed further inside and outside areas of controlled flooding. The greater area of Polder B comprising higher floodplains provides suitable habitats for such small-scale aquaculture developments.

However, FAP 17 studies[27] have shown that considerably greater economic benefits can be derived through mitigation measures from small potential increases in capture fisheries over wide areas compared with those from aquaculture development in the same areas. Future work should therefore focus on mitigation measures.

1. Production of deepwater rice

On the low-lying floodplains of Polder B and similar areas within the lower Atrai basin, the most effective mitigation measure to reduce losses to capture fisheries caused by flood control is to allow a degree of river flooding necessary for the production of deepwater *aman*. The FAP 2 study recommended in its Green River approach, partial flood control on low-lying floodplains bordering the Atrai, particularly along its left bank. However, since river flooding does not normally threaten the security of harvesting winter rice in the lower Atrai basin, the need for even partial flood control is questionable. The low floodplains of Polder B and the rest of the lower Atrai basin might therefore be allowed to flood freely. This should cause the flood to rise more slowly to reduced maximum flood depths over wider areas, resulting in greater potential production of both rice (deepwater *aman*) and fish during the monsoon season. If, on the other hand, full flood control were implemented in Polder B and similar areas in the lower Atrai basin, and assuming there were no public cuts in embankments, considerable fish losses would follow. In addition, biodiversity would be reduced by at least 53% and the few remaining dominant species would be subjected to increased fishing pressure since the area available for fishing would be significantly reduced in both the wet and dry seasons. Under full flood control conditions, with complete sluice gate closures to exclude external river waters, mitigation measures relating to integrated river water management would not be possible.

2. Rehabilitation of dry season habitats

Siltation has resulted in the reduction and, in extreme cases, the disappearance of small perennial *beel* and old river/canal courses on unregulated floodplains of Chalan *Beel* and possibly within Polder B. These areas should be deepened by dredging and the excavated material used to raise the height of structures such as houses or food stores as part of complementary flood proofing measures. These deep water areas would be too deep for the production of deepwater *aman* and would therefore provide areas of open-water fishing during the monsoon. Silted canals should also be excavated to ensure early connection with rivers. Sills should be constructed using changes in gradients of canals to maintain pre-monsoon rainfall flooding levels in areas surrounding the *beel*.

3. Fisheries conservation

Dry season fish sanctuaries should be established using *beel* and *kua* to protect overwintering broodstock. This measure is designed to reduce the negative impacts of increased fishing pressure during the dry season which can result in decreased fish productivity. It is anticipated that protection of overwintering broodstock would result in increased recruitment of juveniles to the fishery which in turn would lead to increased productivity.

4. Retention of links between the lower Atrai basin and the Padma River

In order to maintain species diversity of fish communities in the lower Atrai basin which in turn affects their continued productivity and stability, it is essential that hydrological connections to the Padma River are not reduced in any way. This has two important implications for the future management of flows in the regulated Baral-Nandakuja River. The first relates to the operation of Charghat regulator: whenever possible water level differences across this structure should be minimised to facilitate upstream migrations of adult and juvenile fish and increase the survival of hatchlings swept downstream through the gates. An independent FAP 17 study recorded 135 species of fish transported as drifting hatchlings across Charghat regulator from the Padma River to the Baral-Nandakuja system. Secondly, the proposal by BWDB to proceed with the construction of a second regulator on the Baral River should be at least postponed until detailed and comprehensive social, environmental, agricultural and fisheries evaluations of the potential impact of the project on not only the Baral basin but the whole of the lower Atrai basin have been completed.

5. Increased fish migration across FCD structures

The supply of fish hatchlings into Polder B from the Padma River via the Baral-Nandakuja system should be increased by modification of sluice gate operating schedules within Polder B. This measure is designed to reduce the negative impact of flood control on fish productivity caused by blocking movements of fish hatchlings, especially those of major carps, between the Nandakuja River and floodplains of the polder at critical times of year. Hydrodynamic modelling will be helpful in predicting geographical areas of conflict between the water requirements of rice and fish. These should be taken into account in the design of gate operations to achieve an integrated approach to water management through controlled flooding. It is anticipated that this mitigation measure will also result in increased species diversity as more migratory fish and hatchlings will be able to move from the river to the floodplains of Polder B.

6. Improved fish migration on the Atrai River

The construction of earthen dams on the Atrai River for the purpose of winter rice irrigation should be actively prohibited by local authorities since these not only trap overwintering fish and increase their susceptibility to capture but also delay upstream and possible downstream movements of fish during the pre-monsoon period.

7. Strengthening of technical assessment and planning capabilities of BWDB/WARPO

There is a need to establish within BWDB/WARPO a multidisciplinary technical assessment unit comprising expertise from fisheries, agriculture, environment, hydrology and hydraulic engineering. The unit should be responsible for the re-evaluation of operating procedures of existing structures and for the examination of future flood control projects. Proposals for major new road or rail links should also be assessed by the unit in terms of their impact on flooding patterns, fisheries and agriculture. The eventual siting of the assessment unit would depend on the future roles of BWDB and WARPO.

8. Establishment of national database on FCD/I projects

A detailed and comprehensive national database should be established by BWDB to provide information on all flood control projects in Bangladesh and the major regulatory structures within these projects. The database should provide a basic description of the design and size of each structure, its function within the project area and its state of repair. Daily water level data at each structure should also be provided with computed head differences. The database should be made available, in a user-friendly form, to other government agencies.

9. Improvement of data collection by BWDB

There is an urgent need to improve the quality of data collection by BWDB personnel responsible for the operation of regulatory structures. Supervisory personnel should ensure that accurate detailed daily records are maintained of water levels at the structure (inside and outside), numbers of gates open and height to which each gate is opened. These data should be incorporated into the national database at monthly intervals.

10. Establishment of water-user groups

Local groups of water users should be established in flood control projects to represent the full range of sectors affected by modified flooding patterns. This should include capture fisheries as a water-user group. Representatives from each group should form a local committee in association with relevant government departments to establish operating procedures for regulatory structures. The committee would provide the mechanism for the establishment of local integrated water management.

11. Training within BWDB

An annual series of training courses should be established within BWDB to provide engineers with a basic understanding of the water requirements within each natural resource sector, focusing attention on fisheries and agriculture. The course content relating to fisheries should contain descriptions of identified adverse impacts of flood control on fish and various methods of mitigation against such impacts.

12. Development of flood modelling techniques

There is a need to continue the development of flood modelling techniques using the MIKE11 hydrodynamic model. The SWMC and FAP 19 are currently active in this field but require future support, both financial and technical, to continue to make progress. The work would require detailed field surveys to improve basic topographical information.

8 FUTURE RESEARCH REQUIREMENTS

FAP 17 investigations provided quantitative baseline data on several aspects of freshwater fisheries in various regions of Bangladesh. Because of the widespread nature of sampling effort and the relative short duration of field data collection (12-19 months), it was not possible to obtain a detailed understanding of the ecology, biology or population dynamics of even the few most important floodplain fish in relation to changes in flooding patterns. It is therefore important to use the baseline data of FAP 17 as a foundation for further longer term fisheries studies which should provide both greater detail and scope of research activities. When dealing with the fisheries of such complex agroecological and hydrological systems as the floodplains of Bangladesh, long-term studies for up to 10 years are required to provide a level of understanding and information on which to base predictive mathematical models of fish populations and flood dynamics.

Such studies are a rarity even in more developed counties where resources are often more readily available. In Bangladesh, institutional assistance would be required by national centres to support critical long-term studies. This applies not only to fisheries research studies which are under the responsibility of the Fisheries Research Institute (FRI) but also to deepwater rice studies, already undertaken by the Bangladesh Rice Research Institute (BRRI). There is certainly much scope for the establishment of close collaboration between these research institutions in future research programmes relating to floodplain fisheries and deepwater rice production.

Areas of future research appropriate for Polder B and other areas of the lower Atrai basin are outlined below.

1. Investigation of the biology and ecology of selected fish and prawn species dominating floodplain catches inside and outside FCD areas. Information collected should include data on age, breeding biology, feeding habits and micro-distributions in relation to seasonal changes in flooding and the distribution of aquatic vegetation including deepwater rice. The study should also include detailed limnological investigations which examine plankton, macroinvertebrates and water quality, particularly nutrient levels. The role of deepwater rice fields in providing shelter from certain fishing gears and natural predators in addition to providing food, should also be explored in detail. This study will provide an understanding of the overall

functioning of the dominant fish and prawn community in relation to open-water habitats and deepwater rice fields.

2. Stock assessment using length frequency analysis and ageing techniques to obtain information on the population dynamics of selected species of fish and prawns dominating floodplain catches. This study will provide information on growth, mortality and the status of stocks and allow predictions to be made of the effects on fisheries of further increases in fishing pressure. This study is particularly relevant to flood controlled areas where higher levels of fishing effort have been recorded on fish communities in which diversity has been reduced and a greater dependence placed on a small number of floodplain resident species. The current status of the stocks of these species is not known.

3. Establishment of catch assessment surveys using methods outlined in the FAP 17 Draft Final Report Guidelines to obtain estimates of fish densities and yield per unit area of floodplain. These data, when collected over a long-term period of up to ten years and linked with a concomitant set of quantitative data on flooding patterns, will provide the first rational basis for the development of a quantitative floodplain fisheries model. This can then be used as a predictive tool to provide future advice on fisheries management and development.

4. Investigation of the movements of fish and prawns between rivers and floodplains which are free-flooding and others on which flooding is controlled. This study will require continuous daily monitoring of catches in canals linking rivers with floodplains.

5. Investigation of the movements by passive downstream drift of fish and prawn hatchlings between rivers and floodplains in relation to seasonal changes in river discharge. This study is particularly relevant to engineering proposals such as the Green River approach of FAP 2 which recommends flood control by the installation of submersible weirs.

6. Assessment of the impact of FCD projects on the diversity of fish and prawns. Standardised systematic, intensive sampling is required to record not only the more common species but also the numerous rarer species which may be more vulnerable to adverse impacts of flood control.

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APPENDIX 1

Appendix 1 List of fishing gears recorded during FAP 17 surveys in Bangladesh

Gear Type	Name	Code	Description
Gill Net	*Current jal(Stationary)*	88	Monofilament fixed gill net, usually small mesh
	Current jal(Drifting)	282	Monofilament drifting gill net, usually top set, any mesh size
	Koi jal	123	Multifilament fixed gill net, usually small mesh
	Chandi jal	65	Multifilament drifting gill net, usually top set, any mesh size
	Par jal	315	Multifilament drifting gill net, usually bottom set, large mesh
	Kajuli jal	316	Multifilament drifting gill net, usually bottom set, small mesh
	Awo jal	324	Multifilament fixed gill net set in zig-zag pattern to catch large fish
	Foot jal	327	Very small gill set horizontally at surface in shallow water
	Gai Dasem	132	Drifting net used in rivers, has pockets at base
Seine Net	*Ber jal*	45	Seine net: small, medium or large size
	Baoli jal	306	Medium sized seine net pulled by 2 ropes
	Moi jal	202	Small drag net with pockets at base
	Dora jal	325	Similar to moi jal but pulled by 2 long ropes
	Konaber jal	268	Seine net with pocket at one end
	Dhor jal	89	Small seine usualy pulled by 2 men by sticks on each end of net
	Horhori	297	Seine net with a series of large pockets along net
	Kathi jal	175	Seine net with a series of vertical sticks along net
	Chabi jal	293	Seine/gill net pulled to shore, often used with polo traps
	Hat panch	276	Medium size seine pulled at each end by one man while man in boat beats water to drive fish into net
	Satiber jal	304	Seine net with a series of pockets at base
	Kachitana	277	Type of lift net hung from boat on floodplain or beel. Net used with drag rope to drive fish into net.
	Ferra jal	126	Drag rope used to drive fish into gill net/seine net
Bag Net	*Thaga*	285	Barrier across river with bag nets set perpendicular to it
	Suti jal	271	Single bag net staked to river bed
	Ghori jal	320	Barricade/fence with nets set in gaps to trap fish
	Bhuti jal	328	Clap net on bamboo frame hung from boat anchored in a gap of barrier fence
Lift Net	*Veshal*	266	Triangular lift net on large bamboo frame
	Dharma jal	105	Square or round lift nets on bamboo pole
	Jhali jal	160	Small veshal used on main rivers at night for prawns
	Jhap jal	319	Boat lift net: lifted at 4 corners by men in boats
	Chota jal	323	Gill net fixed horizontally on bottom to catch fish by spines
	Dara jal	329	Lift net and barrier used in canals or small rivers
Scoop Net	*Hat Tana*	287	Oval or triangular scoop nets used with pole and rope or by hand
	Ucha	263	Basket scoop on pole used by hand
	Tukri	296	Small basket scoop used by hand
	Afa/Hat bauli	321	Large thella jal, large mesh, used on boat
	Uttar jal	68	Like a cast net but hung from a boat drifting along river and lifted to catch fish
Clap Net	*Shangla jal*	234	Multifilament drifting bag net on bamboo frame boat used for hilsa fishing
FAD	*Katha*	270	Submerged brush shelter used to attract fish
	Boat Katha	314	Submerged boat filled with branches used to attract fish
	Horgra	149	Submerged basket filled with branches used to attract fish
	Kua	302	Fish pit on floodplain, invariably contains brush shelter

Appendix 1 Continued

Gear Type	Name	Code	Description
Traps	*Polo*	222	Bell-shaped trap used to catch fish by hand
	Doiar trap	95	Small, oval or box traps used for prawns or small fish
	Deal	286	Larger trap, bilaterally divided to catch fish on 2 sides of bana
	Kadum trap	311	Large box traps used to catch larger fish e.g. Koi, Taki
	Kakila bana	310	Bamboo fence pulled downstream to trap fish in small area
	Katra	326	Active trap: fish speared after entering trap
	Kalsi pata	299	Clay pot used to trap fish set in bank side.
	Kotta	318	Bunded area on floodplain used to trap fish as water recedes
	Char jal	322	Tidal fence trap
	Kharia/Kore	330	Fence trap used on floodplain during flood recession
	Malai pata	331	Coconut shell drilled with holes and baited to catch small fish
	Patar savar	332	Large active fence trap used to surround fish on flooplain
	Tui	334	Small polo-type trap used to catch fish in mud on floodplain
Hook/ Lines	*Daun*	272	Long line: many hooks set at intervals on one line
	Sip	30	Rod and line : usually one hook per line
	Nol barsi	278	Hook & line attached to bamboo floats. Many floats/hooks may be joined along line
	Tana barsi	152	Hand line (no rod) from bank or boat with or without groundbait
Spear	*Juti*	170	Spears of various types: fixed or detachable barbs
Other	*Jhaki jal*	164	Multifilament circular net thrown by hand
	Thella jal	255	Small triangular push net set on bamboo frame
	Urani	291	Various barrier nets/fences used to catch jumping fish.
	Akra	298	Pole with metal hooks used to catch mud-dwelling fish e.g. baim
	Chunga	301	Hollow bamboo rod shelter used to attract baim
	Thushi	317	Cloth/basket traps used to drive baim into them
	Hand fishing	307	Picking fish by hand but without dewatering
	By hand/Dewatering	97	Empty water and catch fish by hand in mud
	Net/Basket+Dewatering	98	Empty water through an outlet where net or basket used to trap fish
	Nimbaich	335	Large scale fishing by whole village using many different gears
	Canal dewatering	336	Large section of canal isolated by cross dams and emptied by pumping by other means to catch fish by various methods

Notes:

1. Local names of gears vary between different districts and regions in Bangladesh. Those listed in the table above are generally used in the North Central Region. If gears were not found in this region, the name from the region in which the gear was most recorded was used.
2. Some names e.g. juti (spear) doiar traps and hat tana were used to denote a group of similar gears. A more detailed list and description of individual gears is provided in the FAP 17 database.
3. FAD = Fish Aggregation Device.