The development of the Big Pond Dip invertebrate survey method

Pond Conservation

For Life in Fresh Waters

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1. Introduction

The Big Pond Dip invertebrate survey is a simple biological quality assessment method, designed for use by the wider public, which assesses the overall 'naturalness' of ponds. It has been developed from the methods used for the National Pond Survey and the PSYM system (Williams *et al.* 1996, Williams *et al.* 1998, Biggs *et al.* 2000) which are used by professional biologists to assess pond ecological quality. Although specifically developed for garden ponds, the Big Pond Dip methods can be applied to any pond or lake up to 5 ha in area. Limited testing of the method on lakes indicates that it also reflects adequately lake invertebrate species richness on waterbodies up to about 50 ha.

A high score on the Big Pond Dip indicates that a pond supports animals typical of high quality waterbodies. Ponds with lower scores are likely to be in poorer condition, and not reaching their full potential, because of the impact of one or more stressors (e.g. water pollution, poor habitat structure, unnaturally high fish densities).

The Big Pond Dip score was first developed and used by Pond Conservation in 2009. It has been applied with minor modification for the invertebrate part of the OPAL Water Survey in 2010.

This report summarises the main technical features of the Big Pond Dip and the three main stages in developing the method:

(i) selecting a potential set of easy-to-identify animals to include in the method

(ii) making a final selection of animals that was statistically related to the level of environmental stress affecting ponds.

(iii) testing the index on the National Pond Survey dataset, and on an independent garden pond dataset, to check that it reflected overall variation in pond degradation and pond quality.

2. Methods for assessing pond quality in the UK

The standard UK method for assessing pond quality is the PSYM system, the Predictive System for Multimetrics. PSYM (pronounced 'sim') is a reference-based system that assesses pond and small lake ecological integrity or quality (Pond Conservation and the Environment Agency 2000). In PSYM a prediction of the expected fauna, assuming the pond to be unimpaired, is made from a database of minimally impaired reference sites using simple environmental measurements (e.g. pond area, substrate, vegetation cover etc). The predicted fauna is compared with the observed fauna and the degree of difference between the two used to indicate how close the pond is to its unimpaired state.

It was not possible to use PSYM for the Big Pond Dip because: (a) it requires about a day to survey each pond, and surveyors need a considerable amount of training and practice

to get reliable results and (b) because the NPS database has too few small ponds, the main focus of the Big Pond Dip, to make reliable predictions of their expected fauna. The lack of baseline species level data from such small ponds (i.e. less than 25 m^2) also precluded the development of a new, small-pond specific, version of PSYM for garden ponds.

For the Big Pond Dip, therefore, an approach was developed which is more analogous to a traditional biotic index in which organisms are used as indicators of specific environmental stresses. In such approaches, including the UK's Biological Monitoring Working Party system, the continental European Saprobic system or the North American Family Biotic Index developed by Hilsenhoff (see Williams *et al.* 1996), animals are first scored according to their sensitivity to pollution and then a total waterbody score calculated by adding together the scores for the individual animal groups (typically families) present. This then indicates the level of 'pollution', according to which animals are present in (or absent from) the sample. Unpolluted sites have a good range of animals typical of unpolluted conditions whereas polluted sites have few or no such animals.

Many biological pollution indices using invertebrates effectively assess the extent of organic pollution, although such indices also respond to habitat quality, eutrophication and other stressors, including acidification and pesticide contamination (Beketov *et al.* 2009).

The Big Pond Dip assesses the overall 'naturalness' of the ponds rather than the concentration of a specific pollutant. It does this because it is based on the relationship between invertebrate occurrence and a metric developed in the National Pond Survey called Overall Pollution Index.

Overall Pollution Index is a metric which summarises the overall exposure of a pond to all major stressors potentially damaging pond ecosystems. The index is, in fact, slightly misnamed as it does not just deal with 'pollution' but considers all major stressors affecting ponds including land-use intensity in a 100 m zone around the pond, the presence of road and urban runoff, the presence of piped point sources, the impact of livestock and the impact of biological stressors, particularly fish stocking and waterfowl density.

The Overall Pollution Index is scored on a 0 to 10 scale by expert judgment in the field, where 0 equals no stressors and 10 equals a high level of stress. Minimally impaired reference sites should have low Overall Pollution Index values in the range 0 – 2, indicating the most 'natural' sites. Very highly impacted sites have Overall Pollution Index scores of 8 or above.

In the National Pond Survey database all Overall Pollution Index measurements were made by a single, highly experienced, person, so are internally consistent. In a wide range of tests OPI has proved to be the metric most strongly correlated with biological assemblage quality.

The relationship between invertebrate presence and Overall Pollution Index was used at two stages in the development of the Big Pond Dip: first to develop a set of scores for the animals indicating their association with pond naturalness, and secondly to provide an independent verification of the overall response of the Big Pond Score to pond quality. These two steps are discussed further below.

3. Selection of a potential set of animals

When selecting animals to include in the Big Pond Dip, four factors were taken into account:

(i) the animals selected should include groups which, at the taxonomic level recorded, showed statistically significant responses to pond quality.

(ii) there should not be too many groups included in the index and they should be recognizable to most people, or not too difficult to learn.

(iii) broadly, the selection of animals should represent all the major macroinvertebrate groups present in ponds. However, a small number of additional groups were specifically *included* because they are distinctive and well-known to people (e.g. pond skaters, backswimmers). Smaller invertebrates (e.g. zooplankton) were not included because they have not been used in developing the National Pond Survey/PSYM methods and lacked reliable baseline data.

(iv) 'worm-like' creatures (flatworms, leeches, true worms and fly larvae) were included as a single group because some of these animals are likely to be present in every pond and people often have trouble distinguishing one kind from another. As these groups could not be included at a taxonomic level of sufficient detail (e.g. genus, species) to discriminate habitat quality, there is no loss of information taking this approach.

This selection process led to the selection of an initial 'long-list' of animal groups, and combinations of groups, which could be recorded (note that the groups are not all mutually exclusive). These were:

- Flatworms
- All water snails
- Spired snails
- Ram's-horn snails
- Limpets
- Bivalves
- Leeches
- Shrimps, slaters and crayfish
- Crayfish
- Water slater
- Freshwater shrimps
- Mayflies
- Stoneflies
- Dragonflies + damselflies
- Dragonflies
- Damselflies
- Water bugs
- Pond skaters
- Water scorpions
- Backswimmers
- Lesser water boatmen
- Water beetles
- Diving beetles
- Scavenger beetles
- Whirligig beetles
- Alder flies
- Caddis flies

This list was then refined by excluding groups which were unlikely to be seen by people, or were likely to be too infrequent in garden ponds to make it worth attempting to record them (e.g. stoneflies, crayfish). We considered specifically listing distinctive animals, like the water scorpion (*Nepa cinerea*) and water stick insect (*Ranatra linearis*), but, because they would be recorded too infrequently, and also because they do not convey much information about pond quality, eventually lumped them all together as water bugs.

4. Making a final choice of animals for the index

Screening of the long-list of animals left the following twelve groups which were then tested in more detail:

- Flatworms + Leeches + Worms + Diptera larvae
- Water slaters
- Freshwater shrimps
- Snails
- Mayflies
- Pond skaters
- Water bugs
- Water beetles
- Damselflies
- Dragonflies
- Alder flies
- Caddis flies

Initial exploratory analysis indicated that the strongest correlation between the occurrence of animals and pond quality, assessed using the Overall Pollution Index, was seen with a subset of these animals comprising dragonflies, damselflies, water beetles, alderflies and caddis. This reflected well-known trends in pond quality metrics: number of dragonfly, damselfly and alderfly families and number of water beetle families are both PSYM metrics. Caddis flies include a number of groups widely recognised as sensitive to pollution stress.

Other groups responded less strongly, or negatively, at the taxonomic levels recorded, to pond quality: flatworms + leeches + true worms + Diptera larvae, water snails, water slaters, freshwater shrimps, mayflies, pond skaters, backswimmers and lesser water boatmen. This again reflected well-known relationships as all of these groups include species of relatively low sensitivity to common environmental stressors. For example mayflies, although one of the three most pollution sensitive groups in rivers, are typically represented by only one or two more degradation tolerant species in ponds. Thus the most widespread pond mayfly is the Pond Olive (*Cloeon dipterum*) which is commonly found in both good and poor quality ponds, and is also one of the two most widespread animals in garden ponds, found in about 50% of all pond sites (Pond Conservation unpublished data).

5. Developing the scoring system

To develop the 'naturalness' scores associated with each major animal group the mean Overall Pollution Index value that each invertebrate group was associated with was first established.

For each major group of animals the Overall Pollution Index value of the ponds in the National Pond Survey database in which that group was found was calculated. This was done using both the minimally impaired and variably degraded pond sites in England and Wales of the National Pond Survey (n=310, approximately half the sites were minimally impaired and half variably degraded).

This was the same dataset as used to develop the PSYM system. Mean Overall Pollution Index scores for each major animal group ranged from 2.21 (damselflies) to 2.87 (flatworms + leeches) (Table 1). The Overall Pollution Index score for each animal group was the mean value of the Overall Pollution Index for all ponds where that group was found. For example,

flatworms + leeches and damselflies occurred, respectively, in 199 and 185 of the 310 ponds in the database. The more degradation tolerant flatworms + leeches were found in a large proportion of damaged ponds: 55% of sites had OPI values greater than 3.5. In contrast, only 30% of sites with damselflies had OPI values greater than 3.5.

Overall, the analysis indicated that animals could be grouped into three broad categories reflecting sensitivity to pond quality:

- High sensitivity: dragonflies, damselflies, alder flies and caddis flies
- Medium sensitivity: mayflies, pond skaters, water beetles, water bugs, freshwater shrimps
- Low sensitivity: water snails, water slaters and flatworms + leeches

Table 1. The mean Overall Pollution Index scores for twelve major invertebrate groups derived from National Pond Survey minimally impaired and variably degraded pond sites (n=310)

Invertebrate group	Mean Overall Pollution Index	Indicative of high, medium or low pond quality
Dragonflies	2.18	High
Damselflies	2.20	High
Alder flies	2.32	High
Caddis flies	2.33	High
Pond skaters	2.64	Medium
Water beetles	2.65	Medium
Water bugs (excluding pond skaters)	2.70	Medium
Mayflies	2.70	Medium
Freshwater shrimps	2.74	Medium
Water snails	2.79	Low
Water slater	2.81	Low
Flatworms + Leeches	2.84	Low

Having identified three broad groups of animals - high, moderate and low sensitivity - each group was allocated a sensitivity score as the basis for calculating the Big Pond Dip score. High quality groups (i.e. damselflies, dragonflies, alderflies, caddis flies) were scored 10, medium quality groups were scored 5 and low quality groups were scored 1. The objective

of this weighting of the scoring system was to emphasise the extent to which ponds achieve high biological quality (Table 2).

Table 2. The scores allocated to each animal group included in the Big Pond Dip

Group	Score
Caddis larvae	10
Alderfly larvae	10
Dragonfly larvae	10
Damselfly larvae	10
Water beetles (adult and larvae)	5
Water bugs (excluding pond skaters)	5
Pond skaters (adults or nymphs)	5
Mayfly larvae	5
Freshwater shrimps	5
Water slaters	1
Water snails	1
'Wigglies' (worms, fly larvae, leeches)	1

A simple test of the scoring system was then undertaken to assess its ability to discriminate ponds of different quality.

The mean Overall Pollution Index for all ponds with high sensitivity animals groups was compared with the mean pond score for all ponds with medium sensitivity animals and the mean pond Overall Pollution Index score for ponds with low sensitivity animals (Figure 1).

The results showed that on average, 'low quality' animals were associated with ponds that had the lowest habitat quality (i.e. high Overall Pollution Index). Medium sensitivity animals were associated with intermediate pollution index scores and 'high quality' animal groups were associated with the highest quality ponds (i.e. low Overall Pollution Index scores). Differences in Overall Pollution Index scores between ponds with low, moderate and high sensitivity animals were all statistically significant.

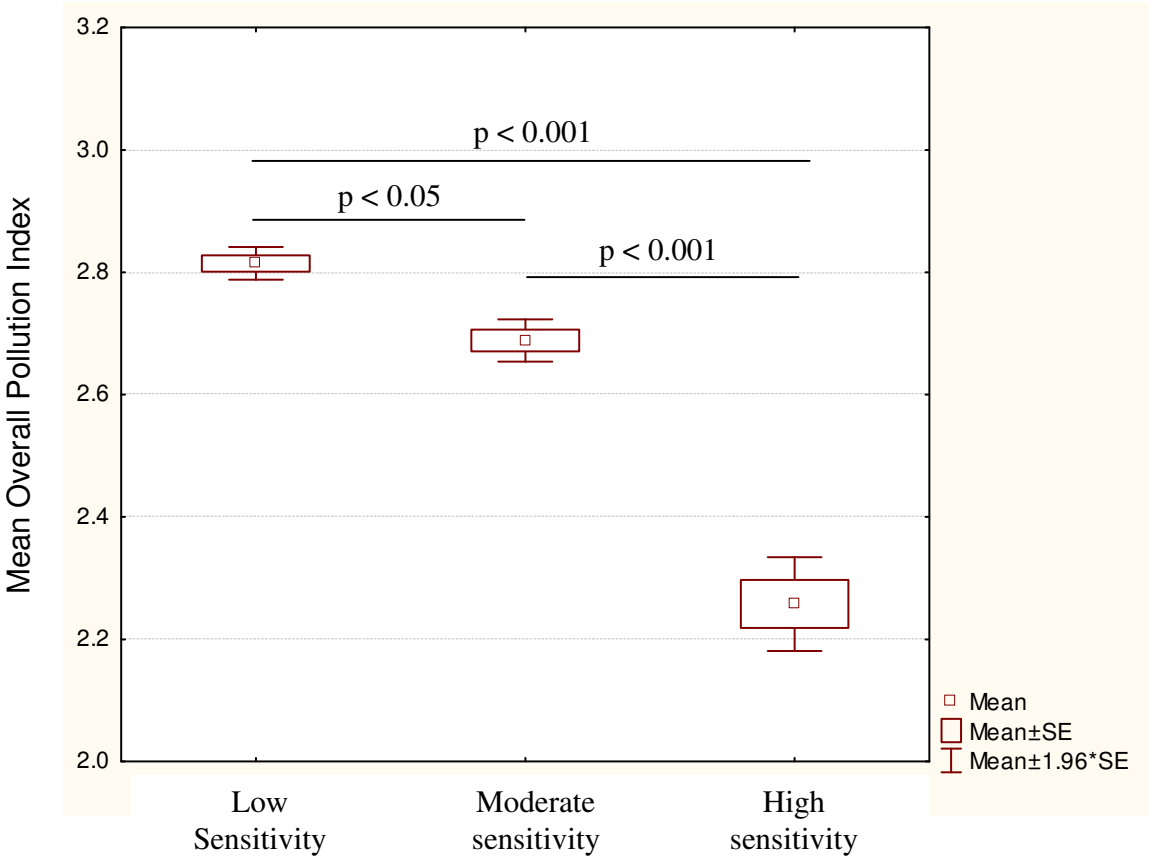

Figure 1. Mean Overall Pollution Index scores for all high, medium and low sensitivity invertebrate groups used in the Big Pond Dip at National Pond Survey sites. Horizontal bars indicate values that are significantly different (Scheffé post-hoc text of differences between groups).

6. Testing the index

The effectiveness of the Big Pond Dip index was tested in three ways:

(i) using the National Pond Survey dataset to determine whether Big Pond Dip scores were related to Overall Pollution Index values throughout the full range of OPI scores;

(ii) assessing the extent to which Big Pond Dip scores matched real patterns of aquatic invertebrate biodiversity in garden ponds.

(iii) assessing the extent to which Big Pond Dip scores reflected the quality of lowland gravel pit lakes, measured as the number of invertebrate species recorded

6.1 Relationship between Big Pond Dip score and Overall Pollution Index

The relationship between Overall Pollution Index and Big Pond Dip index was investigated for all National Pond Survey minimally impaired and variably degraded sites (n=310). An index value, rather than a score, was used in this analysis because index values have less inherent variability than scores. The index is simply the Big Pond Dip score divided by the number of taxa.

For each Overall Pollution Index category (0-10) the mean Big Pond Dip index value was calculated for ponds in that pollution category. Values varied from 5.21 for sites with 0 values of OPI to 3.0 for the one site that had an Overall Pollution Index of 9 (Figure 2).

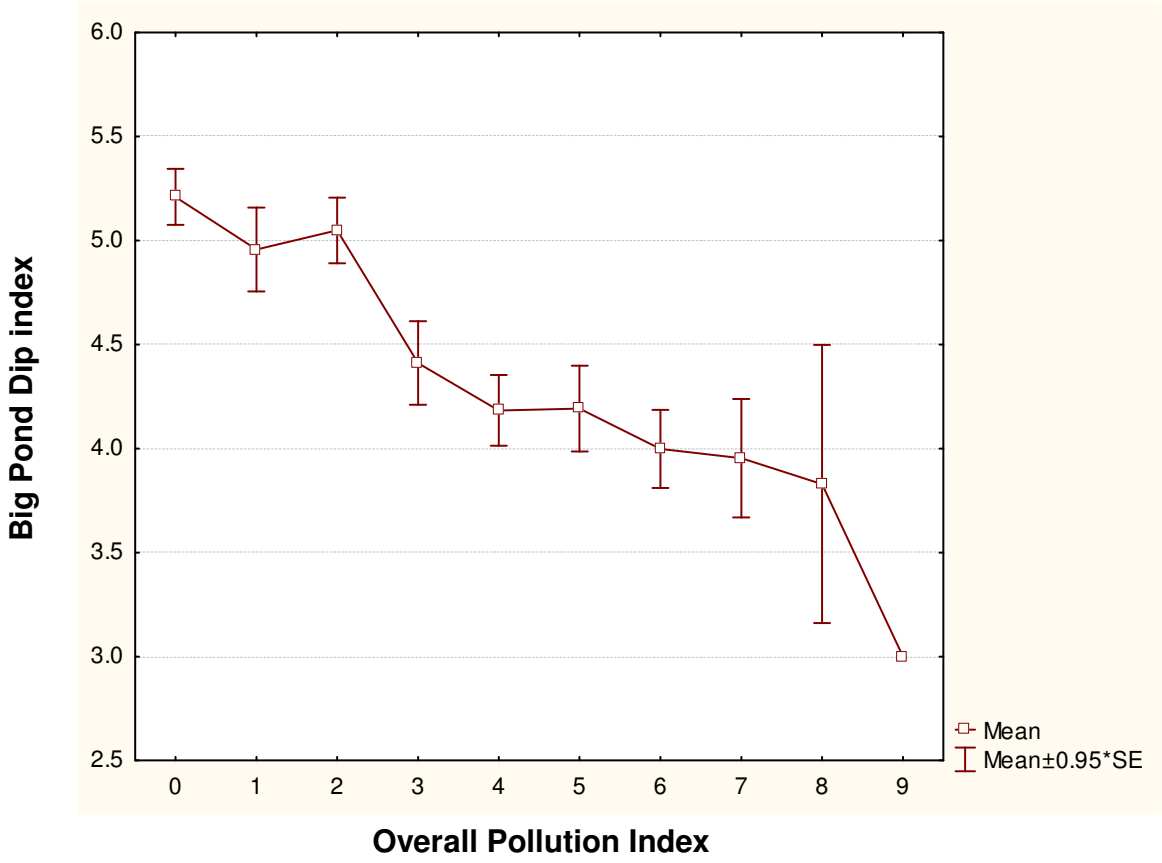

Figure 2. The relationship between Overall Pollution Index and Big Pond Dip index values. There is a significant correlation between Overall Pollution Index and Big Pond Dip Index (Spearman R = -0.39; p < 0.001)

The analysis indicated that there was a good correlation (Spearman R = -0.39, p<0.001) between the Big Pond Dip score and the naturalness of the pond, as indicated by the Overall Pollution Index.

6.2 The relationship between Big Pond Dip scores and invertebrate species richness in garden ponds and lakes

The relationship between the Big Pond Dip score and species richness in garden ponds was also investigated. Ponds were surveyed using standard National Pond Survey methods during autumn 2009 (Pond Conservation, unpublished data).

The results show a very strong correlation between Big Pond Dip score and the number of macroinvertebrate species found in ponds (Spearman R = 0.88, p<0.001; Figure 3).

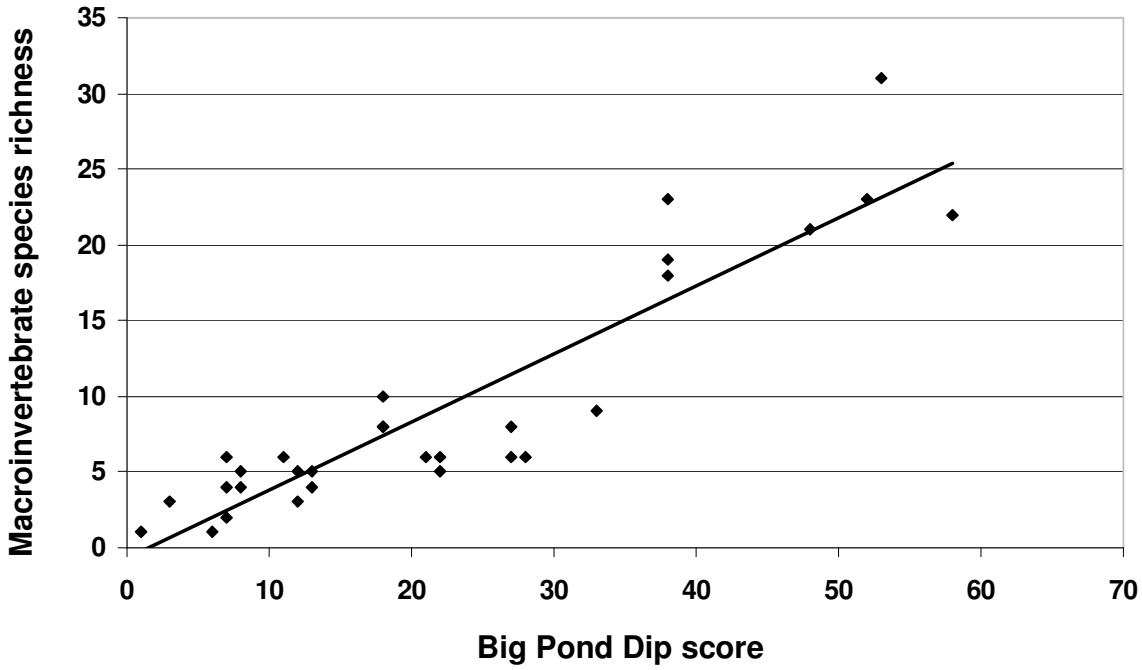

Figure 3. The correlation between Big Pond Dip score and number of aquatic invertebrate species seen in Abingdon garden ponds

6.3 The relationship between Big Pond Dip scores and the quality of lowland gravel pit lakes

Big Pond Dip scores were also calculated for a set of 33 gravel pit lakes in south central England, up to about 50 ha in area and compared to the total number of aquatic macroinvertebrate species seen in standard 3 minute samples from the lakes.

There was a good correlation between Big Pond Dip scores and lake species richness (Spearman R = 0.86, p<0.001; Figure 4).

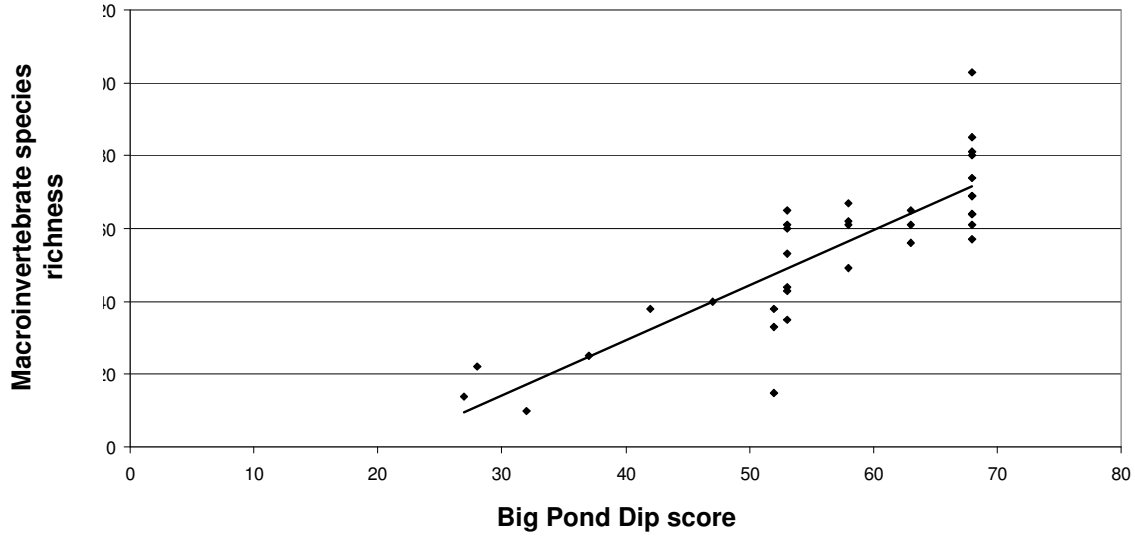

Figure 4. The correlation between Big Pond Dip score and number of aquatic invertebrate species seen in gravel pit lakes in the Thames Valley

5. Interpretation of the Big Pond Dip score

In the first year of the Big Pond Dip, scores were set to indicate whether ponds were fulfilling their potential. Three categories were used to help participants interpret their results, shown below:

- Score less than 5: 'Your pond could be improved for wildlife'
- Score 5-25 'Your pond is good but you could make it even better'
- Score more than 25 'Your pond is really good'.

These three categories were chosen to make the results, even in relatively poor ponds, reasonably encouraging. For the OPAL water survey in 2010 the scoring bands were modified slightly in the light of the first year's Big Pond Dip experience: 0-5: pond or lake could be improved; 6-30: the pond or lake is quite healthy; 31 or more: the pond or lake is very healthy.

Examining the results from the first year of the survey (Pond Conservation, unpublished data) suggests that a further division of the range of the scores, which run from 0 to 68, into four bands of equal width would assist in interpretation of the results. The revised scoring system, which will be used in detailed interpretation of the results of the 2009 Big Pond Dip and could be applied after the event in OPAL 2010, are shown in Table 3. Preliminary analysis of 2009 data show that only 10% of the ponds fell into the top category indicating waterbodies that reached their full potential.

Table 3. The banding of Big Pond Dip scores to be used for detailed analysis of 2009 survey results

Quality band	Score
Low quality	0-17
Moderate quality	18-34
Good quality	35-51
Excellent quality	52-68

References

Biggs J, Williams P, Whitfield M, Fox G, Nicolet P. 2000. *Biological techniques of still water quality assessment. Phase 3. Method development*. R&D Technical Report E110, Environment Agency, Bristol.
Available here: http://publications.environment-agency.gov.uk/epages/eapublications.storefront/4bdd3d2b0057a5e4273fc0a80296067e/Product/View/STRE110&2DE&2DE

Beketov MA, Foit K, Schafer RB, Schriever CA, Sacchi A, Capri E, Biggs J, Wells C, Liess M (2009). *Environmental Pollution*, 157: 1841-1848.

Pond Conservation and the Environment Agency (2000). *A guide to monitoring the ecological quality of ponds and canals using PSYM*. Pond Action, Oxford.
Available here:
http://www.pondconservation.org.uk/Resources/Pond%20Conservation/Documents/PDF/NPMN_PSYM_MANUAL_July09.pdf

Williams P, Biggs J, Dodds L, Whitfield M, Corfield A, Fox G. 1996. *Biological techniques of still water quality assessment. Phase 1 Scoping Study*. R&D Technical Report E7, Environment Agency, Bristol, UK.
Available here:
http://www.pondconservation.org.uk/aboutus/ourwork/publicationsandreports/surveyconferenceandtechnicalreports

Williams P, Biggs J, Whitfield M, Corfield A, Fox G, Adare K. 1998. *Biological techniques of still water quality assessment. Phase 2. Method development*. R&D Technical Report E56, Environment Agency, Bristol.
Available here: http://publications.environment-agency.gov.uk/epages/eapublications.storefront/4bdd3d2b0057a5e4273fc0a80296067e/Product/View/STRE56&2DE&2DE#