The Release of Ammonium and Phosphorus from the Sediments of the River Ant and Barton Broad

Interim Report - 1992

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NRA Anglian Region

Anglian Regional Operational Investigation 542
OI/542/3/A

NRA
National Rivers Authority

Anglian Regional Operational Investigation 542:

Investigations into Nitrogen in Broadland

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CONTENTS

SUMMARY

Release rates of both ammonium and phosphorus were determined for Barton Broad and a site downstream of Wayford Bridge on the river Ant. Comparable concentrations of interstitial phosphorus and ammonium were measured in sediment cores collected from both sites during the summer. The release rates for the riverine sediment cores were lower than those calculated for the broad. A relationship between the number of chironomids and tubificids present in the experimental cores and the rates of release determined for Barton Broad was shown to exist. Bioturbation did not appear to have an effect upon nutrient release at the site downstream of Wayford Bridge.

Key words: sediment, ammonium release, phosphorus release, benthic invertebrates, Norfolk Broads.

1. INTRODUCTION

1.1 Background

Nitrogen and phosphorus are important nutrients which control primary productivity within the Broads. An increase in the supply of both of these nutrients will encourage the growth of phytoplankton. The availability of these nutrients is affected by the rate of external input to the broads and the extent of internal recycling and removal by biological, chemical and physical processes.

Introduction of phosphorus removal at the sewage treatment works discharging into the R. Ant in the late 1970's has lead to a reduction in the phosphorus load being supplied to Barton Broad by the river. It was initially supposed that this reduction in the phosphorus load would limit phytoplankton growth within the Broad. However, despite the significant lowering of the final effluent phosphorus concentration being discharged into the R. Ant a comparable decline in the phosphorus loading within the Broad could not be identified. (Phillips & Chilvers, 1991). Subsequent work (Osborne & Phillips, 1978; Jackson & Phillips, 1990) has illustrated the importance of phosphorus release from the organic sediment of Barton Broad in the supply of phosphorus to phytoplankton.

The control of the external inputs of nitrogen to Barton Broad is not as practicable due to the diffuse nature of the catchment sources. However, the process of denitrification within aquatic sediments removes nitrogen from the aquatic system in a gaseous form to the atmosphere. Aquatic sediments are a concentration site for organic matter which upon decomposition releases ammonium. It is this ammonium which is available for nitrification in the presence of oxygen (to NO_3) and subsequent denitrification to essentially unavailable forms of gaseous nitrogen (N_2, N_2O and NO).(Seitzinger, 1990). Denitrification within the sediments of the river and the broad would, therefore, reduce the amount of nitrogen transported downstream and that available for primary production within the broad.

An understanding of the availability of these nutrients within the river and broad will enable progress to be made towards adequate control of primary productivity. An improvement in water quality and a reduction in phytoplankton biomass may encourage the recolonisation of the Broad by submerged aquatic macrophytes. The decline in macrophytes and associated invertebrate fauna within Broadland has been linked to the effects of nutrient enrichment (Phillips *et al*, 1978).

1.2 Proposed Work

An investigation into the potential release of ammonium from both the riverine and broad sediments was undertaken to complement the construction of a nitrogen budget for the R. Ant (Boar, 1992). During the experimental work measurements were also made of phosphorus release rates.

2. METHODS

2.1 Study Sites

Sediment samples were collected from two sample sites; one set of cores were taken from within the Broad and the other from a depositional riverine site down stream of Wayford Bridge on the R. Ant. (Figure 2.1).

The R. Ant flows through the middle of Barton Broad and is tidal to a little distance up river of the broad. Barton Broad is a shallow, approximately 1m deep on average, well mixed water body which is dominated by phytoplankton for the majority of the year. The Broad and the stretch of the river under study are subject to a considerable amount of boat traffic.

Sediment samples were collected from Barton Broad and down stream of Wayford Bridge during July, August and September. A set of cores were also collected from Barton Broad during June.

2.2 Sediment Sampling

A total of 8 sediment cores were collected from each site on every sampling occasion using the corer and perspex cores described in Jackson and Phillips (1990). Of these, 2 cores were used for the measurement of redox and pH; 3 cores in the analysis of interstitial water and the remaining 3 cores were used in an incubation experiment to determine the extent of ammonium and phosphorus release. The cores were transported back to the laboratory in thermally insulated box and were kept covered by black polythene bags.

2.3 Sediment Analysis

2.3.1 Measurement of pH and Redox Potential

The redox and pH profiles of the top 10 cm of the sediment cores were measured immediately upon return to the laboratory. The measurement of both parameters was carried out as described in Jackson (1990).

2.3.1 Analysis of Interstitial Water

Analysis of the interstitial ammonium, soluble reactive phosphorus and ferrous iron was undertaken the day after collection. The cores were stored overnight in an incubator set at the temperature of the overlying broad water.

Ammonium was determined using the indophenol blue method (Chaney and Morbach, 1982) scaled down to handle 10ml sample volumes. Due to the restricted amount of interstitial water available the actual sample volume was determined on a balance and then the sample diluted to the 10ml volume required for analysis.

Both soluble reactive phosphorus and ferrous iron were determined using methods described in Jackson (1990)

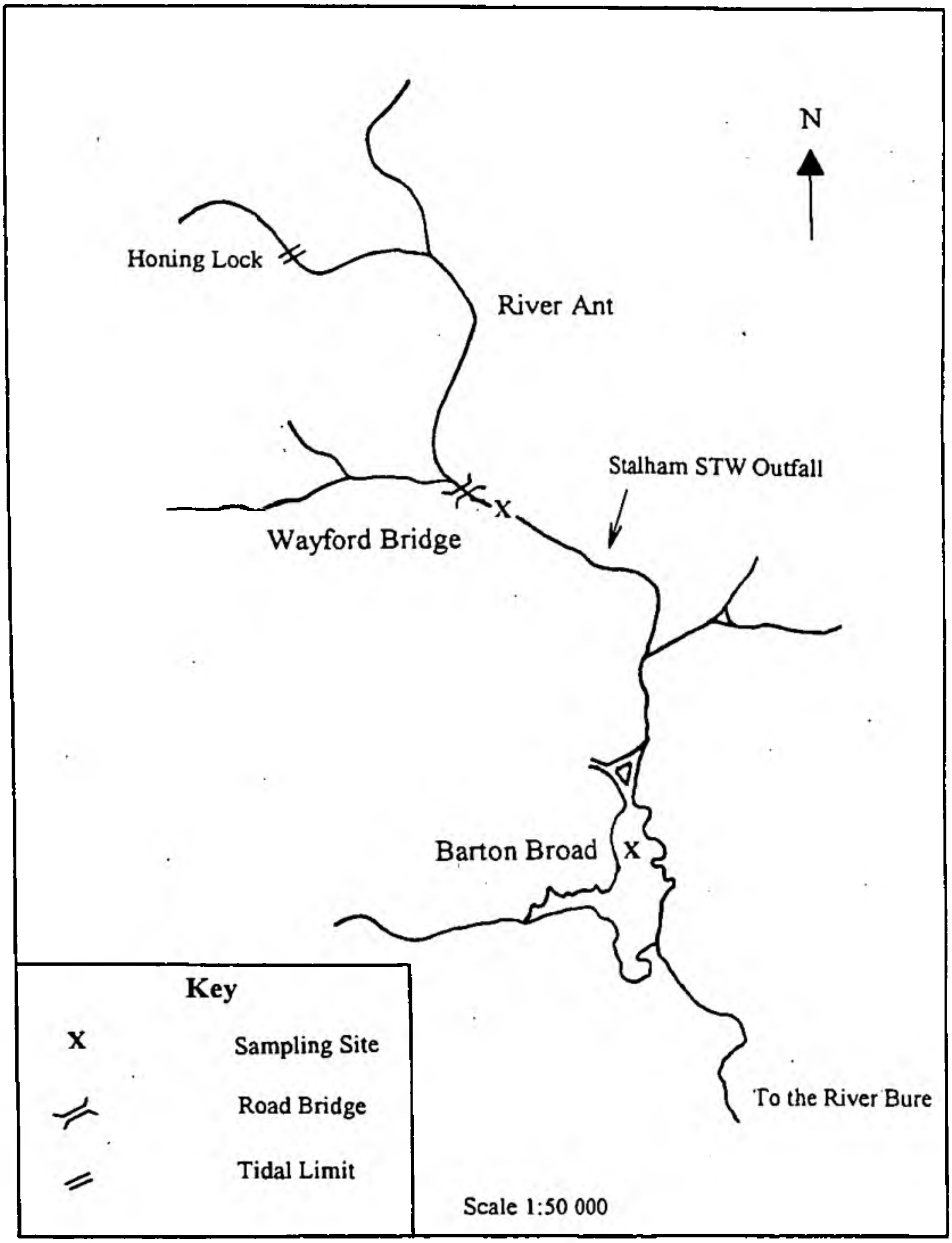


Figure 2.1 Sediment sampling sites, River Ant.

2.4 Measurement of Ammonium and Phosphorus Release Rates

Three cores from both Barton Broad and the river Ant down stream of Wayford Bridge were used in the release experiments. These experiments were initiated upon immediate return to the laboratory using the experimental set-up as described in Jackson and Phillips (1990). The sediment of each core was covered with a black polythene sleeve in order to prevent the deeper horizons coming into contact with light. An initial sample was taken of the water overlying the sediment surface prior to each core being placed within the experimental set-up. Artificial water, based upon the major ion concentration of R. Bure water at Horstead Mill (Jackson, 1991), was used instead of filtered broads water to flow through the cores. This was due to the difficulties of filtering a sufficient quantity of broads water to conduct the experiment. The cores were subjected to diurnal changes in light and dark which closely resembled the natural situation for the specific time of year. Samples of the outflowing water were collected at regular intervals and analysed for both ammonium and soluble reactive phosphorus. Release rates could then be calculated from the change in concentration of both ammonium and phosphorus with time between the inflowing and outflowing water. Cores were normally incubated for approximately 75 hours.

2.5 Invertebrate Numbers

Upon completion of the release experiment each core was sieved (sieve mesh size 0.5mm) and the number of tubificids and chironomids were counted.

3. RESULTS

3.1 Redox Potential

The redox potential profiles for Barton Broad and down stream of Wayford Bridge are shown in Figures 3.1 - 3.2. The profiles represent the average of the two cores taken on each sampling occasion and the results have been adjusted to Eh7.

At both sites there was an decrease in the redox potential throughout the summer sampling period. By September the broad sediment was more anaerobic than the river sediment. The top 2 - 3cm of sediment from all of the cores represents the zone of change from positive to negative Eh values. Below this depth the redox potential remained fairly constant.

3.2 pH

The pH values for the interstitial water at both of the sampling sites decreased with sediment depth (Figures 3.3 - 3.4). This change in pH with depth was more pronounced within the broad sediment especially for the top 3cm. Over the total depth of the sediment core under investigation a difference of between 1 - 2 pH units was recorded for the broad whereas the river sediments only changed by a maximum of 0.5 pH units. There was also a seasonal increase in pH of the water overlying the surface of the sediment from pH 8 to pH 9 within Barton Broad. No seasonal change in the pH of the river sediments was detected. The pH of the interstitial water did not fall below pH 7 at either site throughout the sampling programme.

3.3 Interstitial Water

3.3.1 Ammonium

At both of the sampling sites the concentration of ammonium in the interstitial water increased from June to September (Figures 3.5 - 3.6). With the exception of the June sample taken at Barton Broad the ammonium concentration also increased with sediment depth. The overlying water concentration on all of the sampling occasions was much lower than the concentration of the interstitial water in the first 1cm of sediment. During August there was an increase in the ammonium concentration near the sediment surface at both sites.

3.3.2 Soluble Reactive Phosphorus (SRP)

During the summer the concentration of phosphorus increased within Barton Broad sediment and in September was higher than the concentration found in the river sediments (Figures 3.7 - 3.8). Little variation in phosphorus concentration of the interstitial water was detected down stream of Wayford Bridge over the sampling period. The phosphorus concentration of the water overlying the sediment surface was low, especially within the broad where it was often at or below detection limits.

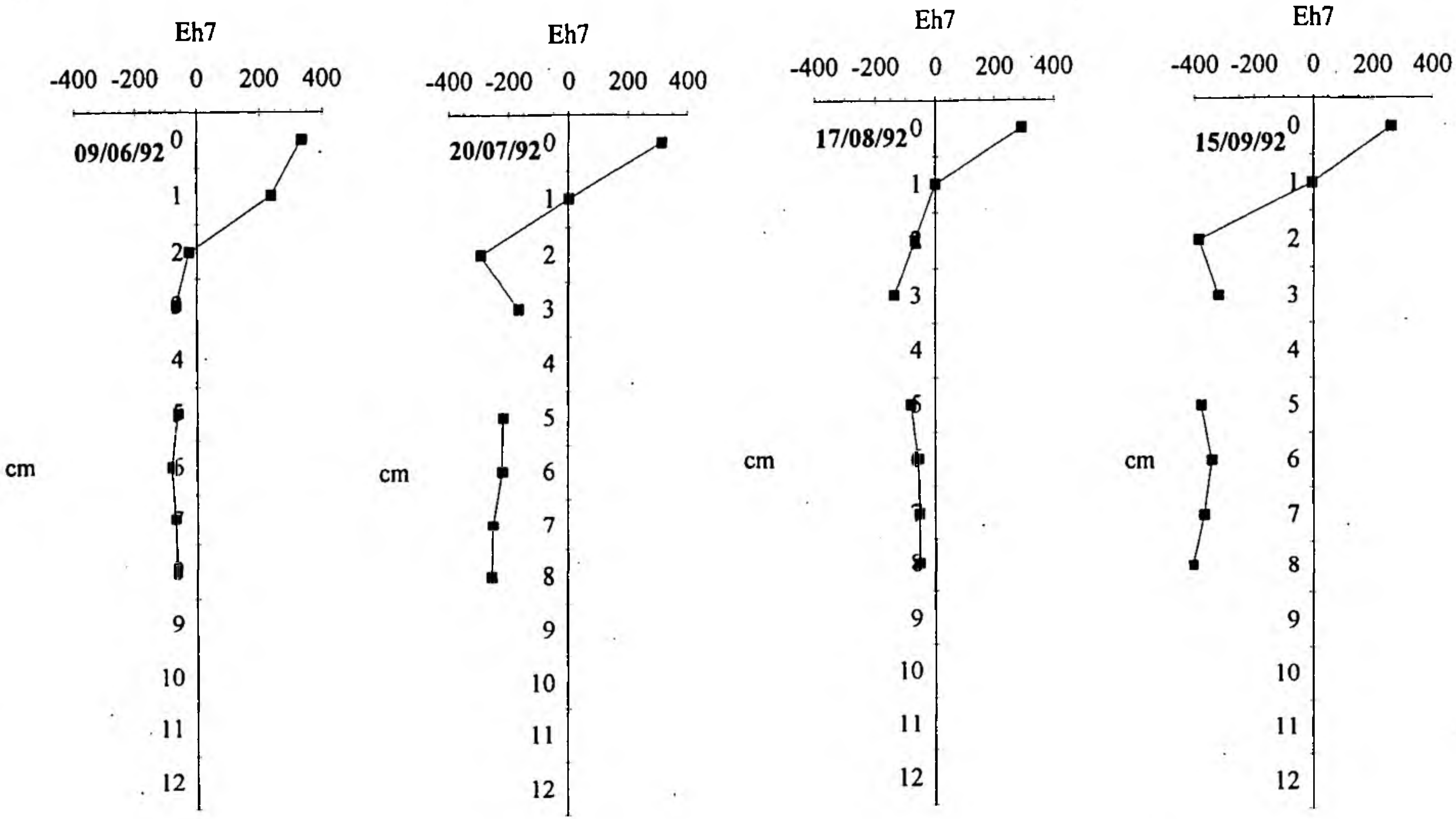


Figure 3.1 Barton Broad 1992, redox potential of sediment adjusted to Eh 7 (mean of 2 cores).

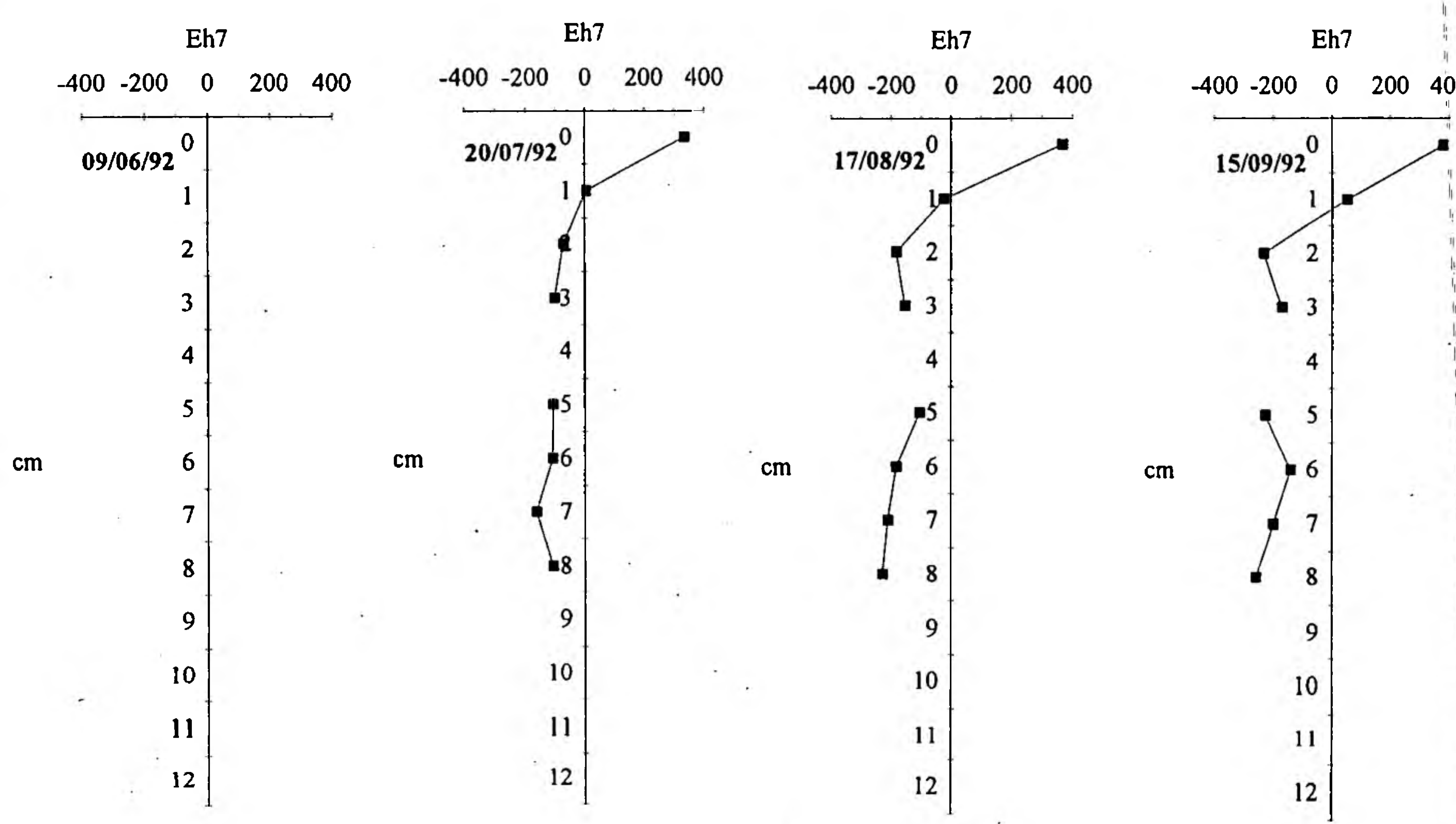


Figure 3.2 D/S Wayford Bridge 1992, redox potential of sediment adjusted to Eh 7 (mean of 2 cores).

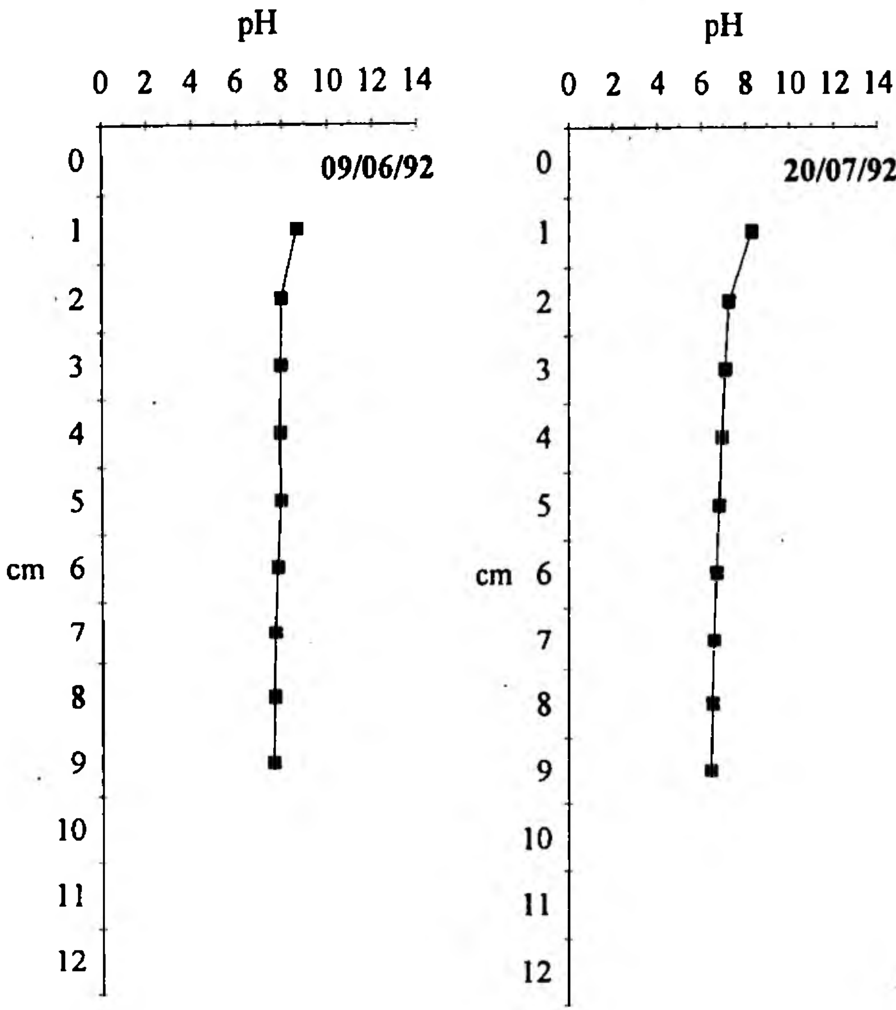
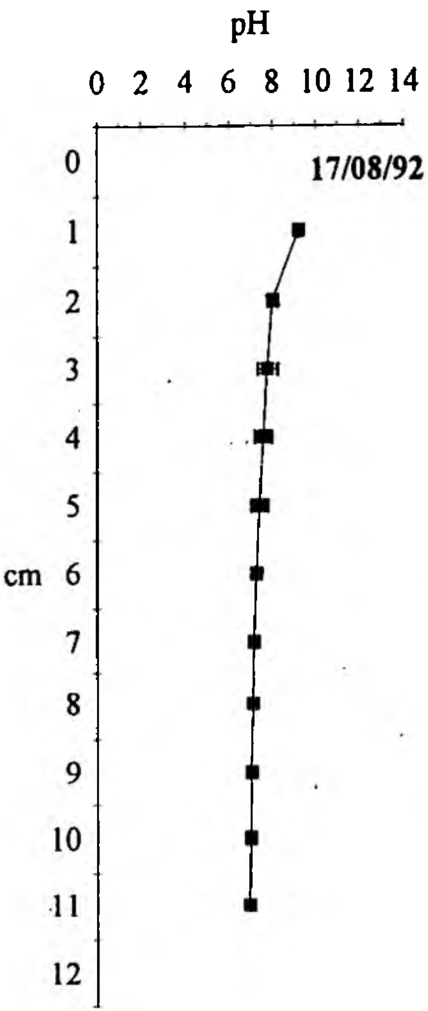


Figure 3.3 Barton Broad 1992, pH of sediment (mean of 2 cores).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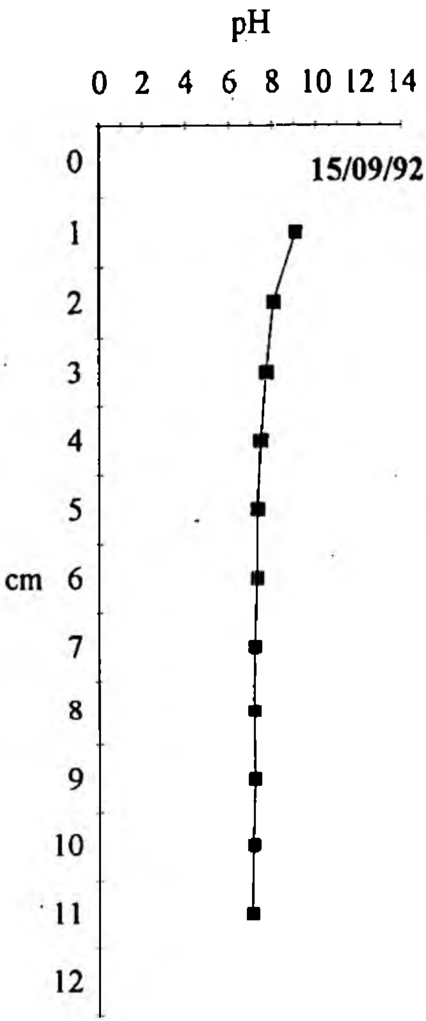
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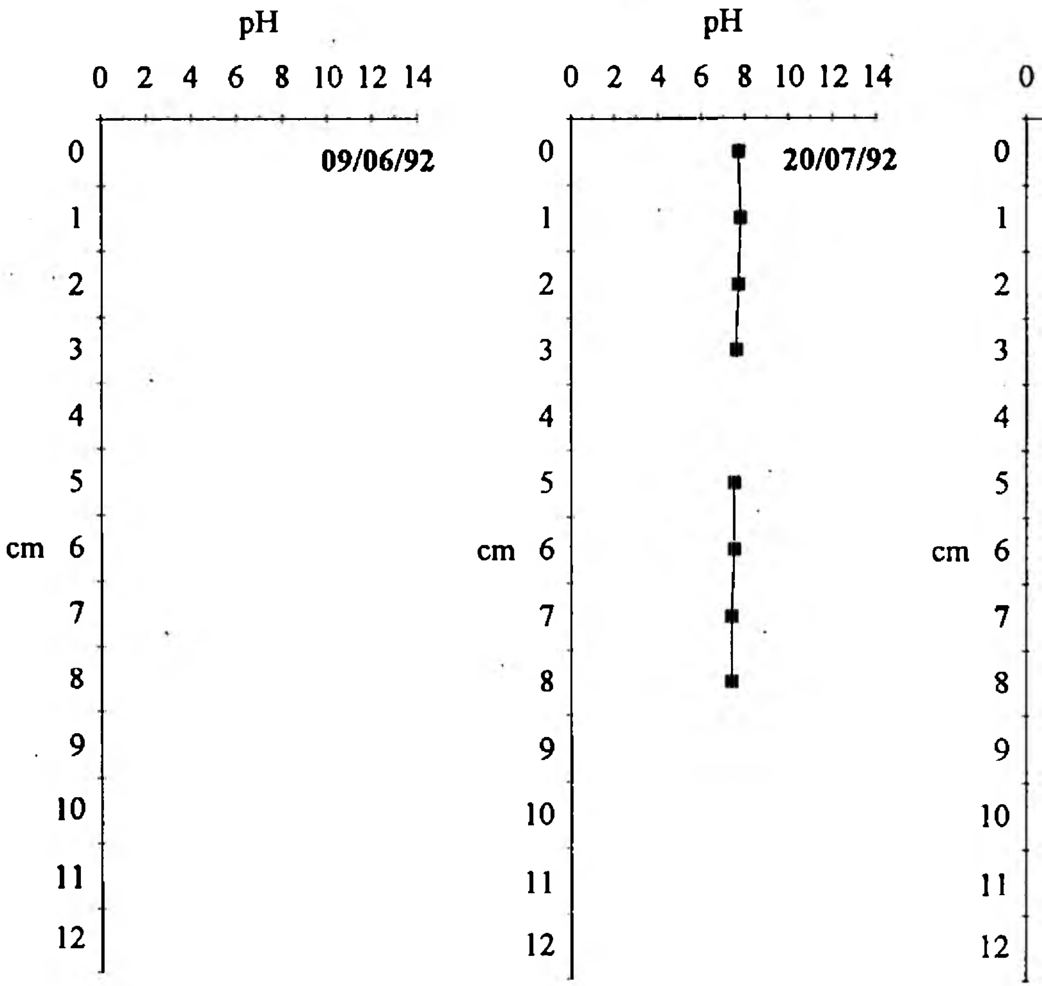
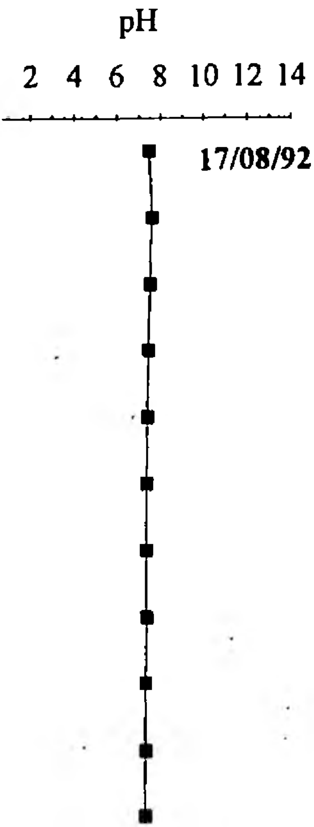


Figure 3.4 D/S Wayford Bridge 1992, pH of sediment (mean of 2 cores).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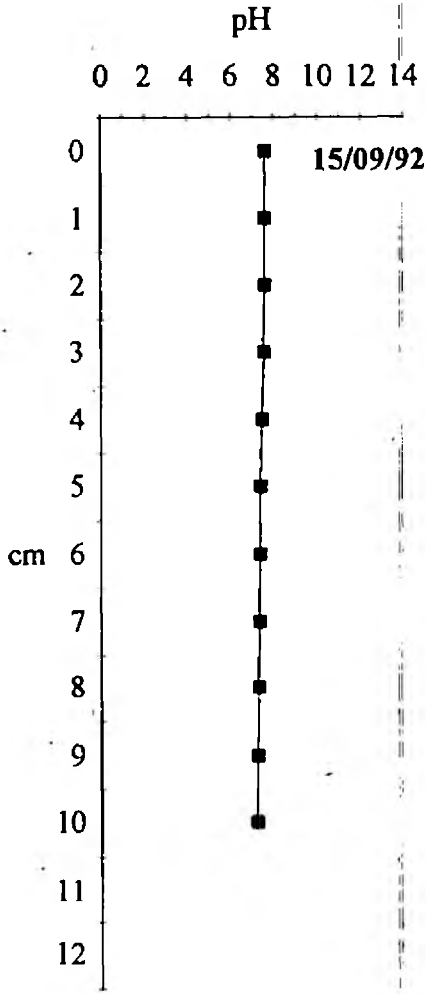
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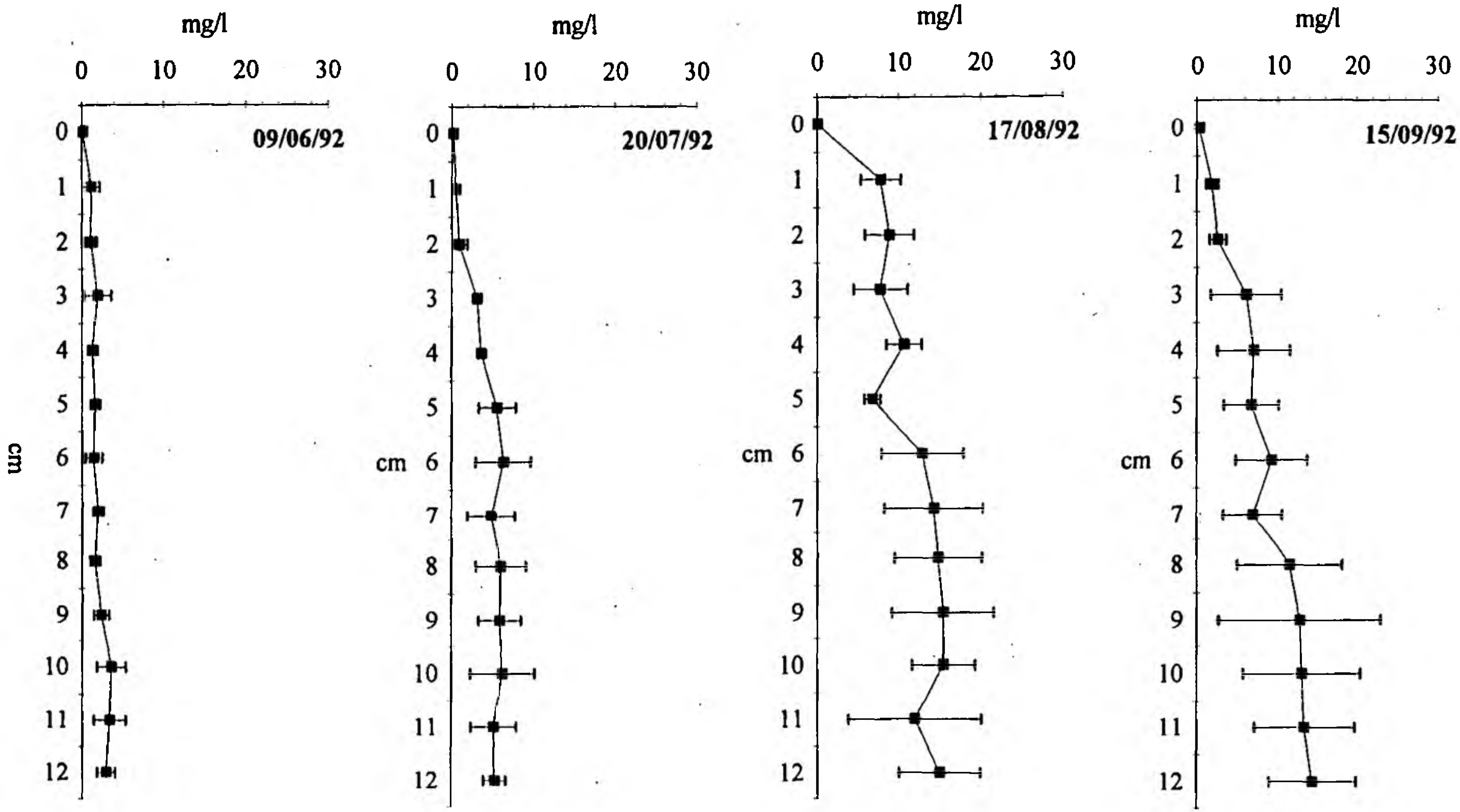


Figure 3.5 Barton Broad 1992, ammonium concentration of interstitial water (mean of 3 cores ± standard deviation).

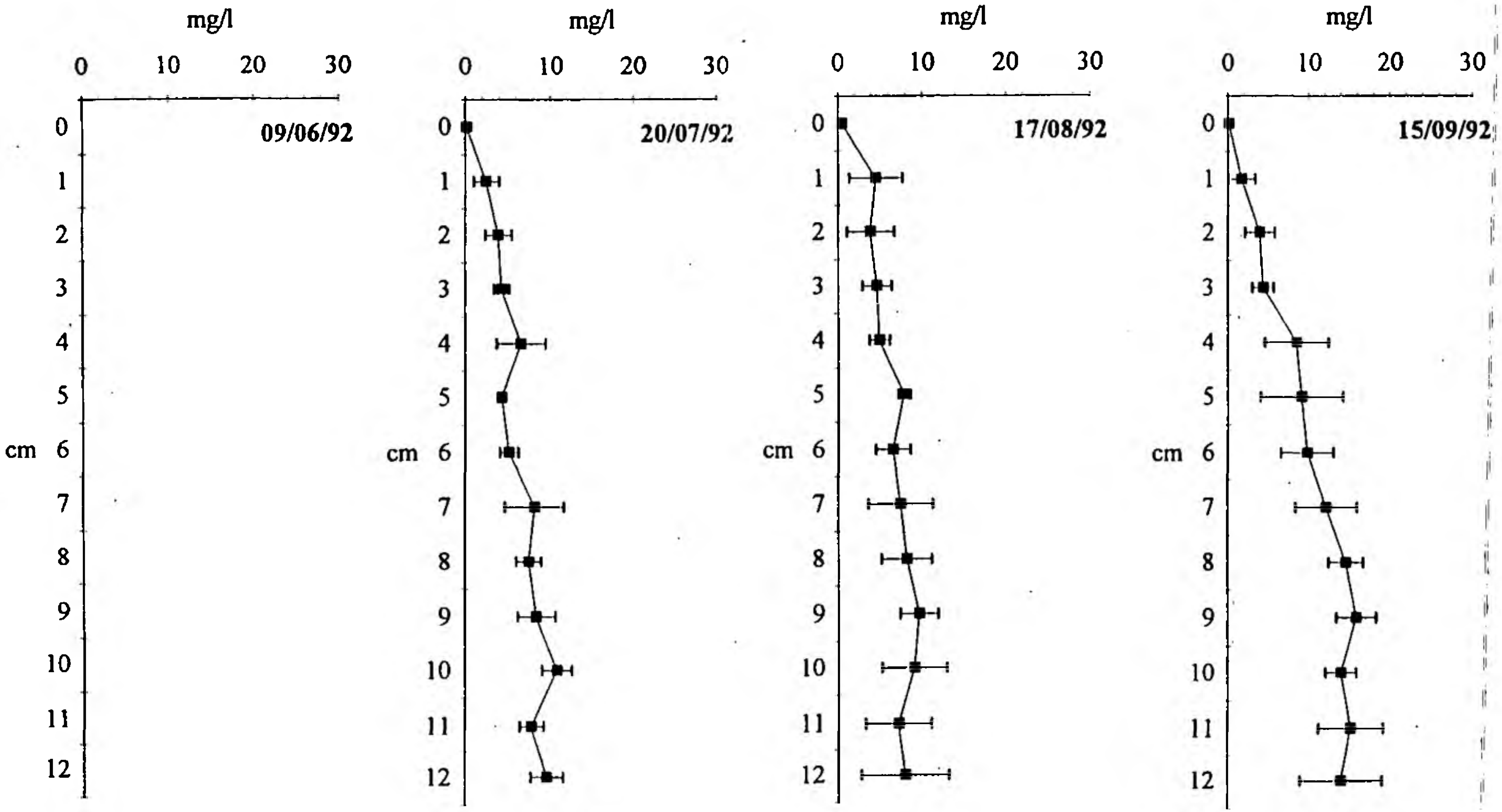


Figure 3.6 D/S Wayford Bridge 1992, ammonium concentration of interstitial water (mean of 3 cores ± standard deviation).

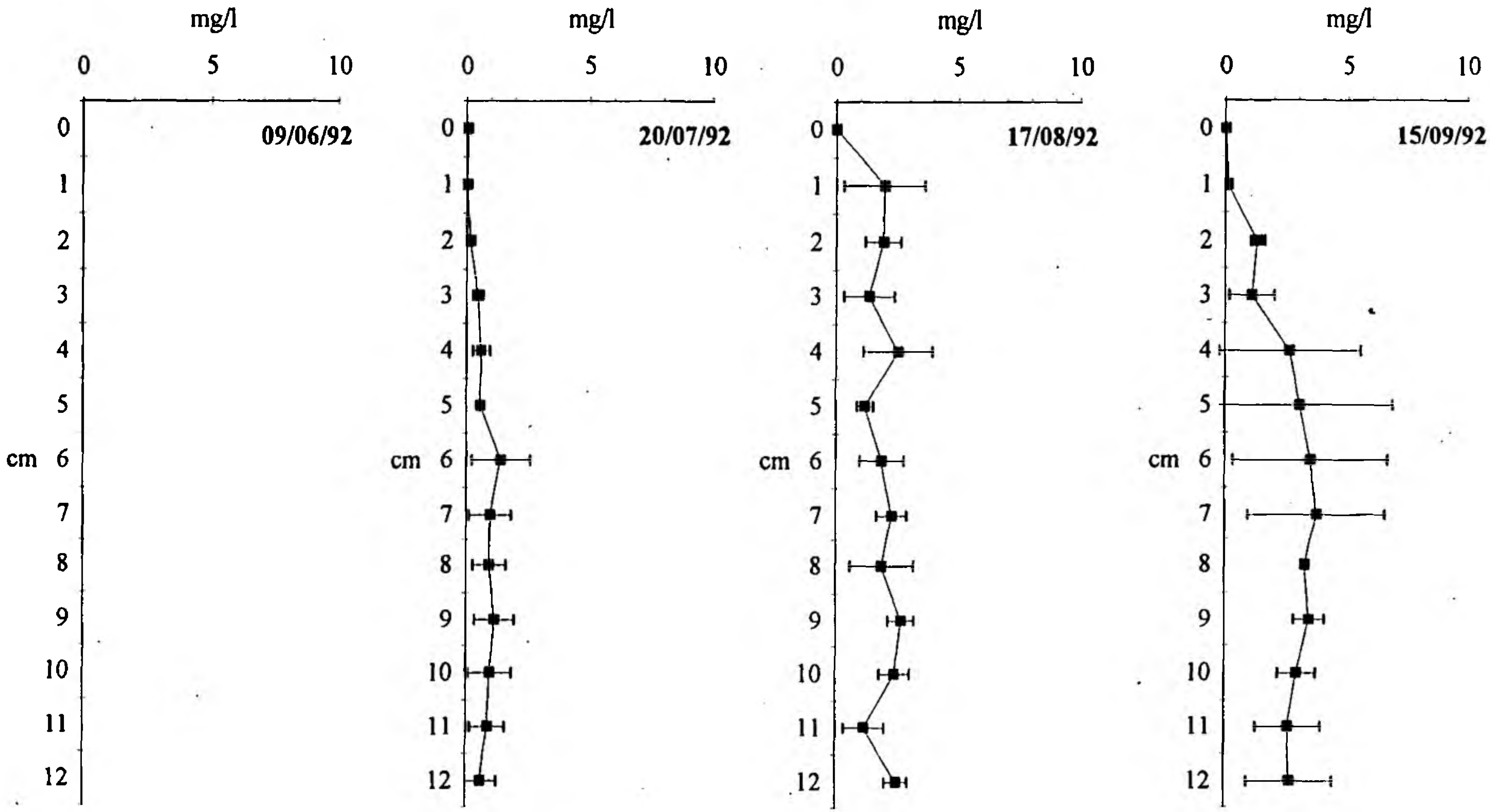


Figure 3.7 Barton Broad, soluble reactive phosphorus concentration of interstitial water (mean of 3 cores ± standard deviation).

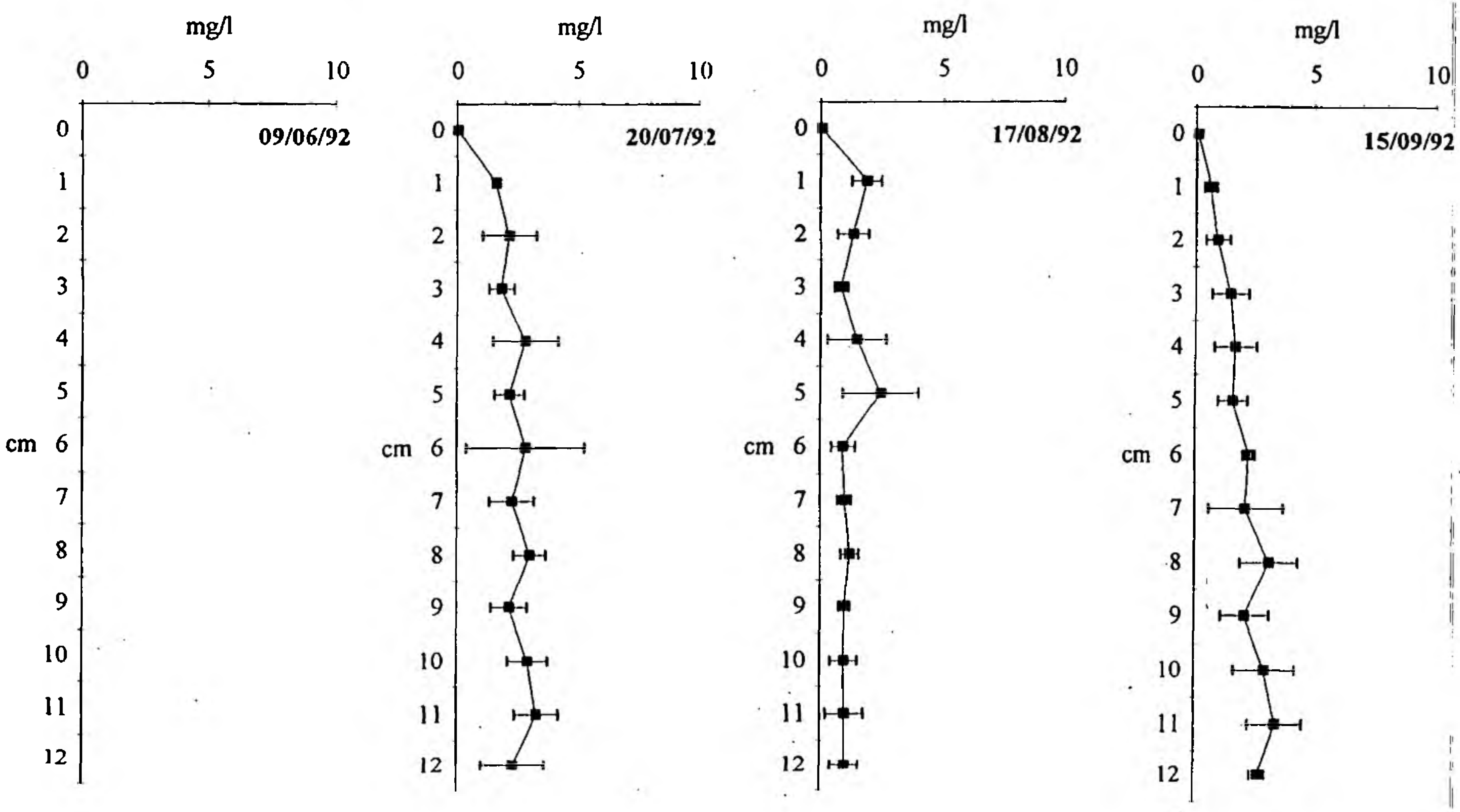


Figure 3.8 D/S Wayford Bridge, soluble reactive phosphorus concentration of interstitial water (mean of 3 cores ± standard deviation).

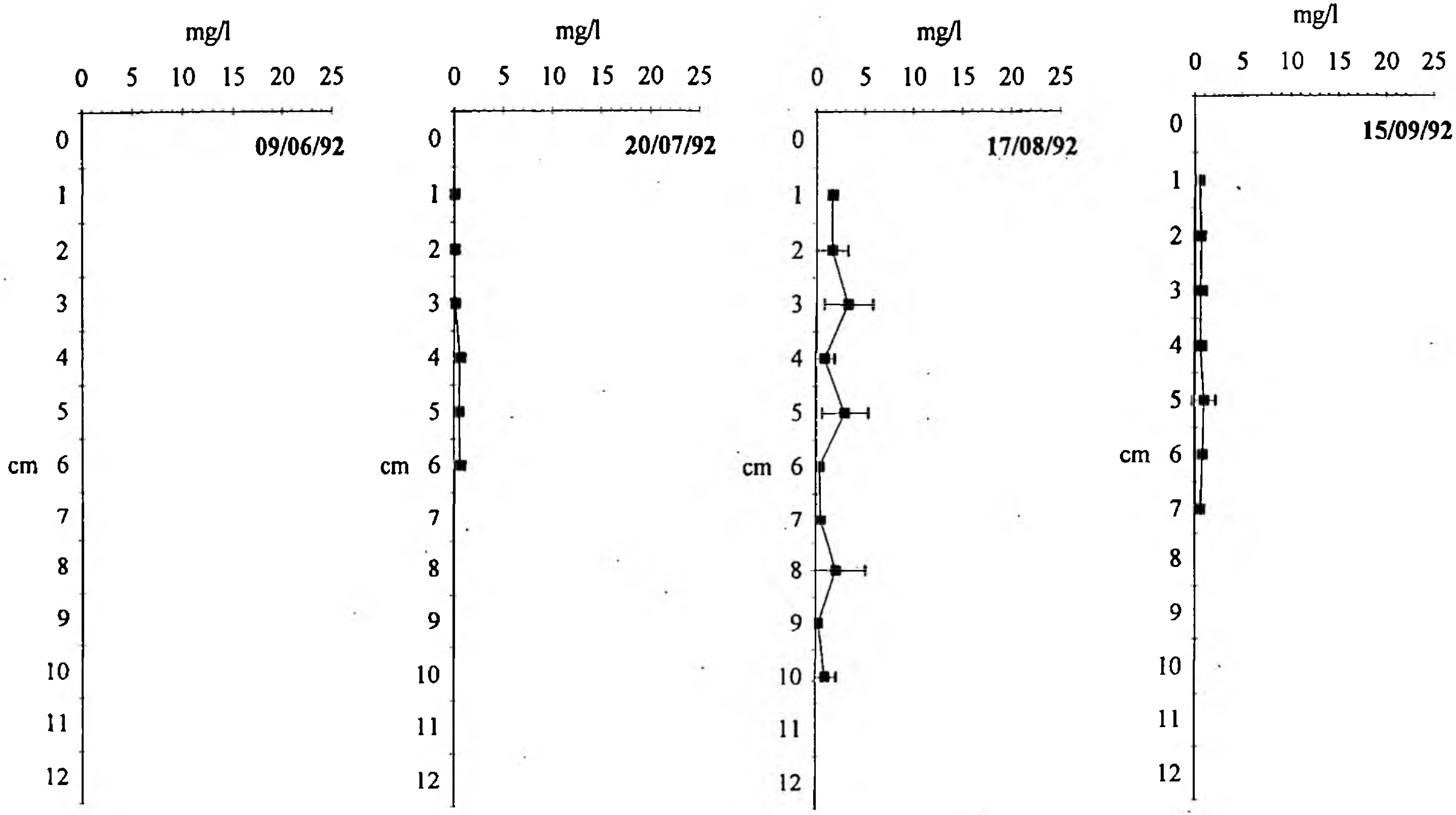


Figure 3.9 Barton Broad 1992, ferrous iron concentration of interstitial water (mean of 3 cores ± standard deviation).

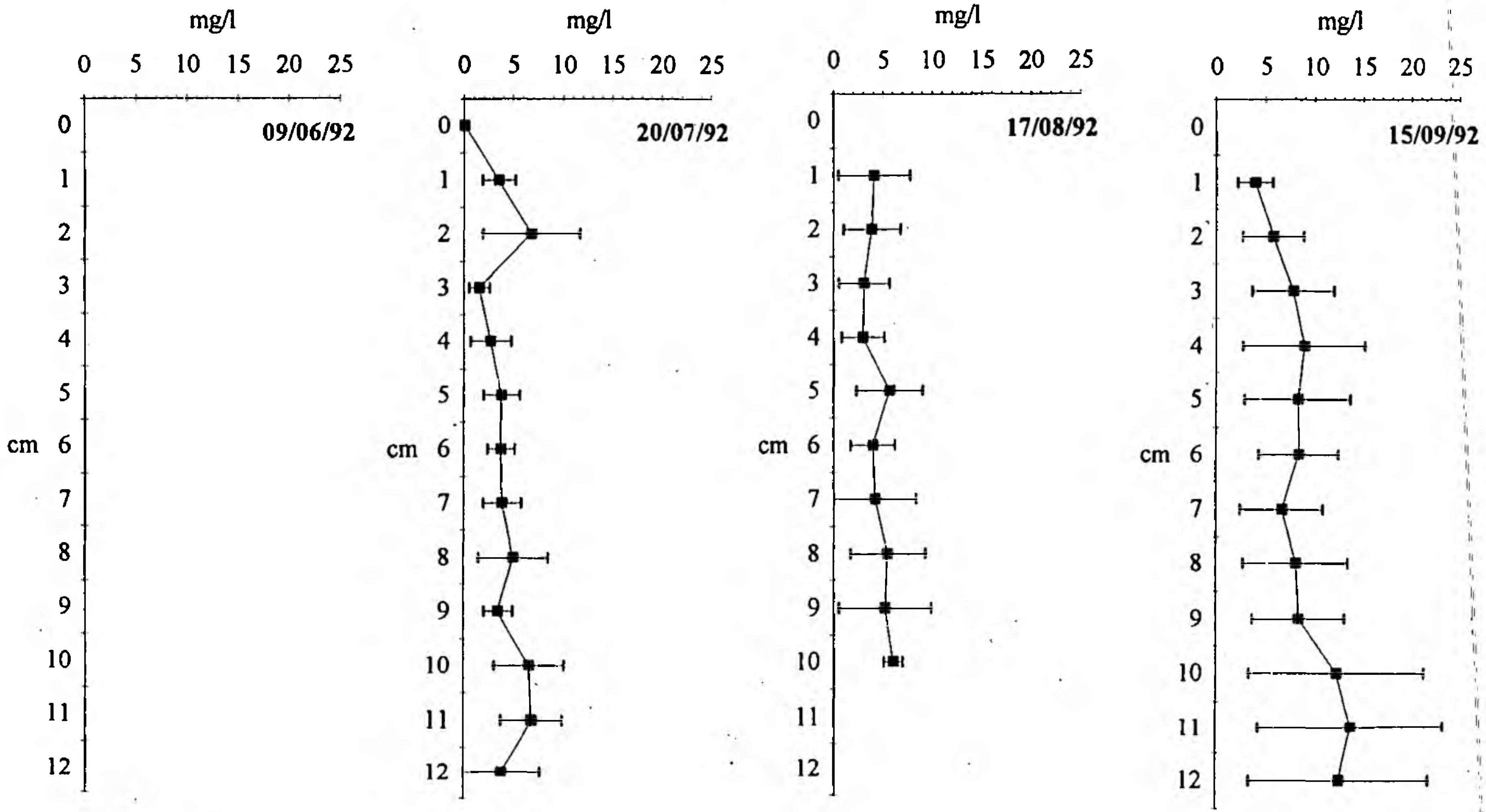


Figure 3.10 D/S Wayford Bridge 1992, ferrous iron concentration of interstitial water (mean of 3 cores ± standard deviation).

3.3.3 Ferrous Iron

The interstitial ferrous iron concentration within the broad sediment was considerably lower than that measured for the river sediments. During July and September the concentration in the broad remained below 2mg/l; only increasing to between 4 and 5 mg/l in August. In comparison, concentrations as high as 14mg/l were detected during September down stream of Wayford Bridge. Figures 3.9 - 3.10 illustrate the change in ferrous iron concentration with depth and between sampling occasions.

3.4 Release Experiments

3.4.1 Ammonium Release

Ammonium was released from the experimental cores each month sampling was undertaken. Figures 3.9 - 3.10 show the concentration of ammonium measured in the outflowing water throughout the duration of the experiment. The pattern of ammonium release does not appear to be affected by the diurnal changes in light and dark.

The release rates calculated from the changes in ammonium concentrating did not vary greatly between sampling occasions (Figure 3.13; Table 3.1). At Barton Broad the highest release rate was recorded in July. However, the variation between the three experimental cores is such that the increase in release is not significantly different from that detected for June and September. The lowest rate of release occurred during August. The rate of ammonium release downstream of Wayford Bridge remained fairly constant throughout July, August and September.

3.4.2 Phosphorus Release

The pattern of phosphorus release at both Barton Broad and downstream of Wayford Bridge is similar to that recorded for ammonium (Figures 3.11 - 3.12). The diurnal changes in light and dark did not appear to affect the release of either phosphorus or ammonium from the experimental cores..

At Barton Broad the release rates during June and July were higher than those calculated for August and September. The rates of phosphorus release downstream of Wayford Bridge remained below those recorded for Barton Broad but were fairly constant throughout the sampling programme (Figure 3.14; Table 3.2).

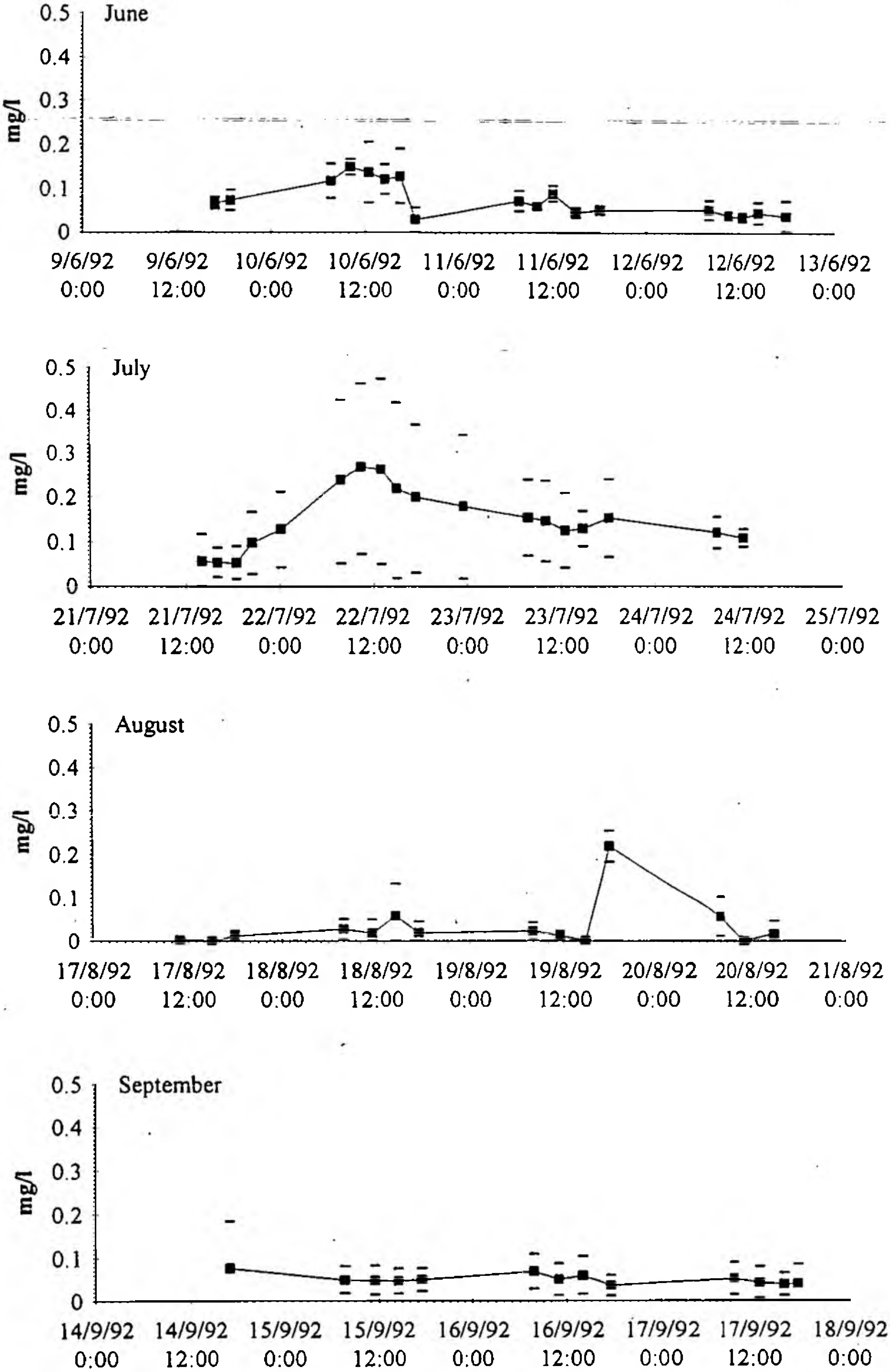


Figure 3.11 Barton Broad, ammonium release experiment (mg/l).

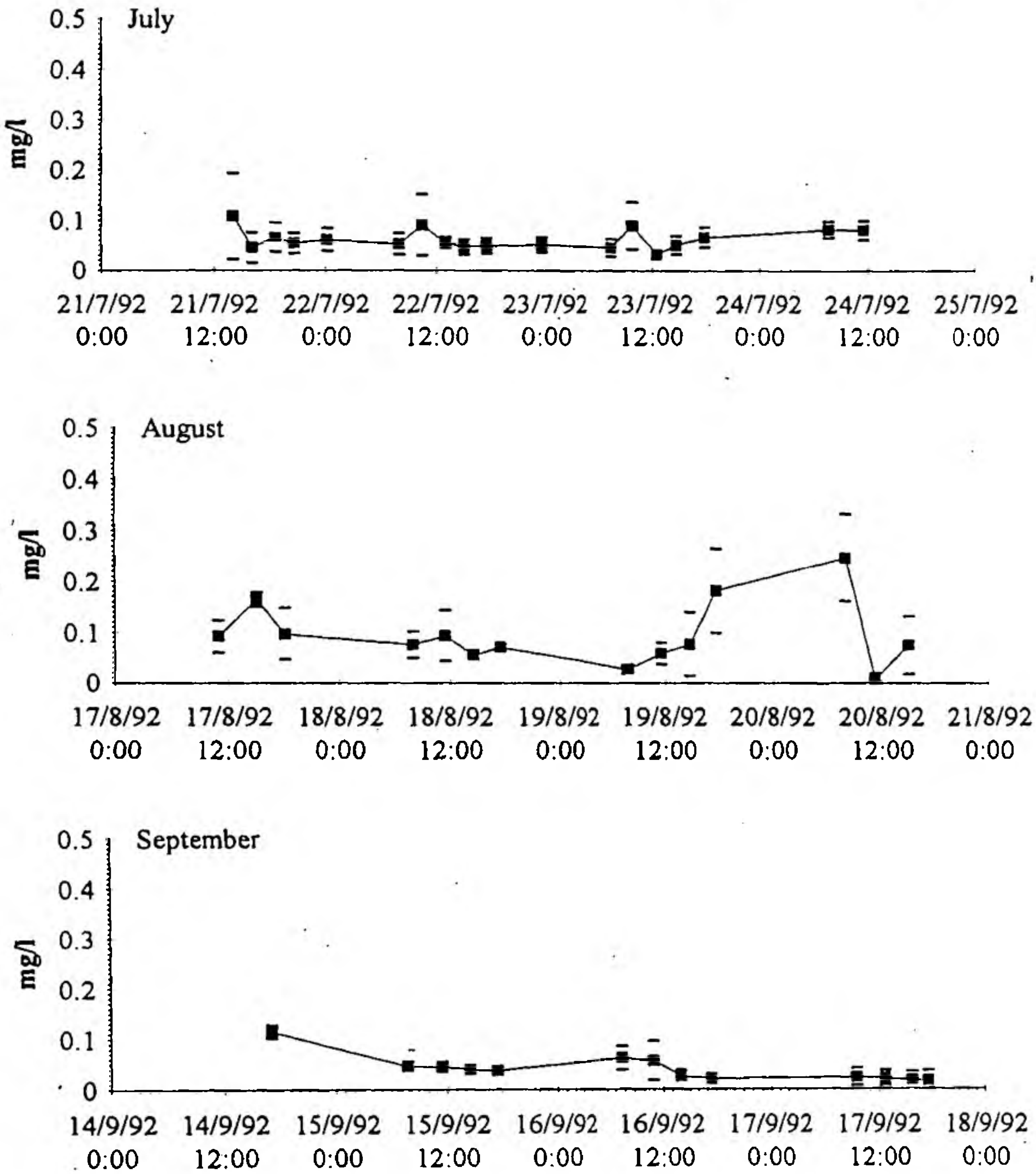


Figure 3.12 D/S Wayford Bridge, ammonium release experiment (mg/l).

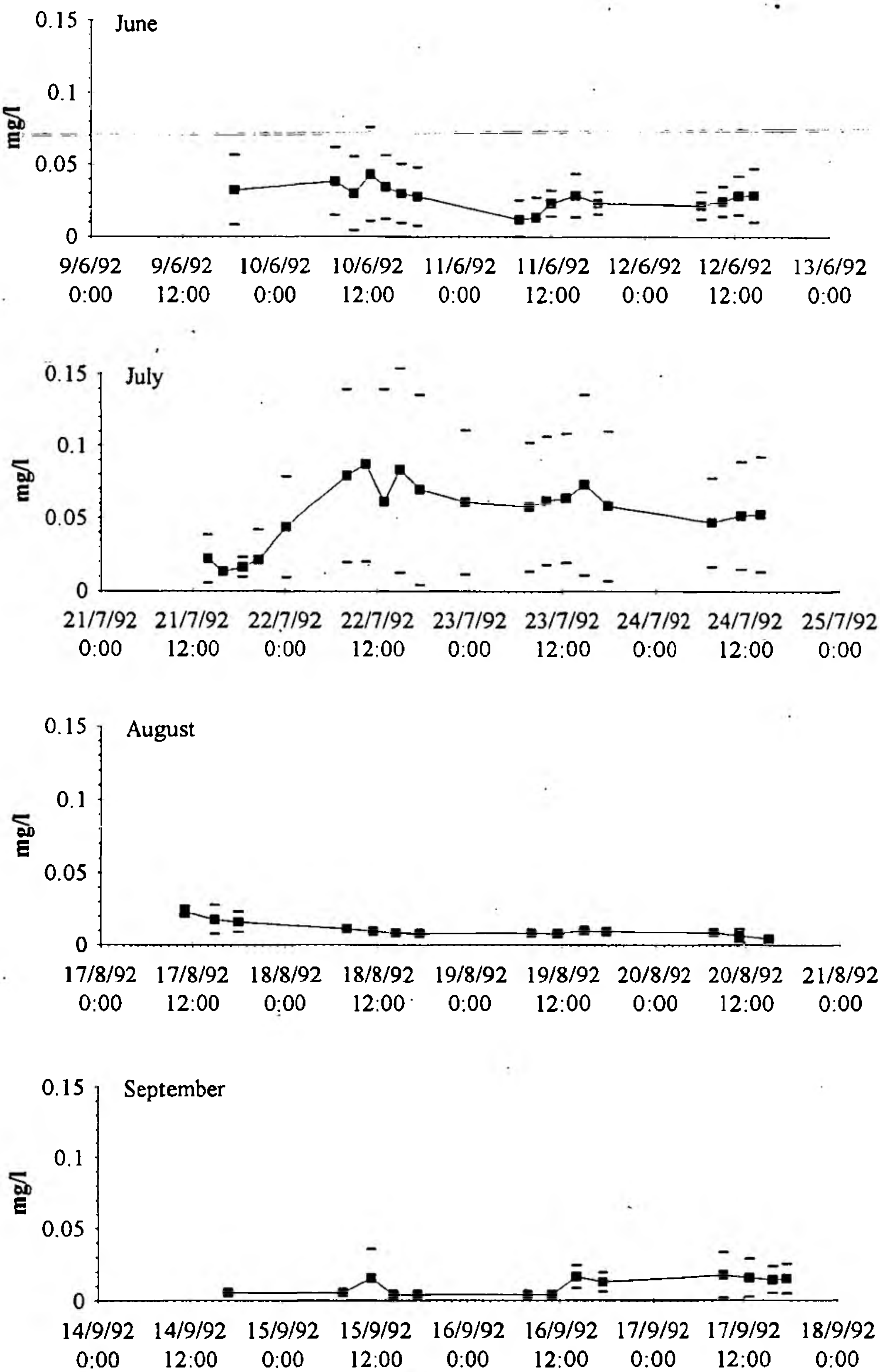


Figure 3.13 Barton Broad, phosphorus release experiment (mg/l).

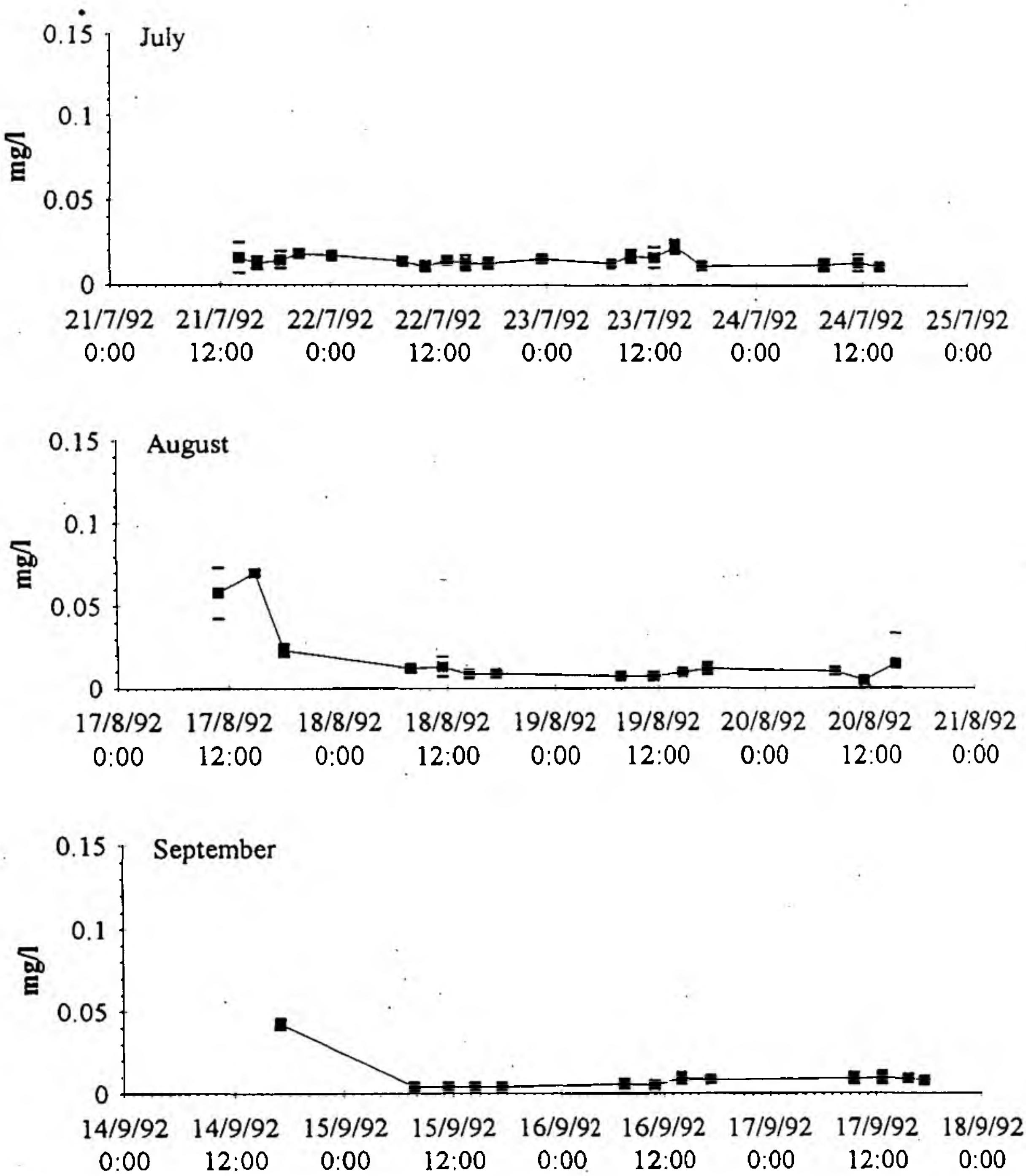


Figure 3.14 D/S Wayford Bridge, phosphorus release experiment (mg/l).

Table 3.1 Ammonium release rates from cores collected from Barton Broad and D/S Wayford Bridge (mg/m²/d).

Date	Core 1	Core 2	Core 3	Mean	S.D.
Barton Broad					
9/6/92	60.62	80.35	87.72	76.23	14.01
20/7/92	169.14	51.30	214.71	145.05	84.33
17/8/92	43.16	20.76	25.09	29.67	11.88
15/9/92	63.22	55.01	27.38	48.54	18.78
D/S Wayford Bridge					
9/6/92	-	-	-	-	-
20/7/92	55.67	52.09	69.63	59.13	9.27
17/8/92	53.05	75.83	107.55	78.81	27.37
15/9/92	41.86	45.01	28.75	38.54	8.62

Table 3.2 Phosphorus release rates from cores collected from Barton Broad and D/S Wayford Bridge (mg/m²/d).

Date	Core 1	Core 2	Core 3	Mean	S.D.
Barton Broad					
9/6/92	14.58	18.24	36.39	23.07	11.68
20/7/92	76.98	12.06	71.80	53.61	36.08
17/8/92	10.60	7.48	6.64	8.24	2.09
15/9/92	7.23	17.42	5.60	10.08	6.41
D/S Wayford Bridge					
9/6/92	-	-	-	-	-
20/7/92	12.72	13.33	14.12	13.39	0.70
17/8/92	14.74	14.54	10.62	13.30	2.32
15/9/92	11.56	8.93	7.63	9.37	2.00

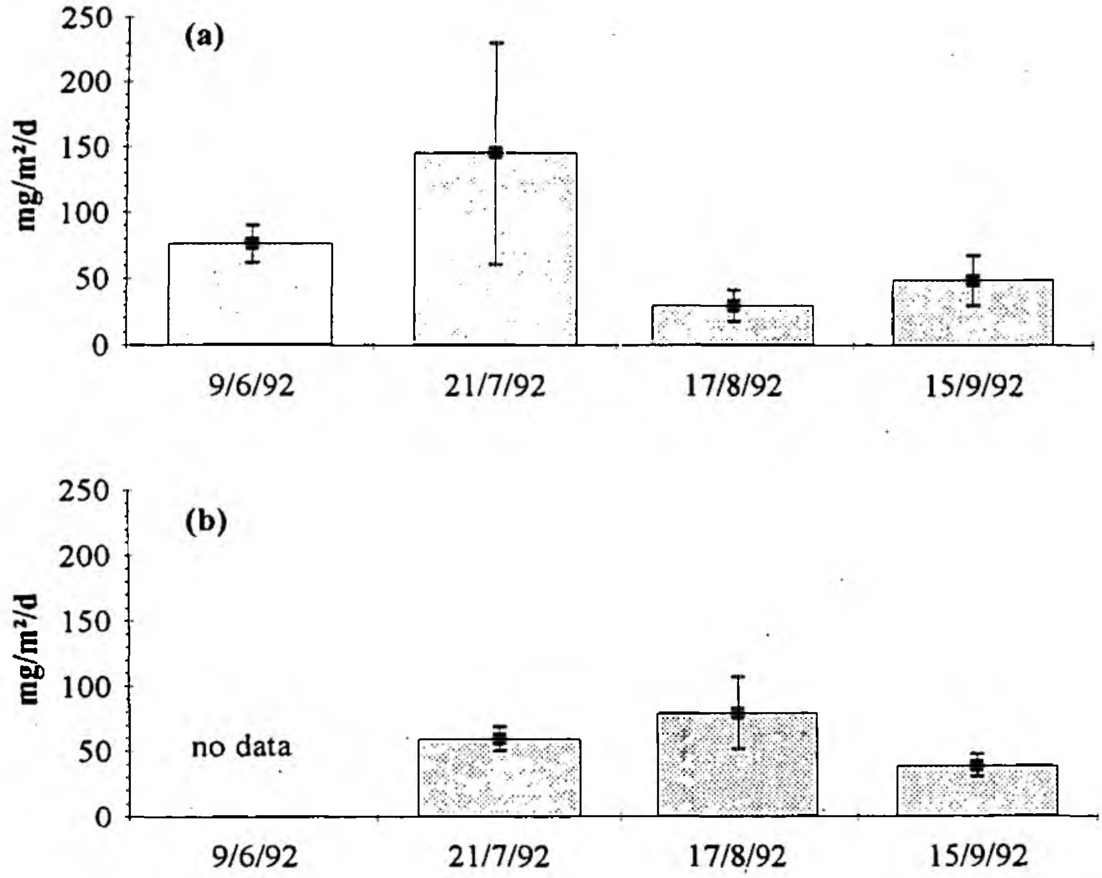


Figure 3.15 Experimentally determined ammonium release rates (a) Barton Broad (b) D/S Wayford Bridge.

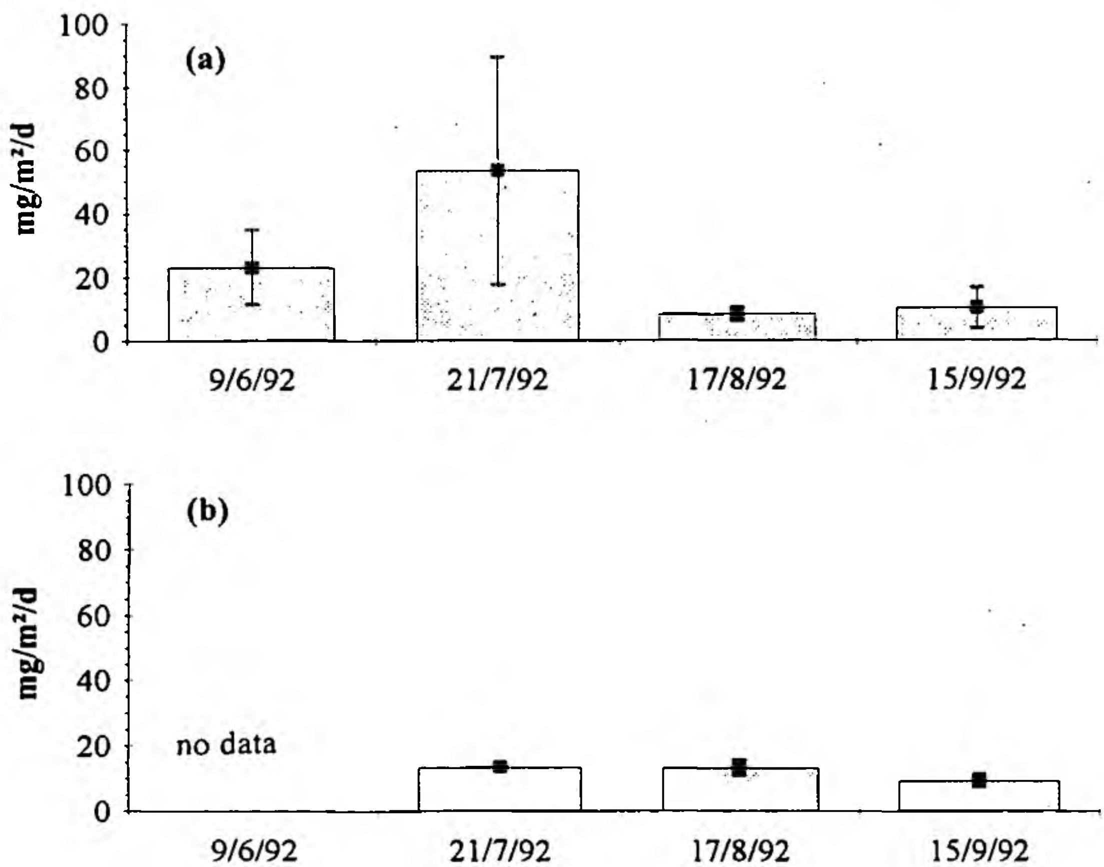


Figure 3.16 Experimentally determined phosphorus release rates (a) Barton Broad (b) D/S Wayford Bridge.

Table 3.3 Benthic invertebrates found in sediment cores used in the release experiments (numbers per m^2)

Date	Chironomids			Tubificids		
	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3
Barton Broad						
09/06/92	2139	3476	2942	24066	41981	67919
21/07/92	1604	1337	2942	21124	5081	56153
17/08/92	534	267	535	20322	18450	5081
15/09/92	802	802	0	10696	19520	12568
D/S Wayford Bridge						
09/06/92	-	-	-	-	-	-
21/07/92	802	2406	1337	7487	13370	9359
17/08/92	0	1337	802	6685	4813	3476
15/09/92	535	267	1337	8022	13102	9359

4. DISCUSSION

Many interrelated factors govern the release of nutrients from lake sediments. Nitrogen and phosphorus must first be mobilised from the particulate to the dissolved form by the action of physical, chemical and biological processes and then be transported from the sediment to the overlying water.

Within the reducing conditions of the deeper sediments phosphorus and ammonium are released into the interstitial water from the breakdown of organic matter. These solutes may then move towards the sediment surface along a diffusion gradient. Raised temperatures will stimulate mineralisation and increase microbial activity thereby liberating more phosphorus and ammonium into the pore water. The increase in microbial activity will lower the redox potential in the sediment surface (Jenson and Andersen, 1992). Greater concentrations of both ammonium and phosphorus were found with increasing sediment depth. Also, at both Barton Broad and downstream of Wayford Bridge the increase in interstitial concentration of ammonium and phosphorus during the summer was associated with a decrease in redox potential. The lowest concentration of interstitial ammonium within Barton Broad sediment was during June. At this time the aerobic sediment layer extended further down into the sediment core with a positive redox being recorded for the top 1cm of sediment.

The concentration of ammonium and phosphorus, in the surface layers of Barton Broad sediment, was lower during the months of June and July when the higher release rates were measured. Also at these times the sediment was reduced in the upper layers. This perhaps allowed a larger proportion of the phosphorus and ammonium to diffuse into the overlying water. However, in shallow lakes such as Barton Broad, the sediment surface is usually aerobic and in the presence of oxygen a proportion of the ammonium will be oxidised to nitrate before it can escape from the sediments. Phosphorus release is also affected by this oxidised sediment surface. In oxidised conditions phosphorus is adsorbed onto iron (III) hydroxides. The major factor governing release under these conditions is the molar ratio of ferrous iron to phosphorus. If the molar ratio is <1.8 then the phosphorus can still be released (Holdren and Armstrong, 1986). Table 3.4 gives the molar ratio for the top 3cm of interstitial water for each core analysed. The molar ratio for Barton Broad is below 1.8 for most of the cores with the exception of two. This may explain the variable nature of phosphorus release between experimental cores. A variation in the molar ratio was also detected downstream of Wayford Bridge but generally it was greater than 1.8.

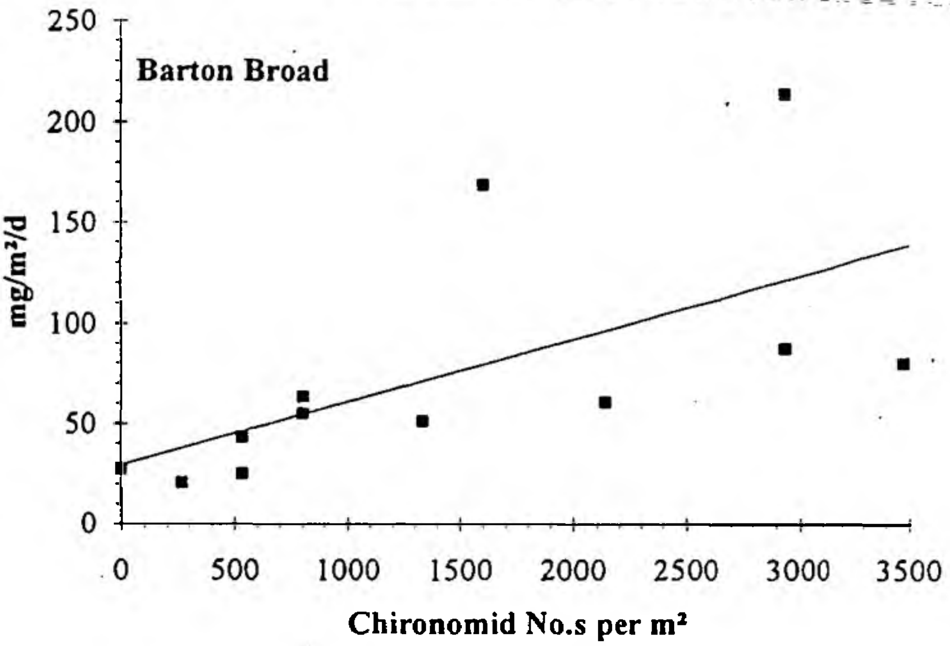
A further factor governing the release of phosphorus is pH. An increase in pH decreases the binding capacity of iron compounds. The rate of phosphorus release can be correlated with pH at values between 8 and 9 (Andersen, 1975). The pH of the water overlying the Barton Broad sediment cores was between 8 and 9. However, despite pH values below 8 phosphorus release was still detected for the downstream of Wayford Bridge sediments.

Ammonium and phosphorus will not only be transferred to overlying water via diffusion but other factors such as resuspension of sediments and bioturbation will affect release. This enhancement of release will be of greatest importance in sediments which maintain an aerobic upper layer.

Bioturbation due to the presence of benthic invertebrates such as chironomids have been shown to increase rates of release (Andersen and Jenson, 1991). Chironomid larvae and tubificids are the dominant benthic invertebrates found within Barton

Table 3.4 Molar ratio of ferrous iron to soluble reactive phosphorus (mean top 3cm of interstitial water)

Date	Core 1	Core 2	Core 2	Mean	S.D.
Barton Broad					
20/07/92	0.66	4.06	0.90	1.87	1.90
17/08/92	3.51	0.67	1.30	1.83	1.49
15/09/92	1.71	1.50	-	1.61	0.15
D/S Wayford Bridge					
20/07/92	1.62	1.66	4.32	2.54	1.55
17/08/92	3.72	0.34	5.50	3.19	2.62
15/09/92	3.70	10.27	6.15	6.71	3.32



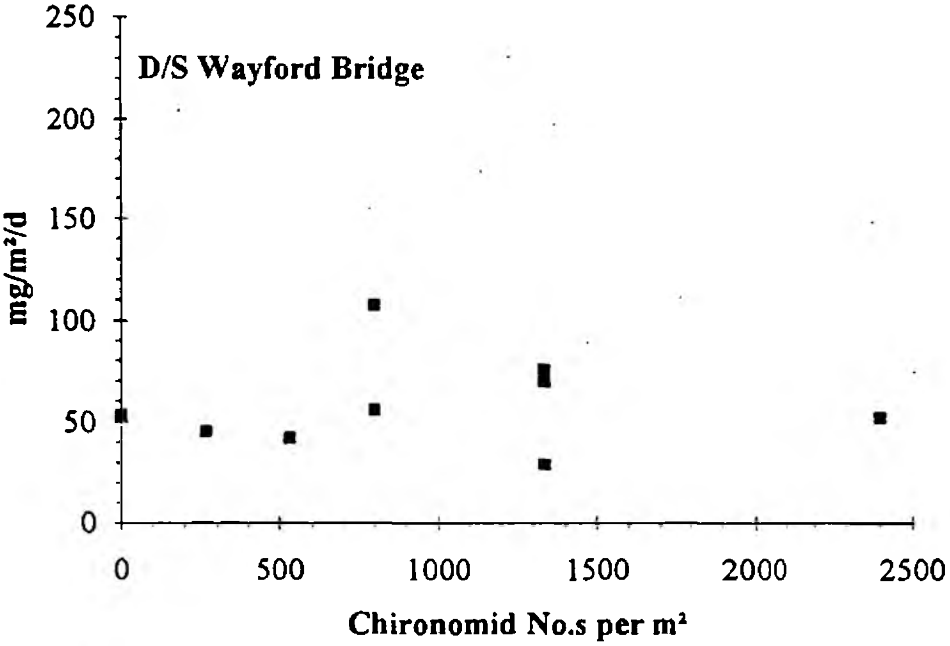
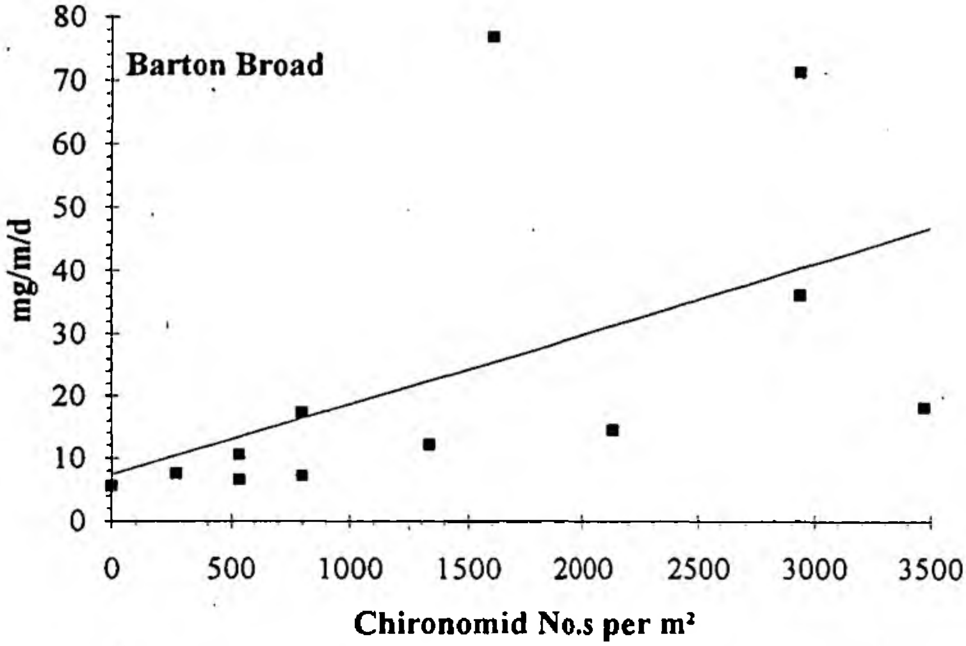


Figure 4.1 **The relationship between the ammonium release rate ($mg/m^2/d$) and the number of chironomids in the cores (No. per m^2)**



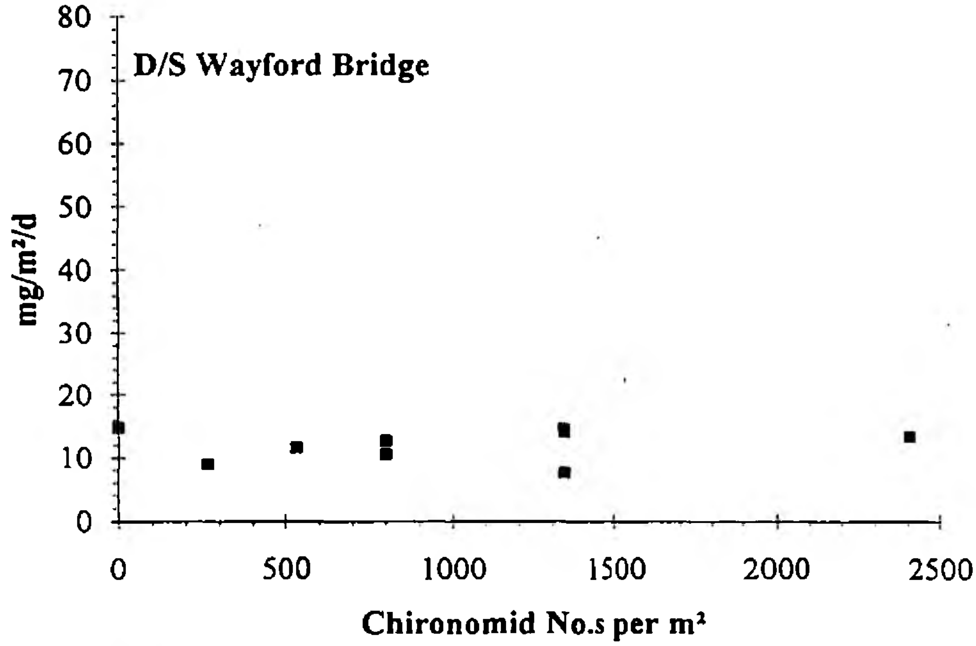
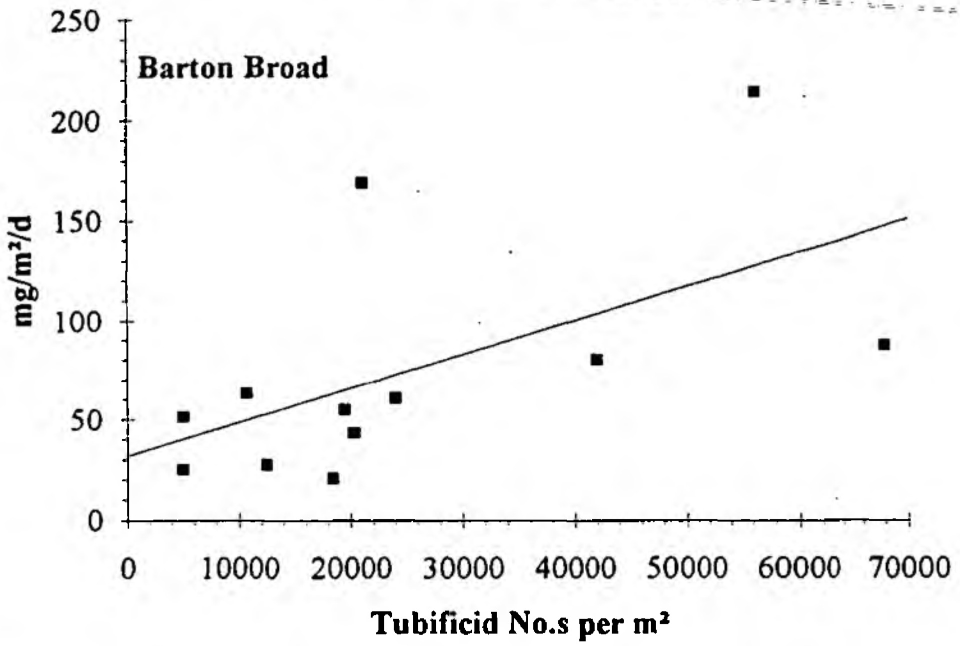


Figure 4.2 **The relationship between the phosphorus release rate (mg/m²/d) and the number of chironomids in the cores (No. per m²)**



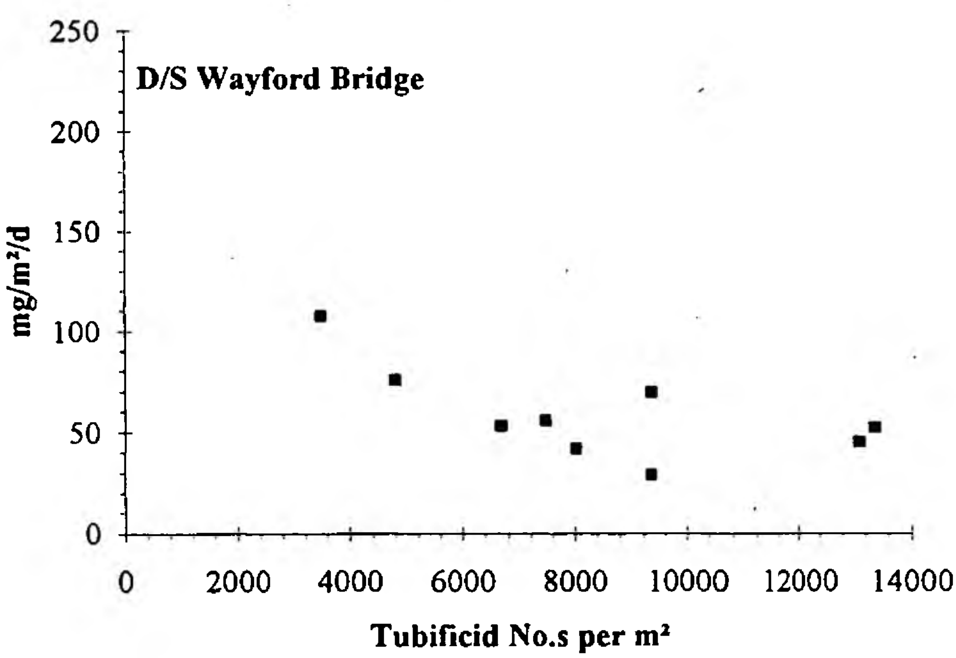


Figure 4.3 **The relationship between the ammonium release rate (mg/m²/d) and the number of tubificids in the cores (No. per m²)**

Broad and downstream of Wayford Bridge. A relationship between chironomid numbers and both ammonium and phosphorus release can be seen for Barton Broad (Figures 4.1 - 4.2). However, no clear relationship exists at the river Ant site downstream of Wayford Bridge. Many chironomids construct u-shaped tubes through which an intermittent irrigation current is maintained to take food in and respire (McLachlan and Cantrell, 1976). The tube building and irrigation through the tube will accelerate the transport of substances to the sediment-water interface. Also phosphate excreted by the chironomids can be exhausted directly to the overlying water. Tubificids will also affect release by carrying deeper, anoxic sediments up to the surface and mixing the sediment vertically. Such activities may also affect the redox potentials within the sediment. The phosphorus concentration within the interstitial water could be lowered by the production of phosphate-iron complexes. Fukuhara and Sakamoto (1987) found that in experiments with tubificids that there is a decrease in the redox potential of deeper muds. Figures 4.3 - 4.4 show the relationship between release rates and numbers of tubificids counted from the experimental cores. The number of Tubificids appears to have no affect upon the rate of ammonium or phosphorus release at downstream of Wayford Bridge. Within Barton Broad the rate of release does appear to increase with an increase in the number of tubificids. It was also suggested by Fukahara and Sakamoto in 1987, that the growth of bacteria is stimulated by the presence of tubificids. Bacterial decomposition of organic matter is most active within a thin layer at the surface of the sediment. Therefore, liberation of both ammonium and phosphorus might be enhanced by the increased microbial action.

5. CONCLUSIONS

Differing rates of phosphorus and ammonium release were detected experimentally at both Barton Broad and downstream of Wayford Bridge. Release of these nutrients occurred to a lesser extent within the river despite interstitial concentrations which were of a similar order of magnitude. The reduced rates of release from the river sediments were probably due to the fact that they remained more aerobic. Ammonium, under oxidising conditions, will be available for nitrification and is therefore not released into the overlying water. Also, phosphorus release would have been suppressed by the higher concentration of ferrous iron in the interstitial water. The release that did occur from the river sediment cores, however, was not brought about physical disturbance of the sediment by benthic invertebrates. The reason for the release of ammonium and phosphorus from the river sediments is not clear.

The supply of these nutrients by the river to the broad will affect the level of primary productivity within the broad. If nitrification is an ongoing process within the river then it is possible that nitrogen is being lost to atmosphere via denitrification. This would lead to an overall reduction in the amount of nitrogen that reaches the broad. However, some ammonium is released directly into the water column during the summer. It is possible that phytoplankton or macrophyte uptake may reduce the concentration of both ammonium and phosphorus within the river. Any phytoplankton transported to the broad will represent a supply of particulate nitrogen and phosphorus.

The recycling of phosphorus and ammonium back to the water column from the Barton Broad sediments will help to maintain a flourishing phytoplankton population even with catchment control of nutrient inputs. Decomposing organic matter within the broads sediments will create a high oxygen demand and support the growth of large numbers of bacteria. The release of ammonium will be enhanced and the coupled processes of nitrification and denitrification restricted. These natural processes act as a check against eutrophication by making much of the nitrogen within the system unavailable for phytoplankton uptake. The high ammonium release rates suggest that in the organic-rich sediments of Barton Broad the majority of the nitrogen is recycled to the overlying water. Further investigation of the nitrification and denitrification processes within Barton Broad are required to obtain a fuller understanding of the importance of internal nitrogen cycling upon the maintainence of phytoplankton dominance. Also, the availability of nitrogen and phosphorus is important in determining the composition of the phytoplankton community by influencing competition and succession.

6. REFERENCES

Andersen, J.M. (1975) Influence of pH on release of phosphorus from lake sediments. Arch. Hydrobiol., 76, 411-419.

Andersen, F.O. and Jensen, H.S. (1991) The influence of chironomids on decomposition of orgainc matter and nutrient exchange in a lake sediment. Verh. int. Verein. Limnol., 24, 3051-3055.

Boar, R. (1992) The importance of nitrogen in the eutrophication of Broadland: a nitrogen budget for the river Ant and Barton Broad. Progress report for 1991-92. R. & D. Project 542 National Rivers Authority, Ipswich.

Chaney, A.L. and Morbach, E.P. (1982) Modified reagents for the determination of urea and ammonia. Clin. Chem., 8, 130-132.

Fukuhara, H. and Sakamoto, M. (1987) Enhancement of inorganic nitrogen and phosphate release from lake sediment by tubificid worms and chironomid larvae. Oikos, 48, 312-320.

Holdren, G.C. and Armstrong, D.E. (1986) Interstitial iron concentrations as an indicator of phosphorus release and mineral formation in lake sediments. In Sly, P.G. (Ed.) Sediments and Water Interactions, Springer, New York, pp 133-147.

Jackson, R.H. and Phillips, G.L. (1990) Investigation of phosphorus dynamics at the mud/water interface. Unpublished final report to the Nature Conservancy Council, Project HF3-03-350.

Jackson, R.H. and Phillips, G.L. (1991) The extent of phosphorus release in the Norfolk Broads: Progress report for 1989-90. R. & D. Project 518 National Rivers Authority, Ipswich.

Jensen, H.S. and Andersen, R.O. (1992) Importance of temperature, nitrate and pH for phosphate release from aerobic sediments of four shallow, eutrophic lakes. Limnol. Oceanogr. 37 (3), 577-589.

McLachlan, A.J. and Cantrell, M.A. (1976) Sediment development and tube structure of *Chironmus plumosus* (Chironomidae, Diptera) in a new impoundment. Freshwat. Biol., 6, 437-443.

Osborne, P.L. and Phillips, G.L. (1978) Evidence for nutrient release from the sediments of two shallow and productive lakes. Verh. int. Verein. Limnol., 20, 654-658.

Phillips, G.L. and Chilvers, A.A., (1991) The control of phosphorus in the catchment of the rivers Ant and Bure. Progress report for 1990. R. & D. Project 540 National Rivers Authority, Ipswich.

Phillips, G.L., Eminson, D.F. and Moss, B. (1978) A mechanism to account for macrophyte decline in progressively eutrophicated freshwaters. Aquat. Bot., 4, 103-126.

Seitzinger, S.P., (1990) Denitrification in aquatic sediments. In Revsbech, N.P. and Sorensen, J. (Ed.) Denitrification in Soil and Sediment., Plenum Press, New York, pp301-322.

Appendix A

Barton Broad **Redox Potentials (Eh7, mV)**

Depth	10-Jun	20-Jul		17-Aug		15-Sep	
(cm)	Core 1	Core 1	Core 2	Core 1	Core 2	Core 1	Core 2
0	333.4	334.5	291.1	290.1	290.9	204.1	260.9
-1	236.1	42.9	-39.5	96.0	0.5	-11.8	-4.2
-2	-27.7	-307.2	-281.6	54.1	-69.7	-65.0	-385.7
-3	-68.9	-241.1	-91.5	-7.2	-139.2	-77.3	-318.1
-4	-	-	-	-	-	-	-
-5	-64.0	-243.6	-192.0	24.4	-82.4	-18.5	-379.1
-6	-81.6	-262.6	-177.0	12.5	-57.3	-13.2	-341.9
-7	-70.1	-283.1	-217.5	-15.2	-53.1	5.5	-367.5
-8	-65.7	-286.8	-221.2	-10.5	-53.6	-37.8	-407.9

Barton Broad **pH**

Depth	10-Jun	20-Jul		17-Aug		15-Sep	
(cm)	Core 1	Core 1	Core 2	Core 1	Core 2	Core 1	Core 2
0	8.7	8.4	8.2	9.2	9.3	9.0	9.2
-1	8.0	7.4	7.2	7.8	8.2	7.9	8.2
-2	7.9	7.2	7.0	7.5	8.1	7.5	7.9
-3	7.9	7.1	6.9	7.3	7.9	7.3	7.7
-4	7.9	6.9	6.7	7.2	7.7	7.1	7.5
-5	7.8	6.8	6.6	7.1	7.5	7.2	7.5
-6	7.7	6.7	6.5	7.0	7.3	7.1	7.3
-7	7.6	6.6	6.4	7.0	7.2	7.2	7.2
-8	7.6	6.6	6.4	7.0	7.1	7.3	7.1

D/S Wayford Bridge , R. Ant Redox Potentials (Eh7, mV)

Depth	10-Jun	20-Jul		17-Aug		15-Sep	
(cm)	Core 1	Core 1	Core 2	Core 1	Core 2	Core 1	Core 2
0	-	410.1	260.1	401.9	109.0	425.1	331.9
-1	-	14.2	-8.8	13.5	-277.0	165.4	-61.6
-2	-	-38.9	-107.9	-160.2	-424.0	-255.9	-204.6
-3	-	-110.1	-94.1	-122.1	-409.0	-154.4	-186.1
-4	-	-	-	-	-	-	-
-5	-	-99.1	-114.4	-72.9	-366.0	-314.6	-138.4
-6	-	-101.2	-117.6	-221.6	-373.0	-134.9	-144.9
-7	-	-96.2	-233.9	-263.4	-387.0	-239.6	-157.7
-8	-	-98.6	-116.2	-230.1	-457.0	-288.7	-225.4

D/S Wayford Bridge , R. Ant pH

Depth	10-Jun	20-Jul		17-Aug		15-Sep	
(cm)	Core 1	Core 1	Core 2	Core 1	Core 2	Core 1	Core 2
0	-	-	-	7.5	7.5	7.7	7.5
-1	-	-	-	7.6	7.6	7.5	7.6
-2	-	-	-	7.4	7.5	7.6	7.5
-3	-	-	-	7.3	7.5	7.5	7.5
-4	-	-	-	7.2	7.5	7.4	7.5
-5	-	-	-	7.2	7.4	7.3	7.4
-6	-	-	-	7.1	7.4	7.3	7.4
-7	-	-	-	7.1	7.4	7.2	7.4
-8	-	-	-	7.1	7.3	7.2	7.3

Appendix B

Barton Broad **Interstitial Ammonium (mg/l)**

Depth		10-Jun			20-Jul			17-Aug			15-Sep	
(cm)	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3
0	0.34	0.23	0.20	0.63	0.04	0.03	0.01	0.01	0.02	0.33	0.24	-
-1	0.46	0.65	2.32	0.93	0.32	0.36	4.96	9.19	9.23	2.38	1.30	-
-2	0.74	0.67	1.91	1.89	1.06	0.04	7.40	6.84	12.33	3.32	1.84	-
-3	1.10	0.80	3.77	3.28	2.70	3.48	7.39	4.61	11.22	9.20	3.02	-
-4	0.96	0.92	1.91	3.47	3.32	4.01	9.18	9.71	13.15	10.26	3.86	-
-5	0.96	1.79	2.08	4.56	3.95	8.11	-	6.09	7.47	9.18	4.34	-
-6	0.68	0.97	2.57	4.10	4.69	10.23	18.37	8.66	11.54	12.48	6.14	-
-7	2.36	1.24	2.32	2.96	3.79	8.10	18.76	7.43	16.70	9.54	4.34	-
-8	1.25	1.27	2.34	3.29	5.52	9.35	17.24	8.73	18.58	16.25	6.96	-
-9	3.34	1.43	2.30	2.94	7.10	7.72	21.27	8.90	16.16	20.06	5.68	-
-10	3.42	1.86	5.40	2.48	5.91	10.35	19.46	11.74	15.23	18.36	7.91	-
-11	4.34	1.10	4.67	2.55	4.82	8.10	21.00	5.03	9.90	17.94	8.97	-
-12	-	3.66	2.13	3.74	6.41	5.58	20.79	12.03	12.23	18.32	10.54	-

D/S Wayford Bridge, R. Ant **Interstitial Ammonium (mg/l)**

Depth		10-Jun			20-Jul			17-Aug			15-Sep	
(cm)	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3
0	-	-	-	0.12	0.20	-	0.60	0.30	0.41	0.02	0.02	0.35
-1	-	-	-	4.17	1.47	1.71	8.05	3.45	2.03	0.42	1.00	3.57
-2	-	-	-	5.32	4.09	2.25	6.90	3.54	1.30	2.85	2.92	6.08
-3	-	-	-	5.22	4.10	3.47	6.71	3.78	3.53	5.09	2.83	5.10
-4	-	-	-	6.14	9.61	3.95	5.87	5.44	3.64	10.44	3.99	11.03
-5	-	-	-	4.81	4.10	4.14	7.87	7.17	8.61	13.32	3.50	10.62
-6	-	-	-	4.37	6.38	4.75	6.64	8.62	4.46	12.57	6.20	10.63
-7	-	-	-	12.12	6.83	5.52	8.27	10.77	3.26	15.16	7.86	13.37
-8	-	-	-	9.15	6.86	6.41	10.61	9.08	4.82	16.99	12.71	14.24
-9	-	-	-	11.02	7.15	7.05	8.66	12.26	8.00	17.62	-	14.14
-10	-	-	-	12.07	-	9.57	7.29	13.50	6.41	16.09	12.37	13.55
-11	-	-	-	7.01	6.96	9.45	5.62	11.60	4.28	17.93	10.57	17.09
-12	-	-	-	10.87	7.44	10.67	7.29	13.50	3.20	18.72	8.64	14.71

Barton Broad — **Interstitial Soluble Reactive Phosphorus (mg/l)**

Depth	10-Jun	20-Jul			17-Aug			15-Sep		
(cm)	Core 1	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3
0	-	0.13	0.02	0.01	0.00	0.04	0.00	0.02	0.02	-
-1	-	0.06	0.01	0.02	0.57	3.79	1.52	0.15	0.08	-
-2	-	0.18	0.08	0.20	1.14	1.98	2.58	1.11	1.52	-
-3	-	0.41	0.32	0.72	0.71	0.80	2.53	1.74	0.44	-
-4	-	1.01	0.44	0.37	0.90	3.10	3.55	4.68	0.58	-
-5	-	0.59	0.54	0.58	1.49	0.85	1.18	5.75	0.36	-
-6	-	0.38	1.13	2.71	2.45	2.28	0.83	5.73	1.25	-
-7	-	0.40	0.56	1.96	2.56	1.55	2.68	5.71	1.77	-
-8	-	0.32	0.90	1.67	1.48	0.83	3.32	3.35	3.23	-
-9	-	0.26	1.85	1.38	3.12	2.07	2.81	3.89	3.01	-
-10	-	0.12	0.96	1.89	3.10	1.90	2.21	3.50	2.42	-
-11	-	0.12	0.96	1.50	1.17	0.31	1.96	3.54	1.66	-
-12	-	0.11	1.33	0.37	2.48	1.98	2.94	3.91	1.44	-

D/S Wayford Bridge, R. Ant — **Interstitial Soluble Reactive Phosphorus (mg/l)**

Depth	10-Jun	20-Jul			17-Aug			15-Sep		
(cm)	Core 1	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3
0	-	0.01	0.03	-	0.03	0.08	0.05	0.08	0.07	0.07
-1	-	1.47	1.76	1.61	2.34	2.03	1.19	0.94	0.55	0.42
-2	-	1.93	3.35	1.16	2.01	1.06	0.86	1.53	0.54	0.79
-3	-	1.76	2.37	1.35	0.97	1.00	0.52	0.63	2.12	1.73
-4	-	1.57	4.24	2.66	1.10	2.79	0.50	2.19	2.27	0.69
-5	-	1.64	2.84	1.99	4.10	2.15	1.06	2.22	0.98	1.62
-6	-	0.16	4.92	3.42	0.58	1.46	0.72	2.53	2.00	2.37
-7	-	1.32	3.15	2.30	1.20	1.06	0.65	3.83	0.69	1.94
-8	-	3.44	2.23	3.32	0.87	1.58	1.13	4.49	2.13	2.82
-9	-	2.48	2.68	1.30	1.23	0.86	0.83	3.27	1.30	1.88
-10	-	2.29	2.60	3.85	0.50	1.55	0.82	4.07	3.26	1.58
-11	-	2.30	3.41	4.10	0.51	1.85	0.59	4.57	2.30	3.42
-12	-	2.19	1.07	3.66	0.75	1.61	0.56	2.89	2.89	2.36

Barton Broad **Interstitial Ferrous Iron (mg/l)**

Depth	10-Jun		20-Jul			17-Aug			15-Sep	
(cm)	Core 1	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3
0	-	-	-	-	-	-	-	-	-	-
-1	-	0.00	0.12	0.04	1.14	1.97	2.00	0.61	0.31	-
-2	-	0.29	0.05	0.08	0.61	1.00	3.56	0.82	0.52	-
-3	-	0.15	0.16	0.15	5.86	0.84	3.36	1.04	0.11	-
-4	-	0.36	0.29	1.19	0.24	0.42	2.11	1.01	0.14	-
-5	-	0.46	0.72	0.45	4.73	0.31	4.08	1.80	0.09	-
-6	-	0.14	0.51	1.17	0.00	0.32	0.79	0.80	-	-
-7	-	-	-	-	0.14	0.77	0.71	0.57	-	-
-8	-	-	-	-	0.00	0.77	5.63	-	-	-
-9	-	-	-	-	0.45	0.17	0.28	-	-	-
-10	-	-	-	-	0.38	0.34	2.38	-	-	-
-11	-	-	-	-	-	-	-	-	-	-
-12	-	-	-	-	-	-	-	-	-	-

D/S Wayford Bridge, R. Ant **Interstitial Ferrous Iron (mg/l)**

Depth	10-Jun		20-Jul			17-Aug			15-Sep	
(cm)	Core 1	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3	Core 1	Core 2	Core 3
0	-	0.13	0.11	-	-	-	-	-	-	-
-1	-	3.74	4.36	5.06	7.16	0.15	5.02	2.85	5.93	2.92
-2	-	-	3.99	-	6.48	0.81	4.39	3.94	9.34	4.02
-3	-	0.38	3.50	1.93	5.07	0.21	4.01	3.68	7.71	11.96
-4	-	3.53	2.49	0.40	4.59	0.50	3.81	2.19	14.44	10.12
-5	-	5.95	5.82	2.73	9.49	3.99	3.48	2.87	13.70	8.27
-6	-	4.12	5.47	2.23	5.91	1.51	4.49	3.67	10.51	10.94
-7	-	2.41	1.46	-	8.22	0.06	4.33	1.78	9.48	8.61
-8	-	8.89	1.20	3.83	9.35	1.83	5.19	1.90	11.61	10.77
-9	-	5.15	1.34	2.57	10.33	1.35	3.87	3.12	12.33	9.62
-10	-	9.19	1.83	7.85	5.30	-	6.63	1.98	16.75	18.16
-11	-	7.77	1.10	9.26	-	-	-	3.01	21.07	17.24
-12	-	6.54	0.61	-	-	-	-	1.93	16.95	18.76

Appendix C

Barton Broad **Ammonium release experiment**

Time/Date	mg/l			Time/Date	mg/l		
	Core 1	Core 2	Core 3		Core 1	Core 2	Core 3
9/6/92 16:45	0.071	0.077	0.051	21/7/92 14:00	0.124	0.014	0.030
9/6/92 18:45	0.080	0.091	0.047	21/7/92 16:00	0.091	0.032	0.037
10/6/92 7:45	0.071	0.138	0.140	21/7/92 18:30	0.093	0.025	0.039
10/6/92 10:15	0.153	0.164	0.129	21/7/92 20:30	0.174	0.042	0.073
10/6/92 12:30	0.183	0.167	0.057	22/7/92 0:10	0.205	0.037	0.138
10/6/92 14:30	0.082	0.136	0.144	22/7/92 8:00	0.242	0.049	0.422
10/6/92 16:30	0.066	0.127	0.189	22/7/92 10:30	0.285	0.063	0.453
10/6/92 18:30	0.060	0.011	0.015	22/7/92 13:00	0.241	0.061	0.483
11/6/92 7:45	0.056	0.061	0.098	22/7/92 15:00	0.200	0.028	0.426
11/6/92 10:00	0.056	0.067	0.054	22/7/92 17:30	0.146	0.063	0.386
11/6/92 12:00	0.108	0.074	0.083	22/7/92 23:30	0.153	0.031	0.351
11/6/92 15:00	0.051	0.032	0.052	23/7/92 7:45	0.219	0.057	0.183
11/6/92 18:00	0.039	0.057	0.055	23/7/92 10:00	0.222	0.046	0.169
12/6/92 7:45	0.031	0.049	0.075	23/7/92 12:30	0.205	0.038	0.129
12/6/92 10:30	0.037	0.032	0.049	23/7/92 14:45	0.155	0.083	0.146
12/6/92 12:30	0.034	0.027	0.046	23/7/92 18:00	0.224	0.055	0.177
12/6/92 14:30	0.025	0.040	0.071	24/7/92 7:45	0.137	0.079	0.142
12/6/92 18:00	0.041	0.002	0.071	24/7/92 11:30	0.108	0.087	0.127
				24/7/92 14:00	0.197	0.086	0.177

Time/Date	mg/l		
	Core 1	Core 2	Core 3
17/8/92 11:00	0.008	0.000	0.000
17/8/92 15:00	0.000	0.000	0.000
17/8/92 18:00	0.025	0.000	0.010
18/8/92 8:00	0.051	0.004	0.028
18/8/92 11:30	0.054	0.000	0.001
18/8/92 14:30	0.035	0.141	0.000
18/8/92 17:30	0.049	0.002	0.006
19/8/92 8:00	0.043	0.002	0.024
19/8/92 11:30	0.023	0.000	0.014
19/8/92 14:45	0.002	0.000	0.004
19/8/92 17:45	0.184	0.215	0.255
20/8/92 8:00	0.109	0.026	0.035
20/8/92 11:15	0.000	0.000	0.000
20/8/92 15:00	0.051	0.000	0.000
21/8/92 8:00	0.000	0.000	0.000
21/8/92 11:30	0.000	0.000	0.000
21/8/92 14:30	0.000	0.000	0.000
12/6/92 18:00	0.041	0.002	0.071

Time/Date	mg/l		
	Core 1	Core 2	Core 3
14/9/92 17:00	0.016	0.016	0.200
15/9/92 7:45	0.062	0.073	0.013
15/9/92 11:30	0.080	0.053	0.012
15/9/92 14:30	0.066	0.061	0.012
15/9/92 17:30	0.066	0.065	0.018
16/9/92 7:45	0.080	0.103	0.023
16/9/92 11:00	0.088	0.048	0.013
16/9/92 14:00	0.083	0.087	0.009
16/9/92 17:30	0.053	0.046	0.008
17/9/92 9:30	0.067	0.081	0.010
17/9/92 12:45	0.076	0.050	0.003
17/9/92 15:45	0.069	0.018	0.030
17/9/92 17:30	0.092	0.026	0.004
18/9/92 7:45	0.059	0.040	0.013

Barton Broad **Phosphorus release experiment**

Time/Date	mg/l			Time/Date	mg/l		
	Core 1	Core 2	Core 3		Core 1	Core 2	Core 3
9/6/92 16:45	-	-	-	21/7/92 14:00	0.041	0.011	0.014
9/6/92 18:45	0.015	-	0.049	21/7/92 16:00	0.015	0.014	0.011
10/6/92 7:45	0.011	0.049	0.054	21/7/92 18:30	0.024	0.014	0.011
10/6/92 10:15	0.013	0.017	0.059	21/7/92 20:30	0.045	0.006	0.013
10/6/92 12:30	0.066	0.020	-	22/7/92 0:10	0.080	0.011	0.041
10/6/92 14:30	0.012	0.034	0.056	22/7/92 8:00	0.087	0.016	0.135
10/6/92 16:30	0.015	0.021	0.053	22/7/92 10:30	0.102	0.014	0.146
10/6/92 18:30	0.016	0.016	0.051	22/7/92 13:00	0.022	0.011	0.151
11/6/92 7:45	<0.004	<0.004	0.027	22/7/92 15:00	0.079	0.015	0.156
11/6/92 10:00	0.004	0.007	0.029	22/7/92 17:30	0.053	0.014	0.142
11/6/92 12:00	0.023	0.014	0.032	22/7/92 23:30	0.113	0.014	0.056
11/6/92 15:00	0.043	0.013	0.029	23/7/92 7:45	0.102	0.013	0.058
11/6/92 18:00	0.014	0.027	0.028	23/7/92 10:00	0.101	0.014	0.071
12/6/92 7:45	0.014	0.018	0.032	23/7/92 12:30	0.104	0.016	0.071
12/6/92 10:30	0.016	0.021	0.036	23/7/92 14:45	0.06	0.018	0.141
12/6/92 12:30	0.014	0.030	0.041	23/7/92 18:00	0.112	0.009	0.054
12/6/92 14:30	0.018	0.018	0.050	24/7/92 7:45	0.067	0.012	0.062
12/6/92 16:30				24/7/92 11:30	0.083	0.011	0.061
				24/7/92 14:00	0.083	0.008	0.067

Time/Date	mg/l		
	Core 1	Core 2	Core 3
17/8/92 11:00	0.027	0.023	0.019
17/8/92 15:00	0.029	0.013	0.011
17/8/92 18:00	0.024	0.012	0.012
18/8/92 8:00	0.013	0.012	0.009
18/8/92 11:30	0.012	0.008	0.009
18/8/92 14:30	0.009	0.009	0.007
18/8/92 17:30	0.009	0.008	0.007
19/8/92 8:00	0.010	0.008	0.007
19/8/92 11:30	0.009	0.008	0.007
19/8/92 14:45	0.011	0.010	0.009
19/8/92 17:45	0.012	0.009	0.007
20/8/92 8:00	0.009	0.009	0.008
20/8/92 11:15	0.012	<0.004	<0.004
20/8/92 15:00	0.005	<0.004	<0.004
21/8/92 8:00	0.009	<0.004	<0.004
21/8/92 11:30	0.007	0.009	0.006
21/8/92 14:30	0.007	<0.004	<0.004
24/7/92 11:30	0.083	0.011	0.061
24/7/92 14:00	0.083	0.008	0.067

Time/Date	mg/l		
	Core 1	Core 2	Core 3
14/9/92 17:00	0.008	<0.004	<0.004
15/9/92 7:45	<0.004	0.008	<0.004
15/9/92 11:30	0.004	0.039	<0.004
15/9/92 14:30	<0.004	<0.004	<0.004
15/9/92 17:30	<0.004	<0.004	<0.004
16/9/92 7:45	<0.004	0.004	<0.004
16/9/92 11:00	<0.004	<0.004	<0.004
16/9/92 14:00	0.020	0.022	0.007
16/9/92 17:30	0.011	0.020	0.007
17/9/92 9:30	0.009	0.036	0.008
17/9/92 12:45	0.009	0.031	0.007
17/9/92 15:45	0.010	0.025	0.008
17/9/92 17:30	0.010	0.027	0.008
18/9/92 7:45	0.008	0.035	0.008

D/S Wayford Bridge, R. Ant **Ammonium release experiment**

Time/Date	mg/l			Time/Date	mg/l		
	Core 1	Core 2	Core 3		Core 1	Core 2	Core 3
				21/7/92 14:00	0.205	0.052	0.064
				21/7/92 16:00	0.079	0.024	0.032
				21/7/92 18:30	0.069	0.035	0.092
				21/7/92 20:30	0.073	0.033	0.055
				22/7/92 0:10	0.080	0.035	0.066
				22/7/92 8:00	0.060	0.028	0.069
				22/7/92 10:30	0.050	0.060	0.160
				22/7/92 13:00	0.053	0.046	0.067
				22/7/92 15:00	0.039	0.037	0.064
				22/7/92 17:30	0.051	0.032	0.063
				22/7/92 23:30	0.042	0.042	0.069
				23/7/92 7:45	0.033	0.065	0.037
				23/7/92 10:00	0.050	0.075	0.141
				23/7/92 12:30	0.027	0.039	0.029
				23/7/92 14:45	0.030	0.064	0.059
				23/7/92 18:00	0.045	0.069	0.085
				24/7/92 7:45	0.065	0.096	0.086
				24/7/92 11:30	0.102	0.065	0.076
				24/7/92 14:00	0.072	0.065	0.042

Time/Date	mg/l		
	Core 1	Core 2	Core 3
17/8/92 11:00	0.128	0.066	0.082
17/8/92 15:00	0.157	0.155	0.180
17/8/92 18:00	0.054	0.084	0.153
18/8/92 8:00	0.058	0.063	0.106
18/8/92 11:30	0.041	0.140	0.099
18/8/92 14:30	0.054	0.047	0.065
18/8/92 17:30	0.062	0.078	0.071
19/8/92 8:00	0.029	0.019	0.033
19/8/92 11:30	0.037	0.058	0.079
19/8/92 14:45	0.030	0.052	0.147
19/8/92 17:45	0.140	0.128	0.277
20/8/92 8:00	0.190	0.205	0.346
20/8/92 11:15	0.000	0.000	0.021
20/8/92 15:00	0.009	0.101	0.113
21/8/92 8:00	0.038	0.039	0.005
21/8/92 11:30	0.016	0.051	0.071
21/8/92 14:30	0.006	0.005	0.02

Time/Date	mg/l		
	Core 1	Core 2	Core 3
14/9/92 17:00	0.106	0.110	0.130
15/9/92 7:45	0.057	0.039	0.044
15/9/92 11:30	0.057	0.039	0.040
15/9/92 14:30	0.048	0.039	0.033
15/9/92 17:30	0.046	0.038	0.029
16/9/92 7:45	0.080	0.071	0.036
16/9/92 11:00	0.078	0.080	0.012
16/9/92 14:00	0.035	0.031	0.015
16/9/92 17:30	0.028	0.026	0.010
17/9/92 9:30	0.017	0.043	0.012
17/9/92 12:45	0.016	0.038	0.010
17/9/92 15:45	0.015	0.035	0.003
17/9/92 17:30	0.012	0.038	0.000
18/9/92 7:45	0.010	0.024	0.014

D/S Wayford Bridge, R. Ant **Phosphorus release experiment**

Time/Date	mg/l			Time/Date	mg/l		
	Core 1	Core 2	Core 3		Core 1	Core 2	Core 3
				21/7/92 14:00	0.026	0.009	0.013
				21/7/92 16:00	0.017	0.011	0.010
				21/7/92 18:30	0.020	0.010	0.014
				21/7/92 20:30	0.019	0.020	0.016
				22/7/92 0:10	0.018	0.019	0.014
				22/7/92 8:00	0.017	0.012	0.013
				22/7/92 10:30	0.014	0.011	0.008
				22/7/92 13:00	0.017	0.013	0.014
				22/7/92 15:00	0.018	0.011	0.010
				22/7/92 17:30	0.014	0.009	0.015
				22/7/92 23:30	0.014	0.015	0.017
				23/7/92 7:45	0.011	0.014	0.013
				23/7/92 10:00	0.014	0.021	0.016
				23/7/92 12:30	0.011	0.015	0.023
				23/7/92 14:45	0.024	0.026	0.018
				23/7/92 18:00	0.009	0.011	0.014
				24/7/92 7:45	0.008	0.013	0.015
				24/7/92 11:30	0.01	0.011	0.019
				24/7/92 14:00	0.009	0.01	0.013

Time/Date	mg/l		
	Core 1	Core 2	Core 3
17/8/92 11:00	0.043	0.057	0.074
17/8/92 15:00	0.072	0.068	0.070
17/8/92 18:00	0.019	0.023	0.027
18/8/92 8:00	0.009	0.013	0.014
18/8/92 11:30	0.009	0.020	0.010
18/8/92 14:30	0.008	0.009	0.008
18/8/92 17:30	0.009	0.009	0.008
19/8/92 8:00	0.007	0.007	0.007
19/8/92 11:30	0.008	0.007	0.006
19/8/92 14:45	0.009	0.009	0.010
19/8/92 17:45	0.010	0.009	0.016
20/8/92 8:00	0.008	0.010	0.012
20/8/92 11:15	<0.004	0.005	<0.004
20/8/92 15:00	<0.004	0.036	0.004
21/8/92 8:00	0.011	0.007	0.005
21/8/92 11:30	<0.004	0.006	0.009
21/8/92 14:30	0.004	<0.004	0.005
14/9/92 17:00	0.040	0.046	0.041
15/9/92 7:45	<0.004	<0.004	<0.004
15/9/92 11:30	<0.004	<0.004	<0.004
15/9/92 14:30	<0.004	<0.004	<0.004
15/9/92 17:30	<0.004	<0.004	<0.004
16/9/92 7:45	0.009	<0.004	<0.004
16/9/92 11:00	0.007	<0.004	<0.004
16/9/92 14:00	0.013	0.007	0.007
16/9/92 17:30	0.011	0.007	0.007
17/9/92 9:30	0.013	0.008	0.006
17/9/92 12:45	0.014	0.007	0.007
17/9/92 15:45	0.012	0.008	0.007
17/9/92 17:30	0.009	0.007	0.007
18/9/92 7:45	0.013	0.008	0.007