The freshwater snail *Anisus vorticulus*: 1998 monitoring survey of ditches in East Anglia

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The freshwater snail *Anisus vorticulus:* 1998 monitoring survey of ditches in East Anglia

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Contents

1. Summary

In 1997 a survey was undertaken to determine ecology and life history of the BAP short-listed aquatic mollusc *Anisus vorticulus*. This work (Willing & Killeen 1998) included monthly sampling (between April and September) of ditches at North Cove and Carlton Marshes, Suffolk. The results gave new information on the life history and ecology, but the snail's unpredictable occurrence prevented an unambiguous description of the life cycle. Previous work had not proved conclusive in establishing the habitat factors that correlated well with the species' presence.

This report describes continuation of the East Anglian work with the following objectives:

- Repeat parts of the 1997 survey to refine the description of the species' life history and to monitor the fate of the snails within the ditches sampled previously to determine the effects of ditch age on their abundance.

- Undertake monthly monitoring of selected ditches at North Cove and Carlton Marshes, Suffolk and at Halvergate, Norfolk.

Eight ditches were selected for monitoring: two at North Cove, three at Carlton Marshes, and three at Halvergate Marshes. The results may be summarised:

- Carlton Marshes ditches CM1 and CM2, and all Halvergate ditches supported a healthy population of *Anisus vorticulus* throughout 1998, although there is no evidence of an increase in abundance. Carlton CM3 continued to support a small population. North Cove NC1 appears not to have recovered from the winter clearance, whereas the population in NC13 is gradually increasing following its clearance in February/March 1997.

- *Anisus vorticulus* appears to have a 12 month life cycle.

- Breeding occurs principally between early June and mid-July. Breeding is not a single event but may be spread over a 6 - 8 week period. There appears to be significant juvenile mortality.

- Breeding in different ditches is not synchronised. In one of the study ditches at Halvergate, breeding occurred some 6 - 8 weeks later than in the others.

- Temperature may be one of the most important factors in determining reproductive timing and growth rate.

- Adults rapidly complete their growth in spring (excluding one Halvergate site) before breeding and dying. Juveniles grow at a slower, but more or less constant rate until the end of September beyond which the growth is slower. More information is needed to determine whether *Anisus* continues to grow over winter.

- *Anisus* occurs in greatest abundance on shallow margins of ditches.

- The snail's powers of recolonisation are relatively poor.

Summary of recommendations

- There does not appear to be justification for English Nature to fund further monitoring throughout 1999. However, at present we have no data on the species' growth rate during winter. To complete the picture, samples will be taken from three ditches (Carlton CM2, and Halvergate H3 and H19) at the end of January and the end of March 1999.

- It would be desirable to re-survey the known *Anisus* populations in East Anglia in 3-5 years time to provide information on long-term changes in status. In addition to those monitored during the present 1998 survey, it should also include the other populations at Halvergate, Carlton Marshes, North Cove and Castle Marshes identified in 1996/7.

- The *Anisus* populations at North Cove are vulnerable as a result of frequent and 'inappropriate' management. It is recommended that the importance of the site should be reinforced with the landowner, either through FWAG or the ESA scheme, so that hopefully future management policy will be more sympathetic towards the snail's survival.

- It is suggested that all other work on the autecology and biology of *Anisus vorticulus* would be best undertaken as part of the recently started PhD project by Alisa Watson at the University of Wales Cardiff. The following areas could be addressed:

    a. Detailed analysis of ditch hydrochemistry to determine if this is a limiting factor in the species' distribution within sites.

    b. Reproduction - determine when eggs are laid, how many, on which plant species, where in the ditch.

    c. Growth and mortality.

    d. Factors affecting 2 and 3 above (temperature, predation).

    e. Food, analysis of gut content to determine food type (e.g. micro-algae, bacteria, diatoms) and whether this may affect timing of reproduction.

2. Background & objectives

The whirlpool ram's horn, *Anisus vorticulus* is a planorbid water snail which inhabits richly vegetated ditches in grazing marsh complexes. It is local and declining throughout its central and southern European range. The main threats to the species are inappropriate ditch management, loss of habitat resulting from change in agricultural practice from traditional grazing to arable, lowering of water tables and nutrient enrichment. It is a priority species in the UK Biodiversity Action Plan (UK Biodiversity Steering Group 1996).

A survey undertaken in 1996 of sites where the species had been recorded in the recent past showed that *Anisus vorticulus* was restricted to ditches at a relatively late hydroseral stage (Killeen & Willing 1997). This work recommended that effort should be spent in establishing the extent of the species within sites where it occurs, and obtaining a better understanding of its autecology, in order to help the species recover to more sustainable levels.

A further survey was undertaken in 1997 (Willing & Killeen 1998) to establish more precisely the snail's life cycle and habitat preferences. This work included monthly sampling (between April and September) of ditches at North Cove and Carlton Marshes, Suffolk. The results gave preliminary ideas on the life history, but the snail's unpredictable occurrence prevented an unambiguous description of the life cycle. Previous work had not proved conclusive in establishing the habitat factors that correlated well with the species' presence.

This contract was issued by English Nature, Peterborough, with support from the Broads Authority, with the following objectives:

- Repeat parts of the 1997 survey to refine the description of the species' life history and to monitor the fate of the snails within the ditches sampled previously to determine the effects of ditch age on their abundance.

- Undertake monthly monitoring of selected ditches at North Cove and Carlton Marshes, Suffolk and at Halvergate, Norfolk.

3. Methodology

The methodology for mollusc sampling was the same as that used in previous English Nature ditch surveys (Killeen & Willing 1997; Willing & Killeen 1998):

Samples of molluscs were collected in the field using a 17cm diameter stainless steel kitchen sieve (0.5mm mesh) attached to a wooden pole. To ensure collection of both the bivalves (which mainly live in the sediment) and the gastropods (which mainly live on the weeds), the samples were obtained from the interface between the sediment and the aquatic vegetation. Ten scoopfuls were collected from each sampling ditch, five from near to one end and a further five approximately half way along the ditch. Sampling for previous projects has indicated that this technique is a reliable method for collecting all mollusc species present and for assessing relative species abundances.

At all sites the samples were tipped into a plastic box. The sample was agitated in water to release snails from the weed, allowed to settle, and then snail-free vegetation (particularly *Lemna* spp.) was removed. The material was placed in labelled self-seal bags and then preserved in 80% alcohol until it was analysed. The samples were subsequently examined microscopically in the laboratory. Specimens of *Anisus vorticulus* were counted individually and separated for measuring. All other species of freshwater molluscs were identified and species abundances were estimated or, for low numbers, were counted. The data were quantified according to an ACFOR scale:

Abundant	A = >101	specimens
Common	C = 51 - 100	specimens
Frequent	F = 16 - 50	specimens
Occasional	O = 6 - 15	specimens
Rare	R = 1 - 5	specimens

Specimens of *Anisus vorticulus* were measured using a stereo microscope at x10 magnification, equipped with a graticule graduated in 0.1mm divisions. Shell diameter was measured across the widest part to the aperture.

At each sampling station the width of the ditch at water level was estimated, and the water depth measured using a graduated cane. Descriptions of bank structure, marginal, emergent and submerged flora, and the management regime of the adjacent land were recorded.

Water temperature was recorded using a 50° thermometer from three locations within each ditch: the ditch margin, the surface and at 30cm below the surface at the centre of the ditch. Other physical and chemical measurements of the water were made in 1997 and wwere not repeated in 1998.

As the contract only provided scope for five sampling visits, the frequency of sampling was approximately six weekly from May to September, with a final sample in late November. The ditches were monitored on the following (1998) dates:

18 May, 27 June, 04 August, 19 September, 28 November

4. Selection of sites

Ditches in three areas of grazing marsh were selected for monitoring: two in the lower Waveney valley at North Cove and Carlton Marshes, and a geographically distant site on the north-western part of Halvergate Marshes, Norfolk. Ditch selection was based on results from the 1996 and 1997 surveys and was aimed mainly at ditches supporting good-sized populations of *Anisus vorticulus*. A total of eight ditches were monitored on a regular basis; the locations are shown on the maps, Figures 1 - 3. To avoid any confusion, the numbering system used in the 1997 survey has been retained.

Carlton Marshes: Ditches CM1, CM2 and CM3 were monitored throughout 1997 and continued in 1998. CM1 and CM2 are similar, and both supported large populations of *Anisus* in 1997. CM3 is a wider ditch with a different plant community, dominated mainly by *Stratiotes aloides*. *Anisus* was present throughout 1997 but always in much lower numbers than the other monitored ditches. In addition to the monitoring, the distribution of *Anisus* in ditch CM2 was determined by taking further samples along and across the ditch. This was mostly carried out in September.

North Cove: Two ditches were monitored, NC1 and NC13. NC1 was the only ditch at North Cove which regularly yielded *Anisus* throughout 1997. It was cleared sometime in March 1998 but continued as a monitoring site to determine whether *Anisus* survived or recolonised. Ditch NC13 was not monitored in 1997 as it had been cleared in February/March that year. In 1996 it had supported *Anisus* which was again present by September 1997. Other ditches (NC4, 5 and 12) were investigated in May 1998 to determine whether they would be suitable for monitoring. NC4 and 5 are at an advanced stage of vegetational succession and support good-sized populations of *Segmentina nitida*. Although occasional specimens of *Anisus vorticulus* occured, the ditches were not considered appropriate for monitoring this species. Ditch NC12 is connected to NC13 and does not offer scope for providing additional or different information from NC13. Other ditches were also checked for presence of *Anisus*, and the results for these and those above not selected are included with this report.

Halvergate: Three ditches were selected on the basis of good-sized populations of *Anisus vorticulus* when sampled in September 1997. Ditch H3 was selected principally because the 1997 results indicated that the *Anisus* population was reproductively out-of-phase with most other ditches, but also adjacent land use and habitat were different. Ditches H18 and 19 are similar in structure and habitat, 200m apart, but over 1km east of H3.

Habitat descriptions and other information for all survey ditches are given in the tables in the Appendix. This information is based upon descriptions and measurements made in 1997 and relates to the ditches at their floristic peak in June/July. Any changes observed in 1998 are also included.

5. Results

5.1 Monitoring

The monthly molluscan faunal composition and abundances for each of the monitored ditches are shown in the tables in the Appendix. Table 1 below shows the actual numbers of *Anisus vorticulus* recorded in 1998.

These results show that Carlton ditches CM1 and CM2, and all Halvergate ditches supported a healthy population of *Anisus vorticulus* throughout 1998. Carlton CM3 continued to support a small population. North Cove NC1 appears not to have recovered from the winter ditch clearance, whereas the population in NC13 is gradually increasing following ditch clearance in February/March 1997.

Table 1: Numbers of *Anisus vorticulus* recorded in monitored ditches in 1998

Site	Ditch	18 May	27 June	4 Aug	19 Sept	28 Nov
Carlton	CM1	30	45	96	76	32
	CM2	77	53	16	24	24
	CM3	5	5	7	12	14
North Cove	NC1	1	0	0	0	0
	NC13	3	0	6	3	23
Halvergate	H3	126	202	189	146	97
	H18	41	32	67	125	69
	H19	62	18	147	305	83

All specimens of *A. vorticulus* in the ditch samples were picked out and measured. These results were analysed statistically. Whilst these data show trends in population dynamics and growth rate, the presence of two cohorts in the samples, particularly in June and August, does not permit reliable interpretation of such data. Therefore, these data are not included as a separate table. The results for individual ditches are described in the following sections:

5.2 Carlton Marshes

5.2.1 Ditch CM1 (Table 2, Figure 4)

A relatively low number of individuals (30) was recorded on 18 May 1998 with the population comprising sub-adults and adults mainly in the 3.1 - 4.5 mm size classes. Comparison with the high numbers of individuals (132) recorded on 25 September 1997 suggests significant winter mortality. Two cohorts were present on 27 June 1998. Adults, mostly in the 3.6 - 5.0 mm size classes, comprised 67% of the population. However, breeding had occurred since May and juveniles (mostly 0.6 - 1.0 mm) comprised 33% of the population. All adults had died by 4 August whereas in 1997 no adults were found after May. Continued growth was recorded until the end of November when the population comprised individuals mostly in the 2.1 - 3.5 mm size classes. The reduction in numbers from September to November indicates significant juvenile mortality. Comparison with the 1997 data shows that in 1997 breeding took place sometime around the end of July, whereas in 1998 it was sometime in mid-June.

5.2.2 Ditch CM2 (Table 3, Figure 5)

In May and June 1998, a similar pattern to CM1 was observed. The sub-adults which dominated in May continued to grow until the end of June, but had virtually disappeared by 4 August. Unlike at CM1, no juveniles were present on 27 June. Although very few individuals (16) were recorded on 4 August, the population was mostly in the 1.1 - 2.0 mm size classes, suggesting that breeding occurred in mid to late July. This is later than for CM1 and also later than in 1997, when juveniles (0.6 - 1.0 mm) comprised 70% of the population on 24 June.

5.2.3 Ditch CM3 (Table 4)

Anisus vorticulus was recorded in this ditch in low numbers throughout 1997 and a similar trend has continued through 1998. Results of population structure similar to those in CM1 and CM2 were recorded although the low numbers of individuals make comparison more difficult. Sub-adults only were present on 18 May and juveniles (0.6 - 2.0mm) present on 4 August. As with CM2, breeding appears to have occurred sometime in July.

5.3 North Cove

5.3.1 Ditch NC1

Reasonable numbers (48 and 40) of *Anisus vorticulus* were recorded in April and May 1997 respectively. However, much lower numbers (6 - 12) were recorded from June to September 1997 (see Willing & Killeen 1998, p. 77). Around March 1998 the ditch was completely cleared from the west bank with a resultant loss of most of the shallow marginal shelf and plant community. The sample taken on 18 May 1998 yielded a single adult *Anisus*, but no further specimens were recorded throughout the remainder of 1998. The molluscan faunal composition of the ditch, however, is largely unchanged (Appendix). Although the fauna is dominated by high numbers of common species such as *Bithynia* spp. and *Planorbis planorbis*, less common species such as *Segmentina nitida* and *Pisidium pseudosphaerium* have persisted in low numbers.

5.3.2 Ditch NC13 (Table 5)

With the exception of June, *Anisus vorticulus* was recorded in low numbers throughout 1998. Adults only were present in May but owing to the sparsity of individuals in August and September, it is impossible to reliably determine the time of breeding. However, by comparing the size classes of the 23 individuals recorded in late November with those at Carlton, we can infer that breeding occurred sometime in July. Although there is only comparative data for July 1996 and September 1997, there is limited evidence to suggest that the *Anisus* population is recovering following the February/March 1997 clearance.

5.4 Halvergate Marshes

5.4.1 Ditch H3 (Table 6, Figure 6)

Very high numbers (97 - 202) of individuals were recorded on each sampling visit in 1998. On 18 May 1998 the population comprised half-grown individuals (126) mainly in the 1.6-3.0 mm size classes. Comparison with the numbers of individuals (165) recorded on 25 September 1997 does not indicate significant winter mortality. Mean shell size increased through to August when the population comprised mainly adults with occasional very young juveniles. Two cohorts were present on 19 September 1998, but adults persisted through to late November. The main breeding took place sometime in August/September, considerably later than in the other monitored ditches. In mid-September, juveniles (0.6 - 1.5 mm size classes) comprised 18% of the *Anisus* population and by late November this had increased to 42%.

5.4.2 Ditch H18 (Table 7, Figure 7)

Moderately high numbers (32 - 125) of individuals were recorded on each sampling visit in 1998. On 18 May 1998 the population comprised adults and sub-adults with 61% of the population in the 3.6 - 4.5 mm size classes. The numbers of individuals (41) recorded compared with 25 September 1997 (96 individuals) indicates significant winter mortality. Breeding occurred sometime in early June and by 27 June, two cohorts were present with juveniles in the 0.6 - 1.5 mm size classes representing 22% of the population. All adults had died by 4 August and continued growth of the population was recorded until the end of November when it comprised individuals mostly in the 2.1 - 3.0 mm size classes. The reduction in numbers from September to November indicates significant juvenile mortality.

5.4.3 Ditch H19 (Table 8, Figure 8)

The numbers of individuals recorded during 1998 varied considerably from 18 in June to 305 in September. On 18 May 1998 the population comprised mostly fully grown adults with 68% of the population in the 4.1-5.5 mm size classes. The numbers of individuals recorded in May (62) compared with 25 September 1997 (54 individuals) suggests negligible or no winter mortality. Only 18 sub-adults and adult individuals were recorded in June, no juveniles were present. Breeding occurred sometime in late June and by 4 August the population was composed entirely of juveniles with 90% of individuals smaller than 2.0 mm. Growth continued through to the end of November although the large reduction in numbers from 305 to 83 since mid-September indicates significant juvenile mortality.

5.5 Growth rate (Figures 9 - 11)

Growth rate curves for the *Anisus* populations in Carlton Marshes ditch CM2 and Halvergate ditches H3 and H19 are shown in Figures 9 - 11. CM2 was selected as it has the most complete dataset from 1997 and 1998. The Halvergate ditches include data from September 1997 plus 1998 and represent ditches with the greatest numbers of measured specimens. A Growth Rate Factor (GRF) derived from the slope of one mean to the next is used to facilitate interpretation. This is equivalent to µm/day. Interpretation of the results is restricted by the absence of winter data.

Ditch CM2 (Figure 9): From the end of April to the end of May 1997 the adult *Anisus* continued to grow rapidly (GRF = 33); however, by late June most adults had died off and the mean shell size of the remaining adult population had only increased slightly. Two cohorts were present in June. The rate of growth of the juveniles from June to late September is more or less linear with a GRF = 13. In 1998 from the first sample on 18 May to the end of June the mean shell size of the adult population increased at a GRF = 11, the period of rapid adult growth having been missed. Two cohorts were present in early August. The GRF = 7 for juveniles from August to the end of September was less than for 1997, and to the end of November the GRF had decreased to 2.

Ditch H3 (Figure 10): From late September 1997 to 18 May 1998 (230 days) the mean shell size of the *Anisus* population only increased at a GRF = 5. The mean shell size of the adult population grew at a GRF = 16 from May to late June and then increased to a GRF = 24 until early August when the population reached its maximum shell size. A single new juvenile was recorded in August but two cohorts were not present until mid-September. From mid-September to the end of November the juveniles increased in size at a GRF = 4.

Ditch H19 (Figure 11): From late September 1997 to 18 May 1998 (230 days) the mean shell size of the *Anisus* population increased at a GRF = 10, higher than that for either CM2 and H3. There was no increase in the mean shell size of the adult population from May to late June. At no time were two cohorts present. The growth rate of the juveniles was generally similar to CM2. From August to the end of September the GRF = 6 and to the end of November the GRF had decreased to 3.

5.6 Distribution in CM2 (Table 9)

At all of the monitoring sites the samples were taken from the ditch margins principally on the basis that the permanent macrophyte community occurring here provided a reliable source of snails. Throughout the season until September the plants (particularly *Hydrocharis* and *Lemna* spp.) expand across the ditches by which time there is often 100% cover. To determine whether the *Anisus* population spreads with the plants, additional samples were taken in Carlton Marshes ditch CM2 at other locations along and across the ditch. The results are shown in Table 10.

In August *Anisus* was found in similar, relatively low numbers and size structure in the centre of the ditch to those at the marginal monitoring location. The results from additional, more widespread locations in the ditch in September showed a broadly similar pattern. *Anisus* was recorded all along the ditch although the numbers were higher at the monitoring site at the southern end of the ditch. However, at all sites the numbers found at the ditch margins were

higher by a factor of 2:1 compared with the middle of the ditch. The size class distribution was much the same throughout.

5.7 Temperature (Table 10, Figure 12)

As the 1997 survey results has indicated the snail's distinct preference for ditches with wide, shallow margins it was inferred that temperature might be an important factor in its location, reproduction timing and growth. With the exception of May, water temperature was measured at three locations in each monitored ditch. The results are shown in Table 11 and those for the marginal sampling locations are also plotted graphically in Figure 12. Whilst it is accepted that water temperature will vary considerably diurnally and seasonally, all measurements made on each sampling visit were within a few hours of each other and allow some trends to be detected.

From June to September the temperatures at the ditch margin was similar or slightly higher than that at the surface in the middle of the ditch. The water temperature in the main body of the ditch (30 cm below surface in the middle) was generally 1-2 °C lower. In November there was a reversal with slightly colder marginal and surface temperatures. With the exception of Halvergate ditch H3, all ditches generally showed an increase in temperature from June to August with only slight or no increase from August to the end of September. Halvergate ditch H3 showed little increase from June to August but continued warming through to the end of September. H3 was also significantly cooler throughout compared with all other ditches (see Figure 12). In June the temperature in H3 was 11.9 °C compared with 14.4 - 18.0 °C in the others, and by late September was 14.6 °C compared with 17.3 - 21.3 °C. This is believed to be significant with respect to the breeding and growth of *Anisus* (see section 4.5 above and Discussion). Whilst the temperatures in the other ditches are broadly similar to each other, the small differences are probably due to aspect and level of shading. For example, ditch CM1 is more heavily shaded by *Phragmites* along its southern bank than the adjacent ditch CM2 and was approximately 1 °C cooler throughout. Halvergate ditches H18 and H19 lie in open locations, are relatively shallow and generally unshaded. Throughout the season, marginal and surface temperatures were approximately 2 °C higher than the other sites and approximately 6 °C higher than H3. Whilst H3 is shaded along its east bank and is choked in places with dense *Carex* and *Sparganium*, these factors alone may not account for such large temperature differences. The adjacent land comprises old species-rich fen meadow, permanently wet in places. It is possible that this and the adjacent ditch H3 are fed by cooler spring water. It is also narrow relative to its depth and the only ditch with ungrazed banks, and, therefore, the cooler water may be a result of ditch shape relative to isolation.

5.8 Other North Cove sites

Four other ditches were sampled at North Cove during 1998. The results of the molluscan composition are shown in the Appendix. Ditch NC5 supported a good-sized population of *Anisus vorticulus* in September 1996, but only very low numbers were recorded throughout the 1997 monitoring. The ditch was sampled twice in 1998 (May and September) but only a single *Anisus* was recorded. Ditch NC6 also supported very low numbers of *Anisus* throughout 1997, but only a single specimen was recorded from the samples taken in May and November 1998. Ditches NC14 and 15 were both cleared in February/March 1997 but have since developed relatively rich plant communities. However, *Anisus* was not recorded from either in September 1998.

6. Discussion

Comparison of the results for Carlton Marshes ditches CM1 and CM2 for which there are two years' datasets does not reveal any significant change in abundance of *Anisus vorticulus* with time. For CM1 an average of 46 individuals per sample was recorded in 1997 compared with 56 in 1998, whereas for CM2 an average of 90 individuals per sample was recorded in 1997 compared with 52 in 1998. Although neither ditch has been managed across this period, on the basis of these results there is insufficient evidence to conclude whether the ditches have become any more or any less suitable for *Anisus*. It might be expected that as a result of plant density increasing over the two years that the population of *Segmentina nitida* would also increase. However, in both ditches *Segmentina* was recorded less frequently and in lower numbers in 1998 compared to 1997. For ditch CM3 the numbers of *Anisus* recorded in 1997 are much the same as those for 1998, however, *Segmentina* has increased in abundance. This latter observation follows the expected pattern as the ditch has become densely choked with plants, particularly sedge and *Stratiotes*, and thus more favourable for *Segmentina*. In mid-November sections of CM3 were cleared at 50m intervals from alternate banks.

With the relatively long intervals between sampling visits (4 weekly in 1997, 6 weekly in 1998) we cannot establish precisely the time of breeding of the *Anisus vorticulus* populations. Also, at present, we do not have any information on when eggs are laid, how long they take to develop, and how long the hatchlings take to grow to a size (>0.5mm) when they would appear in the samples. However, based on the population size structure and extrapolating back, an approximate time of breeding can be determined, enabling ditches to be compared. These times are summarised in Table 11 below:

Table 11: Comparison of *Anisus vorticulus* breeding times in monitored ditches

Ditch	1997	1998
CM1	early June	early June
CM2	early June	mid-July
CM3	early/mid-June	early/mid-July
NC13	-	early/mid-July
H3	-	early August to mid-September
H18	-	mid-June to mid-July
H19	-	mid- to late June

Results from the 1997 survey indicated that breeding of different ditch populations of *Anisus vorticulus* was not synchronised. The results from 1998 substantiate this observation. At Carlton Marshes in 1997 the *Anisus* in all three monitored ditches bred in early June. In CM1 the breeding time was virtually the same in 1998 as for 1997 (early June). However, for ditches CM2 and CM3 breeding appears to have occurred later (early to mid-July). At Halvergate, the populations in H18 and H19 bred from mid-June to mid-July and in H3 it occurred much later, from early August to mid-September. The presence of juveniles less than 1 mm in diameter in several ditches on more than one sampling visit demonstrates that breeding is not a single event, but may be spread over a 6-8 week period.

There are several factors that may affect timing of breeding and the growth rate of the snails e.g. shading, temperature, food availability. Whilst subtle differences in shading have small effects on the temperatures of the ditches, it does not seem likely that this would account for the differences in breeding timing, particularly between adjacent ditches such as CM1 and CM2. However, overall ditch temperatures may be the most important factor in determining reproduction and growth. The results for ditch H3 support this view. From June to September the water temperature was on average 3 - 5 °C colder than the other monitored ditches and it is inferred that this accounts for the much later breeding period than elsewhere. *Anisus* is found in greatest abundance at the shallow margins of ditches. These margins heat up much faster than the main body of the ditch although they are subject to considerable diurnal and seasonal fluctuations, and in cold periods the margins are likely to freeze-up. Whilst water temperature may determine the reproductive timing, the potentially severe conditions in winter suggest that *Anisus* cannot be considered a true thermophile. The effect of temperature on growth rate is less clear, particularly in the absence of winter data. However, the results show that growth rate of adults in spring is relatively rapid, coinciding with a period when the water in the ditches will also warming up rapidly. Following breeding the juveniles grow at a slower rate, coinciding with a period where there is little increase in water temperature. From September to the end of November the ditches cool and *Anisus* growth rate is slower still. From November to April there is also little growth, however, with the information to hand we do not know whether growth stops over winter, followed by rapid growth in early spring, or whether they continue growing at a very slow rate.

The frequent clearance of ditches at North Cove during the 1996 to 1998 survey period has provided opportunities to monitor snail recolonisation. Extensive work carried out by Hingley (1979) on Pevensey Levels demonstrated that recolonisation of ditches following clearance was rapid but the rate varied according to species. In particular, *Anisus vorticulus* and *Segmentina nitida* were less rapid and less frequent colonists. Ditch NC13 supported *Anisus* in low numbers when first surveyed in September 1996. The ditch was cleared from the west bank in February/March 1997 and was not re-sampled until September that year when a single *Anisus* was recorded. The population has slowly increased during 1998. Plant recolonisation has been relatively rapid and as a result of regular poaching, a shallow marginal shelf developed along the east bank. This has meant that the ditch and habitat became suitable again for *Anisus* in a short period of time. These factors along with the fact that *Anisus* inhabits adjoining ditches have resulted in relatively rapid recolonisation by the species. Other ditches cleared during the survey period do not appear to have fared so well. Ditches NC14 and 15 were both cleared in February/March 1997 and have since developed relatively rich plant communities. However, *Anisus* was not recorded from either in September 1998, although *Segmentina nitida* was found in NC14. *Anisus* was not recorded in ditch NC1 during 1998 following its clearance in March that year. The ditch was completely cleared and in the ensuing period plant recolonisation has been very slow. Furthermore, cattle grazing on the adjacent pastures has been light and, therefore, the ditch banks have remained steep due to the lack of poaching. It is not expected that conditions in NC1 will become suitable again for *Anisus* for at least two years. On present evidence, it is likely that on marshes such as North Cove where ditch management is frequent, *Anisus vorticulus* will eventually disappear.

7. Recommendations

The results of the present survey combined with those from 1997 have provided a relatively detailed insight into the reproductive and growth cycle of *Anisus vorticulus*. Whilst it would be of great interest, there does not appear to be justification for English Nature to fund further

monitoring throughout 1999. However, at present we have no data on the species' growth rate during winter. To complete the picture, samples will be taken from three ditches (Carlton CM2, and Halvergate H3 and H19) at the end of January and the end of March 1999.

The Suffolk Wildlife Trust have expressed an interest in continuing with monitoring *Anisus* at Carlton Marshes (Nick Sanderson pers. comm.). Further discussion with the SWT will be held to devise a suitable programme whereby sampling and some analysis could be carried out by Trust personnel or volunteers, supported by independent taxonomic expertise.

The ditches at North Cove are not afforded any protection from SSSI or other conservation status. The work from 1996-98 has demonstrated the vulnerability of the *Anisus* (and *Segmentina nitida*) populations as a result of frequent and 'inappropriate' management. It is recommended that the importance of the site should be reinforced with the landowner, either through FWAG or the ESA scheme, as this will hopefully result in a future management policy that is more sympathetic towards the snail's survival.

Unless monitoring work is carried out under local Biodiversity Action Plans, it would be desirable to re-survey the known *Anisus* populations in East Anglia in say 3-5 years time. In addition to those monitored during the present 1998 survey, the re-survey should also include the other populations at Halvergate, Carlton Marshes, North Cove and Castle Marshes identified in 1996/7. Additional sites have also been identified by Michael Jackson and Roy Baker.

It is suggested that all other work on the autecology and biology of *Anisus vorticulus* would be best undertaken as part of the recently started PhD project by Alisa Watson at the University of Wales Cardiff. The following areas could be addressed:

- Detailed analysis of ditch hydrochemistry to determine if this is a limiting factor in the species' distribution within sites.
- Reproduction - determine when eggs are laid, how much, on which plant species, where in the ditch.
- Growth and mortality
- Factors affecting 2 and 3 above (temperature, predation)
- Food, analysis of gut content to determine food type (e.g. micro-algae, bacteria, diatoms) and whether this may affect timing of reproduction.

8. References

HINGLEY, M.R., 1979. The colonisation of newly dredged drainage channels on the Pevensey Levels (East Sussex), with special reference to gastropods. *Journal of Conchology*, **30**: 105 - 122.

KILLEEN, I.J. & WILLING, M.J. 1997. EN Species Recovery Programme: survey of ditches in East Anglia and south-east England for the freshwater snails *Segmentina nitida* and *Anisus vorticulus*. Peterborough: *English Nature Research Reports*, No. 229.

UK BIODIVERSITY STEERING GROUP. 1996. *Biodiversity: the U.K. steering group report (Vol. 2. Action Plan).* London: HMSO.

WILLING, M.J. & KILLEEN, I.J. 1998. The freshwater snail *Anisus vorticulus* in ditches in Suffolk, Norfolk and West Sussex. Peterborough: *English Nature Research Reports*, No. 287.

1997							1998				
Width (mm)	**30 April**	**28 May**	**24 June**	**27 July**	**29 Aug**	**25 Sept**	**18 May**	**27 June**	**4 Aug**	**19 Sept**	**28 Nov**
0.5 or <											
0.6 - 1.0				1	37	8		14	2	2	
1.1 - 1.5				4	39	28		1	19	5	
1.6 - 2.0	4			5	7	62			41	19	5
2.1 - 2.5	7			2	2	31	1		13	24	6
2.6 - 3.0	14			4		2	3		9	14	11
3.1 - 3.5	11			1	1		7	1	12	8	6
3.6 - 4.0	1		1	1		1	8	6		3	3
4.1 - 4.5							8	15		1	1
4.6 - 5.0							3	6			
5.1 - 5.5								2			
n	37	0	1	18	86	132	30	45	96	76	32

Table 2: Carlton Marshes Ditch CM1 - *Anisus vorticulus* monthly size frequency results for 1997 and 1998

1997							1998				
Width (mm)	**30 April**	**28 May**	**24 June**	**27 July**	**29 Aug**	**25 Sept**	**18 May**	**27June**	**4 Aug**	**19 Sept**	**28 Nov**
0.5 or <			1								
0.6 - 1.0			69							1	
1.1 - 1.5			24	24	8	19			4	5	
1.6 - 2.0	3			40	13	63	1		7	35	6
2.1 - 2.5	16		2	8	23	37	2		2	34	16
2.6 - 3.0	19	1	1	9	18	31	7			12	2
3.1 - 3.5	19	4		4	5	6	15	4	1	2	
3.6 - 4.0	19	7	2		1	2	25	14	1		
4.1 - 4.5	13	14	1	2			19	17	1		
4.6 - 5.0	4	7	2				6	16			
>5.1		2					2	2			
n	93	35	102	87	68	158	77	53	16	89	24

Table 3: Carlton Marshes Ditch CM2 - *Anisus vorticulus* monthly size frequency results for 1997 and 1998

	1997						1998				
Width (mm)	**30 April**	**28 May**	**24 June**	**27 July**	**29 Aug**	**25 Sept**	**18 May**	**27 June**	**4 Aug**	**19 Sept**	**28 Nov**
0.5 or <											
0.6 - 1.0									1		
1.1 - 1.5		2		1		1			2	3	2
1.6 - 2.0		5		1		2			3	6	6
2.1 - 2.5	2	6				1		2		3	5
2.6 - 3.0	3	6						1			1
3.1 - 3.5	2	1					3		1		
3.6 - 4.0	3		1				1	1			
4.1 - 4.5		1									
4.6 - 5.0							1	1			
5.1 - 5.5		1									
n	10	22	1	2	9	4	5	5	7	12	14

Table 4: Carlton Marshes Ditch CM3 - *Anisus vorticulus* monthly size frequency results for 1997 and 1998

Width (mm)	1997	1998				
	23 Sept	18 May	27 June	4 Aug	19 Sept	28 Nov
0.6 - 1.0					1	
1.1 - 1.5						2
1.6 - 2.0				1	1	8
2.1 - 2.5	1					12
2.6 - 3.0				3	1	1
3.1 - 3.5				2		
3.6 - 4.0		1				
4.1 - 4.5						
4.6 - 5.0		1				
5.1 - 5.5		1				
n	1	3	0	6	3	23

Table 5: North Cove Ditch NC13 - *Anisus vorticulus* monthly size frequency results for September 1997 and 1998

Width (mm)	1997	1998				
	23 Sept	18 May	27 June	4 Aug	19 Sept	28 Nov
0.6 - 1.0	14			1	26	23
1.1 - 1.5	111	4	1	1	1	18
1.6 - 2.0	31	30	22	3	1	6
2.1 - 2.5	7	42	33	6	7	6
2.6 - 3.0	1	25	37	12	9	9
3.1 - 3.5	1	17	40	14	12	9
3.6 - 4.0		8	37	40	27	10
4.1 - 4.5			24	63	45	13
4.6 - 5.0			7	45	15	2
5.1 - 5.5			1	5	3	1
n	165	126	202	189	146	97

Table 6: Halvergate Ditch H3 - *Anisus vorticulus* monthly size frequency results for September 1997 and 1998

Width (mm)	1997	1998				
	23 Sept	18 May	27 June	4 Aug	19 Sept	28 Nov
0.6 - 1.0			1	10	1	
1.1 - 1.5	2		6	34	2	2
1.6 - 2.0	50	1	1	18	38	1
2.1 - 2.5	30	5	2	3	67	21
2.6 - 3.0	13	2	2	2	17	40
3.1 - 3.5	1	6	2			3
3.6 - 4.0		12	7			2
4.1 - 4.5		13	9			
4.6 - 5.0		2	2			
5.1 - 5.5						
n	96	41	32	67	125	69

Table7: Halvergate Ditch H18 - *Anisus vorticulus* monthly size frequency results for September 1997 and 1998

Width (mm)	1997	1998				
	23 Sept	18 May	27 June	4 Aug	19 Sept	28 Nov
0.6 - 1.0	2			5	1	
1.1 - 1.5	9			53	51	1
1.6 - 2.0	23			73	163	23
2.1 - 2.5	14		1	12	76	41
2.6 - 3.0	3	1	3	2	12	17
3.1 - 3.5	2	5	2	1	1	1
3.6 - 4.0	1	14	4			
4.1 - 4.5		25	6	1		
4.6 - 5.0		17	1			
5.1 - 5.5			1			
n	54	62	18	147	305	83

Table 8: Halvergate Ditch H19 - *Anisus vorticulus* monthly size frequency results for September 1997 and 1998

	4 August 1998		19 September 1998					
Width	Monitoring site		Monitoring site		Site A		Site B	
(mm)	Margin	Middle	Margin	Middle	Margin	Middle	Margin	Middle
0.5 or <								
0.6 - 1.0		2						
1.1 - 1.5	4	2	1		1	3		2
1.6 - 2.0	7	2	5	9	5	2	7	
2.1 - 2.5	2	2	35	15	16	11	21	5
2.6 - 3.0		5	34	13	21	7	9	9
3.1 - 3.5	1	3	12	2	7	2	9	3
3.6 - 4.0	1		2	5	3	2		
4.1 - 4.5	1	1			1		1	2
4.6 - 5.0		2						
5.1 - 5.5		1						
n	16	20	89	44	54	27	47	21

Site A - approximately half way along the ditch. Site B - close to northern end of ditch

Table 9: Carlton Marshes Ditch CM2 - Size frequency/distribution of *Anisus vorticulus* throughout the ditch

	Sep 1997	May 98	27 June 1998			4 August 1998			19 Sept 1998			28 Nov 1998		
Ditch	**Marg**		**Marg**	**MS**	**MD**	**Marg**	**MS**	**MD**	**Marg**	**MS**	**MD**	**Marg**	**MS**	**MD**
CM1	14.8	NM	14.4	14.0	12.9	17.9	18.0	16.2	17.5	17.1	15.4	6.2	6.1	6.9
CM2	15.1	NM	15.7	15.7	13.3	18.6	18.6	17.1	18.3	18.0	15.6	7.1	7.1	7.5
CM3	14.7	NM	16.0	15.8	14.8	18.6	17.3	17.0	18.3	18.0	17.2	7.0	7.2	7.7
NC1	14.4	NM	14.7	14.9	13.9	18.2	18.0	17.0	18.6	18.5	15.3	7.5	7.3	7.7
NC13	14.3	NM	15.3	15.3	14.8	19.9	19.5	18.9	17.3	17.1	16.2	6.5	6.5	6.9
H3	12.0	NM	11.9	11.3	10.4	12.2	12.0	11.4	14.6	14.0	13.8	5.9	6.1	6.5
H18	14.4	NM	17.8	18.1	14.0	19.6	19.2	17.3	20.8	20.7	17.2	7.9	7.3	8.6
H19	14.6	NM	18.0	18.0	15.2	20.1	19.9	18.2	21.3	20.7	18.5	8.4	8.3	8.9

NM - not measured

Marg - Ditch margin (sample location)
MS - Middle of the ditch, surface
MD - middle of the ditch, 30cm below surface

Table 10: Temperature measurements (^{o}C) for monitored ditches

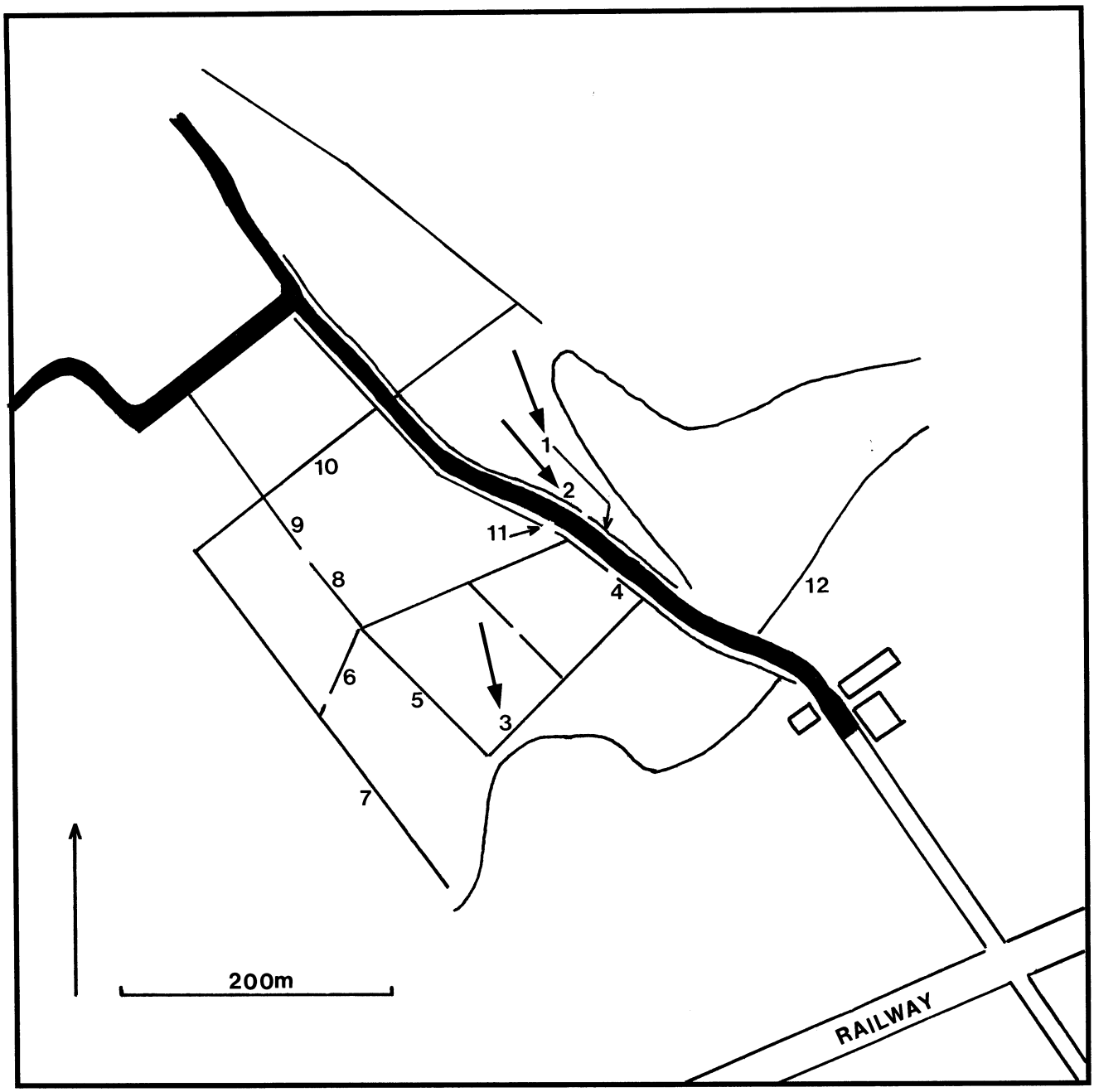

FIGURE 1: CARLTON MARSHESWITH LOCATIONS OF SAMPLING DITCHES

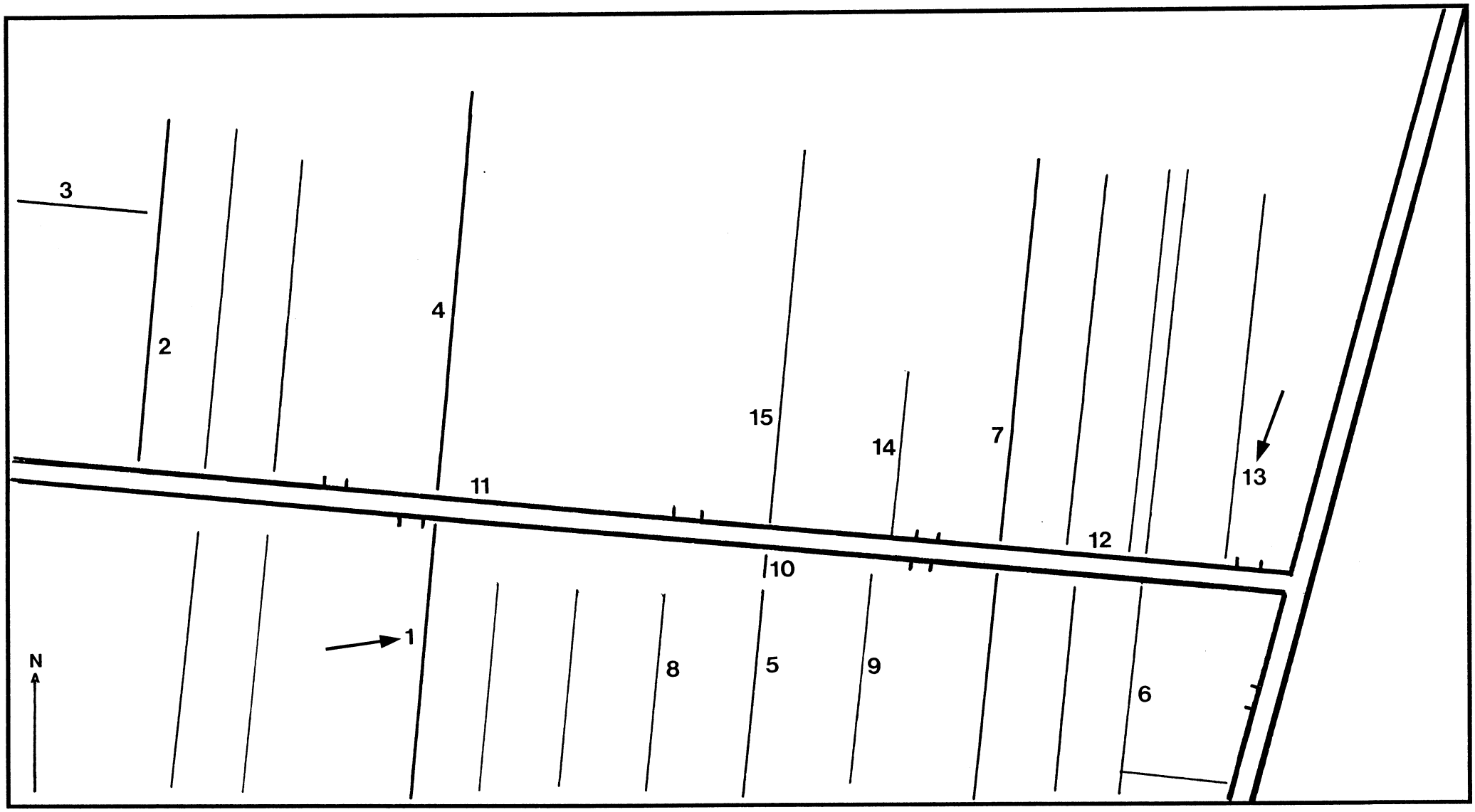

FIGURE 2: NORTH COVE WITH LOCATIONS OF SAMPLING DITCHES

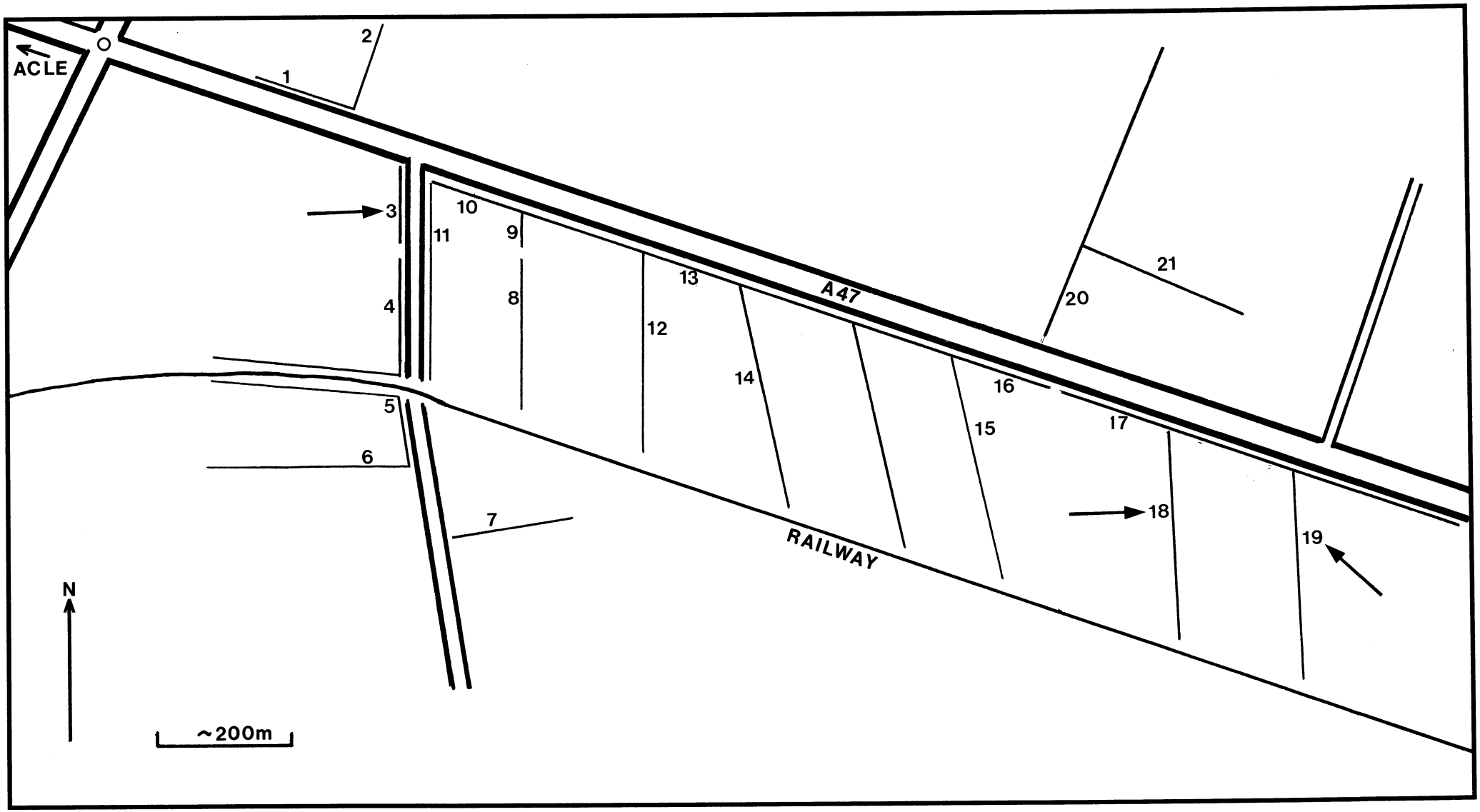

FIGURE 3: HALVERGATE MARSHES SOUTH-EAST OF ACLE SHOWING SAMPLING LOCATIONS

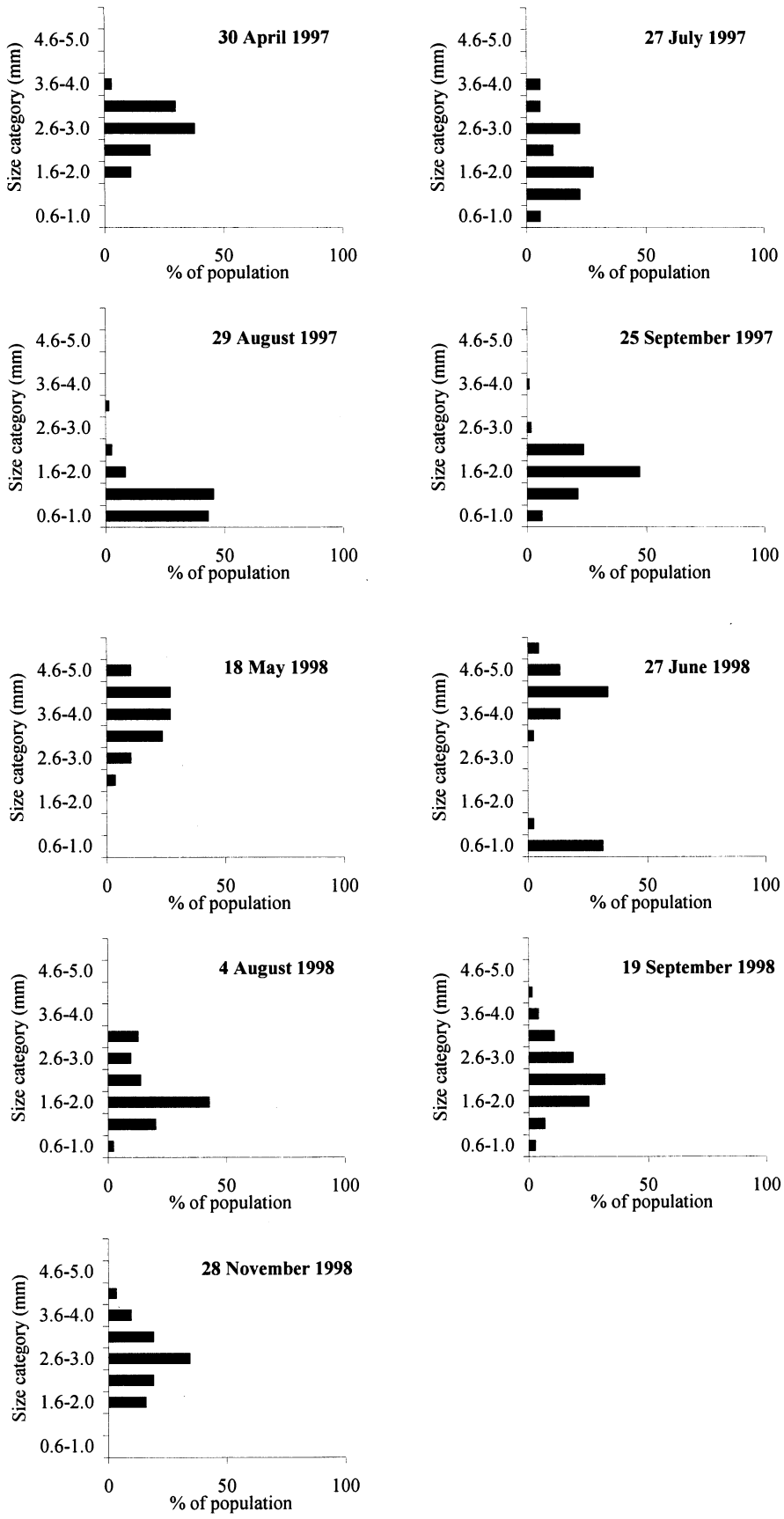

Figure 4: Carlton Marshes Ditch CM1 -
***Anisus vorticulus* monthly size/frequency histograms**

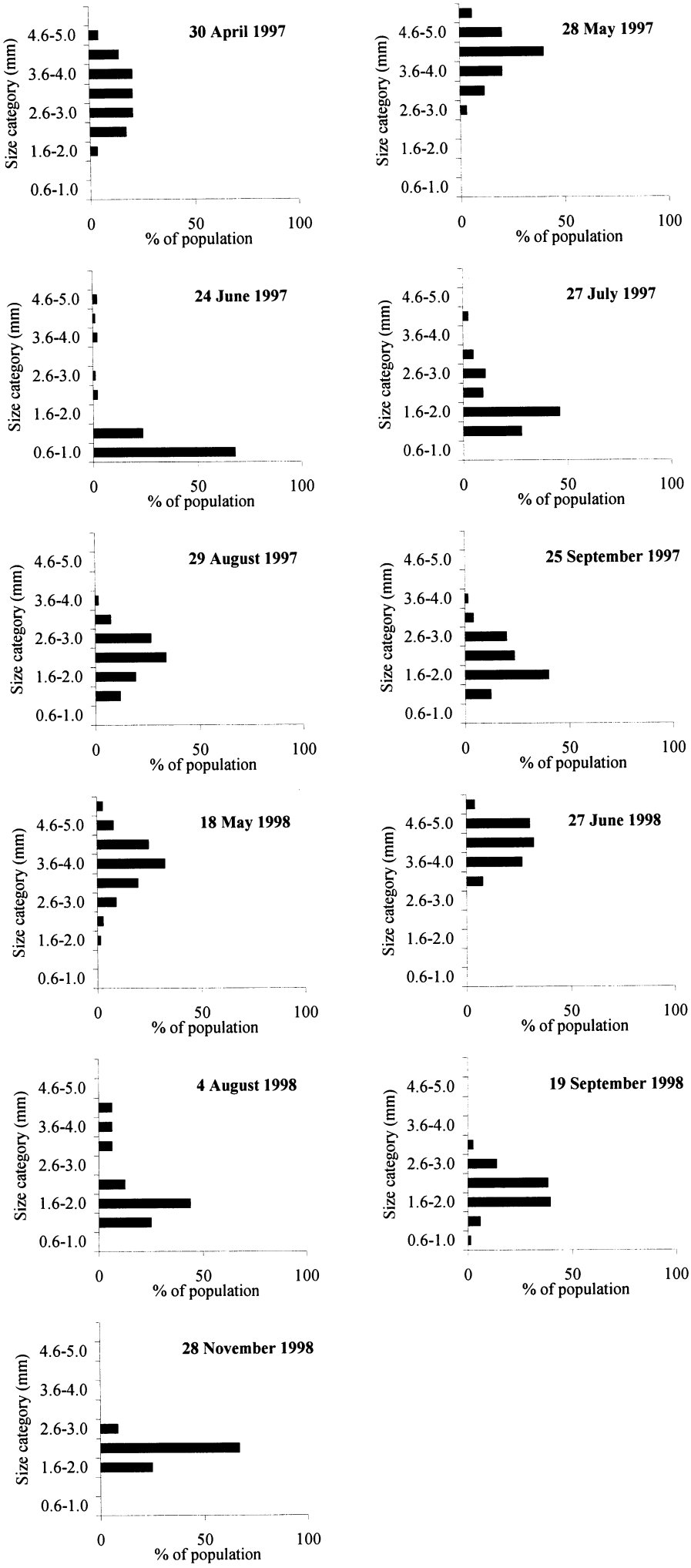

Figure 5: Carlton Marshes Ditch CM2 - Anisus vorticulus monthly size/frequency histograms

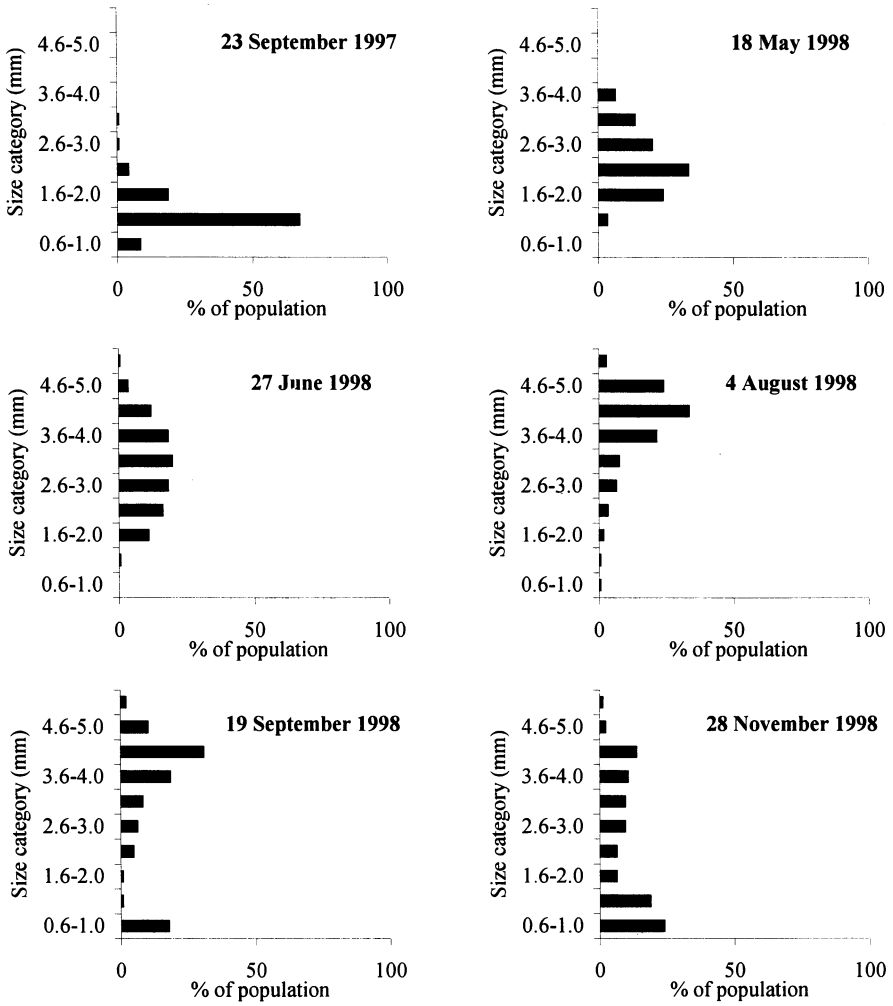

Figure 6: Halvergate Ditch H3 -
***Anisus vorticulus* monthly size/frequency histograms**

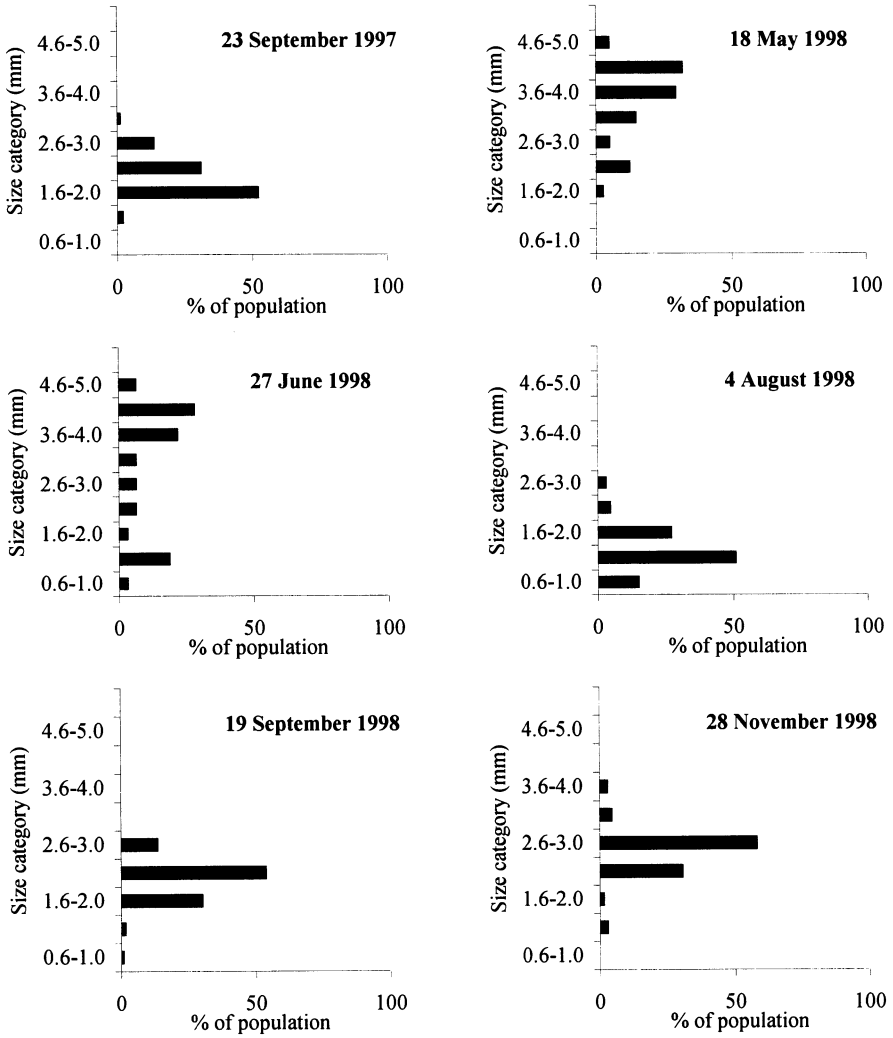

Figure 7: Halvergate Ditch H18 -
***Anisus vorticulus* monthly size/frequency histograms**

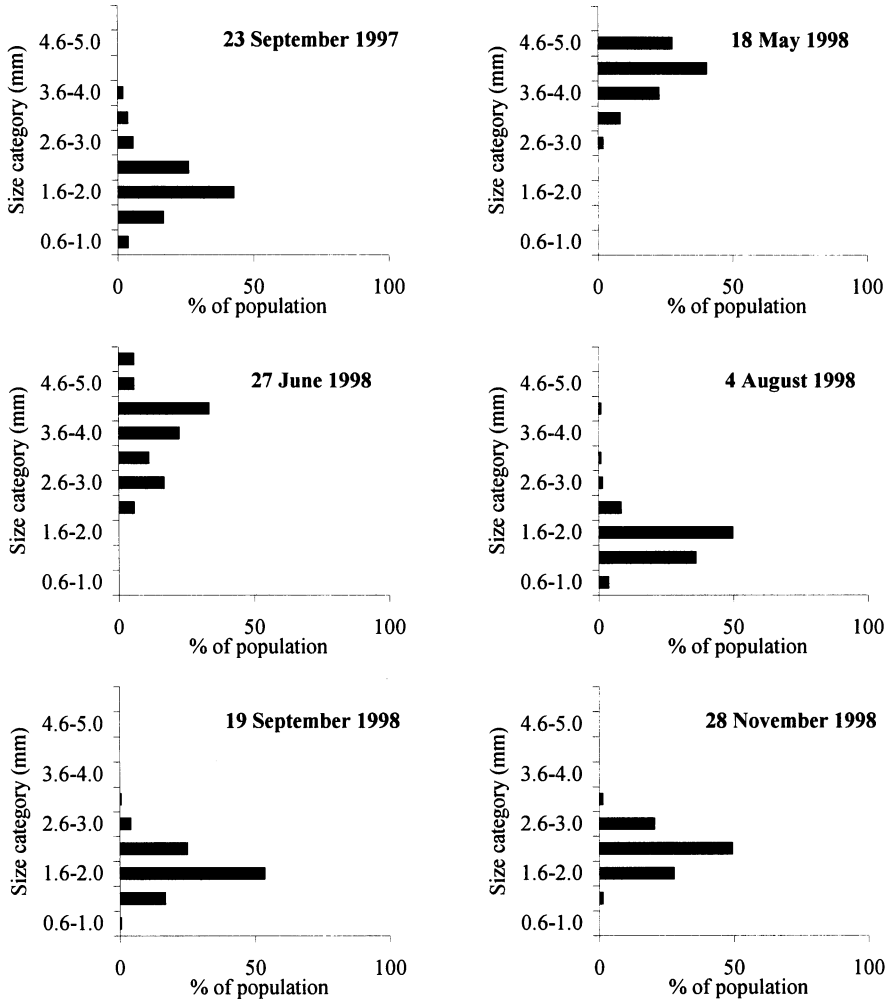

Figure 8: Halvergate Ditch H19 -
***Anisus vorticulus* monthly size/frequency histograms**

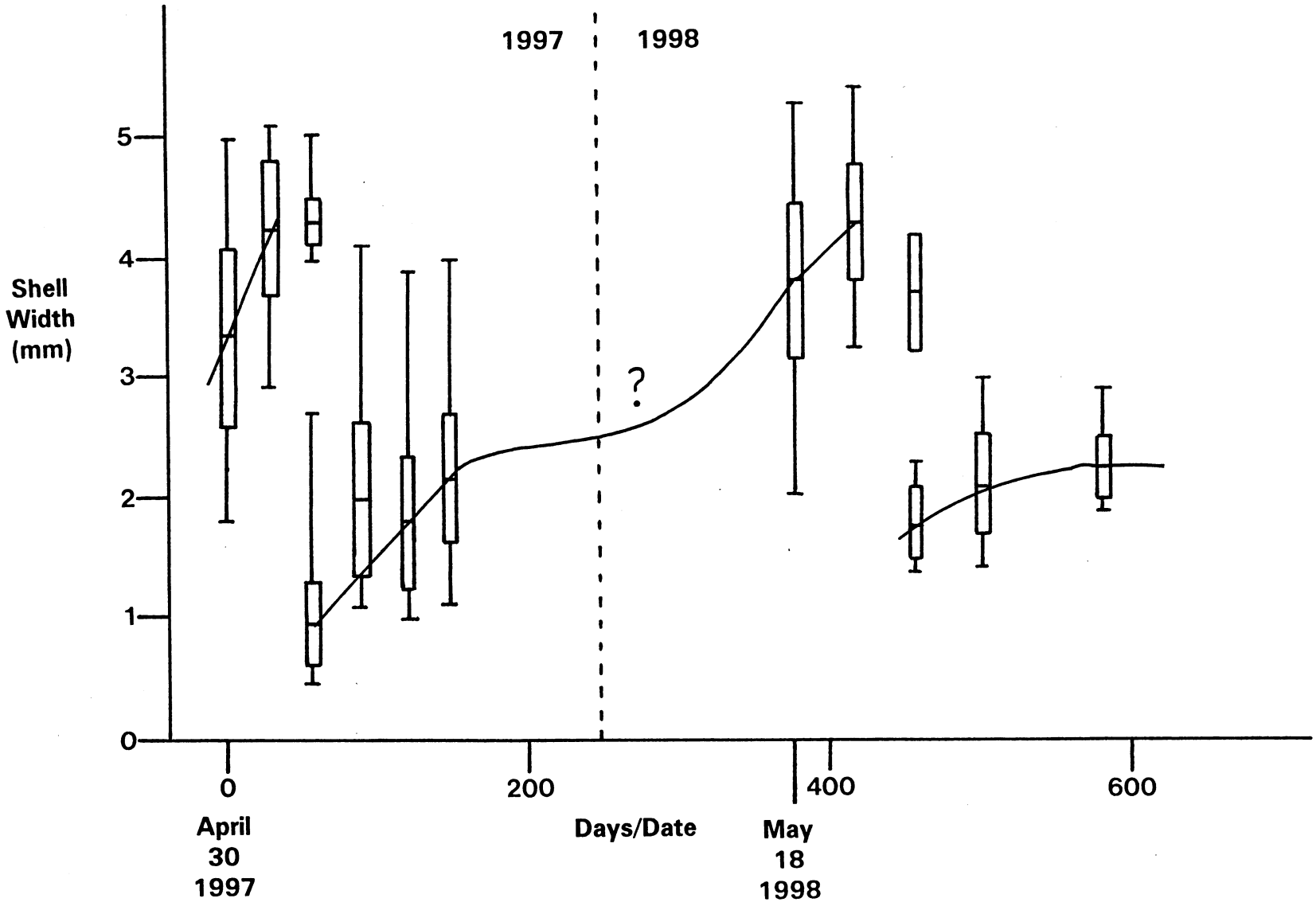

Figure 9: Carlton Marshes Ditch CM2 - *Anisus vorticulus* growth curves

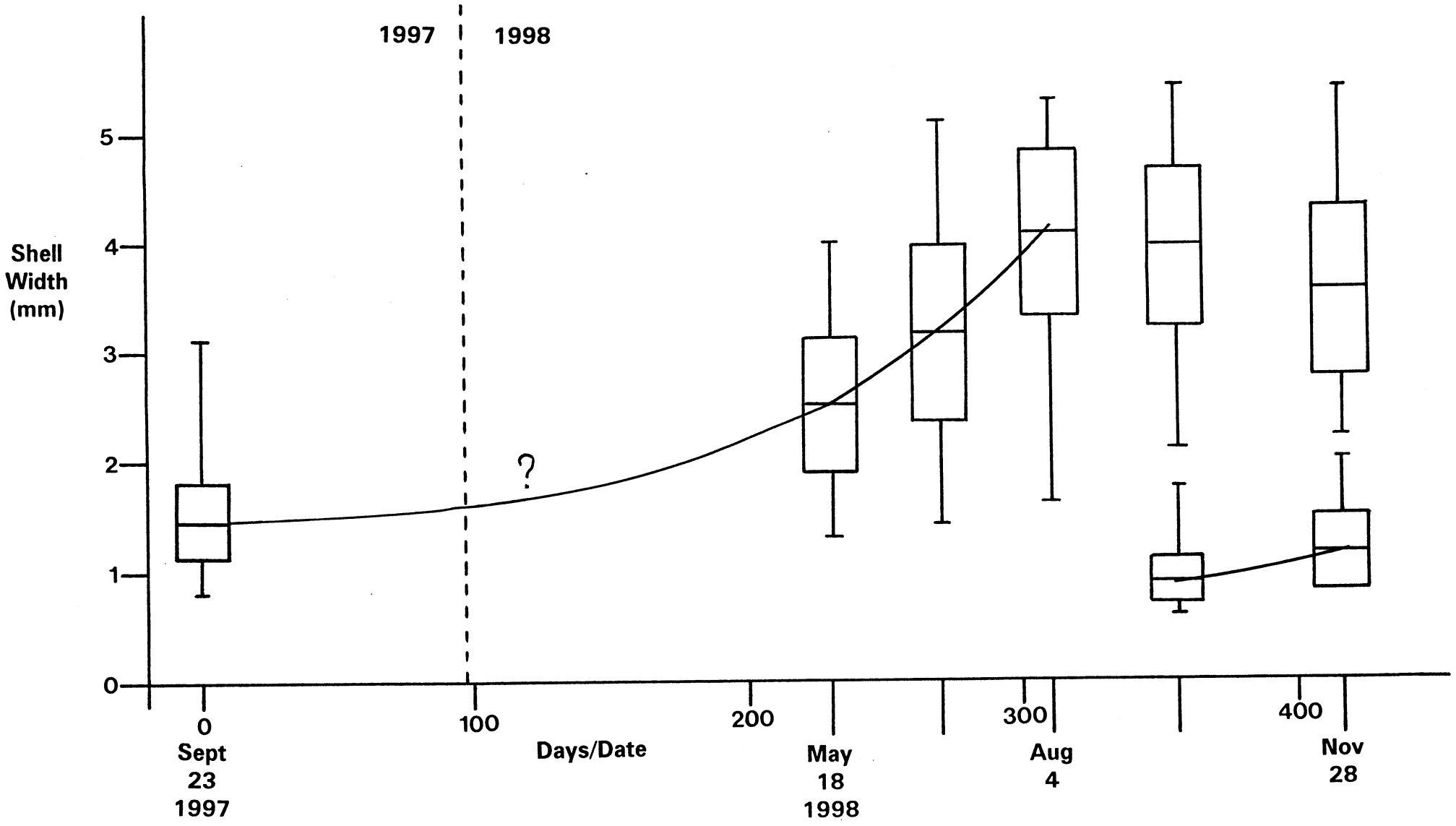

Figure 10: Halvergate Ditch H3 - *Anisus vorticulus* growth curves

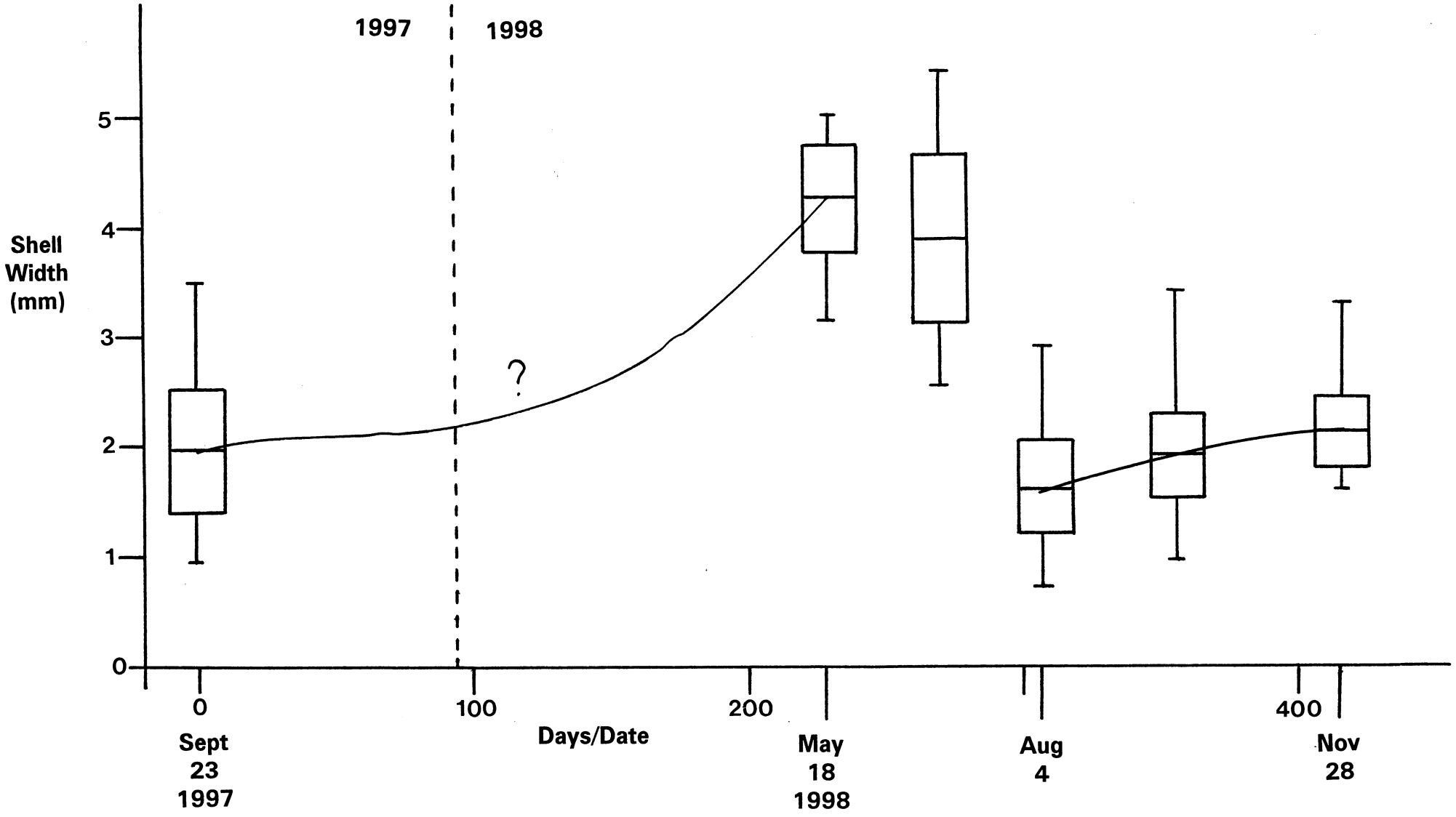

Figure 11: Halvergate Ditch H19 - *Anisus vorticulus* growth curves

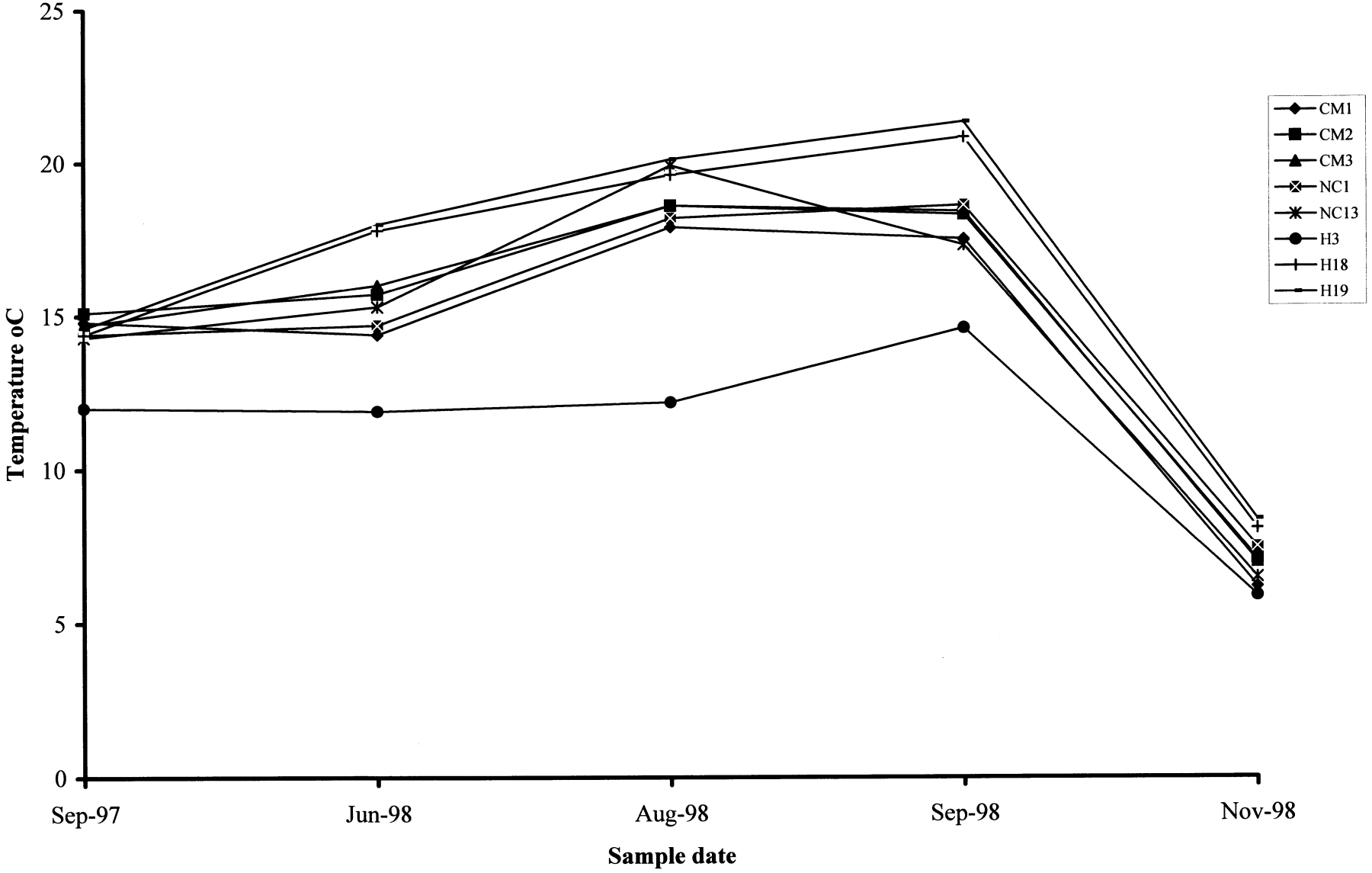

Figure 12: Temperature curves for monitored ditches (measurements from ditch margins)

APPENDIX: SITE DESCRIPTIONS - Based on 1997 observations and measurements

Site: Carlton Marshes

Ditch No.	Description		Width/ Depth (m)	pH/ Cond µS	Adjacent land use
	Banks & marginal vegetation	Emergent vegetation			
CM1	Sloping bank on south side with fringe of *Phragmites*, *Carex riparia* & *Epilobium*. Gently sloping north bank with discontinuous marginal shelf with mainly *Juncus* and *C. riparia*.	Dense *Apium* at sides. Patchy *Hydrocharis* and *Ranunculus*. Almost total cover of *Lemna trisulca*, some *L. minor*. Sparse *Glyceria* at north end.	W 2 - 2.5 D 0.95	pH 7.13 741 µS	Rough, wet, cattle grazed pasture on north, track on south..
CM2	Much the same as CM1 above, but with shallow south end and wider marginal shelf with grasses.	Mainly open water but south end and with dense *Apium*, c. 70% cover of *Lemna minor* & *L. trisulca*, patches of *Hydrocharis*.	W 3 - 3.5 D 0.45 at S end, ~1m elsewhere	pH 7.48 748 µS	Rough, wet, cattle grazed pasture on north, track on south..
CM3	Sloping bank on north side with fringe of *Sparganium*, *Carex riparia* & *Juncus*. Gently sloping south bank with discontinuous marginal shelf with mainly *C. riparia*, occasional *Glyceria* & *Rumex*.	Mainly *Stratiotes* (c. 90% cover), *Lemna minor* and *Hydrocharis*. Occasional *Lemna trisulca*, patchy *Apium* and grasses at margins.	W 2 D 0.7 - 1	pH 7.36 992 µS	Semi-improved, cattle grazed pasture.

Changes in 1998:

CM1 and CM2 virtually no change
CM3 - sections of the ditch were cleared of dense *Stratiotes* in early November but the margins around the sampling area were largely unaffected.

APPENDIX SITE DESCRIPTIONS - Based on 1997 observations and measurements

Site: North Cove

Ditch No.	Description		Width/ Depth (m)	pH/ Cond µS	Adjacent land use
	Banks & marginal vegetation	Emergent vegetation			
NC1	Sloping banks fringed by *Carex riparia*, *Juncus* and occasional *Glyceria maxima*. Marginal shelf in places along west bank with *Apium* and *Glyceria fluitans*.	Cover of *Lemna trisulca* and *L. minor* increasing through season to ~90% cover. Occasional *Hydrocharis* and *Apium* throughout.	W 1 - 1.5 D 0.7	pH 7.24 773 µS	Rough, cattle grazed pasture on east, semi-improved grassland on west.
NC13	Dredged winter 96/97. Sloping banks with marginal *Carex riparia* & *Juncus*.	Generally open water with ~25% cover of *Lemna minor*. Patches of *Apium* and *Hydrocharis* at margins.	W 2.5 D >1.3	pH 7.51 1060 µS	Semi-improved grassland pasture.

Changes in 1998

NC1 - Dredged around late March 1998 with resultant loss of marginal habitat and plants, particularly on the west side
NC13 - Plant community has continued to expand across the ditch and poaching by cattle has resulted in a shallow marginal shelf along the east bank.

Site: Halvergate Marshes

Ditch No.	Description		Width/ Depth (m)	pH/ Cond µS	Adjacent land use
	Banks & marginal vegetation	Emergent vegetation			
H3	*Phragmites* and willow (hedgerow) on east; sloping banks with *Carex riparia*, *C. paniculata* & *Juncus* spp. on west.	Choked with dense *Hydrocharis*, *Apium*, *Lemna trisulca*, *L. minor*, *L. polyrrhiza*. patchy *Sparganium*, Carex and *Phragmites*, occasional *Mentha*.	W 1 D 0.5	pH 7.23 732 µS	Old, ungrazed fen pasture (species rich) on west; track & hedgerow on west.
H18	.Gently sloping banks with marginal *Carex riparia*, *Juncus* & *Apium*.	Dense *Hydrocharis*, *Lemna trisulca*, *L. minor*, <30% *Stratiotes*; patchy *Phragmites*. Surface algal bloom in places.	W 1.5 D 1.2	pH 7.37 1063 µS	Semi-improved grassland, grazed by cattle.
H19	Very similar to H18 above but west side with trampled shelf margin.	As H18 above but with denser patches of *Apium*.	W 1.5 D 0.9	pH 7.29 1054 µS	Semi-improved grassland, grazed by cattle.

Changes in 1998

No change to sampling ditches although most of the ditches adjacent to the A47 road were cleared in late August.

APPENDIX - STATION SPECIES DATA

Site: Carlton Marshes Ditch CM1

SPECIES	STATION NUMBER				
	18 May	27 June	04 Aug	19 Sept	28 Nov
Anisus vorticulus	**30**	**45**	**96**	**76**	**32**
Valvata cristata	O	O	F	F	O
Valvata piscinalis					
Bithynia tentaculata	C	F	F	F	R
Bithynia leachii	C	F	A	A	O
Lymnaea stagnalis					
Lymnaea palustris					
Lymnaea peregra	C	A	C	O	C
Acroloxus lacustris			R		
Planorbis planorbis	O	C	O	F	O
Planorbis carinatus	O		F	F	O
Anisus vortex	O	F	F	F	O
Bathyomphalus contortus					
Armiger crista					
Hippeutis complanatus	O			O	O
Segmentina nitida	R		R	O	R
Planorbarius corneus		R			
Physa fontinalis	A	A	F	C	A
Sphaerium corneum		R	O	O	O
Musculium lacustre	R			R	
Pisidium obtusale			R	R	
Pisidium subtruncatum					
Pisidium milium	R		R	R	O
Pisidium pseudosphaerium	R		F	O	
Pisidium nitidum					

Abundance Scale: A = 100+, C = 51 - 100, F = 16 - 50, O = 6 - 16, R = 1 - 5.

APPENDIX - STATION SPECIES DATA

Site: Carlton Marshes Ditch CM2

SPECIES	STATION NUMBER				
	18 May	27 June	04 Aug	19 Sept	28 Nov
Anisus vorticulus	**77**	**53**	**16**	**89**	**24**
Valvata cristata	C	C	F	F	F
Valvata piscinalis					
Bithynia tentaculata	C	F	F	F	O
Bithynia leachii	A	F	C	A	F
Lymnaea stagnalis		R	F	O	
Lymnaea palustris	R	R	O	O	
Lymnaea peregra	F	A	A	C	C
Acroloxus lacustris			R	R	O
Planorbis planorbis		C	O	O	F
Planorbis carinatus	O		C	F	F
Anisus vortex	F	F	F	F	F
Bathyomphalus contortus					
Armiger crista					
Hippeutis complanatus	O		O	O	O
Segmentina nitida	R				
Planorbarius corneus	R	R	O	O	R
Physa fontinalis	A	A	C	F	A
Sphaerium corneum	R	O	R	O	O
Musculium lacustre			R	R	
Pisidium obtusale			F	O	R
Pisidium subtruncatum					
Pisidium milium			R	R	O
Pisidium pseudosphaerium	R	R	F	F	F
Pisidium nitidum					

Abundance Scale: A = 100+, C = 51 - 100, F = 16 - 50, O = 6 - 16, R = 1 - 5.

APPENDIX - STATION SPECIES DATA

Site: Carlton Marshes Ditch CM3

SPECIES	STATION NUMBER				
	18 May	27 June	04 Aug	19 Sept	28 Nov
Anisus vorticulus	**5**	**5**	**7**	**12**	**14**
Valvata cristata	F	F	F		C
Valvata piscinalis					
Bithynia tentaculata	F	F	O		O
Bithynia leachii	F	F	O		F
Lymnaea stagnalis		R	R		R
Lymnaea palustris	O	F	O		O
Lymnaea peregra	O	F	O		O
Acroloxus lacustris	O	O	R		O
Planorbis planorbis	R	F	O		O
Planorbis carinatus					
Anisus vortex	O	F	F		R
Bathyomphalus contortus	R	O			
Armiger crista					R
Hippeutis complanatus	C	O	F		A
Segmentina nitida	C	F	C		C
Planorbarius corneus	R	O	R		O
Physa fontinalis	O	F	F		O
Sphaerium corneum	O	F	O		F
Musculium lacustre	R	R	R		
Pisidium obtusale	O	O	R		O
Pisidium subtruncatum					
Pisidium milium	O	R			F
Pisidium pseudosphaerium	O	O	R		F
Pisidium nitidum					

Abundance Scale: A = 100+, C = 51 - 100, F = 16 - 50, O = 6 - 16, R = 1 - 5.

APPENDIX - STATION SPECIES DATA

Site: North Cove Ditch NC1

SPECIES	STATION NUMBER				
	18 May	27 June	04 Aug	19 Sept	28 Nov
Anisus vorticulus	**1**	**0**	**0**	**0**	**0**
Valvata cristata	O	O	F	C	F
Valvata piscinalis				R	R
Bithynia tentaculata	O	C	A	A	C
Bithynia leachii	O	A	C	A	F
Lymnaea stagnalis					
Lymnaea palustris	O			O	
Lymnaea peregra		F	O	R	F
Acroloxus lacustris		R	R		
Planorbis planorbis	F	A	A	A	C
Planorbis carinatus					
Anisus vortex		C	F	F	O
Bathyomphalus contortus	R	O			
Armiger crista					
Hippeutis complanatus	O	F	F	F	O
Segmentina nitida	R				R
Planorbarius corneus	O	F	C	O	O
Physa fontinalis		O			O
Sphaerium corneum	R	O	F	F	O
Musculium lacustre		O	O		
Pisidium obtusale	R	O	F	O	R
Pisidium subtruncatum				O	
Pisidium milium					
Pisidium pseudosphaerium		R	R		R
Pisidium nitidum				R	

Abundance Scale: A = 100+, C = 51 - 100, F = 16 - 50, O = 6 - 16, R = 1 - 5.

APPENDIX - STATION SPECIES DATA

Site: North Cove Ditch NC13

SPECIES	STATION NUMBER				
	18 May	27 June	04 Aug	19 Sept	28 Nov
Anisus vorticulus	**3**	**0**	**6**	**3**	**23**
Valvata cristata	O	F	A	A	A
Valvata piscinalis					
Bithynia tentaculata	F	F	C	C	F
Bithynia leachii	F	C	A	A	A
Lymnaea stagnalis					
Lymnaea palustris	O	O	R	F	R
Lymnaea peregra	O	A	F	F	C
Acroloxus lacustris					
Planorbis planorbis	F	F	A	F	F
Planorbis carinatus					R
Anisus vortex	C	A	A	C	F
Bathyomphalus contortus	O		R	R	O
Armiger crista					R
Hippeutis complanatus	F	F	C	F	F
Segmentina nitida	O				
Planorbarius corneus					
Physa fontinalis	F	F			
Sphaerium corneum	R		O	F	
Musculium lacustre		C	F	O	R
Pisidium obtusale	O	F	F	F	
Pisidium subtruncatum					
Pisidium milium	R	R	O	R	
Pisidium pseudosphaerium	R	O		O	O
Pisidium nitidum					

Abundance Scale: A = 100+, C = 51 - 100, F = 16 - 50, O = 6 - 16, R = 1 - 5.

APPENDIX - STATION SPECIES DATA

Site: Halvergate Ditch H3

SPECIES	STATION NUMBER				
	18 May	27 June	04 Aug	19 Sept	28 Nov
Anisus vorticulus	**126**	**202**	**189**	**146**	**97**
Valvata cristata	C	C	C	F	C
Valvata piscinalis					
Bithynia tentaculata	F	F	F	O	R
Bithynia leachii	A	A	A	A	F
Lymnaea stagnalis					
Lymnaea palustris	F	F	F	F	O
Lymnaea peregra	O	O	O	O	O
Acroloxus lacustris	R	R		R	O
Planorbis planorbis					
Planorbis carinatus	O		O	O	O
Anisus vortex	O	O	O	O	R
Bathyomphalus contortus	F	O	O	F	F
Armiger crista					
Hippeutis complanatus	F	F	F	F	C
Segmentina nitida	A	A	A	C	C
Planorbarius corneus		O	O	O	O
Physa fontinalis	C	F	F	F	A
Sphaerium corneum	F		O	R	F
Musculium lacustre					
Pisidium obtusale		R	R	R	R
Pisidium subtruncatum					
Pisidium milium					O
Pisidium pseudosphaerium	F	R	F	F	O
Pisidium nitidum					

Abundance Scale: A = 100+, C = 51 - 100, F = 16 - 50, O = 6 - 16, R = 1 - 5.

APPENDIX - STATION SPECIES DATA

Site: Halvergate Ditch H18

SPECIES	STATION NUMBER				
	18 May	27 June	04 Aug	19 Sept	28 Nov
Anisus vorticulus	**41**	**32**	**67**	**125**	**69**
Valvata cristata	O				R
Valvata piscinalis					
Bithynia tentaculata	F	O	F	C	O
Bithynia leachii	C	F	A	A	C
Lymnaea stagnalis			R	R	
Lymnaea palustris	O	F	F	C	C
Lymnaea peregra		R	R	O	O
Acroloxus lacustris			R	R	
Planorbis planorbis					
Planorbis carinatus	R	F	O	O	O
Anisus vortex	F	F	F	F	O
Bathyomphalus contortus					
Armiger crista			O	R	O
Hippeutis complanatus	F	F	O	A	C
Segmentina nitida					
Planorbarius corneus		R			R
Physa fontinalis	C	F	F	C	F
Sphaerium corneum					
Musculium lacustre					
Pisidium obtusale	O	R	O	O	O
Pisidium subtruncatum					
Pisidium milium	R		R		
Pisidium pseudosphaerium	R			R	
Pisidium nitidum					

Abundance Scale: A = 100+, C = 51 - 100, F = 16 - 50, O = 6 - 16, R = 1 - 5.

APPENDIX - STATION SPECIES DATA

Site: Halvergate Ditch H19

SPECIES	STATION NUMBER				
	18 May	27 June	04 Aug	19 Sept	28 Nov
Anisus vorticulus	**62**	**18**	**147**	**305**	**83**
Valvata cristata					F
Valvata piscinalis					
Bithynia tentaculata	C	F	F	C	R
Bithynia leachii	C	C	A	A	F
Lymnaea stagnalis				R	R
Lymnaea palustris	F	C	C	F	C
Lymnaea peregra	O	O	O	F	F
Acroloxus lacustris			R		
Planorbis planorbis		R		O	O
Planorbis carinatus	R		O	R	O
Anisus vortex	A	C	R	F	O
Bathyomphalus contortus					
Armiger crista		R	R	R	R
Hippeutis complanatus	A	O	F	O	F
Segmentina nitida		R			R
Planorbarius corneus		R			R
Physa fontinalis	A	A	F	F	R
Sphaerium corneum				O	
Musculium lacustre					
Pisidium obtusale	F	A	F	C	C
Pisidium subtruncatum					
Pisidium milium	R	O	R	O	O
Pisidium pseudosphaerium		R		O	O
Pisidium nitidum					

Abundance Scale: A = 100+, C = 51 - 100, F = 16 - 50, O = 6 - 16, R = 1 - 5.

APPENDIX - STATION SPECIES DATA

Site: North Cove additional sites

	Ditch Number/Date					
	NC5	**NC5**	**NC6**	**NC6**	**NC14**	**NC15**
SPECIES	18 May	19 Sept	18 May	28 Nov	19 Sept	19 Sept
Anisus vorticulus	**0**	**1**	**1**	**0**	**0**	**0**
Valvata cristata	F	O	C	F	F	A
Valvata piscinalis						
Bithynia tentaculata	O	F	F	R	C	F
Bithynia leachii	R	F	C	O	F	A
Lymnaea stagnalis						
Lymnaea palustris	F	O	F		F	F
Lymnaea peregra					C	A
Acroloxus lacustris				R		
Planorbis planorbis		O	O		A	F
Planorbis carinatus						O
Anisus vortex	F	F			F	F
Bathyomphalus contortus			O			
Armiger crista						
Hippeutis complanatus	R	R	O	F	R	F
Segmentina nitida	C	A	F	O	O	
Planorbarius corneus				O		
Physa fontinalis						O
Sphaerium corneum	R	F	O	O		F
Musculium lacustre					R	O
Pisidium obtusale	F	A	O	O	R	R
Pisidium subtruncatum						
Pisidium milium				O		
Pisidium pseudosphaerium		O	R	O		
Pisidium nitidum						

Abundance Scale: A = 100+, C = 51 - 100, F = 16 - 50, O = 6 - 16, R = 1 - 5.