Testing and Further Development of RIVPACS (Phase 2)

Progress Report for the Period
January 1993-March 1993

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April 1993

Progress Report 243/4/Y

NRA
National Rivers Authority

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1. INTRODUCTION

This project is in two phases. Phase 1 had two objectives -

- To undertake a comprehensive testing of RIVPACS II
- To formulate a series of bands to express river quality in biological terms.

The main results of this research were presented to the National Rivers Authority in an Interim Report (R&D 243/1/Y) in December 1991. This was followed by an additional report (R&D 243/2/Y) in May 1992 giving a comparison of single, paired and 3 seasons combined macro-invertebrate samples for the biological banding of river quality.

The Phase 2 programme was approved in September 1992 with the following specific objectives -

- To evaluate a number of additional procedures for enhancing the robustness of RIVPACS. Some of these analyses will involve further examination of the 1990 River Quality Survey data.
- To undertake the further development of RIVPACS as follows.
  - include additional sites to make the data-base more comprehensive
  - examine alternative methods of classification and prediction with the objective of increasing the accuracy of the prediction system
  - collate the data, undertake new analyses and incorporate improvements in methodology, leading to the development of RIVPACS III.

After the first three months a progress report was prepared for the period October-December 1992 (R&D 243/3/Y) and this was followed by a progress meeting at the River Laboratory on 14 January 1993 involving both the NRA Project Leader (Mr B. Hemsley-Flint) and the Topic Leader (Dr R. Sweeting). Further informal discussions to brief the NRA Project Leader on progress took place on 24/25 March 1993 in advance of the current three-monthly progress report.

2. TECHNICAL PROGRESS

The timing of each section of the work can be seen by reference to the activity schedule at the end of the report.

2.1 Enhancement of the robustness of RIVPACS

The PIA lists six separate items (i-vi), of which three (items i, iii, iv listed below) are to be undertaken by the end of June 1993 and reported on by the end of September 1993. They are -

i. Investigate the relative merits of using the average or the minimum of single season values of O/E and bands, over the 3 seasons combined data equivalent, to provide a summary of biological quality.

iii. Evaluate a method to provide a fixed value of "E" (Expected) for a site as opposed to reapplying RIVPACS each year.

iv. Evaluate procedures for comparing the presence of individual taxa observed in samples with those predicted by RIVPACS as a means of supplementing quality assessments based on O/E ratios.

Item i is a continuation of the investigation undertaken in the additional report (R&D 243/2/Y) produced for the NRA in May 1992.

Some internal discussions on approaches to items i, iii and iv have taken place, but there is no substantial progress to be reported at this stage. This is because of other contract pressures on some members of the team over the last three months. In view of this, the appropriate time will be made up in the next few months to ensure that the various items of work within this part of the project are undertaken as specified in the contract.

2.2 Further Development of RIVPACS

2.2.1 Inclusion of additional sites to make the data-base more comprehensive

Table 2.1 gives, with slight amendments from the previous version in Progress Report 243/3/Y, the origin and regional allocation of the sites being considered for RIVPACS III. In view of the good progress being made in sample processing and identification, it now looks probable that we can incorporate the request for three additional sites from what used to be NRA Northumbrian region. Hence, the number of new sites in that region will increase from 6 to 9. In contrast, we have removed one site from NRA South West Region (new sites decrease from 10 to 9) after being informed that the Brightley stream is affected by heavy metal pollution and is an inappropriate site for inclusion in RIVPACS III.

Table 2.1 Regional allocation of RIVPACS sites

England and Wales	RIVPACS II sites	'NCC' sites	Headwaters project sites	New sites	Totals
NRA regions					
Anglian	43	8	1 + 5	8	65
Northumbrian	22	5		9	36
North-West	27	1		7	35
Severn-Trent	33	12		7	52
Southern	42	3		2	47
South-West	33	16		9	58
Thames	25	3		8	36
Welsh	44	12	8 + 5	5	74
Wessex	48	12	10 + 5	0	75
Yorkshire	19	14	14 + 5	0	52
NRA totals	336	86	53	55	530
Scotland					
RPB totals	102	17		34	153
GB totals	438	103		89	683

Hence, the number of sites potentially available in Great Britain will increase from 438 (RIVPACS II) to ~683 in RIVPACS III. Note, however, that a small number of sites, including some previously used in RIVPACS II, are likely to be removed due to inadequate quality.

In 1990, RIVPACS II was used for assessing the quality of sites in Northern Ireland, thereby giving full UK coverage, despite the lack of sites from Northern Ireland in the data-set used for generating predictions. To improve the reliability of the system in Northern Ireland, samples from ~60 sites are currently being processed and will be integrated into RIVPACS III for use in the next survey.

Now that the number of new NRA sites has been increased to 55, there are a total of 55 × 3 = 165 samples to be sorted and identified. By the end of March 1993 a total of 149 samples had been sorted so this task is almost complete. Most of the samples are those first taken for the 1990 River Quality Survey, and which are now to be subjected to species level identification, but a small number of sites have been/are to be resampled (see Appendix I for full site listing). In 1993 two samples will be retaken in spring, one in summer and three in autumn. In view of the small numbers of samples involved, this should not delay completion of the identification phase.

Identification of the samples has also progressed well over the past three months and all or most taxa have been identified for 99 samples. In just a subset of the above samples Oligochaeta, Sphaeriidae and Chironomidae await further identification.

In the last progress report we indicated that there could be problems in identifying Sphaeriidae to species at some sites in view of the long period of sample preservation. Hence, there might be a need to ask for new samples to be taken by NRA biologists in selected cases so that Sphaeriidae could be removed for specialist identification by Mr Jon Bass.

The current position is that in a majority of NRA regions an acceptable proportion of Sphaeriidae can be identified, but that at selected sites in South-West, North-West and what was the Northumbrian region, sufficient decalcification of specimens has occurred to make species identification problematic. Therefore, the NRA biologists in these regions have been contacted and they have agreed to retain the Sphaeriidae from spring samples taken at these sites so that they can be identified if required.

In the coming financial year (1993/94) the emphasis will be on sorting the few remaining samples, completing the full identification of the 165 samples and also identifying the Oligochaeta and Chironomidae from a further 60 headwater stream project samples (see Activity Schedule).

2.2.2 Alternative methods of classification and prediction

Good progress has been made over the past three months. Our strategy has been first to address the question of site quality and second to undertake a wide range of classification and prediction procedures on a slightly reduced data-set.

At various times during the development of RIVPACS, there have been questions over whether the sites are all of a sufficiently high quality for inclusion in the system. We are conscious of the need to exclude poor quality sites so that RIVPACS sets realistic 'target' predictions based on information from a wide range of good quality sites. Prior to each stage in the development of the system (268, 370 and 438 sites) the data-sets have been examined and sites have been excluded using a variety of criteria.

A new site appraisal exercise was therefore carried out prior to the investigations of alternative methods of classification and prediction. This involved the removal of apparently poor quality or rogue sites which could influence the structure of the new classifications. In practice, this meant removing a few more sites than was perhaps strictly necessary in order to have greater confidence in the quality of the remaining data-set.

A number of separate criteria were applied to the 438 site data-set to identify sites which might be stressed or which appeared to be very unusual. The major criteria were removal of sites

i) with a BMWP score of less than 100
ii) with less than 35 identified taxa
iii) where the mean observed/expected ratio for BMWP score was ≤0.65, based on results from both the TWINSPAN-MDA classification/prediction system and the more recent WARDS method-MDA system (see Progress Report 243/3/Y for more information on the latter)
iv) where nearest neighbour analysis of the sites gave dissimilarities >0.5. (Analyses from the PATN software package.)

This gave a reduced data-set of 410 sites which was then used in all subsequent classification and prediction exercises.

A total of 17 separate classifications have been carried out to date and each one has then been subjected to multiple discriminant analysis to determine the percentage of sites 'correctly' predicted to group on the basis of environmental features. In addition, a series of further assessments have been undertaken to provide a basis for judging the merits of the various options.

A synopsis of the main results from this part of the project are given in the next section.

3. INTERIM RESULTS

The 17 classifications were all based on 410 sites classified to 24 groups. Classification 1 used TWINSPAN, classifications 2-15 used a variety of techniques available within the PATN software package and numbers 16 and 17 used CANOCO. The methods are listed below.

1. TWINSPAN

2-4. The agglomerative hierarchical option FUSE in PATN in which the Bray-Curtis similarity matrix is subjected to UPGMA with β = -1, -0.5 and -0.1.

5. Bray-Curtis similarity matrix followed by Ward's fusion method.

6. The polythetic divisive technique in PATN termed PDIV.

7. The non-hierarchical clustering strategy in PATN termed ALOC with initial number of seeds = 1 and maximum allocation radius = 0.5. This gave 32 groups which were then recombined to 24 groups using FUSE option UPGMA with β = -0.5 on Bray-Curtis similarities.

8-15. Use of the ordination technique Semi-Strong Hybrid multidimensional scaling (SSH) run in 3, 4, 5 and 6 dimensions followed by generation of groups from ordination scores as follows:-

8-11. SSH_W. Distances were calculated between ordination scores from SSH using Euclidean measure (ASO Option 4 in PATN with p = q = 2). This was followed by classification using Ward's fusion method and was repeated for each of 3 to 6 dimensions.

12-15. SSH_K. Groups were formed directly from ordination scores (scaled by a multiplication factor of 100) using an algorithm (K-means) which finds a local minimum within groups sum-of-squares. The algorithm was seeded with 24 randomly selected sites in each of 5 runs and the optimum run chosen. This was repeated for each of 3 to 6 dimensions.

16. CANO2K. CANOCO was run on the biological data plus latitude and longitude. The option used was DCCA (detrended canonical correspondence analysis) with detrending by segments. The eigenvalues were 0.20692, 0.03158, 0.20348 and 0.09993. The sample scores were then clustered using K-means, and the best of 5 randomly seeded starts.

17. CANO14K. CANOCO as above but using all the 14 environmental variables available in RIVPACS II. In this analysis the eigenvalues were 0.31934, 0.11922, 0.04540 and 0.03386. Again, clustering was by K-means.

Further details of TWINSPAN, PATN, K-means and CANOCO are in the following publications.

1. Hill, M.O. (1979) TWINSPAN - a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Ecology and Systematics, Cornell University, Ithaca, New York.

2. Belbin, L. (1992) PATN - Pattern Analysis Package. Division of Wildlife and Ecology, CSIRO, Australia. Technical Reference, 235 pp.

3. Moss, D. (1985) An initial classification of 10-km squares in Great Britain from a land characteristic data bank. Applied Geography, 5, 131-150.

4. Ter Braak, C.J.F. (1985) CANOCO - A FORTRAN program for canonical correspondence analysis and detrended correspondence analysis, IWIS-TNO, Wageningen, The Netherlands.

Table 3.1 provides a summary of the 17 methods used on the 410 site data-set. In addition to giving information on the range of group size for each classification, the table sets out the results of a series of analyses which can be used for comparing the merits of the different methods. The details are explained in the footnotes which follow:-

1 Standard deviation of numbers of sites per group.
2 % of sites classified to the correct group using MDA on 14 environmental variables.
3 % of total variability between groups in the given biological attribute (one-way ANOVA).
4 % of total variability between groups in principal component scores calculated from 14 environmental variables (one-way ANOVA).
5 % of total variability between groups in the environmental attribute with highest and second-highest such values (one-way ANOVA).
6 % of total variability between groups in combinations of variables: grid easting + northing (not latitude and longitude, which would not preserve geographical distance between sites); Decorana scores on 4 axes; principal components scores on 8 axes. The theoretical maximum given is obtained by use of a non-hierarchical clustering procedure (K-means) which allocates sites to groups in such a way as to seek a (local) maximum between group variability.

Table 3.1 Results of 17 classification and prediction exercises based on the 410 site data-set

Attribute/classification	1 TWINSPAN	2 UPGMA -1	3 UPGMA -.5	4 UPGMA -.1	5 WARD
Range of group size	7-34	8-42	9-28	1-84	6-51
S.D. of group size[1]	7.93	6.87	5.59	18.96	9.82
% sites classified by MDA[2]	57.3	60.5	61.2	66.8	65.9
% variation explained:					
total taxa[3]	50.8	53.3	51.1	51.5	53.5
BMWP scoring taxa[3]	46.5	47.0	47.6	53.3	52.1
BMWP score[3]	44.5	44.2	46.6	55.2	53.1
ASPT[3]	80.4	77.2	79.5	78.7	79.4
Principal component 1[4]	86.1	87.4	88.4	84.0	86.9
Principal component 2[4]	63.2	64.7	65.3	60.9	67.3
Highest environmental variable[5]	68.6 MSUBST	70.8 ALK	73.9 ALK	67.6 MSUBST	71.5 LAT
2nd highest environmental variable[5]	67.6 ALK	66.6 LAT	68.8 MSUBST	67.3 ALK	69.7 ALK
Spatial variables (E + N)[6] (theoretical max. 98.5)	60.5	66.0	66.9	63.4	70.1
Biological (Decorana)[6] (theoretical max. 90.7)	85.5	82.5	84.4	81.6	83.8
Environmental (8 PCA axes)[6] (theoretical max. 79.2)	61.6	62.9	64.2	60.3	64.5

Table 3.1 Continued

Attribute/classification	6 PDIV	7 ALOC	8 SSH3_W	9 SSH4_W	10 SSH5_W	11 SSH6_W
Range of group size	1-149	1-129	7-28	8-33	11-33	6-27
S.D. of group size[1]	31.80	28.50	5.35	5.39	5.91	5.21
% sites classified by MDA[2]	72.4	78.3	39.8	41.7	40.5	56.8
% variation explained:						
total taxa[3]	33.9	38.9	40.9	38.6	33.6	52.7
BMWP scoring taxa[3]	37.2	39.8	33.2	29.9	32.1	50.7
BMWP score[3]	37.0	40.4	28.3	26.1	28.4	51.3
ASPT[3]	78.4	78.6	71.4	71.0	72.6	77.2
Principal component 1[4]	80.8	87.2	78.8	79.0	77.1	84.3
Principal component 2[4]	47.2	48.9	29.6	53.9	33.3	61.6
Highest environmental variable[5]	64.7 ALK	70.5 ALK	60.7 MSUBST	63.1 ALK	58.6 MSUBST	66.6 ALK
2nd highest environmental variable[5]	64.3 MSUBST	67.4 MSUBST	60.0 ALK	59.7 MSUBST	56.4 ALK	63.6 MSUBST
Spatial variables (E + N)[6] (theoretical max. 98.5)	47.7	60.6	45.7	49.9	45.1	62.3
Biological (Decorana)[6] (theoretical max. 90.7)	78.4	79.3	71.0	74.8	71.3	79.4
Environmental (8 PCA axes)[6] (theoretical max. 79.2)	52.1	57.9	45.5	52.8	46.4	60.7

Attribute/classification	12 SSH3_K	13 SSH4_K	14 SSH5_K	15 SSH6_K	16 CANO2_K	17 CAN14_K
Range of group size	6-26	10-27	10-28	10-30	5-38	8-36
S.D. of group size[1]	4.79	4.56	4.18	5.31	8.38	5.93
% sites classified by MDA[2]	39.1	41.7	41.0	60.0	57.3	63.4
% variation explained:						
total taxa[3]	34.3	43.8	29.3	54.6	42.6	44.7
BMWP scoring taxa[3]	27.5	33.7	25.3	53.7	40.5	43.9
BMWP score[3]	23.0	28.4	21.9	56.2	38.2	45.1
ASPT[3]	70.9	70.8	73.1	79.9	79.7	81.6
Principal component 1[4]	77.4	80.0	78.3	85.8	84.0	86.5
Principal component 2[4]	33.5	53.1	29.2	63.2	65.7	71.1
Highest environmental variable[5]	62.4 ALK	60.7 ALK	59.7 ALK	69.3 ALK	69.6 MSUBST	73.0 ALK
2nd highest environmental variable[5]	61.5 MSUBST	56.3 MSUBST	55.5 MSUBST	67.1 MSUBST	65.1 LKM	70.9 LKM
Spatial variables (E + N)[6] (theoretical max. 98.5)	*43.7*	*54.9*	*44.6*	*63.0*	*56.1*	*66.8*
Biological (Decorana)[6] (theoretical max. 90.7)	72.3	75.1	69.4	82.3	86.5	87.8
Environmental (8 PCA axes)[6] (theoretical max. 79.2)	46.3	53.1	44.5	62.2	60.4	65.9

The first classification based on 410 sites (TWINSPAN) offers a useful basis from which to assess the remaining classifications. Group size varied between 7 and 34 sites and 57.3% of the sites were placed into the 'correct' group using MDA equations on an internal test. Classifications 2-5 achieved a higher percentage of sites predicted to group, but the highest (classification 4) achieved this at the expense of very variable group size. Figure 3.1 shows, in histogram form, the gross differences between the first five classifications. Although Ward's fusion method generated one large group, it performed well against TWINSPAN on a number of the other criteria (Table 3.1).

However, it is still important to examine visually the manner in which the component sites are grouped within a classification. To this end Dr Moss has developed a procedure to generate maps based on the 410 sites with the capability of printing four classification groups per map (i.e. 6 maps required for each classification). These should prove useful in future comparisons.

Classifications 6 and 7 (PDIV and ALOC) generated the highest percentage of sites allocated to the 'correct' group but this was at the expense of having very uneven group sizes (1-149 and 1-129 respectively). This is the likely outcome when there are a small number of distinctive groups and the % correct figure would be very high in the absurd case where one group contained 387 sites and the remainder had just one site each. However, such classifications are unlikely to be useful for prediction of the fauna.

In general, the classifications resulting from various procedures after the initial use of Semi-Strong Hybrid multidimensional scaling (SSH) were also rather disappointing. There appeared to be overall improvement in performance from classifications 8 to 11 (3 to 6 dimensions and Ward's fusion method) and from classifications 12-15 (3 to 6 dimensions and K-mean clustering). However, neither classification 11 nor 15 showed a clear sign of improvement over classification 1 (TWINSPAN) or 5 (Ward's method).

In contrast, ordination using CANOCO followed by K-mean clustering, particularly when the initial ordination was based on the biological data plus the 14 environmental attributes (classification 17), produced results which in general compared favourably with classification 1 (TWINSPAN).

Although there is still a need to examine group composition in detail, some of these results are encouraging and give us useful pointers to the next stage of the investigation.

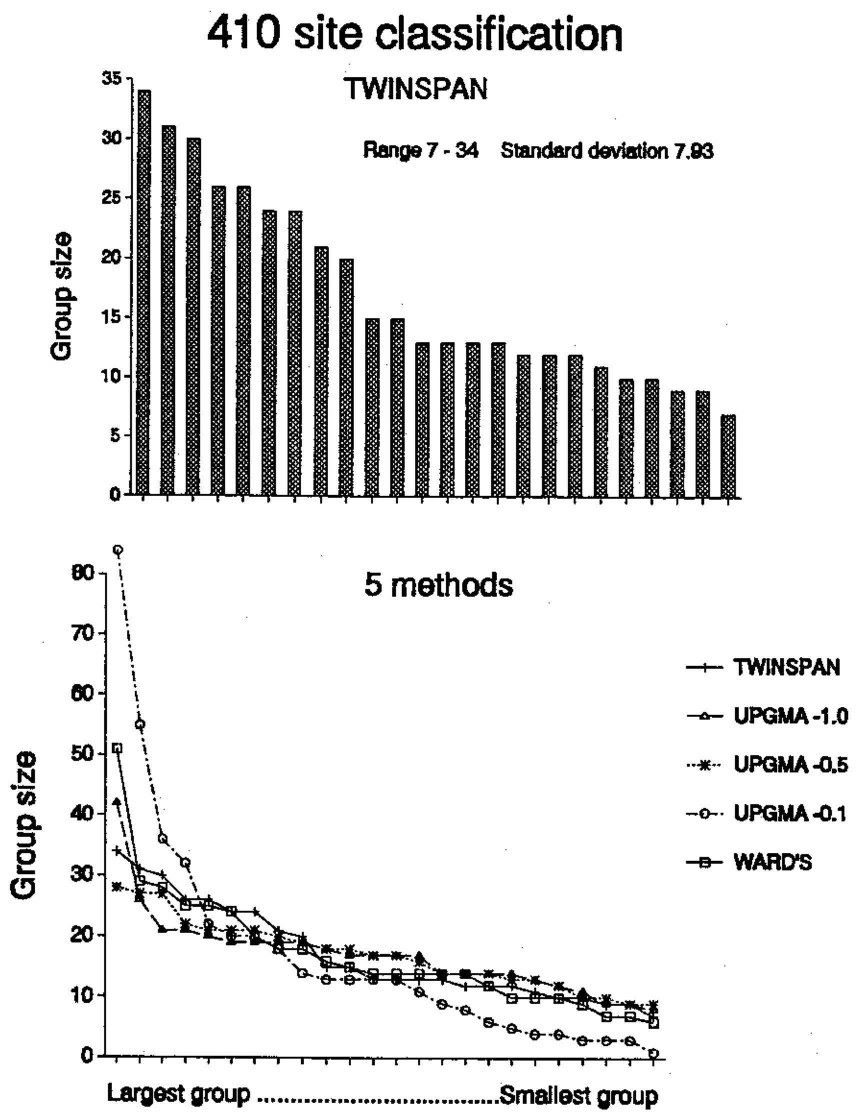

Figure 3.1 Histograms of group size for classifications 1-5 (see this page and next), together with the distribution of group sizes for the 5 classifications.

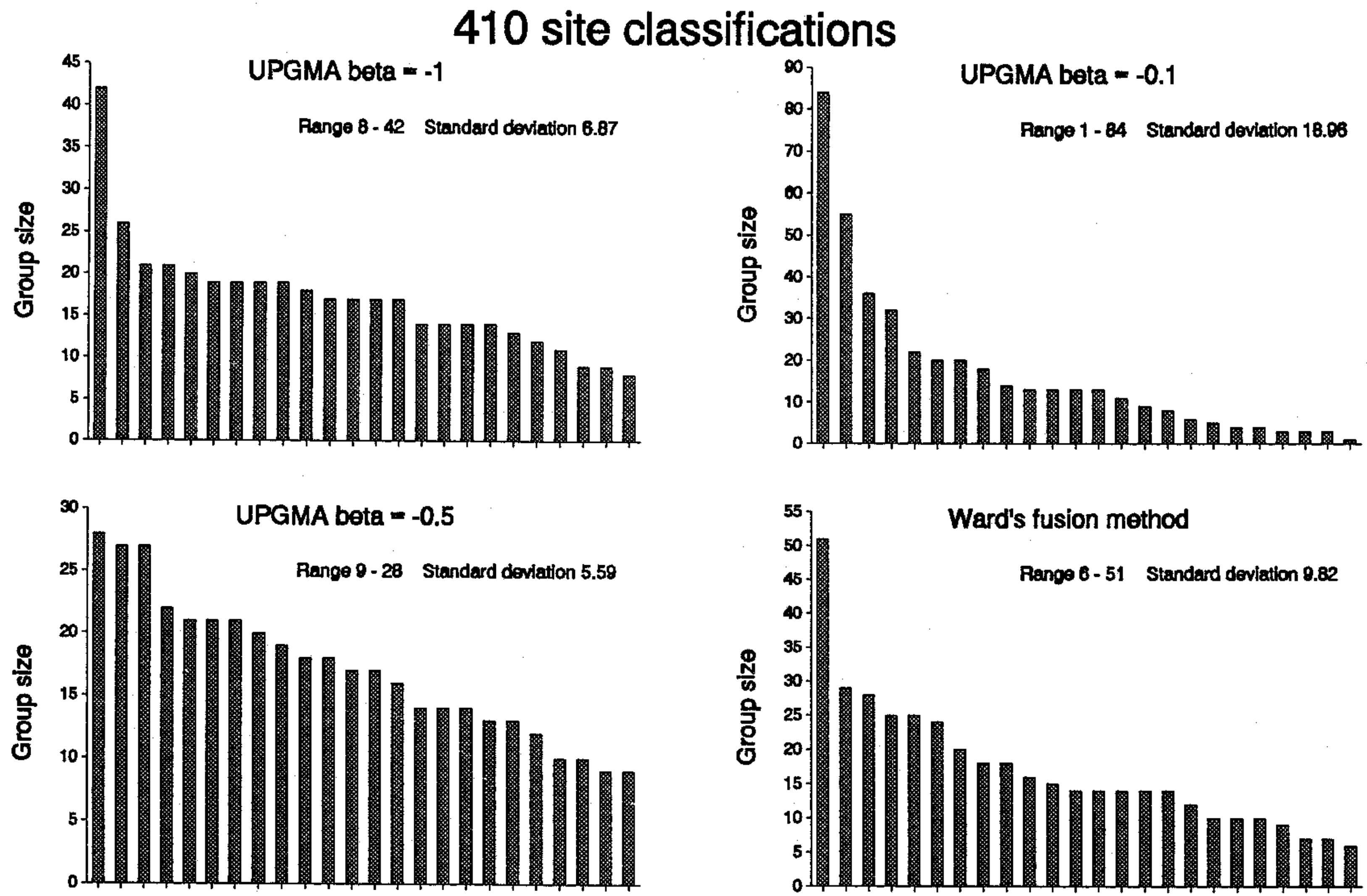

Figure 3.1 Continued

4. FINANCIAL STATEMENTS

This information will be made available by the IFE Finance Officer in due course.

5. FACTORS LIKELY TO AFFECT THE SATISFACTORY COMPLETION OF THE WORK

At present, sample processing is slightly ahead of schedule, examination of robustness is behind schedule and the work on alternative methods of classification and prediction is well on target.

I anticipate that we will continue to remain ahead of schedule on sample processing. On the assumption that this proves to be the case we will be well placed to undertake data logging and verification to ensure that the analyses leading to RIVPACS III can take place on schedule. I hope we will also find time to re-examine some specimens in the genus *Caenis* from the original 438 sites. This is because the recently recorded *C. pusilla* appears to be more widespread than originally recognized and a further species may also be present in Great Britain.

Examination of robustness will move ahead shortly and I see no reason why the interim report dealing with items i, iii and iv should not be delivered on time (end of September).

Similarly, further work on alternative methods of classification and prediction will progress over the next few months to ensure that the appropriate methodology is in place before it is required for RIVPACS III.

APPENDIX I. Amended listing of the 55 running-water sites in England and Wales chosen for sample processing at species level in each of three seasons.

REGION/RIVER	SITE	NGR	SPRING	SUMMER	AUTUMN
Anglian					
Gwash	Belmesthorpe	TF 042104	expect 93	28 Aug 90	13 Nov 90
Cringle Brook	Thunderbridge	SK 920287	5 Apr 90	17 Sep 90	16 Nov 90
Reach Lode	Hallards Fen Road	TL 557678	14 Mar 90	27 Jun 90	1 Oct 90
Monks Lode	Eternity Hall Bridge	TL 212858	2 May 90	2 Aug 90	30 Oct 90
16 Foot Drain	Horseways Corner	TL 421875	25 Apr 90	14 Aug 90	13 Nov 90
Rase	Bully Hills	TF 168918	20 Mar 90	17 Sep 90	30 Nov 90
Orford Beck	Kirmond Le Mire	TF 189926	20 Mar 90	17 Sep 90	30 Nov 90
Bain	Biscathorpe	TF 231849	8 May 90	17 Sep 90	30 Nov 90
Northumbria					
Till	Etal	NT 926395	5 Mar 90	20 Jun 90	14 Oct 90
Till	Chatton	NU 059299	11 May 90	19 Jul 90	24 Oct 90
Glen	Ewart	NT 955302	5 Mar 90	4 Jun 90	4 Oct 90
Glanton Burn	Rothill	NU 069126	8 Mar 90	14 Jun 90	5 Oct 90
Gate Burn	Framlington Gate	NU 118037	8 Mar 90	2 Jul 90	9 Oct 90
Kilton Beck	Lodge Wood	NZ 695160	16 Mar 90	9 Aug 90	12 Oct 90
Balder	U/S Balderhead Reservoir	NY 969195	16 May 90	17 Jul 90	14 Oct 90
College Burn	Hethpool	NT 896281	5 Mar 90	4 Jun 90	4 Oct 90
Harthope Burn	Coronation Wood	NT 973248	6 Mar 90	22 Jun 90	12 Oct 90
North West					
Lune	Old Tebay	NY 618056	23 Apr 90	31 Jul 90	17 Oct 90
Lune	Rigmaden	SD 616846	2 Apr 90	7 Aug 90	5 Nov 90
Lune	Forge Wear	SD 512646	21 Mar 90	23 Jul 90	18 Oct 90
Eden	Temple Sowerby	NY 604282	27 Mar 90	2 Aug 90	26 Oct 90
Eden	Appleby	NY 683206	20 Mar 90	2 Aug 90	23 Oct 90
Eden	Warwick Bridge	NY 470567	29 Mar 90	17 Jul 90	22 Oct 90
Waver	Waver Bridge	NY 223491	12 Mar 90	17 Jul 90	18 Oct 90
Severn-Trent					
Severn	Llandinam	SO 025885	30 Apr 90	expect 93	24 Oct 90
Severn	Isle of Bicton	SJ 468164	22 Mar 90	23 Aug 90	9 Nov 90
Sher Brook	Shugborough	SJ 988213	4 Apr 90	26 Aug 92	16 Oct 90

REGION/RIVER	SITE	NGR	SPRING	SUMMER	AUTUMN
Severn-Trent					
Bradgate Brook	Newton Linford	SK 523098	17 Apr 90	18 Jul 90	29 Oct 90
Derwent	Baslow	SK 252722	17 May 90	22 Aug 90	18 Nov 90
Derwent	Cromford Meadows	SK 301572	expect 93	13 Aug 92	8 Jan 93
Wye (Derwent trib.)	Ashford	SK 194690	26 Apr 90	1 Aug 90	5 Nov 90
Southern					
Ditton Stream	Ditton	TQ 710585	19 Mar 90	4 Jul 90	19 Oct 90
Sutton Stream	Road Bridge	SU 986175	2 May 90	15 Aug 90	19 Oct 90
South-West					
Bodilly Stream	Bodilly Bridge	SW 670318	19 Mar 91	13 Jun 91	3 Sep 91
Newlyn River	Skimmel Bridge	SW 433302	1 Mar 90	5 Jun 90	expect 93
Bala Brook	100 m U/S Zeal Bridge	SX 678625	26 Apr 90	25 Jul 90	16 Oct 90
Poltesco River	Poltesco Bridge	SW 724157	15 May 90	8 Jun 90	11 Sep 90
Stithians Stream	Seauraugh Moor	SW 734374	9 Nov 90	13 Jun 90	20 Sep 90
Trevaylor Stream	Trythogga	SW 476318	2 Mar 90	5 Jun 90	5 Sep 90
Gweek River	Mether-Uny-Mill Bridge	SW 704292	7 Mar 90	13 Jun 90	18 Sep 90
Manaccan River	Polkanoggo	SW 755222	6 Mar 90	11 Jun 90	11 Sep 90
St Keverne Stream	Porthoustock Bridge	SW 805218	6 Mar 90	11 Jun 90	expect 93
Thames					
Kennet	U/S Aldershot Water	SU 544659	17 May 90	28 Aug 90	24 Oct 90
Lambourn	Bagnor	SU 453691	6 Mar 90	7 Aug 90	16 Nov 90
Lyde	Deanlands Farm	SU 696542	21 Mar 90	2 Jul 90	14 Sep 92
Coln	Fosse Bridge	SP 081112	28 Mar 90	5 Jun 90	5 Sep 90
Windrush	D/S Dickler	SP 178177	26 Mar 90	6 Jul 90	26 Sep 90
Clayhill Brook	U/S Burghfield STW	SU 655684	5 Apr 90	3 Jul 90	22 Nov 90
Ash	Easneye	TL 377133	26 Mar 90	18 Jun 90	25 Sep 90
Chess	U/S R. Colne	TQ 066943	2 Apr 90	3 Jul 90	10 Oct 90
Welsh					
Cynfal	Pont Newydd	SH 140409	27 Mar 90	12 Jul 90	2 Oct 90
Seiont	Pont Y Gromlech	SH 628568	29 Mar 90	12 Jul 90	25 Sep 90
Caseg	Braichmelyn	SH 630663	28 Mar 90	13 Jul 90	24 Oct 90
Braint	Pont Mynach	SH 455668	27 Mar 90	6 Jul 90	25 Sep 90
Morlas Brook	D/S Glyn Morlas	SJ 312381	9 Apr 90	19 Jul 90	17 Oct 90

Testing and further development of RIVPACS - Phase 2

Activity Schedule

	1992-93				1993-94				1994-95				1995-96			
1. Evaluation of additional procedures to enhance the robustness of RIVPACS, including further examination of the 1990 RQS data																
See Methods section a) items i, iii, iv			x	x	x											
item v						x	x	x								
Incorporation of developments under items i, iii-v into RIVPACS III									x							
2. Further development of RIVPACS																
a) Selection and processing of samples from new sites																
Retrieval of samples from storage		x														
Full processing of samples from 50 sites (150 samples)			x	x	x	x	x	x								
Oligochaetes and chironomids from 20 sites (60 samples)					x	x	x	x								
b) Examination of alternative methods of classification and prediction			x	x	x	x	x									
Final tests on RIVPACS III data-set									x							
c) Data collation and analyses leading to RIVPACS III																
Data logging and verification							x	x								
Development of RIVPACS III software									x							
Writing of RIVPACS III manual									x							
3. Reporting																
Interim report on 1, items i, iii, iv						x										
Delivery of draft manual and RIVPACS III software									x							
Draft Project Record										x						
Project Record											x					
Draft R&D Report										x						
R&D Report											x					
4. Workshop for regional biologists											x					
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