Assessment of Sampling Methods for Macroinvertebrates (RIVPACS) in Deep Watercourses

R&D Technical Report E134

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Statement of Use
This report describes the assessment of three existing deepwater sampling methods to determine their comparability. It details the performance of each method and recommends how the Environment Agency should approach this type of sampling in future. The report will be used to develop new sampling strategies.

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EXECUTIVE SUMMARY

Background

A comparison of deep-water sampling devices for macroinvertebrates was undertaken at six sites throughout England in July/August 1999. The performances of three devices were compared (Yorkshire airlift, Medium Naturalist's dredge and Long-handled pondnet). Six replicate samples were taken with each device at each site. Each replicate sample was collected from a separate target area covering an estimated 1.5 m^2 of riverbed. The comparison was confined to deep-water habitats.

At the same six deep-water sites a series of six 1-minute replicate samples was taken at the watercourse margin, using the standard FBA pondnet. The range of macroinvertebrates present in the margin samples was compared with those from the deep-water samples at each site.

Deep-water sampling results

Airlift - yielded the largest mean number of taxa at four of the six sites, and the same number as the dredge at one site.

Dredge - yielded the largest mean number of taxa at one of the six sites, the second highest number at three sites and the same number as the airlift at one site.

Long-handled pondnet - performed poorly at most sites, with the lowest mean number of taxa recovered at four sites and the second highest number at two sites.

Margin sampling results

Pondnet samples from the margin - yielded higher mean ASPTs than any of the deep-water methods at two of the six sites.

Community composition differed between margin samples and deep-water samples.

Recommendations

- The airlift sampler is recommended as the most effective device for collecting benthic macroinvertebrates at sites with extensive deep-water habitats.
- On the basis of results from the present study (at six sites), the total area sampled in deep-water habitats by the airlift should not be less than 4.5 m^2 (equivalent to three of the airlift replicate samples taken in this study).
- Sampling activity at deep-water sites should take account of the spatial patchiness of habitats and associated fauna, as is recommended in the present RIVPACS sampling protocol (BT001, 1999).

- To permit the effective assessment of river quality at deep-water sites, sampling activity should target deep-water habitats but also watercourse margin habitats separately, to both reflect the different range of macroinvertebrates present and aid data interpretation.

- For margin samples, a 3-minute margin pondnet sample should be taken from accessible bank-side habitats, with the collecting time and effort split in proportion to those habitats.

- The development of separate RIVPACS modules (deep-water and margin) is necessary for all deep-water sites where the available habitats cannot be sampled effectively with one device.

- Development of new RIVPACS modules (deep-water and margin) for deep-water sites will require the selection of c.40-50 good quality reference sites. The selection process for reference sites needs to take account of major site variables (eg flow/absence of flow; presence/absence of submerged plants) in the context of regional representativeness.

- By adopting these recommendations, future sampling at deep-water sites will incorporate the flexibility to: (1) assess deep-water and margin habitats separately, thereby retaining an ability to detect and monitor different forms of stress; (2) restrict sampling to the deep-water or margin habitats, where the use of one of these options is considered adequate on a given sampling occasion; (3) combine the results from these habitats if this is appropriate.

KEY WORDS

Macroinvertebrates, RIVPACS, water quality, deep water/rivers, airlift sampler, dredge sampler, pondnet sampler, method comparison.

1. INTRODUCTION

1.1 Background

This project was commissioned as a result of a scoping study (Wright *et al*. 1999) which indicated that additional investigations were required to determine the appropriate method(s) for collecting representative macroinvertebrate samples from deep-water sites. The importance of having standard sampling procedures for RIVPACS (River Invertebrate Prediction and Classification System) has always been recognised as critical to ensure that the observed macroinvertebrate data for a site is comparable with the RIVPACS predictions for the site.

The RIVPACS sampling methodology was developed for use at shallow sites (timed pond-net collections) and is comparatively simple with the result that a high degree of standardisation is possible (Murray-Bligh *et al*. 1997). In addition, much effort has been devoted to documenting and reducing sources of error from sampling variation, sorting and identification in order to improve the precision of the technique (Dines and Murray-Bligh, 2000). In contrast, sampling deep waters is inherently more difficult, hazardous and time-consuming. The biologist has much less control of the sampling device and in consequence it is difficult to sample all invertebrate habitats in proportion to their occurrence.

For the 1995 GQA survey, long-handled pond-net sampling from the river-bank was recommended for deep-water sites on practical and safety grounds. In reality, the long-handled pondnet does not allow all habitats (marginal and benthic) to be sampled in proportion to their occurrence with the result that mid-channel taxa will be under-represented.

The use of more appropriate devices for sampling the benthos of deep rivers, such as dredges and airlifts, has been adopted by a number of the Environment Agency regions. However, experience indicates that these methods can be more time-consuming than the standard pondnet technique and usually require several people, resulting in increased costs. In addition, the standardisation of sampling effort with a dredge or airlift is more difficult to achieve in practice.

The appropriate method(s) and protocols for RIVPACS sampling in deep waters need to be clearly defined. There is also a need to adopt standard approaches across regions to ensure that, in future, RIVPACS assessments for deep rivers are as reliable as those currently available for shallow sites. In the context of the current investigations, deep-water sites found on large rivers, impounded rivers and re-engineered channels are included but canals, lakes and ponds are excluded. Biological monitoring strategies for these other waterbodies are the subject of specific investigations.

The scoping study (Wright *et al*. 1999) recommended a series of field investigations designed to deliver clear guidance on the sampling method(s) to be used when collecting benthic samples at deep-water sites. The Report also proposed the protocol to be followed when collecting separate pond-net samples in the margins. The results of the subsequent investigations are detailed in this report. If the Environment Agency accepts the recommendations contained in this report, the new protocols will become the standard methods to be used when undertaking RIVPACS sampling in deep rivers. Before a new RIVPACS module can deliver predictions for deep-water sites there is the need for a data-set from appropriate reference sites. A classification and prediction system applicable to deep-river sites would then be developed, as previously indicated in Wright *et al*. 1999.

The following terms are used within this report:

RIVPACS - River Invertebrate Prediction and Classification System.
BMWP - Biological Monitoring Working Party (defined scoring taxa and scores).
Ntaxa - Number of BMWP scoring taxa present.
BMWP Score - BMWP total score for a sample.
ASPT - Average Score Per Taxon (for a sample).

1.2 Objectives

The main project objective was to compare the effectiveness of sampling devices for collecting freshwater macroinvertebrates in deep watercourses. A second objective was to recommend standard macroinvertebrate sampling protocols for deep-water sites. The third objective of the field trial was to obtain preliminary information on sampling variability equivalent to that previously obtained for a series of shallow water sites (Furse *et al*, 1995).

The macroinvertebrate monitoring methods chosen for use at deep-water locations need to be both scientifically defensible and practical. This requires a suitable balance between the adequacy of information obtained and the availability and cost of manpower, equipment, and time constraints. In addition, Health and Safety issues must, at all times, be of paramount concern. Detailed Agency protocols were provided by Murray-Bligh *et al*, 1997. [Note: after this study was completed the National Biology Technical Group revised recommendations to Environment Agency staff on the use of invertebrate sampling equipment in deep waters (BTG Working Document 38, BT001, October 2000)].

The specific objectives are listed below:

1. The field trial should examine the most appropriate technique(s) to be used when sampling (a) the deep-water benthos and (b) the watercourse margins.

2. Wright *et al*. (1999) recommended assessment of the relative merits of:

   - Long-handled pondnet (with extensions, used at a working length of 4 m)
   - Medium Naturalist's dredge
   - Mackey/Yorkshire pattern airlift

   for the collection of qualitative samples of macroinvertebrates over a range of contrasting deep-water sites.

3. The results should lead to future formulation of guidelines on the sampling device to be used in a given type of river (as specified by width, depth and substratum type).

4. The macroinvertebrate data obtained from the deep-water sampling units should be used to formulate a standard RIVPACS protocol (inclusive of field and laboratory procedures) for use when sampling the benthos.

5. In addition, the field trials are to obtain some limited evidence on whether inter-operator variability using the dredge and airlift is similar to or exceeds that for pondnet sampling. This should indicate whether a comprehensive BAMS-type exercise will be required in the future, as obtained for a series of shallow water sites (Furse *et al.* 1995).

6. The field trial must also include a pondnet sampling programme for the river margins leading to a recommendation on the RIVPACS methodology to be used when sampling deep-river margins.

[Note: this protocol does not follow any of the (varied) RIVPACS procedures currently used at deep-water sites throughout the Environment Agency Regions. To provide an unambiguous comparison of sampler performance in deep-water habitats, the protocol excluded sampling in all the available habitats at each site with each deep-water sampling device. Habitats at the watercourse margin were sampled using a standard pondnet in order to compare the distribution of BMWP taxa between the margins (both banks) and the community in deep-water habitats. This also provided scope to assess the contributions to site quality status from deep-water and margin habitats and the effects of their contrasting representation at each site on Ntaxa and ASPT.]

2. STUDY SITES

2.1 Number and location of sites

Following discussions within the Agency, six sites were selected for field trials on the basis that they encompassed the broad range of deep sites on watercourses included in RIVPACS assessments. Sites with known poor water quality were excluded because the aim of this study was to compare sampler performance rather than site quality. It was initially recommended (Wright *et al*, 1999) that no more than 4-6 sites were to be included within the sampling programme with single sites selected from some of the following rivers:

Yorkshire Ouse
Aire/Calder
Yorkshire Derwent
Severn
Lower Exe
River on Somerset levels
Thames
Dorset Stour
Great Ouse
a Fenland Drain

The six deep-water sites chosen (Figure 2.1) after consultation with Regional Biologists reflect the wide range of contrasting conditions encountered in different Environment Agency regions.

Yorkshire Derwent - Stamford Bridge, NGR SE 710555 - Brian Hemsley-Flint (Leeds)

Yorkshire Ouse- Acaster Malbis, NGR SE 590453 - Brian Hemsley-Flint (Leeds)

Great Ouse/New Bedford River - Earith, NGR TL 394747 - Terry Clough (Brampton)

South Drove Drain - Horseshoe Bridge, NGR TF 219212 -Richard Chadd (Spalding)

River Huntspill - West Huntspill, NGR ST 303450 - Andy Hicklin (Bridgwater)

Severn - Upton-upon-Severn, NGR SO 851407 - Ayleen Clements (Tewksbury)

2.2 Characteristics of the six deep water sites

The site descriptors (full information in Appendix 1) were annotated from map references, Environment Agency records and on-site recording during the survey work.

They include:

River name
Site name and NGR
Water depth in mid-channel

Predominant available habitats

Discharge/flow category at the site (supplied data)
Recent water quality status (supplied data)
Recent biological data were supplied for five of the six sites. These macroinvertebrate data had been collected by different sampling methods and recorded in variable formats, for each site. The data ranged from 3-season sampling to occasional samples taken in one (variable) season. A comparison of these earlier data for the different sites with the current sampling results and comparisons between sites was gauged to be inappropriate in the circumstances.

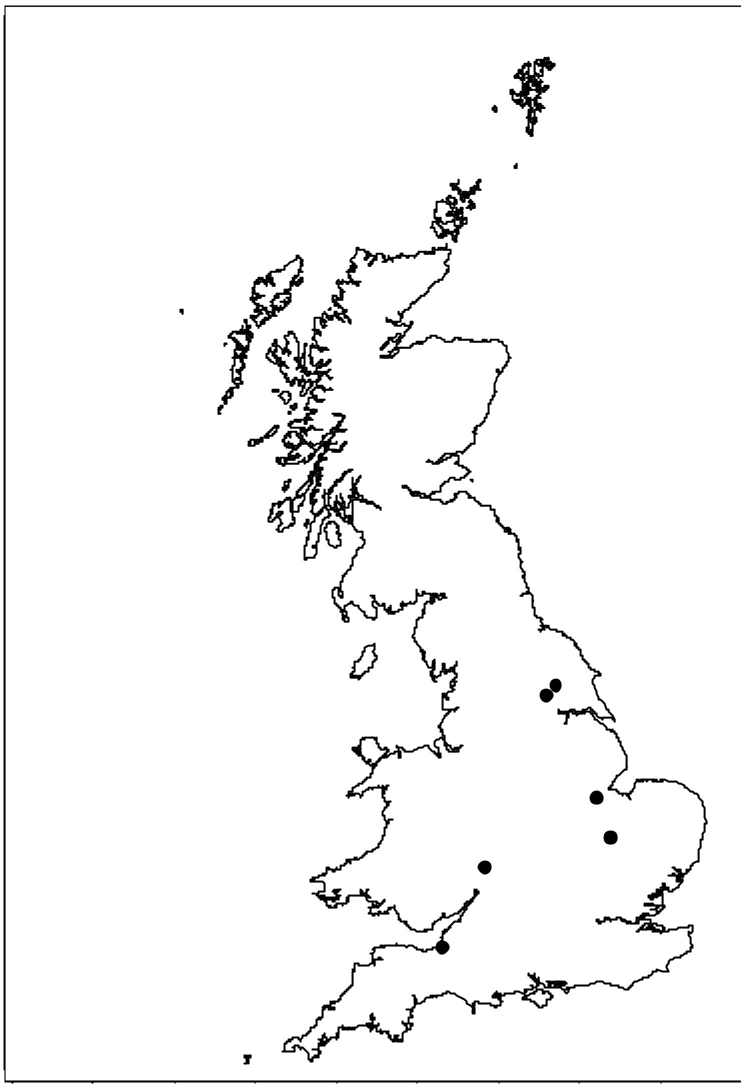


Figure 2.1 Locations of the six sampling sites used to compare the performance of samplers for benthic macroinvertebrates in deep watercourses

Sample descriptors used in the current study include:

Sampling method
Date
Collector (name)
Replicate number (1-6)
BAMS replicate letter/number (2 sites only - dredge and airlift A1-A6, B1-B6, C1-C6)
Proportion of sample retained (initially)
Record of sample volume (1 or 2 containers, each of 1.2 litres capacity)
Note of any pre-sorting/discarding on site (eg, weed)
Right/Left bank - designated looking downstream (margin samples only).

2.3 Site Descriptions

Yorkshire Derwent - Stamford Bridge, NGR SE 710555

The river Derwent is recorded as 22-25 m wide just downstream of Stamford Bridge and the mean water velocity type was recorded as slow (0.15-0.25 m sec^{-1}) under the prevailing normal summer conditions. The channel is mainly unshaded, with a few bank-side trees. Silt and clay are the dominant riverbed substrata. Water depths range from 2.0-2.5 m, under normal flow conditions. The marginal zone supports <10% cover of submerged aquatic plants and the banks have 5-35% cover of emergent plants.

Yorkshire Ouse - Acaster Malbis, NGR SE 590453

The river Ouse at Acaster Malbis is recorded at 22-25 m wide and the mean water velocity type was recorded as slow (0.15-0.25 m sec^{-1}) under the prevailing normal summer conditions. The channel is partially shaded, with a line of trees set back from the left bank. Sand silt and clay are the predominant riverbed substrata. Water depths range from 1.8-4.0 m, under normal summer flow conditions. The marginal zone supports no submerged aquatic plants and the banks have 15-75% cover of emergent plants.

Great Ouse/New Bedford River - Earith, NGR TL 394747

The river is around 25m wide downstream of Earith Bridge, the predominant water mean velocity type was recorded as slack (<0.10 m sec^{-1}) under normal summer conditions, when the direction of flow can change owing to tidal conditions at this site. The channel is unshaded and an embankment is present on the right bank. Silt and clay are the predominant riverbed substrata previously recorded. Water depths range from 1.0-2.0 m, under normal flow conditions. The marginal zone supports <10% cover of submerged aquatic plants and the banks have around 50% cover of emergent plants.

South Drove Drain - Horseshoe Bridge, NGR TF 219212

The South Drove is around 14 m wide just south east from Horseshoe Bridge and the mean water mean velocity type was recorded as slack (<0.10 m sec^{-1}) under the prevailing normal summer conditions. Water height and occasional flow is controlled by sluices and intermittent pumping. The channel is unshaded, with a steeply graded bank stabilised by stonework below the water level. Silt and organic debris are the predominant riverbed substrata. Water depths are consistent at 2.0 m, under normal flow conditions. The marginal zone and mid-channel supports 50-98% cover of submerged aquatic plants and the banks have 2-50% cover of emergent plants.

River Huntspill - West Huntspill, NGR ST 303450

The river Huntspill is around 30 m wide adjacent to Sloway Lane Bridge and the mean water velocity type was recorded as slack (<0.10 m sec^{-1}) under the prevailing normal summer conditions. Water height and occasional flow is controlled by sluices and intermittent pumping. The channel is unshaded, with an low gradient embankment. Silt and clay, with occasional peat are the predominant riverbed substrata. Water depths range from 1.7-2.0 m, under normal flow conditions. The marginal zone supports no submerged aquatic plants and the banks have <35% cover of emergent plants.

Severn - Upton-upon-Severn, NGR SO 851407

The river Severn at Upton-upon-Severn is around 30 m wide just upstream of the A4104 bridge. The mean water velocity type was recorded as slow (0.15-0.25 m sec^{-1}) under the prevailing normal summer conditions. The channel is predominately unshaded, with a few bankside trees on the NE bank. Hard clay is the predominant riverbed substratum. Water depths range from 1.7-3.2 m, under normal flow conditions. The marginal zone supports no submerged aquatic plants and the banks have no emergent plants.

The sites selected, in common with most deep-water sites, are subject to variable water velocity and discharge rates. A definition of the conditions which preclude sampling activity at particular deep-water monitoring sites will need to be formulated by local staff throughout the Environment Agency.

3. SAMPLING METHODS

3.1 Field procedures

3.1.1 Deep water sampling protocols

The Environment Agency selected a range of representative deep-water sites known to support diverse macroinvertebrate communities. This ensured there was a broad scope for comparisons between sampling methods. Operators experienced in the use of an extended long-handled pond-net, Medium Naturalist's dredge and Mackey/Yorkshire pattern airlift collected the primary samples. In order to compare selected methods in a systematic way the sampling effort and range of habitat types sampled needed to be consistent between each replicate sample. The initial scoping for the work envisaged three replicate samples per technique, but this was changed to six replicate samples per technique to provide a more robust indication of sample variability, taxon accretion and for comparison of methods.

The prime objective of the study was to compare the performance and yield of the specified deep-water sampling devices. The sampler operators were asked to restrict their sampling effort for each deep-water replicate sample to an area of about 1.5 m^2 to ensure comparable areas of riverbed were covered by each method. The series of replicate samples was taken within the main channel at dredge-throwing distance from one bank. Samples were taken in an upstream sequence to avoid sampling the same area more than once. As anticipated, it proved difficult to gauge the precise area of riverbed sampled effectively by some devices, but operators made every effort to maintain consistency.

This comparison excluded an assessment of the performance of the full variety of deep-water sampling approaches currently used within different regions of the Environment Agency. In some respects such comparisons would have been informative, but the critical aspect of gauging the effectiveness of individual sampling devices would have been compromised by the need to compare samples of different sizes and, in some cases, derived from material collected with more than one device (eg dredge and standard pondnet).

Decision points during the sampling activity

It was anticipated that some of the sites selected would be unsuitable for certain techniques. Operators were mandated to decide on the day whether to proceed with or abandon a particular method. The following guidance notes were provided.

Is there:

Suitable access for the boat and equipment?
Safe river conditions?
Suitable water depth/velocity to use the equipment?

In flowing water - start downstream, working upstream to avoid disturbing the next areas to be sampled. This does not exclude downstream drifting as individual samples are taken - if this is the most practical method. Note: flowing water may not feature at half the sites.

If the location is deemed suitable (see above) take 6 replicate samples by each sampling method.

Gauging whether a valid (representative) replicate sample has been taken needs to be unambiguous. Reject and re-sample where mechanical failure has occurred (eg interruption of the air supply to the airlift, the dredge snagging or net bag becomes tangled). In the case of 2 or more nil sample returns (< 0.25 litre volume of sample) an additional 2 (or more) samples are to be taken (7 and 8, etc), retaining the small samples as separate units.

Where a replicate sample is excessively large (with quantities of organic/inorganic debris), retain no more than 4 litres (including sufficient preservative volume). In this case a sub-sample is to be taken after elutriating the whole sample thoroughly to reduce the bulk. Remove large pebbles/cobbles after checking and retaining attached fauna. Record the proportion of the sample volume that is preserved and retained and the proportion discarded.(ignoring any stones that have had fauna removed by hand). (In practice, a few large dredge samples were sub-sampled and this was performed without elutriation.)

Airlift sampling activity (Agency staff)

Sufficient compressed air is required to take 6* replicate samples at each site and for 2 sites per trip (* with allowance for some failed sampling attempts at each site). The sampling areas should be within dredge-throwing distance of the bank (to be determined on site).

Dredge sampling (IFE/CEH staff)

A spare dredge frame and extra net bags will be taken. A sinking rope, marked at metre intervals will be available for dredge sampling.

Long-handled Pondnet (IFE/CEH staff)

The long-handled pondnet consists of the standard pondnet (2m handle) with an additional 2m extension to the handle. This is an unwieldy device, particularly when used from a boat. To maintain consistency between methods, the long-handled pondnet should be used from the boat aiming to sample an area of around 1.5 m^2 (for each replicate sample) within dredge-throwing distance of the bank.

River margin pondnet samples (IFE/CEH staff)

Six replicate samples (each one of one minutes duration), with three replicate samples taken from each bank (where possible), Sampling effort divided in proportion to the available habitats. Record proportions of bankside habitat (for each bank) within the reach sampled.

For deep-water sampling methods

If the first 3 sampling attempts are aborted, or 4 out of the first 5 are unsuccessful, or more than 10 attempts are required - abandon that particular technique for the site.

In practice, all sampling techniques yielded samples at all sites - one extra dredge replicate sample was necessary at a single site.

3.1.2 Preliminary BAMS exercise

More extensive data were obtained with two of the deep-water sampling devices to test variability between individuals using the equipment. This latter comparison was undertaken at single sites where the particular devices were known to work effectively.

Three series of six replicate samples were taken by three different people. All were experienced with the particular sampling technique and equipment. The BAMS exercise applied to the airlift and the dredge. The long-handled pondnet had not been used previously and therefore such a test was not felt to be appropriate, at this stage.

The **Yorkshire Derwent** (Stamford Bridge) site was used to compare three operators using the **airlift** sampler. This was undertaken by three designated Agency staff familiar with the equipment and the site - Jonathan Brickland, Vicki Hirst and Martin Christmas.

The BAMS exercise for the **dredge** was undertaken in Anglian Region (**South Drove Drain**) by two IFE/CEH staff and Richard Chadd (Anglian Region, Spalding). All were experienced in using the dredge.

3.1.3 Margin Pond-net samples

The field trial included a pondnet sampling programme for the watercourse margins (Objective 6). Margin sampling and its contribution to site quality assessments required the collection and analysis of separate data series to facilitate interpretation and the development of recommendations for new RIVPACS methodologies at deep-water sites.

A further consideration was the comparison of the fauna from deep-water habitats with the fauna in margin habitats.

The field trial examined the potential benefits of:

- a 3-minute pondnet sample from the watercourse margins in preference to a 1-minute marginal sample
- sampling the margin zone of one or both banks
- utilising results from both the watercourse margins and mid-channel habitats.

3.2 Recovery of macroinvertebrates from samples

The following procedures were adopted for sample processing and data recording:

1. wash the replicate sample free of preservative

2. sort/extract and re-preserve macroinvertebrates (record the time involved and operator's name)

3. identify macroinvertebrates to BMWP family level (record the identifier's name)

4. estimate the abundance of each BMWP family in the replicate sample.

For each replicate sample, this involved the following steps. All traces of preservative were removed from the collected material by thorough washing through a fine sieve (0.5 mm mesh) before sorting the replicates. The washed material to be sorted was dispersed in shallow water in a white tray. The whole tray was scanned and representatives of all macroinvertebrate taxa detected were removed and re-preserved, subsequently to be identified to family and counted. Where particularly large numbers of certain taxa were present, all specimens from a defined fraction of the tray area were removed and counted. Where a known proportion of a particularly abundant taxon was counted, the total number present was calculated by extrapolation.

3.3 Data recording activities for each replicate sample

The following activities were undertaken:

1. note the numbers of each macroinvertebrate taxon present

2. calculate Ntaxa, BMWP Score and ASPT

Complete independent checks on all samples, in terms of:

1. the accuracy and number of taxa recorded

2. the derived BMWP scores

3. accuracy of data transferred to an Access database (primary storage medium).

4. RESULTS

4.1 Sampling activity

A team of four people completed the sampling schedule during one working day, at each site. A boat was used at all sites, providing a stable platform from which to take the airlift and long-handled pondnet samples. Sampling activity at each site included the collection of eighteen deep-water replicate samples and six margin replicate samples, with associated preservation and labelling of the samples. At two sites a series of 12 additional deep-water replicate samples was taken, making a total of 36 replicate samples for these sites.

Deployment and recovery of the boat, conveying sampling equipment and samples occupied around two hours at each site, with the rest of the day taken up with the extensive sampling activities. On this basis, the more limited sampling activities during routine monitoring will permit sampling to be completed at two or possibly three deep-water sites in a standard working day. This assumes <1 hour sailing/driving time between sites.

The deep-water sampling activities described and recommended in this report will require new safe working assessments and new codes of practice, which may mirror those currently adopted by Agency fisheries staff, using boats. A team of three suitably trained staff should be sufficient, except where site conditions for boat-launching and recovery require the help of a fourth person.

4.1.1 Comparison of sample processing time

Two separate steps were involved in sample processing: (1) macroinvertebrate detection and recovery (referred to as sort time) and (2) identification and counting. The sort time for the different sampling devices and different sites was considered to be an important practical consideration in the assessment of, and subsequent recommendations on, sampling methods. The time required to identify and count taxa was also noted.

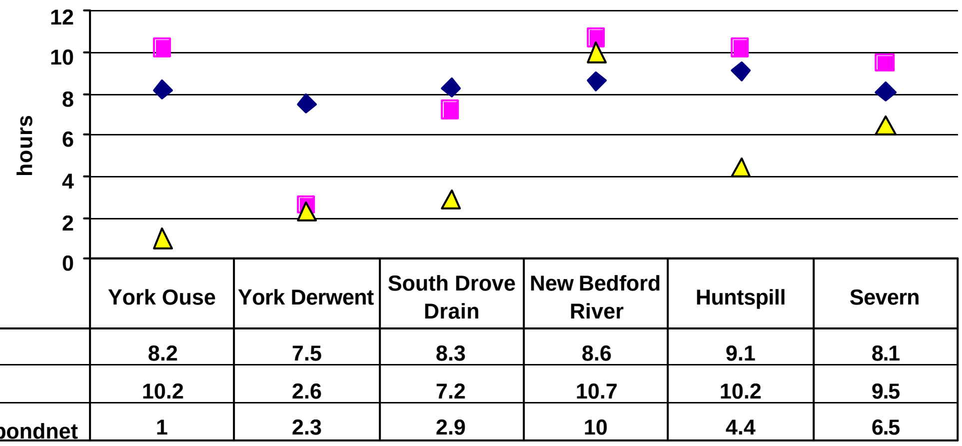
Operator variability was compared with respect to the time taken to sort and recover macroinvertebrates from the samples (Table 4.1). It should be emphasised that sample size varied greatly between methods and sites, despite the attempt to obtain each replicate from a consistent area. Certain operators (A-E) may have sorted a batch of smaller or larger samples than the average. Therefore differences in mean, maximum and minimum sort time is not a definitive measure of operator variability. However, for three (A, B and C) of the five operators the mean sort time was around 7 hours per replicate, with overall sort time ranging very widely from 0.3-20 hours.

The time required to recover macroinvertebrates from the deep-water samples was strongly influenced by sample debris volume and this reflected site conditions, the sampled area size (consistent) and the characteristics of each sampling method. The sample processing time was also extended by the need to gauge sample device performance in terms of taxon abundance. In this exercise the counts were more precise than achieved by attributing the standard log-abundance categories used in RIVPACS.

Table 4.1 Variation within and between operators in the time (in hours) taken to sort replicate samples

Operator	Samples	Mean	Median	Sdev	Min	Max
A	16	7.5	7.6	5.4	0.3	15.5
B	26	7.1	6.8	2.3	3.0	10.2
C	24	7.1	5.7	5.7	0.6	19.5
D	13	9.7	9.0	5.3	2.0	20.0
E	46	5.9	6.25	2.6	1.2	12.2

In general, the comparison of sort times between sampling devices and sites largely reflects sample volume and highlights where major differences occurred (Figure 4.1). The mean sort time required for airlift samples was the most consistent between sites and reflected the consistency in the volume and type of debris obtained. Site comparisons indicate that the Yorkshire Derwent yielded particularly small dredge samples, whilst the long-handled pondnet provided samples of relatively small mean volume at 4 of the 6 sites.



	York Ouse	York Derwent	South Drove Drain	New Bedford River	Huntspill	Severn
airlift	8.2	7.5	8.3	8.6	9.1	8.1
dredge	10.2	2.6	7.2	10.7	10.2	9.5
long-handled pondnet	1	2.3	2.9	10	4.4	6.5

Figure 4.1 Comparison of mean sample sort times between sampler types and sites

4.1.2 Taxa recovery over time

The rate at which new BMWP taxa were recovered during sample sorting and identification was compared between airlift, dredge and long-handled pondnet. This comparison excluded the additional BAMS series (2 and 3). The mean recovery rates of BMWP taxa (Ntaxa) per hour were: airlift - 2.06; dredge - 2.14; long-handled pondnet - 2.98. The airlift samples, though slower to sort, provided the most consistent return per hour (Figure 4.2a). The dredge and long-handled pondnet methods yielded more variable return rates. Both techniques yielded similar Ntaxa to the airlift in less sorting time (at two sites), but crucially they also required more time to sort and yielded lower Ntaxa at other sites (Figure 4.2b and c). [Note: in the context of sample processing for standard RIVPACS assessments, for most deep water samples the quantities of material collected with the dredge and

the airlift were not exceptionally large, but the high proportion of fine detritus present extended the sort times.]
The BMWP taxa present at each site and recovered from each sampling technique are listed in Appendix II. Summaries of the Ntaxa, BMWP score and Average Score Per Taxon (ASPT), for each replicate sample are provided in Table 4.2.

During the sample processing in the laboratory, one of the six airlift samples from the Yorkshire Ouse was mislaid and, despite protracted searches, it has not been found.

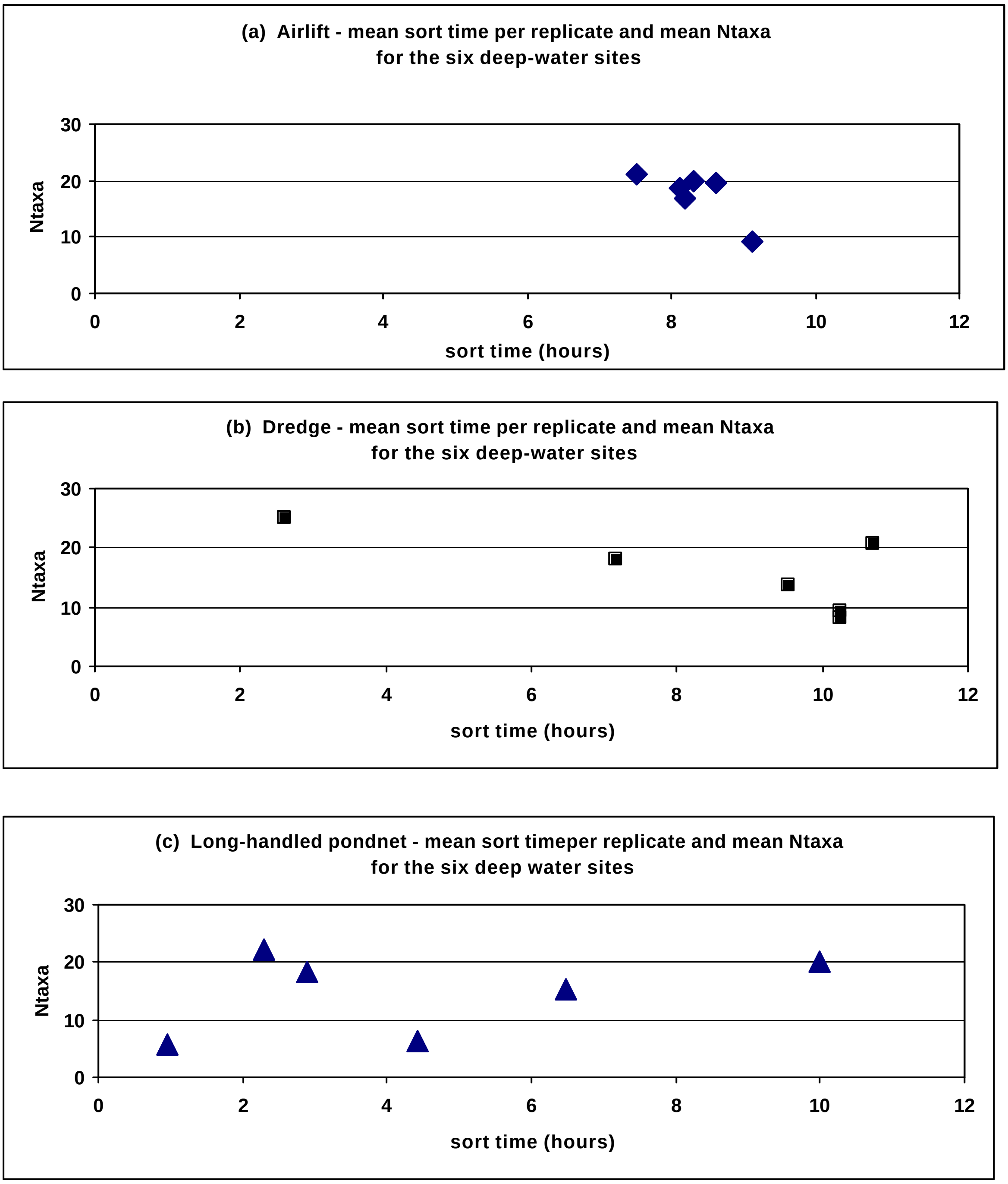


Figure 4.2 Comparison of NTaxa yield and sample sort time using the airlift, dredge and long-handled pondnet

Table 4.2 Summaries of the number of BMWP taxa (Ntaxa), BMWP Total Score and Average Score Per Taxon (ASPT), for each sample replicate at each site, with mean and standard deviation (SD) of the replicate values

BMWP NTaxa

Replicate	1	2	3	4	5	6	**mean**	**SD**
Airlift								
Y. Ouse	16	19	16	16	17		**16.8**	**1.2**
Y. Derwent 1	17	23	22	21	22	22	**21.2**	**0.7**
Y. Derwent 2	20	30	25	24	23	28	**25.0**	**2.6**
Y. Derwent 3	23	21	23	19	25	23	**22.3**	**2.0**
South Dr.	18	21	21	21	18	21	**20.0**	**1.2**
New Bedford	15	20	24	20	19	19	**19.5**	**1.9**
Huntspill	11	8	9	12	9	6	**9.2**	**1.9**
Severn	16	19	20	16	22	20	**18.8**	**2.0**

Replicate	1	2	3	4	5	6	**mean**	**SD**
Dredge								
Y. Ouse	10	6	9	10	5	10	**8.3**	**2.1**
Y. Derwent	16	21	14	15	14	19	**16.5**	**2.9**
South Dr 1	14	16	17	22	17	22	**18.0**	**2.7**
South Dr 2	16	21	16	22	23	21	**19.8**	**2.4**
South Dr 3	13	19	19	21	18	23	**18.8**	**1.9**
New Bedford	20	24	22	25	17	17	**20.8**	**3.4**
Huntspill	13	10	8	8	9	7	**9.2**	**1.1**
Severn	12	13	20	18	16	3	**13.7**	**6.0**

Replicate	1	2	3	4	5	6	**mean**	**SD**
LHP								
Y. Ouse	8	5	4	7	4	7	**5.8**	**1.7**
Y. Derwent	15	13	16	12	13	18	**14.5**	**2.2**
South Dr.	19	18	17	17	19	19	**18.2**	**0.9**
New Bedford	15	19	23	23	21	20	**20.2**	**1.7**
Huntspill	12	5	5	6	5	5	**6.3**	**0.6**
Severn	13	12	16	15	25	11	**15.3**	**5.0**

Table 4.2 (continued)

BMWP Total Score

Replicate	1	2	3	4	5	6	**mean**	**SD**
Airlift								
Y. Ouse	70	87	74	70	77		**75.6**	**6.3**
Y. Derwent 1	108	136	133	120	131	140	**128.0**	**6.9**
Y. Derwent 2	116	183	150	131	140	178	**149.7**	**20.8**
Y. Derwent 3	134	127	139	119	141	139	**133.2**	**8.6**
South Dr.	75	88	93	96	76	97	**87.5**	**7.7**
New Bedford	66	103	124	105	93	100	**98.5**	**10.7**
Huntspill	40	31	32	53	31	18	**34.2**	**11.3**
Severn	75	96	107	81	116	112	**97.8**	**12.8**

Replicate	1	2	3	4	5	6	**mean**	**SD**
Dredge								
Y. Ouse	51	15	31	49	17	37	**33.3**	**12.8**
Y. Derwent	90	117	76	72	81	109	**90.8**	**18.4**
South Dr 1	56	71	74	96	70	103	**78.3**	**14.0**
South Dr 2	70	97	71	98	100	95	**88.5**	**10.8**
South Dr 3	48	84	90	95	76	109	**83.7**	**11.5**
New Bedford	98	122	108	120	82	74	**100.7**	**19.7**
Huntspill	48	36	27	26	32	22	**31.8**	**5.1**
Severn	58	57	109	86	77	6	**65.5**	**34.8**

Replicate	1	2	3	4	5	6	**mean**	**SD**
LHP								
Y. Ouse	23	14	9	22	9	21	**16.3**	**5.6**
Y. Derwent	84	80	85	72	79	108	**84.7**	**12.3**
South Dr.	84	76	79	73	89	90	**81.8**	**6.9**
New Bedford	72	93	119	114	106	95	**99.8**	**10.5**
Huntspill	51	15	15	18	15	15	**21.5**	**2.7**
Severn	65	51	89	71	140	50	**77.7**	**33.2**

Table 4.2 (continued)

ASPT

Replicate	1	2	3	4	5	6	**mean**	**SD**
Airlift								
Y. Ouse	4.38	4.58	4.63	4.38	4.53		**4.50**	**0.09**
Y. Derwent 1	6.35	5.91	6.05	5.71	5.95	6.36	**6.06**	**0.21**
Y. Derwent 2	5.80	6.10	6.00	5.46	6.09	6.36	**5.97**	**0.30**
Y. Derwent 3	5.83	6.05	6.04	6.26	5.64	6.04	**5.98**	**0.20**
South Dr.	4.17	4.19	4.43	4.57	4.22	4.62	**4.37**	**0.18**
New Bedford	4.40	5.15	5.17	5.25	4.89	5.26	**5.02**	**0.14**
Huntspill	3.64	3.88	3.56	4.42	3.44	3.00	**3.65**	**0.47**
Severn	4.69	5.05	5.35	5.06	5.27	5.60	**5.17**	**0.21**

Replicate	1	2	3	4	5	6	**mean**	**SD**
Dredge								
Y. Ouse	5.10	2.50	3.44	4.90	3.40	3.70	**3.84**	**0.78**
Y. Derwent	5.63	5.57	5.43	4.80	5.79	5.74	**5.49**	**0.36**
South Dr 1	4.00	4.44	4.35	4.36	4.12	4.68	**4.33**	**0.18**
South Dr 2	4.38	4.62	4.44	4.45	4.35	4.52	**4.46**	**0.09**
South Dr 3	3.69	4.42	4.74	4.52	4.22	4.74	**4.39**	**0.21**
New Bedford	4.90	5.08	4.91	4.80	4.82	4.35	**4.81**	**0.24**
Huntspill	3.69	3.60	3.38	3.25	3.56	3.14	**3.44**	**0.18**
Severn	4.83	4.38	5.45	4.78	4.81	2.00	**4.38**	**1.19**

Replicate	1	2	3	4	5	6	**mean**	**SD**
LHP								
Y. Ouse	2.88	2.80	2.25	3.14	2.25	3.00	**2.72**	**0.37**
Y. Derwent	5.60	6.15	5.31	6.00	6.08	6.00	**5.86**	**0.30**
South Dr.	4.42	4.22	4.65	4.29	4.68	4.74	**4.50**	**0.22**
New Bedford	4.80	4.89	5.17	4.96	5.05	4.75	**4.94**	**0.14**
Huntspill	4.25	3.00	3.00	3.00	3.00	3.00	**3.21**	**0.09**
Severn	5.00	4.25	5.56	4.73	5.60	4.55	**4.95**	**0.55**

Table 4.2 (continued)

BMWP Ntaxa

Replicate	1	2	3	4	5	6	**mean**	**SD**
Margin								
Y. Ouse	12	9	12	13	15	15	**12.7**	**2.2**
Y. Derwent	19	26	17	22	23	22	**21.5**	**2.9**
South Dr.	28	23	23	21	29	21	**24.2**	**3.0**
New Bedford	25	28	21	24	26	28	**25.3**	**2.7**
Huntspill	15	15	17	8	12	13	**13.3**	**3.0**
Severn	9	8	6	16	10	15	**10.7**	**3.9**

BMWP Total Score

Replicate	1	2	3	4	5	6	**mean**	**SD**
Margin								
Y. Ouse	54	33	44	55	71	65	**53.7**	**13.8**
Y. Derwent	103	139	85	111	135	120	**115.5**	**19.4**
South Dr.	141	100	100	95	131	95	**110.3**	**13.8**
New Bedford	134	145	98	119	128	137	**126.8**	**16.2**
Huntspill	58	59	69	27	47	50	**51.7**	**14.0**
Severn	42	33	20	69	39	72	**45.8**	**20.5**

ASPT

Replicate	1	2	3	4	5	6	**mean**	**SD**
Margin								
Y. Ouse	4.50	3.67	3.67	4.23	4.73	4.33	**4.19**	**0.41**
Y. Derwent	5.42	5.35	5.00	5.05	5.87	5.45	**5.36**	**0.31**
South Dr.	5.04	4.35	4.35	4.52	4.52	4.52	**4.55**	**0.09**
New Bedford	5.36	5.18	4.67	4.96	4.92	4.89	**5.00**	**0.17**
Huntspill	3.87	3.93	4.06	3.38	3.92	3.85	**3.83**	**0.23**
Severn	4.67	4.13	3.33	4.31	3.90	4.80	**4.19**	**0.48**

4.2 Macroinvertebrates

4.2.1 Range of macroinvertebrate taxa recorded

A total of 90 macroinvertebrate 'families' were recorded from 168 replicate samples collected at the six sites (Table 4.3). The full list of 'families' includes some non-scoring taxa (as defined by the BMWP system). The taxa are listed alphabetically for the convenience of checking with historical data from the selected sites. Twenty taxa only occurred at one of the six sites and ten of these taxa were represented by single specimens. The non-scoring taxa were later excluded from the comparison of sampling methods in order to permit comparisons with historical and future RIVPACS results.

Table 4.3 List of taxa and number of +ve samples at all sites, includes non-BMWP taxa

River	Yorkshire Ouse	Yorkshire Derwent	South Drove Dr.	New Bedford River	Huntspill	Severn	Grand Total	overall % occurrence
Total No. Samples	24	36	36	24	24	24	168	
Taxa								
Acroloxidae	5						5	3.0%
Aeshnidae			2				2	1.2%
Ancylidae	1	4		1			6	3.6%
Aphelocheiridae		31		10		6	47	28.0%
Argulidae					8		8	4.8%
Asellidae	21	35	36	21	1	18	132	78.6%
Baetidae	1	2	36	18	13	3	97	57.7%
Bithyniidae	18	8	32	23	4	14	99	58.9%
Brachycentridae		31				6	37	22.0%
Caenidae	7	34	27	19	1	2	90	53.6%
Calopterygidae				2		1	3	1.8%
Ceratopogonidae	7	21	14	14	13	7	76	45.2%
Chaoboridae		1	7	7			15	8.9%
Chironomidae	22	36	36	24	24	24	166	98.8%
Chrysomelidae	1		1		1	1	4	2.4%
Cladocera	1		6	3	2		12	7.1%
Coenagriidae	1		36	10	10		57	33.9%
Copepoda			3	1			4	2.4%
Corixidae		4	36	24	11		75	44.6%
Corophiidae						13	13	7.7%
Crangonyctidae	6	1	12			2	21	12.5%
Culicidae			16	1			17	10.1%
Curculionidae			2		2		4	2.4%
Dendrocoelidae	5	21	6	1		7	40	23.8%
Dixidae			1				1	0.6%
Dreissenidae						1	1	0.6%
Dryopidae			2				2	1.2%
Dugesiidae	6	1	15	3	1	15	41	24.4%
Dytiscidae	3	9	20	16	5	2	55	32.7%
Ecnomidae		1			1		2	1.2%
Elmidae	3	26	11			10	50	29.8%
Ephemerellidae	3	36					39	23.2%
Ephemeridae		18				3	21	12.5%
Ephydridae		4	3		3		10	6.0%
Erpobdellidae		26	6	24		11	67	39.9%
Gammaridae	6	36	19	24	3	21	109	64.9%
Gerridae		1	9	1	4		15	8.9%
Glossiphoniidae	17	21	32	24	9	19	122	72.6%
Gomphidae						4	4	2.4%
Gyrinidae			5				5	3.0%
Haliplidae		2	32	5			39	23.2%
Heptageniidae		28				5	33	19.6%
Hydracarina	9	26	27	14	11	4	91	54.2%
Hydraenidae			4				4	2.4%
Hydridae	1		3				4	2.4%

River	Yorkshire Ouse	Yorkshire Derwent	South Drove Dr.	New Bedford River	Huntspill	Severn	Grand Total	overall % occurrence
Hydrobiidae	13	25	36	9	7	7	97	57.7%
Hydrometridae			2		3		5	3.0%
Hydrophilidae			16	1	2	2	21	12.5%
Hydropsychidae		13				10	23	13.7%
Hydroptilidae		1	13	1		3	18	10.7%
Lepidoptera	1		8		5		14	8.3%
Lepidostomatidae		3					3	1.8%
Leptoceridae	3	21	30	21	3	14	92	54.8%
Leptophlebiidae		1					1	0.6%
Leuctridae	1	23				1	25	14.9%
Libellulidae			1	1			2	1.2%
Limnephilidae	2	8		6		1	17	10.1%
Lumbricidae		2	2				4	2.4%
Lymnaeidae	7	4	23	6	12	1	53	31.5%
Mesovelidae			1		1		2	1.2%
Microturbellaria	1						1	0.6%
Molannidae	1	4	4	24			33	19.6%
Naucoridae			5		6		11	6.5%
Nemouridae		1					1	0.6%
Nepidae			5		2		7	4.2%
Neritidae		21		16		12	49	29.2%
Noteridae			1				1	0.6%
Notonectidae			5	4	7		16	9.5%
Oligochaeta	22	35	36	24	24	24	165	98.2%
Ostracoda	1	1		5		7	14	8.3%
Palaemonidae				2			2	1.2%
Phryganeidae			7	8		5	20	11.9%
Physidae	3	2	8	6	13	1	33	19.6%
Piscicolidae	1	22	18	11	4		56	33.3%
Planariidae	9	20	15	3		3	50	29.8%
Planorbidae	2	2	36	3	3		46	27.4%
Polycentropodidae	7	7	10	16		14	54	32.1%
Psychodidae		1					1	0.6%
Psychomyiidae	7					2	8	4.8%
Pyralidae			19	1			20	11.9%
Rhyacophilidae		1					1	0.6%
Scathophagidae	1						1	0.6%
Sciomyzidae			3		3		6	3.6%
Sericostomatidae		2					2	1.2%
Sialidae	8	10	6	23		12	59	35.1%
Simuliidae	1	16					17	10.1%
Sisyridae	6					2	8	4.8%
Sphaeriidae	20	28	32	24	18	24	146	86.9%
Stratiomyidae		2			1		3	1.8%
Succineidae		1	9		3	1	14	8.3%
Syrphidae		1					1	0.6%
Tipulidae	1	10	12		1	1	25	14.9%
Unionidae	9	8	3	23	17	18	78	46.4%
Valvatidae	8	1	15	20	20	3	67	39.9%
Veliidae		2	6		2		10	6.0%
Viviparidae	13	12		23		15	63	37.5%

4.2.2 ASPT (Average Score Per Taxon)

The ASPT derived for each replicate sample generated similar trends to the BMWP Scores, with some notable exceptions (Figure 4.3). Though airlift samples provided relatively high ASPTs from the Yorkshire Ouse and Derwent, the other sampling methods yielded some replicates with higher scores (Figure 4.3). Consistency between replicates for all methods was most evident on the Derwent, South Drove and New Bedford (Figure 4.3). The mean ASPTs derived for each site confirm that the airlift sampler also produced the highest ASPTs at 5 of the 6 sites, when comparisons are restricted to the deep-water sampling methods (Figure 4.4).

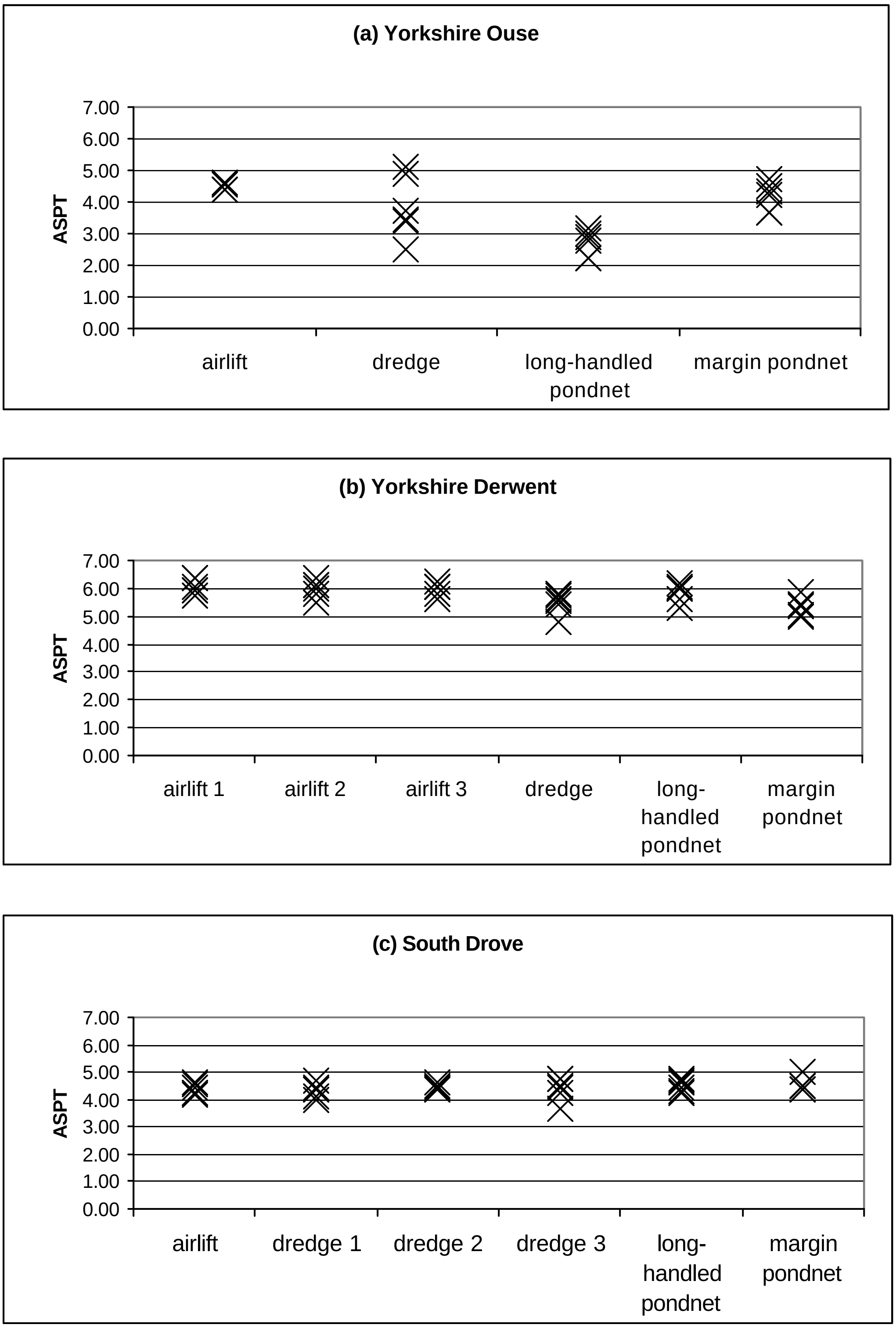


Figure 4.3 Variation in replicate Average Score Per Taxon (ASPT) for each of the sampling methods for each site (a-c)

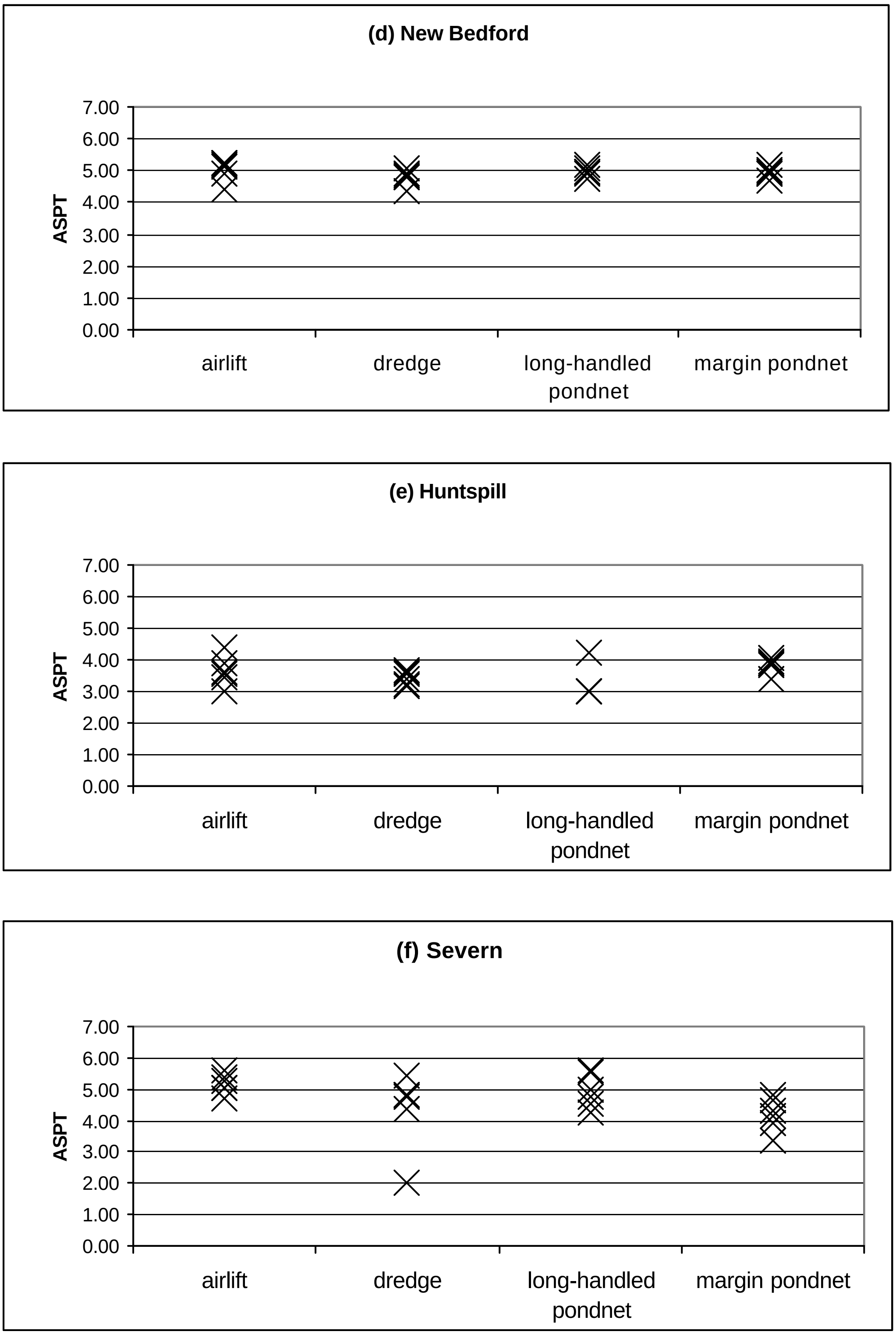
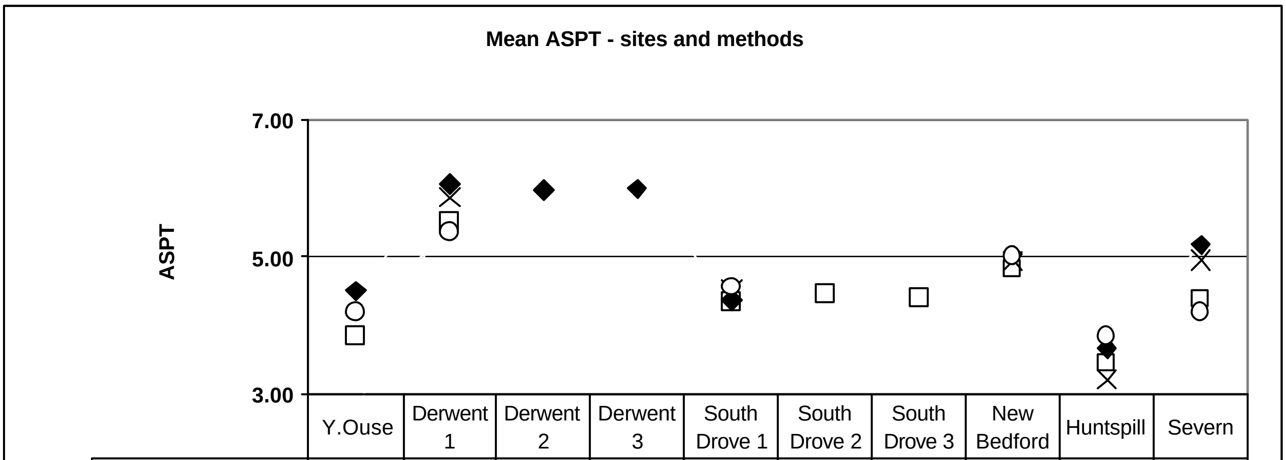


Figure 4.3 (continued) Variation in replicate Average Score Per Taxon (ASPT) for each of the sampling methods for each site (d-f)



	Y.Ouse	Derwent 1	Derwent 2	Derwent 3	South Drove 1	South Drove 2	South Drove 3	New Bedford	Huntspill	Severn
◆ airlift	4.50	6.06	5.97	5.98	4.37			5.02	3.65	5.17
□ dredge	3.84	5.49			4.33	4.46	4.39	4.81	3.44	4.38
× long-h p-net	2.72	5.86			4.50			4.94	3.21	4.95
o margin pondnet	4.19	5.36			4.55			5.00	3.83	4.19

Figure 4.4 Mean Average Score Per Taxon for each sampling method and site

4.2.3 BMWP Score

Comparisons of the Ntaxa were expanded to include the BMWP Scores. The variability of the replicates for each sampling method was compared across sites (Figure 4.5a-f). Note: some closely similar values overlay and obscure symbols, eg for South Drove Drain). Contrasting patterns of variability in BMWP Scores were evident. There was a marked lack of consistent pattern in terms of which sampling method yielded the highest BMWP Scores at all sites. The airlift samples from the Yorkshire Ouse and Derwent (Figure 4.5a and b) generated the highest BMWP Scores in all replicates compared (Note: one airlift sample, from the Ouse, was mislaid). The mean BMWP Scores derived for each site confirm that the airlift sampler produced the highest BMWP Scores at 5 of the 6 sites, when comparisons are restricted to the deep-water sampling methods (Figure 4.6).

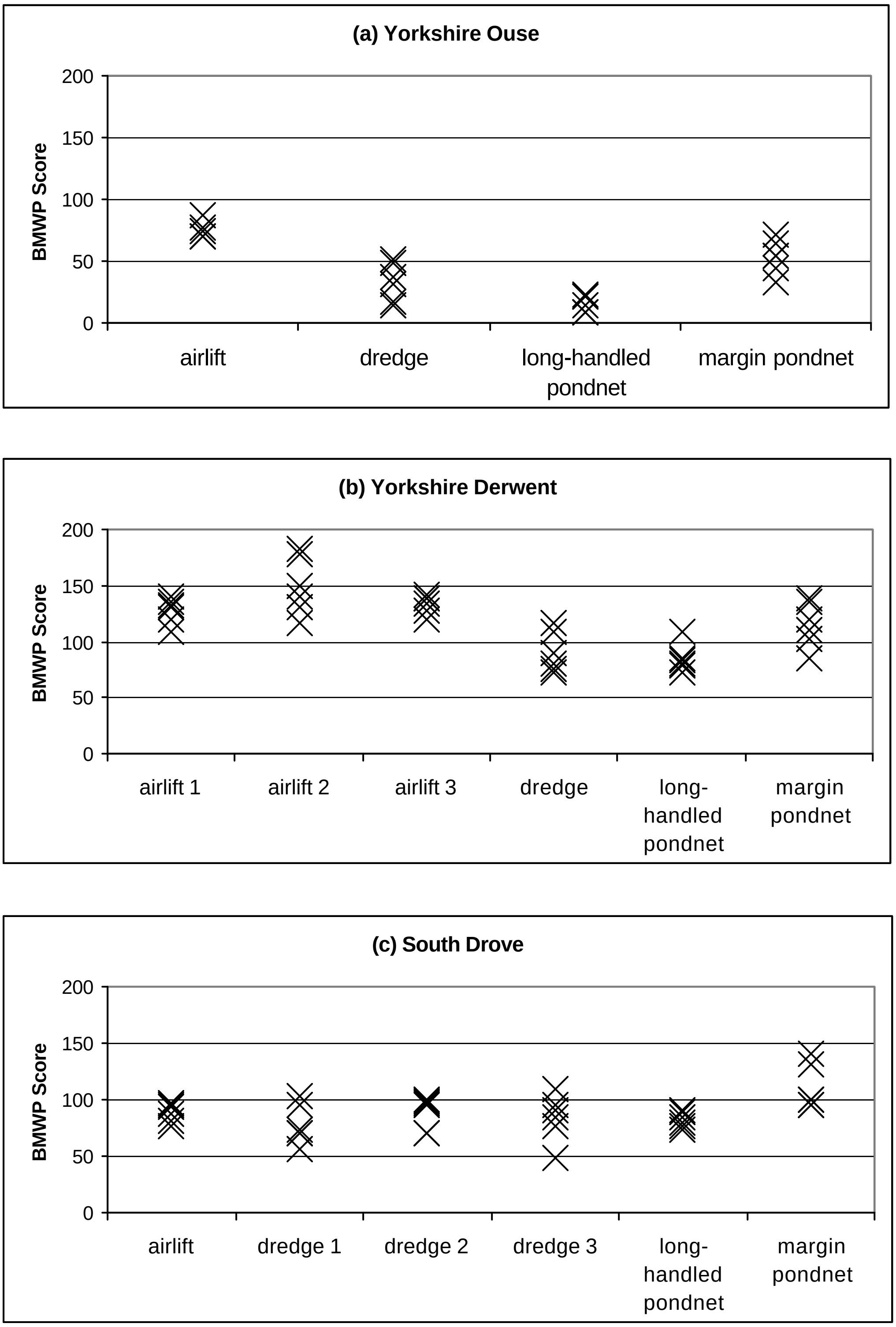


Figure 4.5 Variation in replicate BMWP Score for each of the sampling methods for each site (a-c)

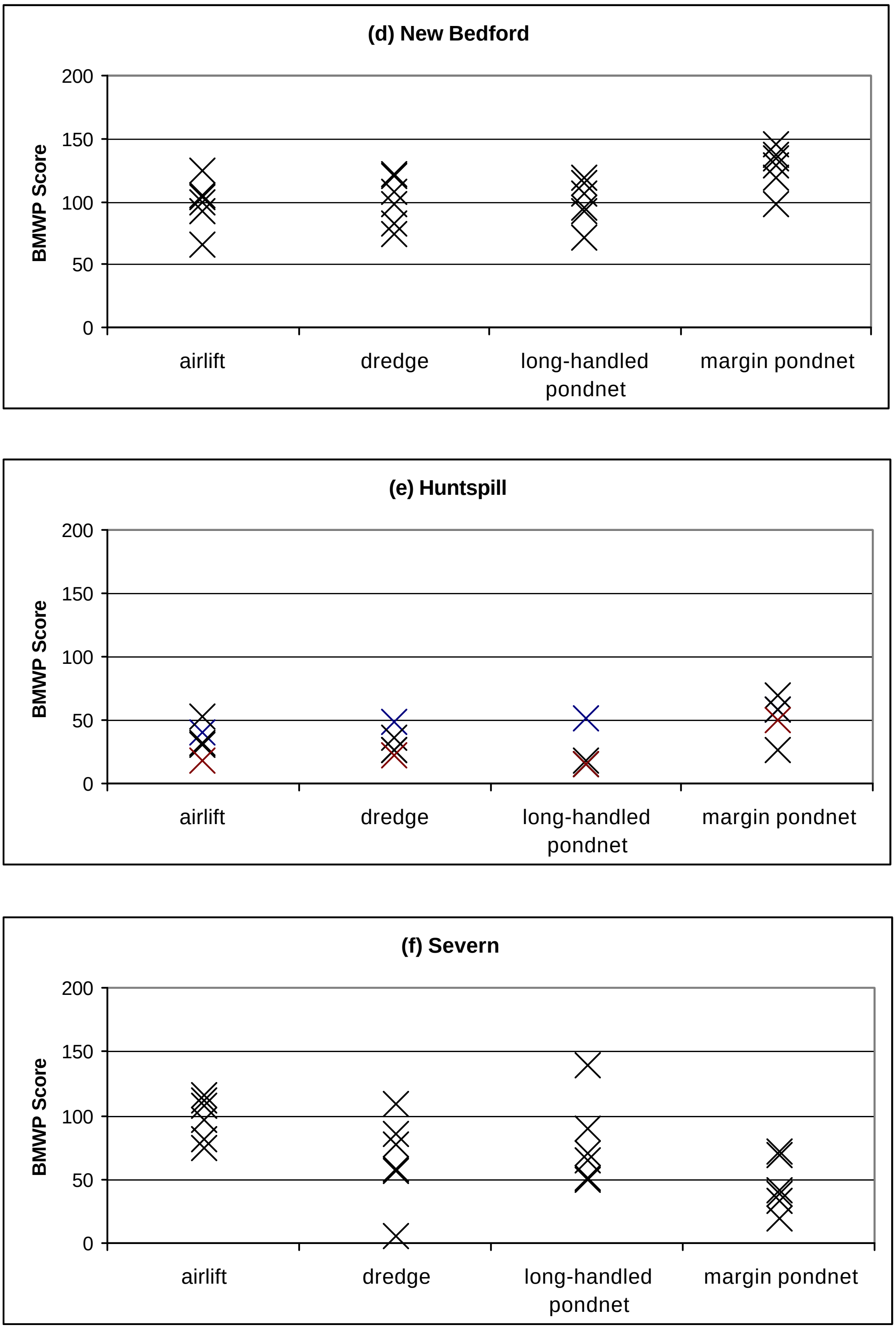
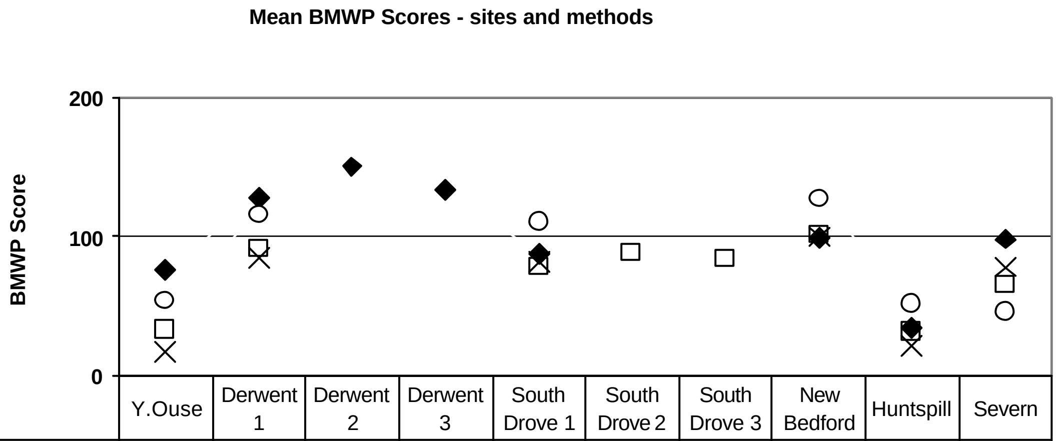


Figure 4.5 (continued) Variation in replicate BMWP Score for each of the sampling methods for each site (d-f)



	Y.Ouse	Derwent 1	Derwent 2	Derwent 3	South Drove 1	South Drove 2	South Drove 3	New Bedford	Huntspill	Severn
◆ airlift	76	128	150	133	88			99	34	98
□ dredge	33	91			78	89	84	101	32	66
× long-h p-net	16	85			82			100	22	78
○ margin pondnet	54	116			110			127	52	46

Figure 4.6 Mean BMWP Score for each sampling method and site

4.3 Taxon accretion rates

Ntaxa and variability of taxon recovery from each set of six sample replicates were examined using the software package 'Species Diversity and Richness - Version 2' (PISCES Conservation Ltd, 1998). The data were used to generate a smoothed 'species' accretion curve by setting the software to simulate 100 runs of sample collecting, using the present dataset. The accretion curve for one method at one site shows the mean Ntaxa found in any single, pair, 3, 4, 5, or 6 random samples (out of the total of six replicate samples taken by that method). Curves which are still rising at six replicate samples indicate that even six samples is not enough to capture all the taxa present at the site, which could eventually be captured by that sampling method.

4.3.1 Comparison of taxon accretion rates between sites

Airlift

Taxon accretion curves flattened out most conspicuously in three airlift series (South Drove, New Bedford and Derwent series 1), whilst accretion continued to rise in four series (Huntspill, Severn and Derwent series 2 and 3) (Figure 4.7). Assessment of the accretion rate for the Yorkshire Ouse was compromised by the loss of one airlift sample.

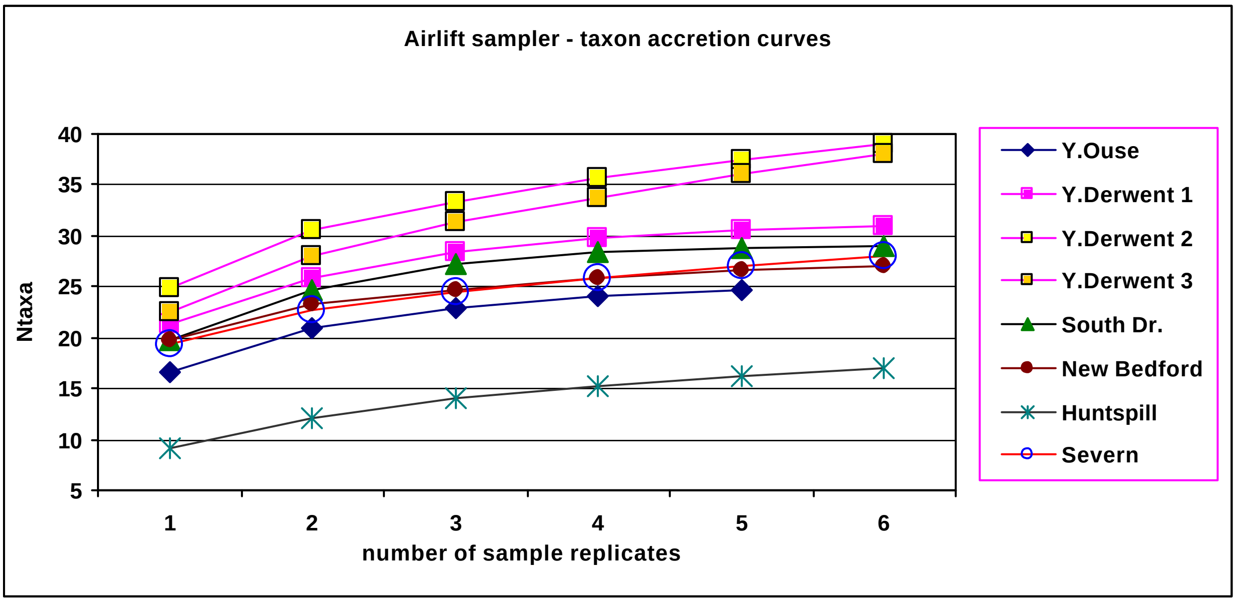


Figure 4.7 Taxon accretion curves for the airlift. See text 4.3, for details.

Dredge

The slopes of dredge accretion curves (Figure 4.8) were fairly consistent between sites. With the exception of the Huntspill, all slopes failed to flatten out as rapidly as the flattest generated from three of the airlift series (Figure 4.7), indicating that species accretion with replicate sample number is relatively slower with the dredge compared to the airlift.

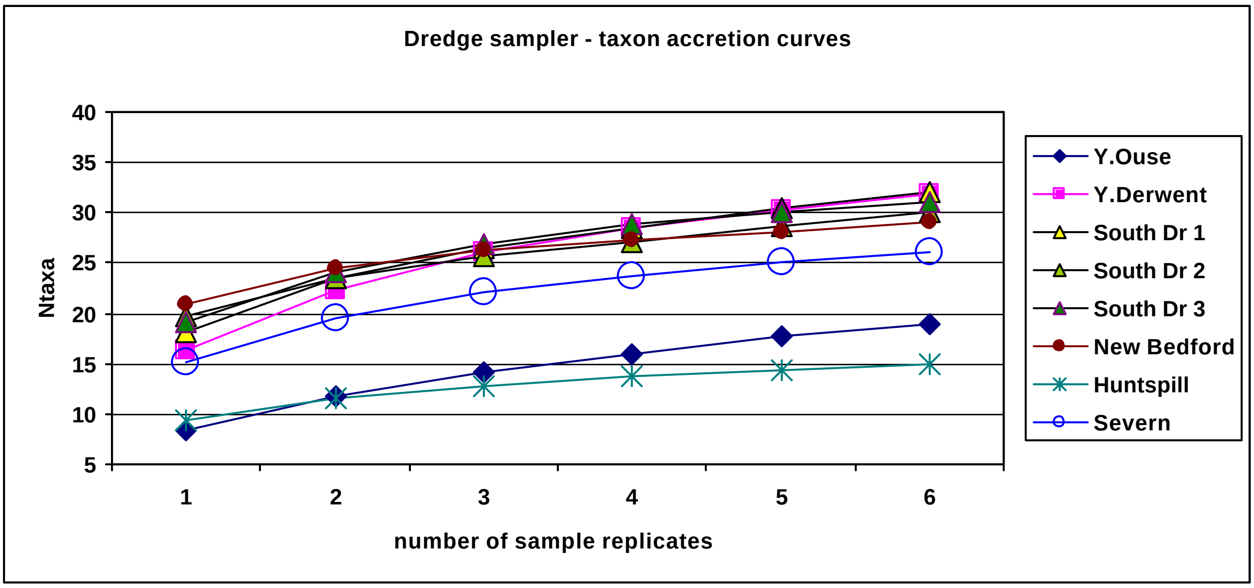


Figure 4.8 Taxon accretion curves for the dredge. See text 4.3, for details.

Long-handled Pondnet

In general the long-handled pondnet accretion curves (Figure 4.9) showed similar tendencies to flatten off as the other sampling devices, although at two sites (Yorkshire Ouse and Huntspill) the curves failed to flatten-off and yielded comparatively low Ntaxa.

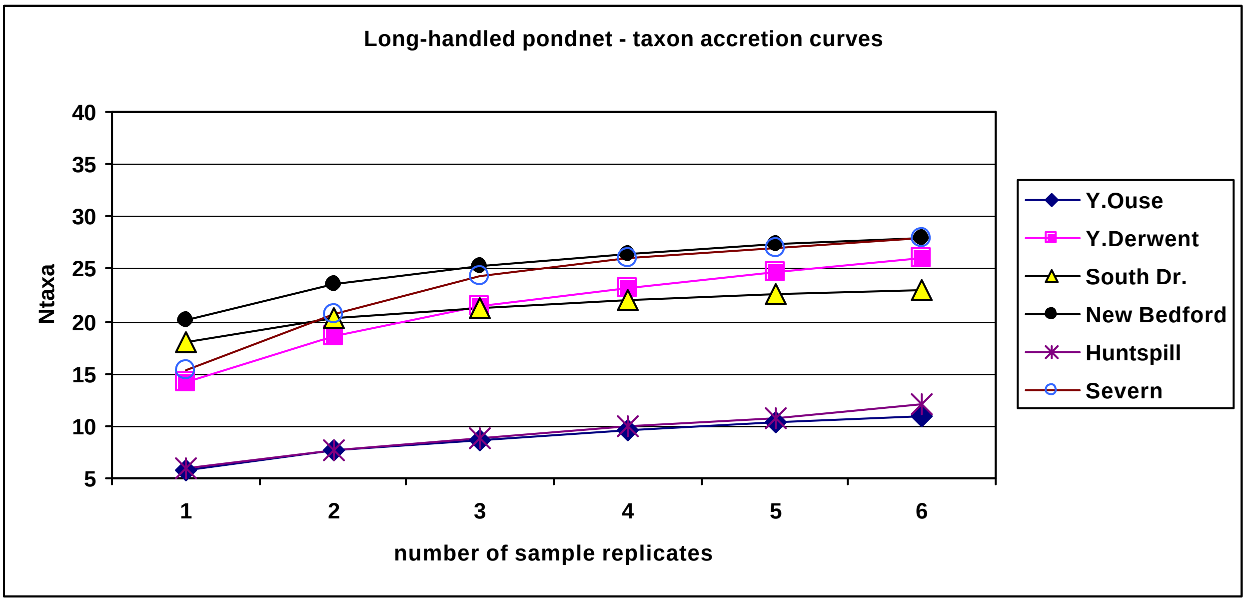


Figure 4.9 Taxon accretion curves for the long-handled pondnet. See text 4.3, for details.

4.3.2 Comparison of taxon accretion rates between samplers at each site

This approach highlights the differing results generated by choice of sampling method between sites (Figure 4.10a-f). For the Severn and New Bedford sites, sampling method had least influence on the total taxa recorded, or on accretion rates. Two sites (Huntspill and South Drove) showed similar taxon recovery by airlift and dredge, with relatively poor recovery rates by the long-handled pondnet replicate samples. The Yorkshire Ouse and Derwent display strongly contrasting taxon recovery and accretion rates between all methods. The long-handled pondnet produced the poorest total taxa count at four of the six sites.

Sampling effort and yield were compared, in terms of the relationship between the calculated taxon accretion rate and numbers of animals recovered and identified (Figure 4.11a-f). The standard RIVPACS sampling approach is designed to recover a minimum of 70% of the Ntaxa present at a site without compromising site quality assessment. We selected an 80% recovery rate for comparisons (line superimposed) of the maximum Ntaxa recorded at each site. (In Figure 4.11a-f all sampling methods used at a given site are included). This provides a visual comparison of sampler performance between methods and sites. The time required to achieve 80% recovery at each site was calculated by combining the known sort time for each sampling method, the number of samples and equivalent number of specimens requiring identification and counting (Table 4.4). It should be noted that the sample processing included more precise estimations of taxon abundance than applies in the standard RIVPACS approach, to aid sampling device yield comparisons.

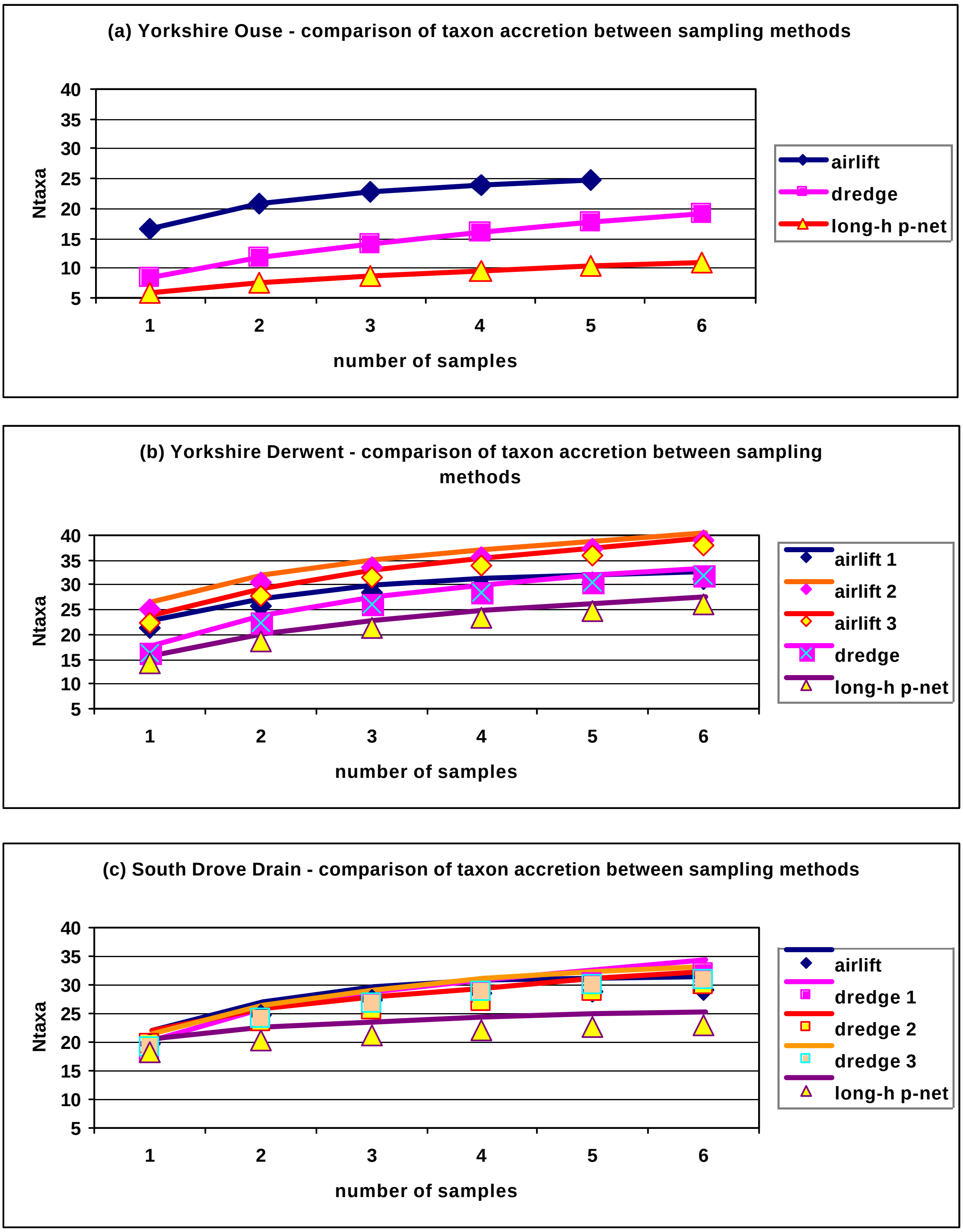
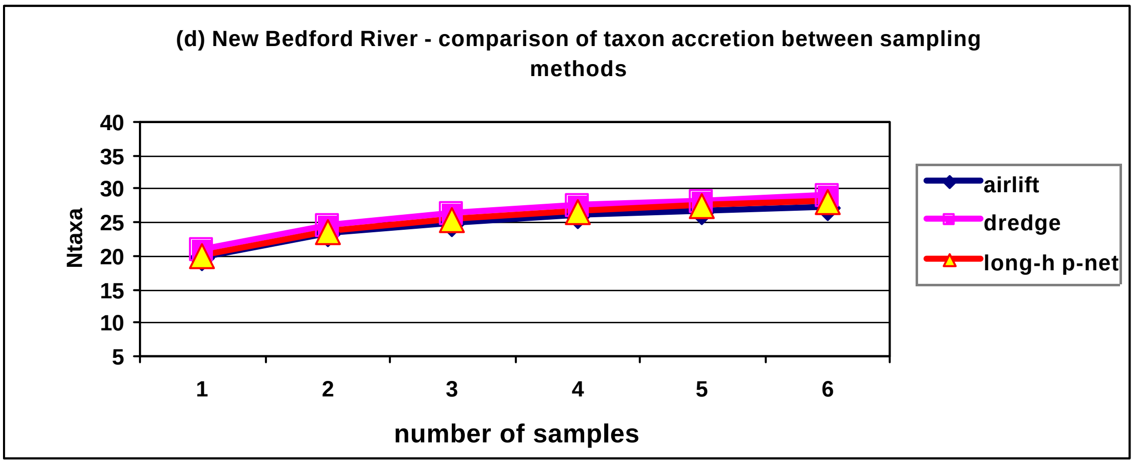
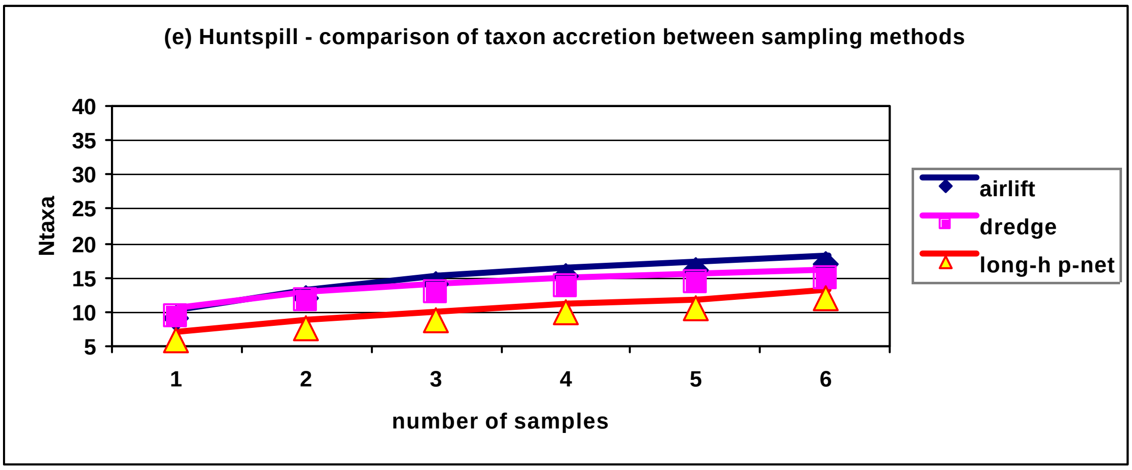


Figure 4.10 Comparison of macroinvertebrate taxon accretion rates between the different deep-water samplers at each site (a-c)





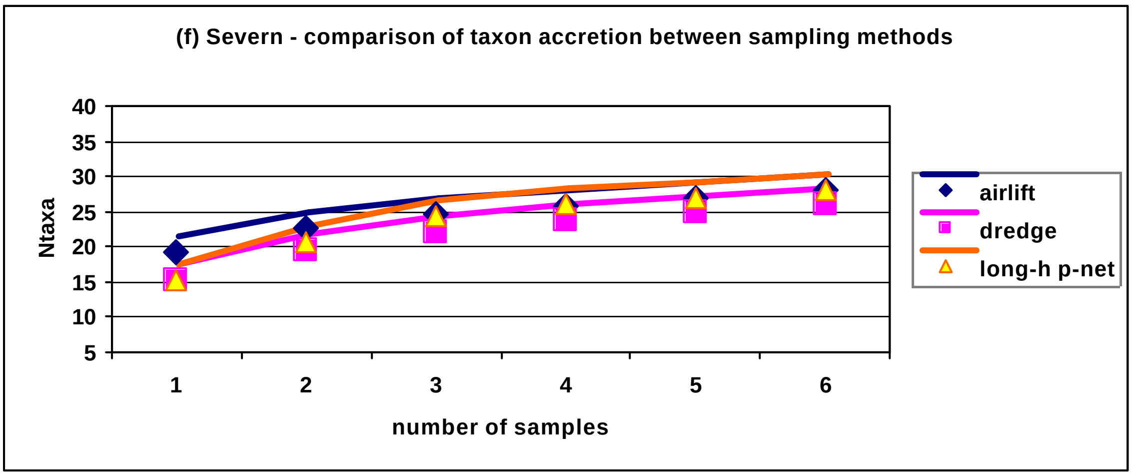
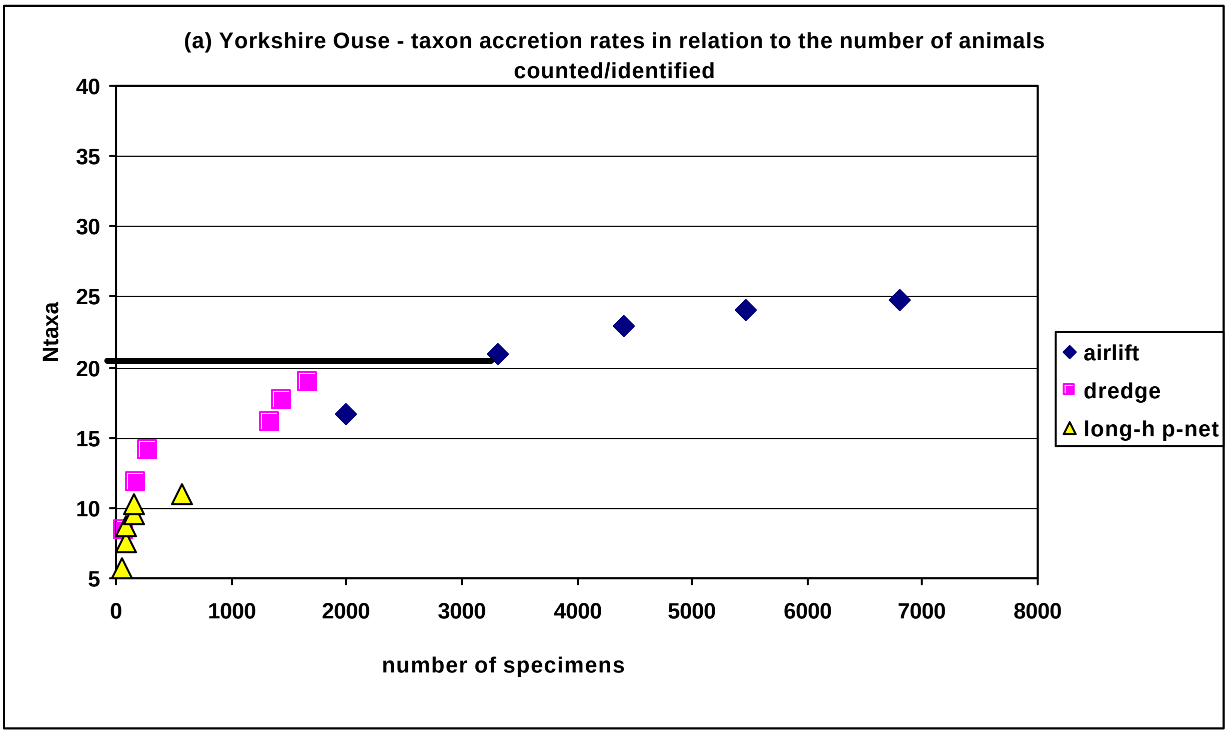


Figure 4.10 (continued) Comparison of macroinvertebrate taxon accretion rates between the different deep-water samplers at each site (d-f)



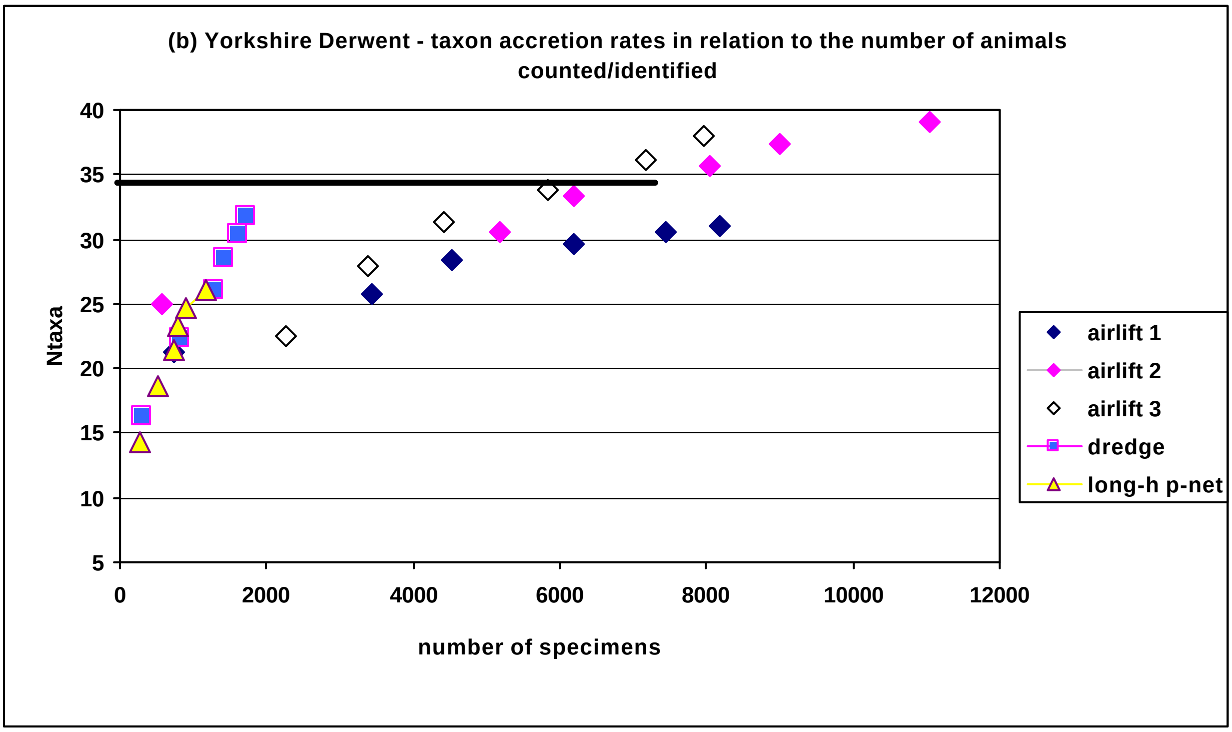
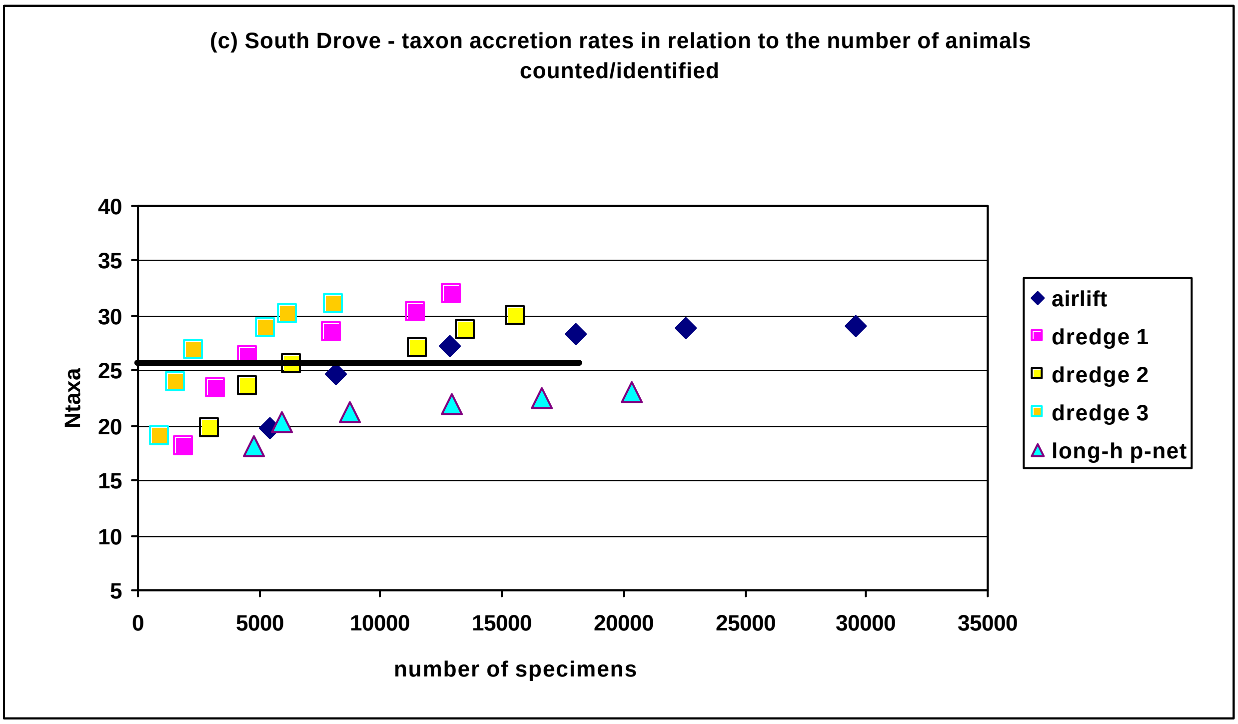


Figure 4.11 Relationship between taxon accretion rates and the number of animals recovered from each deep-water sample, for each sampling method (80% of recorded taxa indicated)



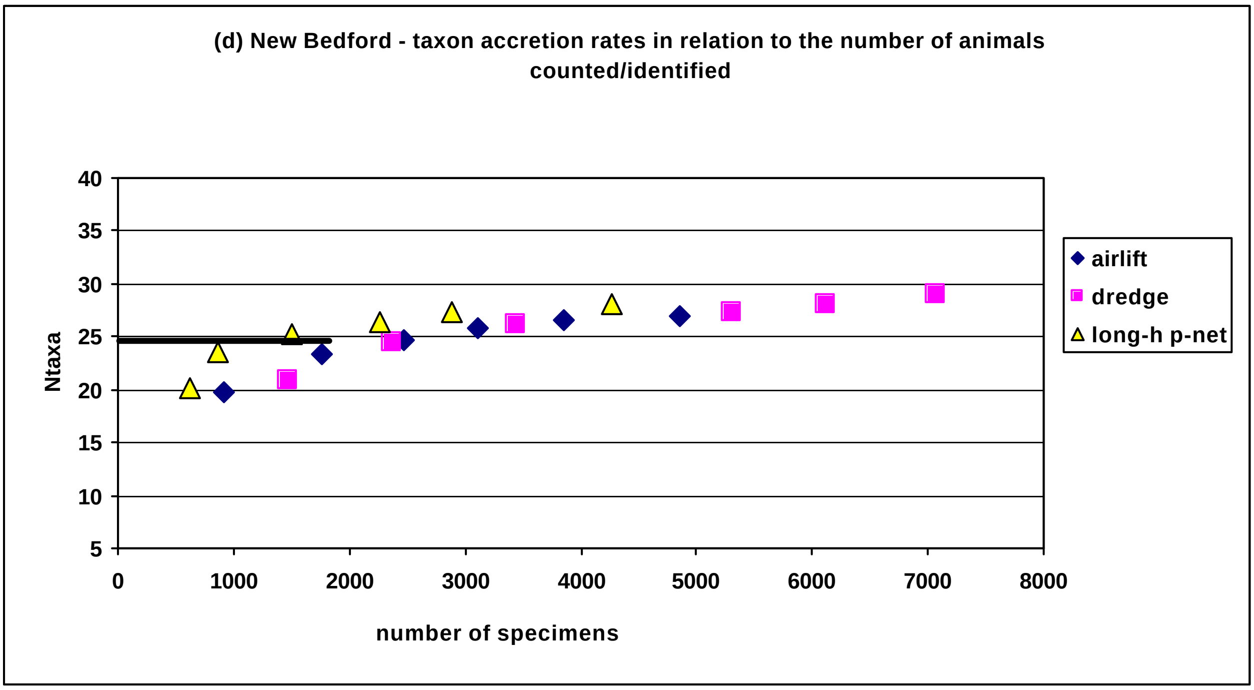
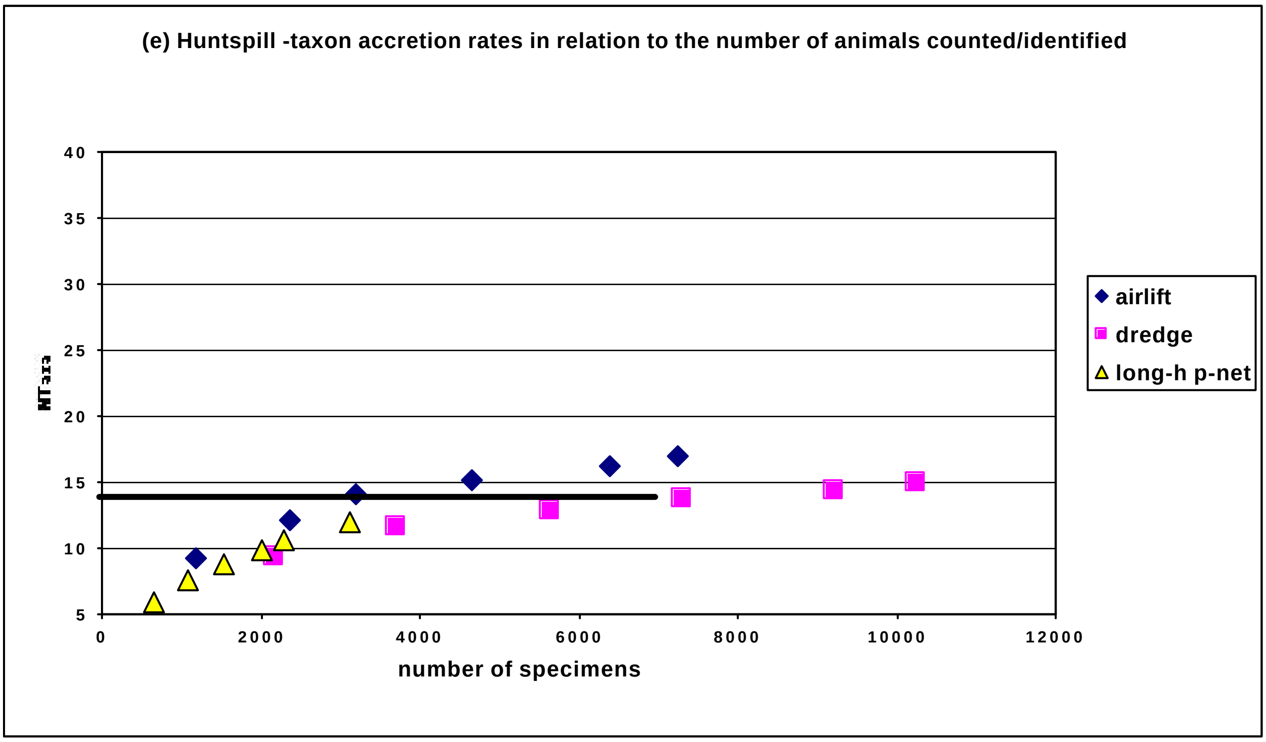


Figure 4.11 (continued) Relationship between taxon accretion rates and the number of animals recovered from each deep-water sample, for each sampling method (80% of recorded taxa indicated)



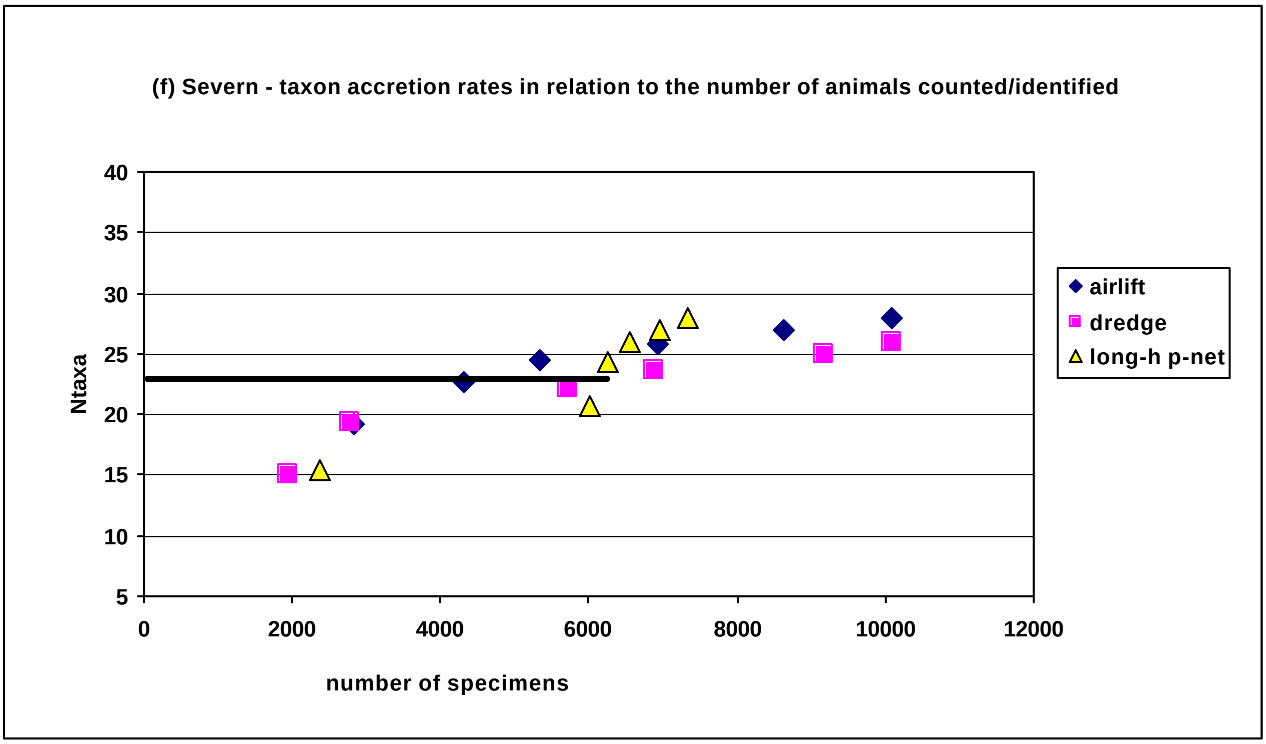


Figure 4.11 (continued) Relationship between taxon accretion rates and the number of animals recovered from each deep-water sample, for each sampling method (80% of recorded taxa indicated)

Table 4.4 Comparison of time (hours) and the equivalent number of sample replicates required to recover 80% of the BMWP Scoring Taxa recorded at each site by the deep-water sampling methods tested. (Fastest options highlighted). Note variable results between BAMS series. N/A denotes the yield cannot reach 80% of the recorded taxa

	Ntaxa Maximum	Ntaxa 80% of max.	Samples to yield 80%	Hours sort time per sample	Hours to yield 80%	Numbers individuals	Hours sort time + Identification	Hours
Yorkshire Ouse								
Airlift	**25**	20	2	8.2	16.4	3300	20.4	
Dredge	19	20	6	10.2	61.2	1750	73.2	
Long-handled pondnet	11	20	N/A	1	N/A	N/A	N/A	
Yorkshire Derwent								BAMS series **Airlift mean**
Airlift 1	31	31	4	6.2	24.8	7500	32.8	
Airlift 2	**39**	31	2	8	16	5000	20	27.6
Airlift 3	38	31	3	8.3	25	4500	31	
Dredge	32	31	5	2.6	11.2	1800	21.2	
Long-handled pondnet	26	31	N/A	2.3	N/A	N/A	N/A	
South Drove Drain								BAMS series **Dredge mean**
Airlift	29	25.6	3	8.3	24.9	12500	30.9	
Dredge 1	**32**	25.6	3	5.2	15.6	5000	21.6	
Dredge 2	30	25.6	3	8.9	26.7	12500	32.7	27.4
Dredge 3	31	25.6	3	7.3	21.9	2500	27.9	
Long-handled pondnet	23	25.6	N/A	2.9	N/A	N/A	N/A	
New Bedford River								
Airlift	27	23.2	2	8.6	17.2	1800	21.2	
Dredge	**29**	23.2	2	10.7	21.4	2400	25.4	
Long-handled pondnet	28	23.2	2	10	20	1000	24	
Huntspill								
Airlift	**17**	13.6	3	9.1	27.3	3300	33.3	
Dredge	15	13.6	4	10.2	40.8	7500	48.8	
Long-handled pondnet	12	13.6	N/A	4.4	N/A	N/A	N/A	
Severn								
Airlift	**28**	22.4	2	8.1	16.2	4500	20.2	
Dredge	26	22.4	3	9.5	28.5	5500	34.5	
Long-handled pondnet	**28**	22.4	3	6.5	19.5	6500	25.5	

4.4 Assessing inter-operator differences in sampling

If the biological information obtained for a site is highly dependent on who took the sample, then it is more difficult to assess spatial and temporal changes when different personnel have been used. It is, therefore, important to assess the sampling variability between operators.

In this study, we assessed differences between operators in their values for the biological indices Ntaxa, ASPT, BMWP Score and total number of individuals per sample. At the Yorkshire Derwent site, three operators each took six replicate airlift samples and at the South Drove Drain site, three operators each took six replicate dredge samples. Tests for statistically significant differences between operators were performed using both parametric one-way analysis of variance (ANOVA), giving test probability values denoted by p and Kruskal-Wallis ANOVA by ranks, giving test probability values denoted by p_K; the latter test does not assume normality for the distribution of within-operator variability. In addition, we used the standard ANOVA "method of moments equating observed to expected means squares" (Snedecor and Cochran, 1968) to estimate the variance (Var_B) between operators, the variance (Var_W) of replicate samples within operators and hence the percentage ($\%Var_B = 100\ Var_B /(Var_B + Var_W)$) of the total variance in values which is due to inter-operator differences (Tables 4.5 and 4.6).

Table 4.5 Test probabilities for differences in biological index values between operators derived from airlift samples from the Yorkshire Derwent. (see text for further details)

	p	p_K	Var_B	Var_W	$\%Var_B$
NTaxa	0.069	0.079	2.7	7.2	27%
ASPT	0.822	0.898	0.0	0.069	0%
BMWP Score	0.113	0.263	77	304	20%
(log) Individuals	0.889	0.949	0.0	0.054	0%

Table 4.6 Test probabilities for differences in biological index values between operators derived from dredge samples from the South Drove Drain. (see text for further details)

	p	p_K	Var_B	Var_W	$\%Var_B$
NTaxa	0.627	0.699	0.0	10.5	0%
ASPT	0.699	0.472	0.0	0.075	0%
BMWP Score	0.618	0.637	0.0	313	0%
(log) Individuals	0.059	0.077	0.019	0.046	29%

Inter-operator differences were not statistically significant (ie all test $p > 0.05$) for any index, for either the airlift or dredge sampling method. This could be partly due to the small number of replicates and operators involved and hence the lower power of the test to identify differences. However, the estimates of the practical importance of inter-operator effects on total variance in index values, as measured by $\%Var_B$, which is not biased by replicate or operator number, suggest that there is little or no inter-operator effect on ASPT values. For the airlift sampling method, difference between operators may account for 20-30% of total replicate variation in both Ntaxa and BMWP score (which are, as usual, highly correlated with $r = 0.95$, $n = 18$). For the dredge sampling method, difference between operators may account for 20-30% of total replicate variation in total number of individuals recovered. A more intensive replicated sampling study across a range of sites is needed to improve assessments of inter-operator effects.

This comparison of field sample operators excludes any potential bias introduced at the laboratory sample sorting/identification stage. Previous tests have indicated that sample sorting/identification errors are relatively small, when experienced personnel are used.

5. MARGIN PONDNET SAMPLES

Habitats at the watercourse margin were sampled separately from the deep-water zone in order to compare the distribution of BMWP taxa between the margins (both banks) and the community in deep-water habitats. This also provided scope to assess the contributions to site quality status from deep-water and margin habitats and the effects of their contrasting representation at each site on Ntaxa and ASPT. The margin samples targeted the habitats accessible when using a standard FBA pondnet (2m handle). The samples were not equivalent to the standard RIVPACS 3-minute sample which incorporates an extra one minute of manual searches for fauna strongly attached to objects and fauna on the water surface film.

A series of six one-minute pondnet margin samples were taken at each of the sites. The Ntaxa, BMWP Scores and ASPTs were examined as: (1) separate 1-minute replicates, (2) three 1-minute replicates from each bank, (3) two composite 3-minute samples, one from each bank. In addition, the margin pondnet taxon composition was compared: (4) between sites, opposite banks of the same watercourse and with the contemporary deep-water sample replicates. Non-BMWP taxa, which appeared in some samples, were excluded from interpretations.

5.1 Comparison of 1-minute margin pondnet with deep-water sample replicates

The 1-minute pondnet sample replicates from the margin generally yielded more higher Ntaxa and BMWP Scores than the deep-water methods at South Drove, New Bedford River and the Huntspill (Table 4.2 and Figure 4.5c-e). On the Severn, margin sample BMWP Scores were most variable and generally lower than those from the deep-water samples (Figure 4.5f), whereas margin samples yielded intermediate results from the Yorkshire Ouse and Derwent (Figure 4.5a and b). The ASPTs for margin samples showed similar trends to the BMWP Scores. Two of the six sites yielded higher mean ASPTs from margin pondnet samples than the concurrent deep-water sampling methods (Table 4.2 and Figure 4.3c and d).

5.2 Comparison of pondnet sample replicates from each bank

At four sites (Yorkshire Ouse and Derwent, South Drove and New Bedford) margin pondnet sample results were similar from opposite banks of the watercourse. One bank yielded considerably higher BMWP Scores than the other bank on the Huntspill (replicates 1-3). left bank, looking downstream). and the Severn (replicates 4-6). right bank, looking downstream (Table 4.2, page 18). The reasons for this are examined more fully in Section 6. The clear differences in results between opposite banks of the Huntspill and Severn were not evident in the ASPT values for the 6 replicates (Table 4.2, page 18).

5.3 Comparison of combined scores for margin pondnet samples, from each bank

The margin pondnet results were compared in three ways: (a) as mean BMWP Scores and ASPTs from the three 1-minute replicate samples (each bank), (b) composite scores for the three 1-minutes of sampling on each bank, (c) composite scores for both banks (six 1-minute samples). The mean scores of three replicates were always considerably lower than the composite BMWP score for the same samples (Figure 5.1) and also in most cases for the ASPTs (Figure 5.2).

Figure 5.1 Mean BMWP Scores derived from three margin pondnet replicate samples from each bank, together with the composite BMWP Score for the same three replicates and all six replicates.

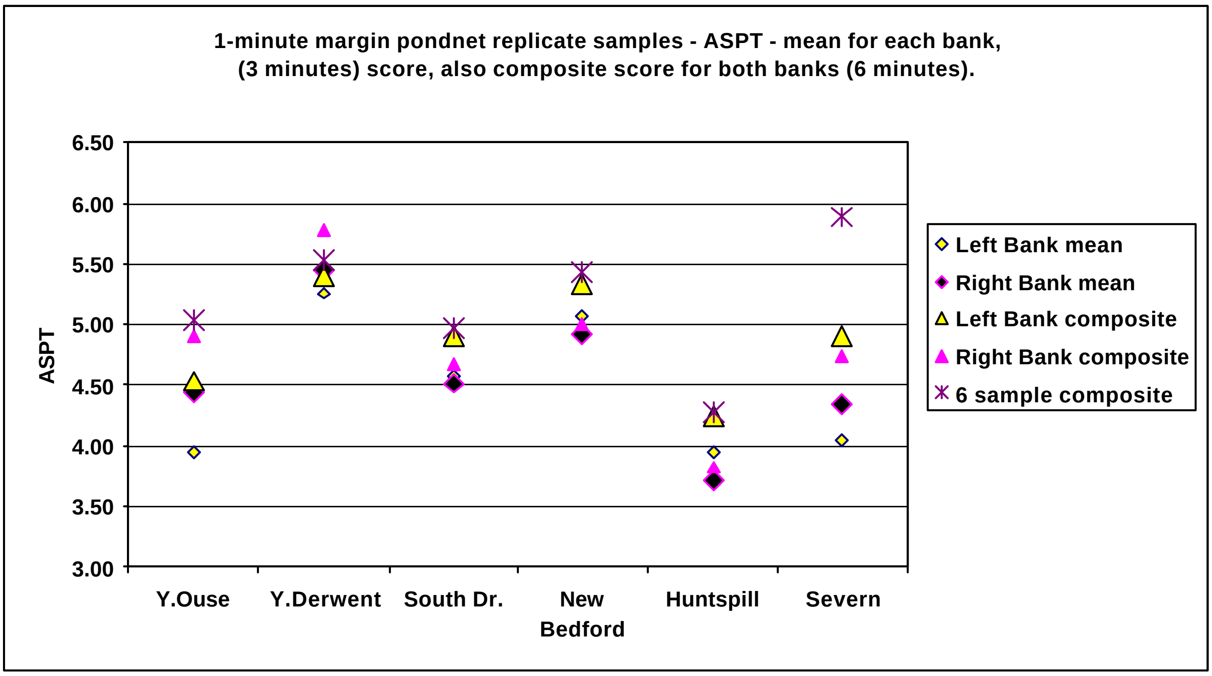


Figure 5.2 Mean Average Score Per Taxon derived from three margin pondnet replicate samples from each bank, together with the composite ASPT for the same three replicates and all six replicates (each site)

This indicates that 1-minute margin samples were too short to provide an adequate description of the macroinvertebrate community. In the case of the ASPT, combining replicates also increased ASPT values but had less influence in this respect. The margin samples from the Severn showed the greatest variability in ASPT values.

The degree of variability in taxon representation between 1-minute margin replicate samples was similar to, or greater than the deepwater samples at corresponding sites (Standard Deviations, Table 4.2).

The composite margin samples were generated by combining the number of different taxa recorded (Ntaxa) in the three 1-minute replicate samples from each bank. They represented a sampling effort similar (but not equivalent) to the standard 3 minute RIVPACS sample (ie they excluded the 1-minute manual search). Where large differences in Ntaxa, BMWP Scores and ASPT occur between replicates, they reflect either the spatial distribution of taxon richness, variation in sampling efficiency, or a combination of both factors. Comparisons of the scores derived from means and composite scores confirm the relative inadequacy of margin pondnet sampling for one minute in contrast to sampling for three minutes. Nevertheless, 1-minute margin replicates still yielded higher scores than most deep-water replicates at the South Drove, New Bedford and Huntspill sites (Figure 4.5).

Where between-bank differences in margin replicate scores are notable (Yorkshire Ouse, Huntspill and Severn), the records of the watercourse margin habitats show a clear relationship between faunal richness and available habitat at the former two sites. The replicates with least taxa came from areas where aquatic vegetation was most poorly represented, in terms of estimated percentage cover (%EP) of emergent plants. (Table 5.1, correlation between Ntaxa and %EP: Yorkshire Ouse $r = 0.79$, Huntspill $r = 0.71$). The river margin habitats sampled on the Severn lacked any aquatic vegetation and the banks shelved steeply into deep water. Here there was no obvious reason for contrasting faunal richness between the two banks.

Table 5.1 Comparison of percentage cover of aquatic vegetation at margin pondnet sample locations with faunal richness (BMWP taxa recorded). Where present, coinciding low plant cover and faunal richness is highlighted

Sample replicate number	**1**	**2**	**3**	**4**	**5**	**6**
Yorkshire Ouse						
% emergent plant cover	20	15	30	50	75	40
% submerged plant cover	0	0	0	0	0	0
Number of taxa	12	9	12	13	15	15
BMWP Scores	54	33	44	55	71	65
Yorkshire Derwent						
% emergent plant cover	5	10	10	35	30	25
% submerged plant cover	10	5	0	2	5	1
Number of taxa	19	26	17	22	23	22
BMWP Scores	103	139	85	111	135	120
South Drove Drain						
% emergent plant cover	2	2	7	50	10	50
% submerged plant cover	98	98	93	50	88	50
Number of taxa	28	23	23	21	29	21
BMWP Scores	141	100	100	95	131	95
New Bedford River						
% emergent plant cover	50	50	50	50	50	50
% submerged plant cover	0	10	0	5	0	0
Number of taxa	25	28	21	24	26	28
BMWP Scores	134	145	98	119	128	137
Huntspill						
% emergent plant cover	95	75	95	60	50	90
% submerged plant cover	0	5	0	40	5	5
Number of taxa	15	15	17	8	12	13
BMWP Scores	58	59	69	27	47	50
Severn						
% emergent plant cover	0	0	0	0	0	0
% submerged plant cover	0	0	0	0	0	0
Number of taxa	9	8	6	16	10	15
BMWP Scores	42	33	20	69	39	72

5.4 Patterns in taxon composition: sites, sampling methods and opposite banks

5.4.1 Sites

Lists of taxa occurring in all samples were scanned from each site, in an attempt to detect any systematic bias in taxon recovery between sampling methods. Clearly, where taxa were represented by single specimens and the taxon richness was comparatively low, less importance should be attached to presence/absence of particular taxa and the precise values of biotic indices. The deep-water sampling methods generally excluded taxa strongly associated with emergent vegetation and other habitats confined to the watercourse margin. Contrasts in faunal composition were normally strongest between margin samples and the deep-water samples, but there was one notable exception to this trend. At sites where the dredge passed through vegetation during its retrieval, some additional elements of the margin fauna were incorporated into the sample. Such additions boosted the BMWP Scores from the dredge samples in South Drove (Figure 4.5c) and attenuated the corresponding taxon accretion rate for the dredge (Figures 4.8 and 4.10c).

5.4.2 Sampling Methods

The contrast in faunal composition between sampling methods was explored more fully. The frequency of occurrence of 'margin' taxa in the deep-water samples was examined, also the presence of 'benthic' taxa in the margin pondnet samples. Lists (Table 5.2) were compiled of candidate 'margin' and 'benthos' taxa covering all taxonomic groups with a known strong association with habitats confined to the watercourse margin or, conversely, open water habitats. Some sites had mid-channel vegetation present and consequently yielded 'margin' taxa from deep-water samples. This was particularly noticeable at South Drove Drain where, in addition, surface-skimming insects (Mesovelidae and Gerridae) were obtained in dredge samples as they were lifted in the margin zone.

The occurrence pattern of 'margin' taxa (Table 5.3) highlights the differences/similarities between sites with respect to the contribution of 'margin' taxa to the macroinvertebrate communities found in deep-water. It should be noted that considerably greater sampling effort was expended in sampling and sorting the deep-water benthos (Figure 4.1) compared to the fauna in the watercourse margin (six 1-minute sample replicates, each requiring 2 hours sort time). Table 5.4 shows the taxa recovered solely from deep-water samples at each site and the number of replicates in which the taxon was present. Few of these taxa were recovered exclusively from deep-water at more than one site, the Yorkshire Ouse and Severn yielding the highest numbers. Unionidae (3 sites), Leptoceridae (2 sites) and Hydropsychidae (2 sites) were the only BMWP taxa restricted to the deep-water samples at more than one site.

Table 5.2 Lists of candidate 'margin' and 'benthos' taxa, covering all groups with a known strong association with habitats confined to the watercourse margin or, conversely, open water habitats at deep-water sites

'Margin' taxa	'Benthos' taxa
Corixidae	Unionidae
Hydrometridae	Corophidae
Mesovelidae	Ephemeridae
Notonectidae	Aphelocheiridae
Gerridae	
Nepidae	
Hydrophilidae	
Calopterygidae	
Coenagriidae	
Baetidae	

Table 5.3 Occurrence of 'margin' taxa in the deep-water benthos samples.
(**n** - number of sample replicates, out of 18, in which the taxon was present)

Site	Margin taxa	n
Yorkshire Ouse	Coenagriidae	1
Yorkshire Derwent	No additions	
South Drove Drain	Hydrometridae	2
	Notonectidae	5
New Bedford River	Notonectidae	4
	Gerridae	1
	Calopterygidae	2
Huntspill	Hydrometridae	3
	Mesovelidae	1
	Gerridae	4
	Nepidae	2
	Hydrophilidae	2
Severn	No additions	

As anticipated, for all sites a combination of BMWP taxa recovered from deep-water and watercourse margin yielded higher Ntaxa than samples from just one zone. The combined totals of Ntaxa from margin pondnet samples and each deep-water sampling method (Table 5.5) revealed that variable method combinations provided the highest Ntaxa at sites. The combined airlift and margin pondnet samples yielded the highest Ntaxa at three of the six sites and at the remaining three sites their totals were within one or two taxa of the site maximum obtained from combining dredge plus margin pondnet, or long-handled pondnet plus margin pondnet. Perhaps surprisingly the relative contribution from margin pondnet samples did not consistently mirror the level of habitat complexity at sites. The River Severn margin pondnet samples contributed seven additional taxa (to the airlift total) or eight additional taxa (to the long-handled pondnet total), in spite of the complete lack of aquatic plants in the River Severn margins. In contrast, although South Drove Drain had extensive stands of aquatic plants both in the deep-water and margin zones, the margin pondnet samples still boosted the Ntaxa by around 25%, when combined with Ntaxa yields from each deep-water sampler (Table 5.5).

Table 5.4 Occurrence of taxa confined to deep-water samples
(**n** - number of sample replicates, out of 18, in which the taxon was present)

Site	**Deep-water**	**n**
Yorkshire Ouse	Dendrocoelidae	5
	Planaridae	9
	Leptoceridae	3
	Simuliidae	1
Yorkshire Derwent	Hydropsychidae	7
	Unionidae	3
South Drove Drain	Unionidae	2
New Bedford River	No additions	
Huntspill	Unionidae	17
	Leptoceridae	3
Severn	Corophidae	13
	Heptageniidae	5
	Ephemeridae	3
	Aphelocheiridae	2
	Elminthidae	10
	Hydropsychidae	10
	Brachycentridae	6

Table 5.5 Comparison of the numbers of scoring taxa (Ntaxa) recorded from deep-water samples, margin pondnet samples and combined methods at each site. The combined methods yielding the highest Ntaxa are highlighted

Sampling method: (BMWP Ntaxa)	**Site**					
	Ouse	**Derwent**	**South Drove**	**New Bedford**	**Huntspill**	**Severn**
Margin pondnet	24	34	37	36	23	25
Airlift 1	25	31	29	27	17	28
Dredge 1	19	33	30	29	15	25
Long-handled pondnet	11	26	23	28	12	28
Combined airlift and margin pondnet	31	38	40	36	28	35
Combined dredge and margin pondnet	27	39	39	37	24	29
Combined long-handled pondnet and margin pondnet	27	37	39	38	26	36

5.4.3 Opposite banks

Margin pondnet samples were taken from both banks of the watercourse at each site, in order to compare possible variations in the taxa present. The Ntaxa, BMWP Scores and ASPTs provided an initial comparison between opposite banks. They indicated there were differences between the left and right bank on the Severn, Yorkshire Ouse and Huntspill. (Table 5.6). When taxon composition was investigated it was clear that 'margin' taxa were not strongly represented at the former two sites, but provided a large proportion of the community on the Huntspill. Despite the strong representation by 'margin' taxa in deep-water samples from the Huntspill (Table 5.3), the gross differences between the margin pondnet replicates from each bank (ie skewed presence of taxa between each bank, Table 5.7) were actually strongly influenced by the uneven distribution of 'benthic' taxa at this site. Variable patterns of taxon distribution (margin versus deep-water and left bank versus right bank) were evident at the other five sites and indicate more information is required to characterise and interpret the distribution of taxa present at deep-water sites. The development of new monitoring protocols for deep-water sites will therefore benefit from additional equivalent data from a larger number of sites.

Table 5.6 The numbers of scoring taxa and derived Scores recorded from margin pondnet samples at each bank and at each site. * denotes sites for which all three values for one bank were less than all three values for the other bank

Margin sample no.	1	2	3	4	5	6	mean 1-3	mean 4-6	mean 1-6	Strong bias to one bank
Yorkshire Ouse										
Margins	R	R	R	L	L	L				
Number of taxa	12	9	12	13	15	15	11.0	14.3	12.7	*
ASPT	4.50	3.67	3.67	4.23	4.73	4.33	3.9	4.4	4.2	
BMWP	54	33	44	55	71	65	43.7	63.7	53.7	*
Yorkshire Derwent										
Margins	L	L	L	R	R	R				
Number of taxa	19	26	17	22	23	22	20.7	22.3	21.5	
ASPT	5.42	5.35	5.00	5.05	5.87	5.45	5.3	5.5	5.4	
BMWP	103	139	85	111	135	120	109.0	122.0	115.5	
South Drove Drain										
Margins	L	L	L	R	R	R				
Number of taxa	28	23	23	21	29	21	24.7	23.7	24.2	
ASPT	5.04	4.35	4.35	4.52	4.52	4.52	4.6	4.5	4.5	
BMWP	141	100	100	95	131	95	113.7	107.0	110.3	
New Bedford River										
Margins	R	R	R	L	L	L				
Number of taxa	25	28	21	24	26	28	24.7	26.0	25.3	
ASPT	5.36	5.18	4.67	4.96	4.92	4.89	5.1	4.9	5.0	
BMWP	134	145	98	119	128	137	125.7	128.0	126.8	
Huntspill										
Margins	L	L	L	R	R	R				
Number of taxa	15	15	17	8	12	13	15.7	11.0	13.3	*
ASPT	3.87	3.93	4.06	3.38	3.92	3.85	4.0	3.7	3.8	
BMWP	58	59	69	27	47	50	62.0	41.3	51.7	*
Severn										
Margins	L	L	L	R	R	R				
Number of taxa	9	8	6	16	10	15	7.7	13.7	10.7	*
ASPT	4.67	4.13	3.33	4.31	3.90	4.80	4.0	4.3	4.2	
BMWP	42	33	20	69	39	72	31.7	60.0	45.8	*

Table 5.7 Huntspill BMWP Taxa - occurrence rate (range 0-3) in margin pondnet samples from each bank and in deepwater samples (range 0-18). Note: absence/low occurrence rates of certain 'margin' taxa from benthos samples (highlighted light grey) and contrasting occurrence rates of certain sediment dwellers in benthos samples (highlighted dark grey)

Taxa recorded on the Huntspill	**Margin samples**		**Deepwater**
Out of a possible:	3	3	18
	Left	**Right**	**(All)**
Valvatidae	2	0	18
Hydrobiidae (incl. Bithyniidae)	3	2	3
Physidae	3	2	8
Lymnaeidae	3	3	6
Planorbidae	1	2	0
Unionidae	0	0	17
Sphaeriidae	0	0	17
Oligochaeta	3	3	18
Piscicolidae	1	0	3
Glossiphoniidae	1	0	8
Asellidae	1	0	0
Gammaridae (incl. Crangonyctidae and Niphargidae)	2	0	2
Baetidae	3	3	7
Caenidae	0	0	1
Coenagriidae	2	3	5
Mesovelidae	0	1	0
Hydrometridae	2	1	0
Gerridae	3	1	0
Nepidae	1	1	0
Naucoridae	2	1	3
Notonectidae	3	2	2
Corixidae	3	2	6
Dytiscidae (incl. Noteridae)	3	2	1
Hydrophilidae (incl. Hydraenidae)	2	0	0
Tipulidae	1	0	0
Chironomidae	3	3	18

6. CONCLUSIONS

6.1 Background

A comparison of deep-water sampling devices for macroinvertebrates was undertaken at six sites throughout England in July/August 1999. The performances of three devices were compared (Yorkshire airlift, Medium Naturalist's dredge and long-handled pondnet). Six replicate samples were taken with each device at each site. Each sample was collected from a separate target area covering an estimated 1.5 m^2 of riverbed. The comparison was confined to deep-water habitats.

At the same six deep-water sites a series of six 1-minute samples was taken at the watercourse margin, using the standard FBA pondnet. The range of macroinvertebrates present in the margin samples was compared with those from the deep-water samples at each site.

6.2 Deep-water sampling method performance

6.2.1 Sample Processing Time

The time required to recover macroinvertebrates from the deep-water samples was strongly influenced by sample debris volume and this reflected site conditions, the sampled area (consistent) and the characteristics of each sampling method. The sample processing time was also extended by the need to gauge sample device performance in terms of taxon abundance. In this exercise the counts were more precise than achieved by attributing the standard log-abundance categories used in RIVPACS.

Airlift - the mean sample sorting time required was very consistent ranging from around 7.5-9 hours per sample replicate across the six sites.

Dredge - mean sorting time ranged from around 2.5-10.5 hours between sites, reflecting large differences in debris volumes. Dredge sample sorting times were comparable with the airlift at five of the six sites.

Long-handled Pondnet - mean sorting time ranged from around 1-10 hours between sites, with three sites yielding relatively small samples that were each sorted in <3 hours.

6.2.2 Maximum taxon recovery

Taxon recovery was compared in terms of the mean number of taxa per sample replicate, with comparisons between all deep-water sampling methods, including some additional series at two sites to examine operator variability (a preliminary BAMS exercise).

	Mean Ntaxa		
	Airlift	**Dredge**	**LHP**
Yorkshire Ouse	16.8	8.3	5.8
Yorkshire Derwent 1	21.2	16.5	14.5
Yorkshire Derwent 2	25.0		
Yorkshire Derwent 3	22.3		
South Drove 1	20.0	18.0	18.2
South Drove 2		19.8	
South Drove 3		18.8	
New Bedford	19.5	20.8	20.2
Huntspill	9.2	9.2	6.3
Severn	18.8	13.7	15.3

Airlift - yielded the highest mean number of taxa at four of the six sites, and the same number as the dredge at one site.

Dredge - yielded the highest mean number of taxa at one of the six sites, the second highest number at three sites and the same number as the airlift at one site.

Long-handled Pondnet - performed poorly at most sites, with the lowest mean number of taxa recovered at four sites and the second highest number at two sites.

6.2.3 Consistency and taxon accretion

Sites varied with respect to sampler performance. The Yorkshire Ouse and Severn showed the highest variability in taxon recovery between different sampling methods, whilst the South Drove Drain and New Bedford River showed little variability in total taxa recovered or in their derived BMWP scores.

Taxon accretion rates indicated the number of replicate samples required to recover BMWP taxa susceptible to a particular sampling method (as represented in a total of six replicate samples). The slopes of these trend lines varied between sampling methods and sites. In general, the airlift accretion curves flattened out after fewer replicates at higher Ntaxa and at noticeably more sites than the accretion curves for dredge samples. Some series of long-handled pondnet samples also reached a taxon accretion plateau, but in these cases the Ntaxa were considerably lower than recovered by other sampling devices at the same sites.

6.3 Choice of deep-water sampling method

In terms of BMWP taxon representation, the airlift sampler performed more effectively than the dredge at most sites (5 out of 6, equally well at one site) and required fewer sample replicates to yield 80% of the Ntaxa detected at each site. The dredge yielded very similar results to the airlift at three sites, but only when all six sample replicates were taken into account. The long-handled pondnet under-performed in terms of recovering available BMWP Scoring Taxa and should be discounted as a reliable sampling method for deep-water benthos.

Sample size and duration was standardised in the present study, as far as possible. All accretion curves indicate that a single deep-water benthic sample - taken from an area of 1.5 m^2 - is not sufficient to recover 80% of the Ntaxa recorded from each site.

The number of sample replicates needed to recover 80% of taxa detected at each site was combined with the equivalent sample processing time. This provided an empirical estimate of the time required to yield 80% of the recorded taxa at each site for each deep-water sampling method. On this basis, 2 replicate samples (2 x 1.5 m^2) with the airlift were required at three sites and three replicate samples at the other three sites. To achieve similar taxon recovery rates the dredge required 2, 3 (two sites), 4, 5 and 6 sample replicates at the corresponding sites. For each site the combined processing and identification time, together with the number of replicates, provided an estimate of total laboratory manpower time required to achieve a recovery of 80% of the recorded taxa:

Yorkshire Ouse - airlift (2 replicates)	20.4 hours
Y. Derwent (mean of 3 series of 6 samples) - airlift (3 replicates)	28.0 hours
South Drove - airlift (3 replicates)	30.9 hours
New Bedford - airlift (2 replicates)	21.2 hours
Huntspill - airlift (3 replicates)	33.3 hours
Severn - airlift (2 replicates)	20.2 hours

At one site (South Drove Drain) the Dredge performed more effectively than the Airlift:

South Drove - (mean of 3 series of 6 samples) - Dredge (3 replicates) - 27.4 hours

[Important Note: following the standard RIVPACS methodology for sample processing and calculating the log-abundance of each taxon will probably halve the time input for large samples. The airlift and dredge yielded comparatively large samples (2 litres) at most sites, where deposits of coarse detritus were evident.]

Additional considerations - not covered by this study - there are differing costs of manpower, equipment and safety aspects of the particular sampling devices that were tested. All devices require specific training in their use. The Environment Agency commissioned an assessment of the physiological aspects of using deep-water sampling devices (Rayson, 2000). Subsequently, the Agency decided to exclude the use of the Naturalists Dredge for routine monitoring work, on safety grounds (Brian Hemsley-Flint, pers comm). If, in future, the use of a smaller (lighter) dredge is envisaged, specific tests will be necessary to gauge its efficacy.

6.4 Comparisons of deep-water samples with contemporary margin pondnet samples

The one-minute pondnet sample replicates from the margin generally yielded higher BMWP Scores than the deep-water methods at South Drove, New Bedford River and the Huntspill. Margin sample

BMWP Scores were most variable and generally lower in comparison with deep-water sampling methods on the Severn, but they yielded intermediate results from the Yorkshire Ouse and Derwent. The series of margin samples yielded higher mean ASPTs than any of the deep-water methods at two of the six sites.

The sampling duration necessary to include most of the taxa present in the watercourse margin was unclear because of the high degree of variability between 1-minute margin replicate samples, particularly those from the Yorkshire Ouse, Huntspill and Severn.

6.4.1 Patterns in taxon composition

As would be anticipated, the deep-water sampling methods generally excluded taxa strongly associated with emergent vegetation and similar habitats confined to the watercourse margin, though this did not apply at all sites. The contrasts in faunal composition were clearly strongest between margin samples and the deep-water samples, rather than between deep-water methods. There was a notable exception to this trend. At sites where the dredge passed through marginal vegetation at the end of its retrieval, some additional margin fauna were incorporated in the sample. Few taxa were recovered exclusively from deep-water benthic samples at more than one of the six sites, the Yorkshire Ouse and Severn yielding the highest numbers. Unionidae (3 sites), Leptoceridae (2 sites) and Hydropsychidae (2 sites) were the only BMWP taxa restricted to deep-water samples at more than one site.

Margin pondnet samples were taken from both banks of the watercourse at each site. They indicated that there were faunal differences between the left and right bank at three of the six sites (Severn, Yorkshire Ouse and Huntspill).

7. RECOMMENDATIONS

7.1 Choice of deep-water sampling method

- **The airlift sampler is recommended for the routine monitoring of benthic macroinvertebrates at sites with extensive deep-water habitats**

During tests the airlift performed more effectively than the dredge at most sites (four out of six, equally well at one site) and required fewer sample replicates to yield 80% of the BMWP Scoring Taxa (Ntaxa) detected at each site.

The dredge yielded very similar results to the airlift at three of the six sites, but only when results from all six sample replicates at each site (rather than 2 or 3) were combined.

The long-handled pondnet under-performed in terms of recovering the available BMWP Scoring Taxa (Ntaxa) and should be discounted as a reliable sampling method for deep-water benthos.

- **To permit the effective assessment of river quality at deep-water sites, sampling activity should target deep-water habitats but also watercourse margin habitats separately, to both reflect the different range of macroinvertebrates present and aid data interpretation**

The deep-water sampling methods tested generally excluded taxa strongly associated with emergent vegetation and similar habitats confined to the watercourse margin. Contrasts in faunal composition were clearly stronger between margin samples and the deep-water samples than between the different deep-water sampling methods. The series of 1-minute margin pondnet samples yielded higher mean ASPTs than the deep-water series at two of the six sites and show the potential for information loss at some sites if monitoring is confined to the deep-water zone.

7.2 Sample size

- **On the basis of results from the present study (at six sites), the total area sampled in deep-water habitats by the airlift should not be less than 4.5 m^2 (equivalent to three of the airlift replicate samples taken in this study)**

Sample size/duration was standardised in the present study, as far as possible. Taxon Accretion curves for all sampling methods, at all sites, indicate that one deep-water benthic sample taken from an area of 1.5m^2 is insufficient to recover 80% of the Ntaxa present at deep-water sites (as recorded in six replicate samples).

For monitoring purposes there is the need to select a sufficiently large sampling area to recover a consistently high proportion of (representative) macroinvertebrate taxa occurring at any given site, whilst minimising the time required to deal with samples in the laboratory. Therefore, on the basis of results from the present study, the area sampled by the airlift should be equivalent to three 1.5 m^2 sample replicates in order to have a standard procedure at each site. This was shown to yield a sample volume (including preservative and debris) in the region of one to two litres. In the laboratory, this equated to sample processing, macroinvertebrate identification and data recording occupying approximately 3 man-days for each deep-water sample**. [Note: the sampling device comparison included more precise abundance estimates than used in the standard RIVPACS methodology, when the time input for large samples will be considerably less than this].**

7.3 Extent of sampling activity in deep-water habitats

- **Sampling activity at deep-water sites should take account of the spatial patchiness of habitats and associated fauna, as is recommended in the present RIVPACS sampling protocol (BT001, 1999)**

In deep watercourses the distribution and proportions of contrasting habitats for macroinvertebrates is frequently difficult or impossible to assess. To minimise the potential for bias in sampling small, discrete, areas the following approach is proposed:

The area from which the three Airlift samples are collected should consist of a diagonal traverse or traverses across the deepwater zone of the watercourse, in order to incorporate the potential spatial variation in macroinvertebrate communities. In the laboratory, our current recommendation is that for future monitoring the three replicate samples should be combined such that a single listing of taxa and family log abundances is generated for each site.

7.4 Extent of sampling activity in margin habitats

- **For margin samples, a 3-minute margin pondnet sample should be taken from accessible bank-side habitats, with the collecting time and effort split in proportion to those habitats**

Margin pondnet samples should include a total of three minutes sampling effort and include material from the range of accessible bankside habitats, sampled in proportion to their representation at the site. In addition, the 1-minute manual search of surface habitats for additional taxa should also be performed, with the catch incorporated within the 3-minute sample. The margin samples should be used to generate a listing of taxa and family log abundance, comparable to the shallow water module of RIVPACS.

7.5 Sampling logistics

- **By adopting these recommendations, future sampling at deep-water sites will incorporate the flexibility to: (1) assess deep-water and margin habitats separately, thereby retaining an ability to detect and monitor different forms of stress; (2) restrict sampling to the deep-water or margin habitats, where the use of one of these options is considered adequate on a given sampling occasion; (3) combine the results from these habitats if this is appropriate.**

Information from three deep-water replicate samples, as taken for the assessment of sample variability within the present study, will assist with the refinement of the deep-water sampling protocol during development of the deep-water RIVPACS module (see Section 7.6). It is acknowledged that for routine monitoring a single sample from deep-water and a single sample from

the margin is preferable for practical and logistical reasons. This would also be in line with the procedure used for the current shallow water module of RIVPACS.
A further consideration, not covered by this study, is the cost of additional manpower required for the fieldwork involved in deep-water sampling. The recommended airlift sampler requires specific training in its use and the development of appropriate protocols stipulating the procedures to be followed, under the range of conditions that will be encountered. Current practice in one Agency Region is to deploy the airlift from a bridge at some monitoring sites. This approach would need to be justified, in the light of recommendations in BT001 (for standard RIVPACS sampling).

In general, it would appear that margin samples are only required from a single bank. However, the option of taking samples on each bank is always available if regarded as necessary by local Agency biologists.

7.6 Recommendations on the future development of RIVPACS modules for macroinvertebrate monitoring at deep-water sites

- **Development of new RIVPACS modules (deep-water and margin) for deep-water sites will require the selection of c.40-50 good quality reference sites. The selection process for reference sites needs to take account of major site variables (eg flow/absence of flow; presence/absence of submerged plants) in the context of regional representativeness**

Results from the widely differing watercourses sampled during the present investigation confirm, unsurprisingly, that there is not a single discrete deep-water macroinvertebrate community. Where sites included extensive submerged plant growth in deep water, then a range of additional taxa can be present. Also, the presence/absence of water flow dictates which taxa can persist at a site.

Selection of suitable deep-water reference sites is necessary for the further development of RIVPACS. The range of contrasting deep-water sites included in the current study indicate that a suite of approximately 40-50 good quality deep-water sites would incorporate scope for defining the pattern of macroinvertebrate community structure at deep-water sites in England and Wales.

The development of separate RIVPACS modules (deep-water and margin) is necessary for all deep-water sites where the available habitats cannot be sampled effectively with one device.

The benthic and marginal areas at deep-water sites represent strongly contrasting habitats, with their own distinct macroinvertebrate assemblages. Although there is often considerable overlap in taxonomic composition, the abundances at family-level are frequently very different. Whereas deep-water samples may reflect water and sediment quality, the margin samples may be influenced more strongly by the range of available habitats and the way in which they have been managed or influenced by man (eg by boat traffic). Therefore, there is merit in developing separate RIVPACS modules for the margin and deep-water samples. A further advantage of this approach is that whereas both modules may be used in a GQA survey year to provide maximum information, a short-cut appraisal using either the margin or deep-water module may be acceptable at other times.

8. REFERENCES

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Appendix 1

Sample site and sample characteristics

Yorkshire Ouse NGR SE 590453

Environment Agency site data summary - recent biological data supplied - Yes

Channel width (at water surface) - 80m: estimated depth - 2.0m: predominate substrates - sand and silt: water flow - 0.1-0.25m per sec.

Deep-water sampling 6th July 1999

Operators, Derwent/Ouse: airlift - Jon Brickland, dredge - Rick Gunn, standard pondnet/long-handled pondnet - John Davy-Bowker

mid-channel depth (m)	sample type	replicate Number:	fraction retained:	No. sample pots used:	specimens discarded:	photo	%em	vegetation cover % subm	%plant-free	R/L bank
	Margin	1	all				20	0	80	R
	Margin	2	all				15	0	85	R
	Margin	3	all				30	0	70	R
	Margin	4	0.5				50	0	50	L
	Margin	5	all				75	0	25	L
	Margin	6	0.5				40	0	60	L
	Dredge	1	all							
	Dredge	2	all							
	Dredge	3	all							
	Dredge	4	all							
	Dredge	5	all							
	Dredge	6	all							
	Air-lift	1	0.5							
	Air-lift	2	all							
	Air-lift	3	all							
	Air-lift	4	all							
	Air-lift	5	all							
	Air-lift	6	all							
2.9	Long-h p-net	1	all							
3.3	Long-h p-net	2	all							
3.5	Long-h p-net	3	all							
3.5	Long-h p-net	4	all							
3.35	Long-h p-net	5	all							
3.2	Long-h p-net	6	all							

Yorkshire Derwent NGR SE 710555

Environment Agency site data summary - recent biological data supplied - Yes

Channel width (at water surface) - 22m: estimated depth - 1.5m: dominate substrates - pebbles/gravel: water flow - 0.10-0.25m per sec.

Deep-water sampling 7th July 1999

Operators, Derwent/Ouse: dredge - Rick Gunn, standard pondnet/long-handled pondnet - John Davy-Bowker

with BAMS - (airlift) A - V Hirst, B - Jon Brickland, C - M Christmas

mid-channel depth (m)	sample type	replicate Number:	fraction retained:	No. sample pots used:	specimens discarded:	photo	%em	vegetation cover % subm	%plant-free	R/L bank
	Margin	1	all	2		19	5	10	85	L
	Margin	2	all	2		20,21	10	5	85	L
	Margin	3	all	2		22,23	10	0	90	L
	Margin	4	all	2		26,27	35	2	63	R
	Margin	5	all	2		28,29	30	5	65	R
	Margin	6	all	2		30,31	25	1	74	R
	Dredge	1	all							
	Dredge	2	all							
	Dredge	3	all							
	Dredge	4	all							
	Dredge	5	all	<2.25l collected						
	Dredge	6	all							
	Air-lift	1	0.5	2						
	Air-lift	2	all	2						
	Air-lift	3	all	2						
	Air-lift	4	all	2						
	Air-lift	5	all	2						
	Air-lift	6	all	2						

2.25	Long-h p-net	1	all	1						
2.3	Long-h p-net	2	all	1						
2.1	Long-h p-net	3	all	1						
2.35	Long-h p-net	4	all	1						
2.25	Long-h p-net	5	all	1						
2.2	Long-h p-net	6	all	1						

South Drove Drain NGR TF
219212
Environment Agency site data summary - recent biological data supplied - Yes
Channel width (at water surface) - 14m: estimated depth - 2m: predominate substrates - boulders and silt: water flow - static
Deep-water sampling 20th July
1999
Operators, South Drove Drain: airlift - Viki Hirst, dredge - Rick Gunn, standard pondnet/long-handled pondnet - John Davy-Bowker
with BAMS - (dredge) A - R Gunn, B - J D-B, C - R Chadd

mid-channel	sample	replicate	fraction	No. sample	specimens			vegetation cover		R/L
depth (m)	type	Number:	retained:	pots used:	discarded:	photo	%em	% subm	%plant-free	bank
	Margin	1	all	2			2	98	0	L
	Margin	2	all	2			2	98	0	L
	Margin	3	all	2			7	93	0	L
	Margin	4	all	2			50	50	0	R
	Margin	5	all	2			10	88	2	R
	Margin	6	all	2			50	50	0	R
	Dredge	1	all							
	Dredge	2	all							
	Dredge	3	all							
	Dredge	4	all							
	Dredge	5	all							
	Dredge	6	all							
	Air-lift	1	(*)	2	1 Anodonta					
	Air-lift	2	(*)	2						
	Air-lift	3	(*)	2						

	Air-lift	4	[ ]	2	1 Anodonta					
	Air-lift	5	all	2						
	Air-lift	6	(*)	2	1 Anodonta					
1.9	Long-h p-net	1	all	1						
1.8	Long-h p-net	2	all	1						
1.9	Long-h p-net	3	all	1						
2.1	Long-h p-net	4	all	1						
1.9	Long-h p-net	5	all	1						
1.9	Long-h p-net	6	all	1						

(*) - 50% of weed retained after washing, [ ] - 25% of weed retained after washing

New Bedford NGR TL 394747

Environment Agency site data summary - recent biological data supplied - Yes

Channel width (at water surface) - 25m: estimated depth - 2-3m: predominate substrates silt/hard clay: flow - reverses with the tide

Deep-water sampling 21th July 1999

Operators, New Bedford: airlift - Viki Hirst, dredge - Rick Gunn, standard pondnet/long-handled pondnet - John Davy-Bowker

mid-channel depth (m)	sample type	replicate Number:	fraction retained:	No. sample pots used:	specimens discarded:	photo	%em	vegetation cover % subm	%plant-free	R/L bank
	Margin	1	all			19	50	0	50	R
	Margin	2	all			20	50	10	40	R
	Margin	3	all			21	50	0	50	R
	Margin	4	all			28	50	5	45	L
	Margin	5	all			30	50	0	50	L
	Margin	6	all			31	50	0	50	L
	Dredge	1	all			1				
	Dredge	2	0.25							
	Dredge	3	0.25							
	Dredge	4	0.5							
	Dredge	5	0.25							
	Dredge	6	0.25							
	Air-lift	1	all							
	Air-lift	2	all							

	Air-lift	3	all							
	Air-lift	4	all							
	Air-lift	5	all							
	Air-lift	6	all							
1.2	Long-h p-net	1	all							
1.2	Long-h p-net	2	all							
1	Long-h p-net	3	all							
1	Long-h p-net	4	all							
1	Long-h p-net	5	all							
1	Long-h p-net	6	all							

West Huntspill NGR ST 303450

Environment Agency site data summary - recent biological data supplied - No

Channel width (at water surface) - 25m: estimated depth - 1.5-2m: predominate substrates - silt and peat: flow rate - static

Deep-water sampling 17th August 1999

Operators, Hunspill/Severn: airlift - Jon Brickland, dredge - Rick Gunn, standard pondnet/long-handled pondnet - John Davy-Bowker.

mid-channel	sample	replicate	fraction	No. sample	specimens			vegetation cover		R/L
depth (m)	type	Number:	retained:	pots used:	discarded:	photo	%em	% subm	%plant-free	bank
	Margin	1	all	1		1	95		5	L
	Margin	2	all	1		1	75	5	20	L
	Margin	3	all	1		1	95	0	5	L
	Margin	4	all	1		1	60	40	0	R
	Margin	5	all	1		1	50	5	45	R
	Margin	6	all	1		1	90	5	5	R
	Dredge	1	0.25	2	6 Anodonta					
	Dredge	2	0.25	2	10 Anodonta					
	Dredge	3	0.25	2						
	Dredge	4	0.25	2						
	Dredge	5	0.25	2						
	Dredge	6	0.25	2						
	Air-lift	1	all	2						
	Air-lift	2	all	2						
	Air-lift	3	all	2						
	Air-lift	4	all	2						
	Air-lift	5	all	2						
	Air-lift	6	all	2	5 Anodonta					
1.9	Long-h p-net	1	all	1						
1.8	Long-h p-net	2	all	1						
1.8	Long-h p-net	3	all	1						
1.8	Long-h p-net	4	all	1						
1.7	Long-h p-net	5	all	1						
1.8	Long-h p-net	6	all	1						

Upton-upon-Severn NGR SO 848410

Environment Agency site data summary - recent biological data supplied - Yes

Channel width (at water surface) - 30m: estimated depth - >1m: predominate substrates - silt/clay: flow rate - 0.1-0.25m per sec.

Deep-water sampling 18th August 1999

Operators, Hunspill/Severn: Airlift - Jon Brickland, Dredge - Rick Gunn, standard pondnet/long-handled pondnet - John Davy-Bowker

mid-channel depth (m)	sample type	replicate Number:	fraction retained:	No. sample pots used:	specimens discarded:	photo	%em	vegetation cover % subm	%plant-free	R/L bank
	Margin	1	all	1		9			100	L
	Margin	2	all	1		10			100	L
	Margin	3	all	1		11			100	L
	Margin	4	all	1		13			100	R
	Margin	5	all	1		14,15			100	R
	Margin	6	all	1		16			100	R
	Dredge	1	all	1						
	Dredge	2	0.125	2						
	Dredge	3	0.25	2						
	Dredge	4	0.125	2						
	Dredge	5	0.25	2						
	Dredge	6	0.25	1						
	Air-lift	1	all	1						
	Air-lift	2	all	1						
	Air-lift	3	all	2						
	Air-lift	4	all	2						
	Air-lift	5	all	2						
	Air-lift	6	all	2						
3.2	Long-h p-net	1	all	1						
3	Long-h p-net	2	all	1						
2.3	Long-h p-net	3	all	1						
2	Long-h p-net	4	all	1						
1.7	Long-h p-net	5	all	1						

2.2	Long-h p-net	6	all	1						

Appendix 2

The BMWP taxa present at each site and recovered by each sampling technique

Ouse airlift

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5
Dendrocoelidae	1	1	2	1	0
Planariidae (incl. Dugesiidae)	8	8	11	7	8
Viviparidae	21	45	51	80	44
Valvatidae	7	19	3	3	8
Hydrobiidae (incl. Bithyniidae)	39	63	79	91	95
Lymnaeidae	4	1	0	0	0
Planorbidae	0	2	1	0	0
Ancylidae (incl. Acroloxidae)	0	5	0	2	4
Unionidae	2	3	2	3	0
Sphaeriidae	307	159	119	138	146
Oligochaeta	590	469	460	232	520
Glossiphoniidae	105	68	39	37	69
Asellidae	544	282	234	295	186
Gammaridae (incl. Crangonyctidae & Niphargidae)	0	7	2	4	3
Caenidae	0	5	0	2	3
Leuctridae	1	0	0	0	0
Dytiscidae (incl. Noteridae)	1	0	0	0	1
Elmidae	3	0	0	0	0
Sialidae	0	2	0	1	2
Polycentropodidae	1	0	2	1	0
Psychomyiidae (incl. Ecnomidae)	0	2	1	0	1
Limnephilidae	0	0	0	0	2
Leptoceridae	0	2	1	0	0
Simuliidae	0	0	0	0	1
Chironomidae	354	178	98	157	240
Number of taxa	16	19	16	16	17
ASPT	4.38	4.58	4.63	4.38	4.53
BMWP	70	87	74	70	77

Ouse dredge

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Planariidae (incl. Dugesiidae)	0	0	0	3	0	5
Viviparidae	1	0	2	5	0	3
Hydrobiidae (incl. Bithyniidae)	6	2	3	3	0	14
Lymnaeidae	1	0	0	0	0	0
Ancylidae (incl. Acroloxidae)	0	0	1	1	0	0
Sphaeriidae	14	1	10	0	3	12
Oligochaeta	0	56	26	947	70	49
Piscicolidae	0	0	0	0	0	1
Glossiphoniidae	2	2	3	0	0	11
Asellidae	48	16	39	57	13	106
Gammaridae (incl. Crangonyctidae & Niphargidae)	1	0	0	0	0	0
Ephemerellidae	1	0	0	0	0	0
Caenidae	1	0	0	0	0	2
Elmidae	0	0	0	1	0	0
Sialidae	0	0	1	0	0	0
Polycentropodidae	1	0	0	0	0	0
Psychomyiidae (incl. Ecnomidae)	0	0	0	2	2	0
Leptoceridae	0	0	0	1	0	0
Chironomidae	0	19	17	37	24	24
Number of taxa	10	6	9	10	5	10
ASPT	5.10	2.50	3.44	4.90	3.40	3.70
BMWP	51	15	31	49	17	37

Ouse
long-handled pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Dendrocoelidae	0	0	0	1	0	0
Planariidae (incl. Dugesiidae)	0	1	0	1	0	0
Valvatidae	1	0	0	0	0	0
Hydrobiidae (incl. Bithyniidae)	2	0	0	2	2	9
Sphaeriidae	11	4	0	6	0	43
Oligochaeta	31	1	1	27	2	297
Glossiphoniidae	2	0	1	0	0	1
Asellidae	5	15	1	15	1	27
Gammaridae (incl. Crangonyctidae & Niphargidae)	0	0	0	0	0	5
Dytiscidae (incl. Noteridae)	1	0	0	0	0	0
Chironomidae	4	1	1	13	1	44
Number of taxa	8	5	4	7	4	7
ASPT	2.88	2.80	2.25	3.14	2.25	3.00
BMWP	23	14	9	22	9	21

Ouse
margin pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Viviparidae	1			1	1	1
Valvatidae	1					1
Hydrobiidae (incl. Bithyniidae)	1	1	1	1	1	1
Physidae			1	1		1
Lymnaeidae	1	1	1			1
Ancylidae (incl. Acroloxidae)					1	
Unionidae	1	1	1	1	1	
Sphaeriidae	1	1	1	1	1	1
Oligochaeta	1	1	1	1	1	1
Glossiphoniidae		1	1	1	1	1
Asellidae			1	1	1	1
Gammaridae (incl. Crangonyctidae & Niphargidae)	1		1	1	1	1
Baetidae					1	
Ephemerellidae	1					1
Caenidae		1			1	
Coenagriidae	1					
Elmidae	1					
Chrysomelidae		1				
Sialidae			1	1	1	1
Polycentropodidae				1	1	1
Psychomyiidae (incl. Ecnomidae)				1		1
Limnephilidae			1			
Molannidae					1	
Tipulidae		1				
Chironomidae	1	1	1	1	1	1
Number of taxa	12	9	12	13	15	15
ASPT	4.50	3.67	3.67	4.23	4.73	4.33
BMWP	54	33	44	55	71	65

Derwent
airlift_BAMS_1

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Dendrocoelidae	0	4	1	0	0	0
Planariidae (incl. Dugesiidae)	0	30	4	0	0	0
Neritidae	5	4	2	16	5	2
Viviparidae	0	0	1	12	1	1
Hydrobiidae (incl. Bithyniidae)	2	1	3	2	3	19
Unionidae	1	0	0	0	0	0
Sphaeriidae	0	9	7	6	15	18
Oligochaeta	24	100	22	22	4	18
Piscicolidae	0	0	1	4	7	1
Glossiphoniidae	2	2	2	4	1	0
Erpobdellidae	2	11	0	4	2	0
Asellidae	3	72	32	0	17	22
Gammaridae (incl. Crangonyctidae & Niphargidae)	29	228	70	167	167	73
Baetidae	0	0	1	8	1	9
Heptageniidae	2	1	1	5	1	3
Ephemeridae	2	1	4	0	4	5
Ephemerellidae	20	24	15	93	11	31
Caenidae	2	48	44	74	33	13
Leuctridae	5	4	2	3	3	2
Aphelocheiridae	37	21	23	139	68	60
Dytiscidae (incl. Noteridae)	0	0	0	0	2	3
Elmidae	0	9	4	13	3	3
Sialidae	0	8	0	0	0	0
Polycentropodidae	0	0	0	4	0	0
Hydropsychidae	3	4	0	4	0	0
Brachycentridae	3	28	5	13	2	1
Molannidae	0	0	1	0	0	1
Leptoceridae	0	8	0	0	2	1
Tipulidae	20	0	0	4	0	0

Derwent
airlift_BAMS_1

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Simuliidae	0	21	0	0	0	2
Chironomidae	576	2068	830	1081	887	460
Number of taxa	17	23	22	21	22	22
ASPT	6.35	5.91	6.05	5.71	5.95	6.36
BMWP	108	136	133	120	131	140

Derwent
airlift_BAMS_2

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Dendrocoelidae	3	4	5	5	1	5
Planariidae (incl. Dugesiidae)	0	8	14	12	0	16
Neritidae	9	1	0	5	3	5
Viviparidae	0	1	4	0	1	0
Hydrobiidae (incl. Bithyniidae)	1	1	11	8	6	30
Planorbidae	0	1	0	0	0	0
Ancylidae (incl. Acroloxidae)	0	0	0	1	0	0
Unionidae	0	0	1	4	1	0
Sphaeriidae	1	15	20	5	4	41
Oligochaeta	6	183	8	37	3	40
Piscicolidae	0	5	6	2	2	8
Glossiphoniidae	0	3	5	17	0	8
Erpobdellidae	2	7	0	2	3	6
Asellidae	3	78	27	56	29	53
Gammaridae (incl. Crangonyctidae & Niphargidae)	47	355	66	137	68	412
Baetidae	1	0	3	1	3	6
Heptageniidae	2	1	4	0	3	5
Leptophlebiidae	0	0	0	0	0	1
Ephemeridae	0	3	3	0	2	5
Ephemerellidae	19	63	22	45	16	85
Caenidae	0	64	45	38	30	51
Nemouridae	0	1	0	0	0	0
Leuctridae	1	1	2	17	1	1
Aphelocheiridae	84	72	20	96	52	37
Dytiscidae (incl. Noteridae)	0	0	1	0	0	0
Elmidae	3	4	5	10	2	16
Sialidae	0	7	0	4	0	4
Hydroptilidae	0	0	0	0	1	0
Polycentropodidae	0	2	0	0	0	1

Derwent
airlift_BAMS_2

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Hydropsychidae	4	2	1	2	0	0
Brachycentridae	5	8	31	9	3	26
Lepidostomatidae	0	0	0	0	0	4
Limnephilidae	0	0	2	0	0	4
Sericostomatidae	0	1	0	0	0	4
Molannidae	0	1	0	0	0	0
Leptoceridae	1	2	4	8	4	2
Tipulidae	2	0	0	0	0	0
Simuliidae	1	25	0	0	0	0
Chironomidae	380	3690	695	1336	710	1178
Number of taxa	20	30	25	24	23	28
ASPT	5.80	6.10	6.00	5.46	6.09	6.36
BMWP	116	183	150	131	140	178

Derwent
airlift_BAMS_3

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Dendrocoelidae	0	0	2	1	2	2
Planariidae (incl. Dugesiidae)	0	4	8	0	6	3
Neritidae	5	0	4	14	4	0
Viviparidae	0	0	1	0	0	0
Hydrobiidae (incl. Bithyniidae)	10	8	8	0	1	13
Physidae	0	0	0	0	1	0
Planorbidae	0	0	0	0	1	0
Ancylidae (incl. Acroloxidae)	1	0	0	0	0	0
Unionidae	0	2	1	0	0	0
Sphaeriidae	22	8	6	12	4	9
Oligochaeta	160	34	9	33	38	28
Piscicolidae	0	1	2	0	1	3
Glossiphoniidae	17	4	0	14	3	1
Erpobdellidae	1	0	1	5	1	1
Asellidae	34	8	24	38	49	9
Gammaridae (incl. Crangonyctidae & Niphargidae)	120	60	38	134	126	105
Baetidae	34	0	1	0	0	3
Heptageniidae	4	1	0	1	0	5
Ephemeridae	0	7	3	2	1	3
Ephemerellidae	156	7	16	103	18	32
Caenidae	30	13	38	74	63	18
Leuctridae	8	4	2	7	3	3
Aphelocheiridae	227	88	43	152	62	27
Haliplidae	0	0	0	0	1	0
Dytiscidae (incl. Noteridae)	0	0	0	0	0	1
Elmidae	21	0	6	14	2	1
Sialidae	0	1	0	0	0	0
Rhyacophilidae (incl. Glossosomatidae)	1	0	0	0	0	0

Derwent
airlift_BAMS_3

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Polycentropodidae	0	0	0	0	1	0
Hydropsychidae	8	1	0	0	0	0
Brachycentridae	36	7	1	5	2	5
Lepidostomatidae	0	0	0	0	0	2
Limnephilidae	0	0	0	0	2	0
Molannidae	0	0	1	0	0	0
Leptoceridae	1	1	1	1	6	2
Tipulidae	4	1	0	0	0	0
Simuliidae	105	0	0	4	0	0
Chironomidae	1257	868	820	790	950	512
Number of taxa	23	21	23	19	25	23
ASPT	5.83	6.05	6.04	6.26	5.64	6.04
BMWP	134	127	139	119	141	139

Derwent
Dredge

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Dendrocoelidae	1	3	0	0	1	1
Planariidae (incl. Dugesiidae)	1	0	0	5	2	0
Neritidae	0	0	1	2	0	1
Viviparidae	0	1	0	0	0	0
Hydrobiidae (incl. Bithyniidae)	0	0	0	1	0	3
Lymnaeidae	0	0	0	1	0	0
Unionidae	0	1	0	0	0	1
Sphaeriidae	1	1	0	0	0	1
Oligochaeta	10	2	24	5	15	1
Piscicolidae	1	2	1	1	1	0
Glossiphoniidae	0	0	0	2	2	0
Erpobdellidae	0	1	1	0	0	2
Asellidae	2	11	2	10	6	2
Gammaridae (incl. Crangonyctidae & Niphargidae)	37	35	40	12	8	3
Baetidae	34	24	21	8	0	12
Heptageniidae	2	1	4	0	0	0
Ephemerellidae	20	21	8	20	2	4
Caenidae	2	4	5	3	4	0
Leuctridae	0	0	0	0	1	1
Gerridae	0	1	0	0	0	0
Aphelocheiridae	10	19	0	5	5	3
Corixidae	0	0	1	0	0	1
Dytiscidae (incl. Noteridae)	0	0	0	0	0	0
Elmidae	0	2	0	0	2	3
Sialidae	0	0	0	0	0	0
Polycentropodidae	0	0	0	0	0	1
Psychomyiidae (incl. Ecnomidae)	0	0	0	0	0	0
Brachycentridae	6	11	2	0	1	3
Limnephilidae	0	1	0	0	0	0

Derwent
Dredge

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Leptoceridae	0	0	0	0	0	2
Tipulidae	1	1	0	0	0	0
Simuliidae	108	231	32	5	0	0
Chironomidae	65	147	316	59	128	66
Number of taxa	16	21	14	15	14	19
ASPT	5.63	5.57	5.43	4.80	5.79	5.74
BMWP	90	117	76	72	81	109

Derwent
Long-handled pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Planariidae (incl. Dugesiidae)	0	0	2	0	0	3
Neritidae	0	0	0	0	0	1
Valvatidae	0	0	0	0	2	0
Hydrobiidae (incl. Bithyniidae)	0	0	0	1	0	0
Lymnaeidae	0	0	3	0	0	0
Ancylidae (incl. Acroloxidae)	0	0	3	0	0	0
Sphaeriidae	0	1	0	0	1	2
Oligochaeta	14	19	8	3	0	19
Glossiphoniidae	2	0	0	0	0	2
Erpobdellidae	1	1	1	0	0	1
Asellidae	3	6	11	3	2	11
Gammaridae (incl. Crangonyctidae & Niphargidae)	39	9	17	7	11	53
Baetidae	1	0	1	0	0	6
Heptageniidae	0	1	0	2	2	2
Ephemeridae	0	0	0	0	0	1
Ephemerellidae	2	9	14	5	1	26
Caenidae	3	1	7	2	6	3
Leuctridae	0	1	0	1	0	2
Aphelocheiridae	19	4	16	5	11	6
Elmidae	1	0	2	1	1	0
Hydropsychidae	0	0	1	1	1	1
Brachycentridae	19	4	5	0	2	4
Leptoceridae	1	0	0	0	0	0
Tipulidae	1	0	0	0	0	0
Simuliidae	9	2	2	0	2	0
Chironomidae	167	91	120	26	56	141
Number of taxa	15	13	16	12	13	18
ASPT	5.60	6.15	5.31	6.00	6.08	6.00
BMWP	84	80	85	72	79	108

Derwent
margin pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Dendrocoelidae		1	1	1	1	1
Planariidae (incl. Dugesiidae)	1	1	1	1	1	
Neritidae		1			1	
Viviparidae		1	1	1		
Hydrobiidae (incl. Bithyniidae)	1	1	1	1	1	1
Physidae		1				
Lymnaeidae	1		1			
Ancylidae (incl. Acroloxidae)		1				
Sphaeriidae	1	1	1	1		1
Oligochaeta	1	1	1	1	1	1
Piscicolidae	1			1	1	1
Glossiphoniidae		1		1		1
Erpobdellidae	1	1		1	1	1
Asellidae	1	1	1	1	1	1
Gammaridae (incl. Crangonyctidae & Niphargidae)	1	1	1	1	1	1
Baetidae	1	1	1	1	1	1
Heptageniidae	1	1	1	1	1	1
Ephemeridae	1	1				1
Ephemerellidae	1	1	1	1	1	1
Caenidae	1	1	1	1	1	1
Aphelocheiridae	1				1	
Corixidae		1			1	
Haliplidae						1
Dytiscidae (incl. Noteridae)		1	1	1	1	1
Elmidae		1		1		1
Sialidae	1	1		1	1	1
Polycentropodidae		1		1		
Brachycentridae	1				1	1
Lepidostomatidae					1	

Derwent
margin pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Limnephilidae		1	1		1	1
Leptoceridae		1		1	1	1
Tipulidae			1		1	
Simuliidae	1			1		
Chironomidae	1	1	1	1	1	1
Number of taxa	19	26	17	22	23	22
ASPT	5.42	5.35	5.00	5.05	5.87	5.45
BMWP	103	139	85	111	135	120

South Drove Drain
airlift

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Dendrocoelidae	4	4	12	0	0	0
Planariidae (incl. Dugesiidae)	0	0	0	6	19	10
Valvatidae	4	12	0	0	9	2
Hydrobiidae (incl. Bithyniidae)	3176	1132	1972	2922	1322	4784
Physidae	0	4	2	0	0	0
Lymnaeidae	0	1	1	4	0	4
Planorbidae	24	16	32	92	157	152
Unionidae	1	0	1	0	0	1
Sphaeriidae	64	140	176	49	325	104
Oligochaeta	152	184	136	160	548	744
Piscicolidae	4	12	0	8	0	0
Glossiphoniidae	20	16	12	22	9	12
Erpobdellidae	0	0	0	0	1	4
Asellidae	1676	580	1988	1396	1696	800
Gammaridae (incl. Crangonyctidae & Niphargidae)	28	20	52	29	85	48
Baetidae	136	100	84	164	89	112
Caenidae	52	20	0	28	0	40
Coenagriidae	24	40	40	46	49	28
Corixidae	12	16	2	42	20	17
Haliplidae	8	8	28	17	16	9
Dytiscidae (incl. Noteridae)	4	0	1	1	0	0
Elmidae	0	4	0	4	0	0
Sialidae	0	1	1	0	11	0
Hydroptilidae	0	0	1	4	0	9
Polycentropodidae	4	0	4	4	10	0
Phryganeidae	0	0	0	1	8	0
Molannidae	0	0	0	0	0	1
Leptoceridae	0	4	2	0	0	16
Chironomidae	52	420	84	221	150	97

South Drove Drain
airlift

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Number of taxa	19	21	21	21	18	21
ASPT	4.26	4.19	4.43	4.57	4.22	4.62
BMWP	81	88	93	96	76	97

South Drove Drain
dredge_BAMS_1

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Dendrocoelidae	4	4	4	0	0	0
Planariidae (incl. Dugesiidae)	0	0	1	5	2	3
Hydrobiidae (incl. Bithyniidae)	1588	850	904	1606	2718	633
Physidae	0	0	0	6	0	1
Lymnaeidae	0	0	1	5	24	3
Planorbidae	24	56	32	112	44	56
Sphaeriidae	8	28	4	17	9	0
Oligochaeta	20	60	24	392	33	84
Piscicolidae	0	0	0	0	1	5
Glossiphoniidae	0	4	4	3	9	4
Erpobdellidae	0	0	0	0	0	4
Asellidae	120	56	148	436	76	44
Gammaridae (incl. Crangonyctidae & Niphargidae)	1	1	0	1	0	9
Baetidae	72	100	68	184	168	256
Caenidae	0	8	12	10	0	12
Coenagriidae	12	16	4	30	48	45
Gerridae	1	0	0	0	0	0
Naucoridae	0	1	0	1	0	0
Corixidae	1	20	16	69	35	28
Haliplidae	16	4	4	17	9	12
Gyrinidae	0	0	0	0	0	1
Dytiscidae (incl. Noteridae)	0	0	0	2	1	1
Hydrophilidae (incl. Hydraenidae)	1	0	0	2	4	0
Elmidae	0	0	0	1	0	0
Chrysomelidae	0	0	0	0	0	1
Curculionidae	0	0	1	0	0	0
Sialidae	0	0	0	1	0	0
Hydroptilidae	0	0	4	0	0	0
Polycentropodidae	0	0	0	0	0	2

South Drove Drain
dredge_BAMS_1

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Phryganeidae	0	0	0	0	0	1
Leptoceridae	0	1	4	1	6	14
Chironomidae	48	64	108	596	217	298
Number of taxa	14	16	17	22	17	22
ASPT	4.00	4.44	4.35	4.36	4.12	4.68
BMWP	56	71	74	96	70	103

South Drove Drain
dredge_BAMS_2

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Planariidae (incl. Dugesiidae)	0	11	0	13	14	9
Valvatidae	0	1	0	5	1	0
Hydrobiidae (incl. Bithyniidae)	2500	246	870	3517	1424	1749
Lymnaeidae	0	0	4	1	1	1
Planorbidae	42	3	40	86	57	34
Sphaeriidae	3	48	0	5	6	1
Oligochaeta	32	84	45	45	24	17
Piscicolidae	2	5	0	1	0	1
Glossiphoniidae	11	14	4	2	4	2
Erpobdellidae	0	0	0	0	2	0
Asellidae	200	768	654	671	80	69
Gammaridae (incl. Crangonyctidae & Niphargidae)	5	3	0	5	5	1
Baetidae	99	200	80	141	120	81
Caenidae	4	32	4	2	25	1
Coenagriidae	30	7	17	39	15	37
Gerridae	0	0	0	0	1	0
Nepidae	0	0	1	0	0	0
Corixidae	10	36	6	27	52	19
Haliplidae	11	7	13	10	8	13
Dytiscidae (incl. Noteridae)	1	0	0	1	3	1
Hydrophilidae (incl. Hydraenidae)	0	4	1	2	16	5
Elmidae	0	0	0	0	8	0
Curculionidae	0	0	0	1	0	0
Sialidae	0	4	0	0	0	0
Hydroptilidae	0	0	1	0	0	0
Polycentropodidae	0	0	0	1	0	8
Molannidae	0	4	0	0	0	0
Leptoceridae	1	4	9	7	6	3
Tipulidae	0	4	0	4	18	2

South Drove Drain
dredge_BAMS_2

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Chironomidae	33	76	74	564	88	22
Number of taxa	16	21	16	22	23	21
ASPT	4.38	4.62	4.44	4.45	4.35	4.52
BMWP	70	97	71	98	100	95

South Drove Drain
dredge_BAMS_3

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Planariidae (incl. Dugesiidae)	0	0	0	5	0	9
Valvatidae	4	0	2	2	0	0
Hydrobiidae (incl. Bithyniidae)	545	275	390	2133	498	1156
Lymnaeidae	1	0	0	0	2	1
Planorbidae	8	10	1	32	10	51
Sphaeriidae	0	3	7	1	14	2
Oligochaeta	30	34	39	130	33	12
Piscicolidae	0	2	1	0	0	4
Glossiphoniidae	1	3	0	6	1	4
Asellidae	29	130	25	387	64	187
Gammaridae (incl. Crangonyctidae & Niphargidae)	0	4	1	4	5	9
Baetidae	152	118	171	77	41	196
Caenidae	1	0	15	5	2	6
Coenagriidae	10	9	7	22	2	56
Mesovelidae	0	0	0	0	0	2
Gerridae	0	0	1	1	0	0
Nepidae	0	0	0	0	0	1
Naucoridae	0	2	0	0	0	0
Corixidae	43	15	45	36	5	42
Haliplidae	0	10	2	5	1	16
Gyrinidae	0	0	0	0	0	1
Dytiscidae (incl. Noteridae)	2	1	1	0	1	0
Hydrophilidae (incl. Hydraenidae)	0	0	1	4	1	4
Elmidae	0	2	0	1	0	0
Hydroptilidae	0	1	0	1	0	1
Polycentropodidae	0	0	0	0	1	0
Phryganeidae	0	0	0	0	0	10
Molannidae	0	0	2	0	0	0
Leptoceridae	0	11	1	5	0	13

South Drove Drain
dredge_BAMS_3

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Tipulidae	0	2	0	3	1	0
Chironomidae	54	47	46	79	257	108
Number of taxa	13	19	19	21	18	23
ASPT	3.69	4.42	4.74	4.52	4.22	4.74
BMWP	48	84	90	95	76	109

South Drove Drain
long-handled pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Planariidae (incl. Dugesiidae)	2	1	1	12	3	7
Valvatidae	2	1	0	2	0	2
Hydrobiidae (incl. Bithyniidae)	4394	670	2153	2348	2138	3154
Lymnaeidae	1	4	1	0	1	2
Planorbidae	1	17	16	47	79	63
Unionidae	1	0	0	0	0	0
Sphaeriidae	19	12	8	28	6	3
Oligochaeta	10	28	15	95	515	60
Piscicolidae	0	2	0	3	2	0
Glossiphoniidae	1	3	0	6	1	0
Asellidae	268	114	498	1284	440	182
Gammaridae (incl. Crangonyctidae & Niphargidae)	5	0	4	12	2	12
Baetidae	54	238	46	134	228	104
Caenidae	3	3	1	14	15	3
Coenagriidae	10	16	21	27	37	71
Corixidae	4	12	3	33	45	19
Haliplidae	4	4	6	3	7	12
Dytiscidae (incl. Noteridae)	0	0	0	0	0	1
Hydroptilidae	2	1	1	0	2	4
Polycentropodidae	0	0	1	0	0	0
Phryganeidae	0	0	0	0	1	1
Leptoceridae	1	1	1	7	1	1
Chironomidae	10	8	12	128	184	74
Number of taxa	19	18	17	17	19	19
ASPT	4.42	4.22	4.65	4.29	4.68	4.74
BMWP	84	76	79	73	89	90

South Drove Drain
margin pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Planariidae (incl. Dugesiidae)	1	1	1	1	1	1
Valvatidae						1
Hydrobiidae (incl. Bithyniidae)	1	1	1	1	1	1
Physidae		1	1		1	1
Lymnaeidae	1	1			1	
Planorbidae	1	1	1	1	1	1
Sphaeriidae	1	1	1		1	1
Oligochaeta	1	1	1	1	1	1
Piscicolidae	1			1	1	
Glossiphoniidae	1	1	1	1	1	1
Erpobdellidae		1	1			
Asellidae	1	1	1	1	1	1
Gammaridae (incl. Crangonyctidae & Niphargidae)	1	1	1	1	1	1
Baetidae	1	1	1	1	1	1
Caenidae	1	1				
Coenagriidae	1	1	1	1	1	1
Aeshnidae	1					1
Libellulidae					1	
Hydrometridae				1	1	
Gerridae	1		1	1	1	1
Nepidae			1	1	1	
Naucoridae	1				1	
Notonectidae	1	1	1	1	1	
Corixidae	1	1	1	1	1	1
Haliplidae	1	1			1	
Gyrinidae	1	1				1
Dytiscidae (incl. Noteridae)	1	1	1	1	1	1
Hydrophilidae (incl. Hydraenidae)	1	1	1	1	1	
Dryopidae			1		1	

South Drove Drain
margin pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Elmidae	1	1	1	1	1	
Sialidae					1	
Polycentropodidae						1
Phryganeidae	1					
Molannidae	1					
Leptoceridae	1	1	1	1	1	1
Tipulidae	1		1	1	1	1
Chironomidae	1	1	1	1	1	1
Number of taxa	28	23	23	21	29	21
ASPT	5.04	4.35	4.35	4.52	4.52	4.52
BMWP	141	100	100	95	131	95

New Bedford River
airlift

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Neritidae	2	0	1	13	4	0
Viviparidae	0	12	9	19	27	40
Valvatidae	0	1	11	9	10	15
Hydrobiidae (incl. Bithyniidae)	18	8	29	57	30	58
Lymnaeidae	0	0	1	0	0	0
Planorbidae	0	0	0	4	0	0
Unionidae	10	5	7	3	7	13
Sphaeriidae	133	51	168	164	189	216
Oligochaeta	453	484	268	136	247	506
Piscicolidae	1	0	4	0	0	0
Glossiphoniidae	70	24	41	34	13	16
Erpobdellidae	10	10	7	8	5	8
Asellidae	13	8	12	0	1	10
Gammaridae (incl. Crangonyctidae & Niphargidae)	76	32	22	29	14	22
Baetidae	0	20	15	0	0	0
Caenidae	9	8	2	8	16	0
Coenagriidae	0	2	0	0	0	0
Aphelocheiridae	0	1	2	6	0	1
Corixidae	12	24	20	12	8	12
Dytiscidae (incl. Noteridae)	0	3	5	0	1	2
Sialidae	3	0	5	4	3	1
Polycentropodidae	0	2	5	2	0	4
Phryganeidae	0	0	1	0	0	1
Limnephilidae	0	0	0	1	1	0
Molannidae	18	14	25	38	34	17
Leptoceridae	0	2	6	9	1	5
Chironomidae	93	132	44	80	126	60
Number of taxa	15	20	24	20	19	19
ASPT	4.40	5.15	5.17	5.25	4.89	5.26
BMWP	66	103	124	105	93	100

New Bedford River dredge

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Planariidae (incl. Dugesiidae)	0	0	0	4	0	0
Neritidae	5	1	4	1	5	0
Viviparidae	96	5	4	2	27	4
Valvatidae	0	1	22	10	17	12
Hydrobiidae (incl. Bithyniidae)	38	7	22	17	43	20
Physidae	0	0	0	4	0	0
Lymnaeidae	0	0	4	0	0	0
Unionidae	7	6	16	6	7	23
Sphaeriidae	4	69	140	36	361	50
Oligochaeta	461	540	396	1164	173	286
Piscicolidae	0	2	1	5	0	0
Glossiphoniidae	17	11	5	30	10	6
Erpobdellidae	33	6	4	6	15	21
Asellidae	28	7	5	21	0	9
Gammaridae (incl. Crangonyctidae & Niphargidae)	317	68	129	336	47	63
Baetidae	123	11	96	10	4	16
Caenidae	0	9	2	4	0	4
Coenagriidae	4	1	13	1	0	0
Aphelocheiridae	0	0	1	0	1	0
Corixidae	178	46	80	25	19	40
Haliplidae	8	1	0	4	0	0
Dytiscidae (incl. Noteridae)	4	1	0	7	0	4
Sialidae	6	8	28	9	18	29
Polycentropodidae	9	1	0	7	0	0
Phryganeidae	0	1	0	0	0	0
Limnephilidae	0	0	0	0	4	0
Molannidae	4	7	23	8	12	16
Leptoceridae	6	1	9	6	0	0
Chironomidae	121	82	68	153	44	344

New Bedford River dredge

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Number of taxa	20	24	22	25	17	17
ASPT	4.90	5.08	4.91	4.80	4.82	4.35
BMWP	98	122	108	120	82	74

New Bedford River
long-handled pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Dendrocoelidae	0	1	0	0	0	0
Planariidae (incl. Dugesiidae)	0	0	2	0	0	1
Neritidae	0	3	2	2	5	4
Viviparidae	31	13	8	16	89	16
Valvatidae	0	1	4	13	2	12
Hydrobiidae (incl. Bithyniidae)	43	12	93	83	89	25
Planorbidae	0	0	0	2	0	0
Unionidae	5	2	3	2	0	19
Sphaeriidae	58	33	117	140	112	66
Oligochaeta	273	68	64	217	44	796
Piscicolidae	0	0	0	1	2	0
Glossiphoniidae	14	26	36	26	50	20
Erpobdellidae	28	10	26	18	26	12
Asellidae	19	10	18	22	14	6
Gammaridae (incl. Crangonyctidae & Niphargidae)	30	18	39	33	86	44
Baetidae	0	0	6	1	1	1
Caenidae	0	2	18	20	5	4
Aphelocheiridae	0	0	4	3	1	0
Corixidae	10	2	54	37	10	1
Haliplidae	0	0	0	0	0	4
Dytiscidae (incl. Noteridae)	0	0	2	2	0	0
Sialidae	2	6	6	4	2	12
Hydroptilidae	0	0	0	0	1	0
Polycentropodidae	3	0	6	2	16	0
Limnephilidae	0	1	2	0	0	0
Molannidae	6	13	38	14	33	12
Leptoceridae	1	3	11	6	4	1
Chironomidae	92	29	72	93	38	320
Number of taxa	15	19	23	23	21	20

New Bedford River
long-handled pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
ASPT	4.80	4.89	5.17	4.96	5.05	4.75
BMWP	72	93	119	114	106	95

New Bedford River
margin pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Planariidae (incl. Dugesiidae)	1	0	0	1	1	0
Neritidae	0	1	0	0	0	1
Viviparidae	1	1	1	1	1	1
Valvatidae	1	1	1	0	1	1
Hydrobiidae (incl. Bithyniidae)	1	1	1	1	1	1
Physidae	0	1	1	1	1	1
Lymnaeidae	0	1	0	1	1	1
Planorbidae	0	0	0	0	0	1
Ancylidae (incl. Acroloxidae)	0	0	0	0	1	0
Unionidae	1	1	1	1	1	1
Sphaeriidae	1	1	1	1	1	1
Oligochaeta	1	1	1	1	1	1
Piscicolidae	1	1	0	1	1	0
Glossiphoniidae	1	1	1	1	1	1
Erpobdellidae	1	1	1	1	1	1
Asellidae	0	1	1	1	1	1
Gammaridae (incl. Crangonyctidae & Niphargidae)	1	1	1	1	1	1
Baetidae	1	1	1	1	1	1
Caenidae	1	1	1	0	1	1
Coenagriidae	1	1	1	0	1	1
Calopterygidae	1	0	0	1	0	0
Libellulidae	1	0	0	0	0	0
Gerridae	1	0	0	0	0	0
Aphelocheiridae	0	1	0	0	0	0
Notonectidae	0	1	1	1	0	1
Corixidae	1	1	1	1	1	1
Haliplidae	0	0	0	0	0	1
Dytiscidae (incl. Noteridae)	1	1	1	1	1	1
Hydrophilidae (incl. Hydraenidae)	0	0	0	0	0	1

New Bedford River
margin pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Sialidae	1	1	1	1	1	1
Polycentropodidae	1	1	0	1	1	1
Phryganeidae	1	1	0	1	1	1
Limnephilidae	0	1	0	0	0	0
Molannidae	1	1	1	1	1	1
Leptoceridae	1	1	1	1	1	1
Chironomidae	1	1	1	1	1	1
Number of taxa	25	28	21	24	26	28
ASPT	5.36	5.18	4.67	4.96	4.92	4.89
BMWP	134	145	98	119	128	137

Huntspill airlift

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Valvatidae	24	76	47	81	83	68
Hydrobiidae (incl. Bithyniidae)	0	1	0	0	0	0
Physidae	4	0	0	32	4	0
Lymnaeidae	1	1	1	9	1	0
Unionidae	2	5	0	6	16	16
Sphaeriidae	214	285	124	386	302	184
Oligochaeta	88	339	224	492	896	380
Piscicolidae	3	0	6	0	4	0
Glossiphoniidae	0	0	3	8	0	4
Gammaridae (incl. Crangonyctidae & Niphargidae)	0	0	2	0	0	0
Baetidae	3	0	0	0	0	0
Caenidae	0	0	3	0	0	0
Coenagriidae	9	0	0	22	5	0
Corixidae	5	0	0	4	0	0
Psychomyiidae (incl. Ecnomidae)	0	0	0	1	0	0
Leptoceridae	0	1	0	7	0	0
Chironomidae	824	449	426	420	428	192
Number of taxa	11	8	9	12	9	6
ASPT	3.64	3.88	3.56	4.42	3.44	3.00
BMWP	40	31	32	53	31	18

Huntspill dredge

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Valvatidae	9	12	45	52	9	10
Hydrobiidae (incl. Bithyniidae)	0	12	0	0	0	0
Physidae	20	7	21	8	1	0
Lymnaeidae	3	0	0	0	0	0
Unionidae	20	11	16	12	6	11
Sphaeriidae	29	75	184	244	102	48
Oligochaeta	1648	1008	1076	972	1421	607
Glossiphoniidae	1	0	0	4	0	1
Baetidae	30	2	5	0	4	1
Coenagriidae	0	1	0	0	0	0
Naucoridae	3	0	0	1	4	0
Notonectidae	1	2	0	0	0	0
Corixidae	11	0	9	0	18	0
Dytiscidae (incl. Noteridae)	1	0	0	0	0	0
Chironomidae	400	388	593	368	351	343
Number of taxa	13	10	8	8	9	7
ASPT	3.69	3.60	3.38	3.25	3.56	3.14
BMWP	48	36	27	26	32	22

Huntspill long-handled pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Planariidae (incl. Dugesiidae)	2	0	0	0	0	0
Valvatidae	1	5	24	11	7	17
Hydrobiidae (incl. Bithyniidae)	2	0	0	0	0	0
Unionidae	3	7	6	7	3	13
Sphaeriidae	28	24	32	83	67	32
Oligochaeta	276	293	158	200	172	508
Glossiphoniidae	3	0	0	6	0	0
Baetidae	1	0	0	0	0	0
Coenagriidae	1	0	0	0	0	0
Corixidae	1	0	0	0	0	0
Leptoceridae	1	0	0	0	0	0
Chironomidae	336	109	216	186	27	262
Number of taxa	12	5	5	6	5	5
ASPT	4.25	3.00	3.00	3.00	3.00	3.00
BMWP	51	15	15	18	15	15

Huntspill
margin pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Valvatidae	1		1			
Hydrobiidae (incl. Bithyniidae)	1	1	1	1	1	1
Physidae	1	1	1	1		1
Lymnaeidae	1	1	1	1	1	1
Planorbidae	1				1	1
Oligochaeta	1	1	1	1	1	1
Piscicolidae		1				
Glossiphoniidae		1				
Asellidae			1			
Gammaridae (incl. Crangonyctidae & Niphargidae)	1		1			
Baetidae	1	1	1	1	1	1
Coenagriidae		1	1	1	1	1
Mesovelidae						1
Hydrometridae	1	1				1
Gerridae	1	1	1			1
Nepidae			1		1	
Naucoridae		1	1		1	
Notonectidae	1	1	1	1	1	
Corixidae	1	1	1		1	1
Dytiscidae (incl. Noteridae)	1		1		1	1
Hydrophilidae (incl. Hydraenidae)		1	1			
Chrysomelidae			1			
Curculionidae	1			1		
Tipulidae	1					
Chironomidae	1	1	1	1	1	1
Number of taxa	15	15	17	8	12	13
ASPT	3.87	3.93	4.06	3.38	3.92	3.85
BMWP	58	59	69	27	47	50

Severn airlift

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Dendrocoelidae	1	1	2	0	0	0
Planariidae (incl. Dugesiidae)	2	13	25	15	20	3
Neritidae	0	1	6	2	5	4
Viviparidae	1	7	2	1	3	4
Hydrobiidae (incl. Bithyniidae)	0	2	5	11	22	0
Unionidae	7	5	0	0	17	4
Sphaeriidae	824	488	555	741	946	998
Oligochaeta	1472	576	17	152	118	76
Glossiphoniidae	6	39	39	27	44	12
Erpobdellidae	1	0	3	0	3	0
Asellidae	2	10	8	15	26	12
Corophiidae	1	6	15	7	10	9
Gammaridae (incl. Crangonyctidae & Niphargidae)	27	51	128	208	110	136
Baetidae	0	0	0	0	0	1
Heptageniidae	0	0	0	1	0	2
Ephemeridae	0	0	0	0	0	4
Caenidae	0	0	0	0	8	0
Leuctridae	0	0	0	0	2	0
Gomphidae	0	0	1	0	0	0
Aphelocheiridae	0	1	6	0	2	2
Elmidae	0	8	8	4	15	4
Sialidae	1	2	0	0	3	3
Polycentropodidae	5	3	8	16	7	3
Hydropsychidae	1	2	3	9	3	8
Brachycentridae	0	0	3	0	1	1
Leptoceridae	1	2	3	8	0	0
Tipulidae	0	0	0	0	2	0
Chironomidae	476	272	180	379	342	152
Number of taxa	16	19	20	16	22	20

Severn airlift

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
ASPT	4.69	5.05	5.35	5.06	5.27	5.60
BMWP	75	96	107	81	116	112

Severn dredge

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Planariidae (incl. Dugesiidae)	0	2	30	6	1	0
Neritidae	0	0	4	0	0	0
Viviparidae	0	0	5	2	1	0
Valvatidae	0	0	0	2	0	0
Hydrobiidae (incl. Bithyniidae)	1	0	0	1	5	0
Unionidae	8	3	15	6	6	0
Sphaeriidae	254	100	290	113	145	5
Oligochaeta	1336	556	2148	722	1612	832
Glossiphoniidae	2	7	32	14	17	0
Erpobdellidae	1	1	1	2	4	0
Asellidae	0	1	4	4	1	0
Corophiidae	2	0	1	3	2	0
Gammaridae (incl. Crangonyctidae & Niphargidae)	10	4	76	20	48	0
Gomphidae	0	1	1	0	0	0
Dytiscidae (incl. Noteridae)	0	0	0	1	0	0
Hydrophilidae (incl. Hydraenidae)	1	0	0	0	0	0
Elmidae	0	0	5	0	0	0
Chrysomelidae	0	0	0	0	4	0
Sialidae	0	5	15	1	5	0
Hydroptilidae	0	1	0	0	4	0
Polycentropodidae	0	1	17	12	0	0
Hydropsychidae	0	0	1	0	0	0
Phryganeidae	1	0	1	1	1	0
Brachycentridae	0	0	1	0	0	0
Leptoceridae	1	0	2	4	1	0
Chironomidae	332	159	280	231	456	80
Number of taxa	12	13	20	18	16	3
ASPT	4.83	4.38	5.45	4.78	4.81	2.00
BMWP	58	57	109	86	77	6

Severn
long-handled pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Dendrocoelidae	0	0	0	0	2	0
Planariidae (incl. Dugesiidae)	2	1	9	14	26	0
Neritidae	0	0	0	3	3	0
Viviparidae	2	0	1	2	6	1
Hydrobiidae (incl. Bithyniidae)	0	2	3	1	8	0
Unionidae	1	3	0	0	1	1
Sphaeriidae	755	414	140	168	121	175
Oligochaeta	1184	2571	6	12	18	76
Glossiphoniidae	6	5	4	8	5	5
Erpobdellidae	2	0	0	0	1	0
Asellidae	1	1	6	1	6	3
Corophiidae	0	0	0	3	32	1
Gammaridae (incl. Crangonyctidae & Niphargidae)	32	5	28	16	21	10
Baetidae	0	0	0	0	1	0
Heptageniidae	0	0	1	0	2	1
Ephemeridae	1	0	1	0	0	0
Caenidae	0	0	0	0	1	0
Calopterygidae	0	0	0	0	1	0
Aphelocheiridae	0	0	1	0	1	0
Elmidae	0	1	4	1	4	0
Sialidae	0	12	0	0	0	1
Hydroptilidae	0	0	0	0	4	0
Polycentropodidae	0	0	3	5	4	0
Hydropsychidae	0	0	1	2	7	0
Brachycentridae	0	0	0	1	23	0
Limnephilidae	1	0	0	0	0	0
Leptoceridae	1	1	1	0	1	0
Chironomidae	384	613	53	55	115	80
Number of taxa	13	12	16	15	25	11

Severn
long-handled pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
ASPT	5.00	4.25	5.56	4.73	5.60	4.55
BMWP	65	51	89	71	140	50

Severn
margin pondnet

Taxa	replicate 1	replicate 2	replicate 3	replicate 4	replicate 5	replicate 6
Dendrocoelidae	1		1	1		
Planariidae (incl. Dugesiidae)						1
Neritidae	1	1		1	1	
Viviparidae				1		
Valvatidae				1		1
Hydrobiidae (incl. Bithyniidae)	1	1	1	1	1	1
Physidae						1
Lymnaeidae				1		
Unionidae	1	1	1	1	1	
Sphaeriidae	1	1	1	1	1	1
Oligochaeta	1	1	1	1	1	1
Glossiphoniidae					1	1
Erpobdellidae				1		
Asellidae				1		1
Gammaridae (incl. Crangonyctidae & Niphargidae)	1			1	1	1
Baetidae					1	
Gomphidae		1				
Dytiscidae (incl. Noteridae)					1	
Hydrophilidae (incl. Hydraenidae)						1
Sialidae		1		1		
Polycentropodidae				1		1
Psychomyiidae (incl. Ecnomidae)				1		1
Phryganeidae						1
Leptoceridae	1					1
Chironomidae	1	1	1	1	1	1
Number of taxa	9	8	6	16	10	15
ASPT	4.67	4.13	3.33	4.31	3.90	4.80
BMWP	42	33	20	69	39	72