Leibniz-Institut für Gewässerökologie und Binnenfischerei
im Forschungsverbund Berlin e.V.

Abt. Limnologie von Flussseen, Müggelseedamm 301, 12561 Berlin, Germany, garcia@igb-berlin.de

Selecting Potential Type-Specific Lakes of Reference in Implementing the EU-Water Framework Directive

Xavier-F. Garcia Mario Brauns Martin Pusch Norbert Walz

Outline

The Water Framework Directive (WFD-Directive 2000/60/EC) imposes a new method for the ecological assessment of lakes in Europe. This method proposes to compare actual ecological conditions with type-specific reference conditions previously described for each type of lake. However, the current strong ecological degradation of most of the aquatic ecosystems in Europe makes undisturbed lakes of reference difficult to locate. This is especially true for the riverine lakes, which are connected with a river network.

According to recent discussion in official EU-working groups, lakes of reference should be defined as the less disturbed as possible for a given type, and not only as lakes exhibiting pristine conditions. Consequently a statistical method has to be established which enables to identify such reference lakes. In this poster, we present a multivariate method developed using a data-base of benthic macroinvertebrates collected in 31 lakes from Brandenburg (NE Germany).

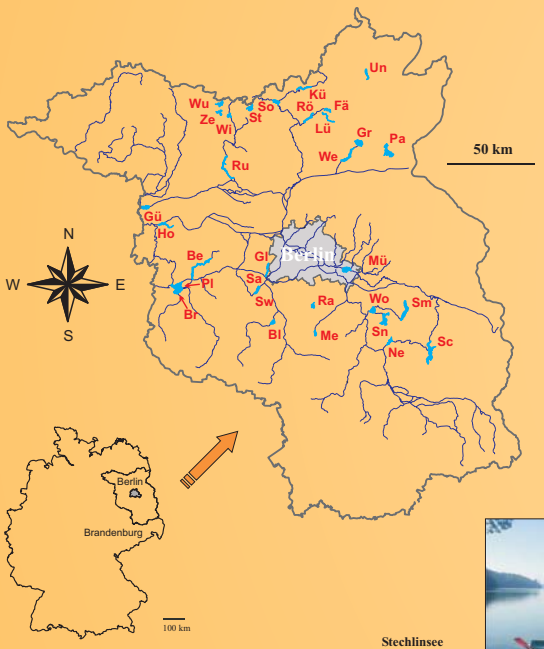
Method developed in the WFD

The WFD obliges to assess the level of degradation of lakes according to changes in comparison to type-specific reference conditions. Thus, four working steps are required:

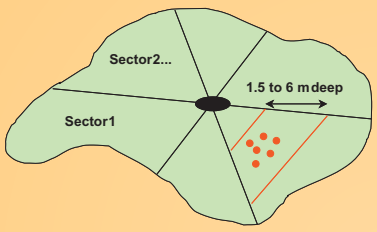
1) Define the lake types according to the geographical and morphological characteristics of the lakes. Additionally, it has to be demonstrated that each type is colonized by a specific faunistic assemblage indicative for that type.
2) Identify the undisturbed or less disturbed type-specific lakes of reference.
3) Describe the type-specific reference conditions, including faunistic assemblage, diversity, hydromorphology and physico-chemistry.
4) Assess the level of degradation of lakes according to five imposed ecological status: High, Good, Moderate, Poor and Bad. Specific metrics have to be developed to assign the lakes to these status.

Sampling location and methods

31 Brandenburg lakes prospected in two seasons
Benthic macroinvertebrate collections
Autumn 2000 - Spring 2001



Lakes divided into 6 sectors
Sampling with 6 replicates per sector
Infraprofundal to littoriprofundal zone



Sediment samples taken with an Ekman-Birge grab sampler, and sieved directly in the field with a net of 355 µm mesh size

Faunistic outputs		
Species	261	Specimens
Families	58	193 000
Genera	131	

Definition of lake types (Working Step 1)

The annex II of the WFD provides a set of obligatory and optional factors to be used for creating a typology (Table 1).

The 31 studied lakes shared common geomorphological characteristics as follows:

- ✓ **Ecoregion : Central plains**
- ✓ **Altitude : < 200 m**
- ✓ **Surface area : 1-10 km²**
- ✓ **Geology : Calcareous**

As types have also to show specific biological characteristics, the influence of each factor on the composition of the species assemblages was tested for validation using a discriminant analysis.

Finally, 5 factors subdivided into 3 modalities each were selected for creating the typology (Table 2).

Four lake types were finally identified using a cluster analysis on abiotic factors (Fig. 1).

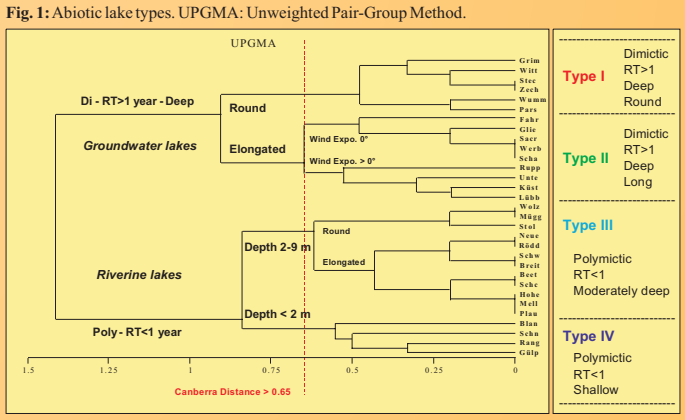
Table 1: Annex II of the WFD.

Type characterisation	Obligatory factors	Optional factors
Physical and chemical factors that determine the characteristics of the lake and hence the biological population structure and composition	Altitude Latitude Longitude Maximum water depth Geology Size	Mean water depth Lake shape Residence time Mean air temperature Air temperature range Mixis characteristics Acid neutralising capacity Background nutrient status Mean substratum composition Water level fluctuation

Table 2: Factors and modalities used for creating the typology.

Mean Depth (m)	Residence Time (years)	Mixis Type	Shape (L / W)	Wind Exposure (° / SW)
<2	<1	Polymictic	Round	0
2-9	1-5	Monomictic	Oval	45
>9	>5	Dimictic	Long	90

Fig. 1: Abiotic lake types. UPGMA: Unweighted Pair-Group Method.



Identification of the type-specific lakes of reference (Working Step 2)

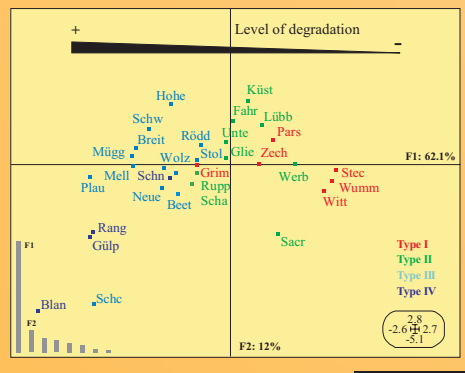


Fig. 2: Canonical correspondance analysis (CCA). 136 taxa - 11 abiotic variables. The lakes are spread along a gradient of degradation (F1). Each lake is ordinated by comparison to the less disturbed one (Stechlinsee) without any consideration of the type.

Table 3: Significance of each explanatory variable in the CCA. Variables reflecting the level of eutrophication of the lakes are more correlated to the first axis than variables reflecting their hydro-morphological characteristics.

Expl. Variables	Correlation/F1	Correlation/F2
Secchi Depth	**0.77**	0.04
Conductivity	**-0.67**	0.25
Mixis Type	**0.65**	-0.26
Residence Time	**0.64**	-0.25
Phosphor	**-0.61**	-0.01
Chla	**-0.61**	**-0.44**
Mean Depth	**0.53**	-0.13
pH	0.32	-0.13
Alkalinity	-0.22	**0.44**
Shape	-0.03	**0.40**
Wind Exposure	0.01	**0.38**

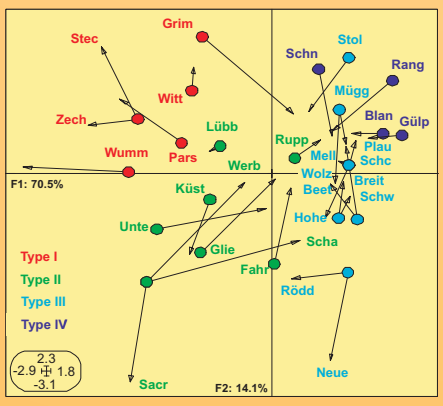


Fig. 3: Co-Inertia analysis (CoI). 136 taxa - 11 abiotic variables. Circles : position of lakes according to their types, Arrows : position of lakes according to their faunal assemblages. Lakes are ordinated according to their level of degradation, nevertheless under the constraint of the type.

A Canonical Correspondance Analysis (CCA) was used to built a lake typology based on the benthic invertebrate assemblages (Fig. 2). The CCA shows that lakes are ordinated along the first axis (F1), interpreted as an axis of degradation. However, the CCA plot is not practical to identify the lakes of reference for each type, because the level of eutrophication mainly influences the structure and the composition of the faunal assemblages (Table 3). The identification of lakes of reference is supported by a Co-Inertia Analysis (CoI) which relates the abiotic and the faunistic data sets (Fig. 3). In the CoI it can be seen that the arrows of the disturbed lakes are directed towards the same subarea of the factorial plan, due to the paucity and the similarity of their faunal assemblages. In contrast, arrows of lakes harbouring unique and diversified faunal assemblages escape this area. Such lakes can be considered as type-specific lake of reference (Table 4).

Table 4: Comparison of the ecological status of the 31 studied lakes defined by the CoI with their faunistic diversity. Potential type-specific lakes of reference in bold.

Type	Lake	Ecological status	Diversity (Log series
I	**Stec**	**High**	**8.8**
I	**Wumm**	**High**	**8.4**
I	**Pars**	**High**	**7.8**
I	**Zech**	**High**	**7.8**
I	Witt	Moderate	6.5
I	Grim	Poor	5.1
II	**Küst**	**High**	**9.2**
II	**Lübb**	**Good**	**6.8**
II	**Sacr**	**Good**	**5.4**
II	Werb	Moderate	7.7
II	Fahr	Moderate	7.6
II	Unte	Moderate	6.4
II	Glie	Moderate	6.2
II	Rupp	Bad	5.3
II	Scha	Poor	4.5
III	**Rödd**	**High**	**7.1**
III	**Neue**	**High**	**6.8**
III	Stol	Moderate	7.9
III	Hohe	Moderate	4.7
III	Schw	Bad	5.5
III	Wolz	Bad	5.1
III	Mell	Bad	3.9
III	Mügg	Bad	3.9
III	Plau	Bad	3.5
III	Beet	Bad	2.9
III	Breit	Bad	2.5
III	Schc	Bad	2.2
IV	Gülp	Bad	3.2
IV	Schn	Bad	2.2
IV	Rang	Bad	1.8
IV	Blan	Bad	1.3

Conclusions

The example of the 31 lakes of Brandenbourg clearly illustrates that in many cases it will be impossible to find type-specific lakes of reference exhibiting pristine conditions. This is especially true for riverine lakes influenced by the general eutrophication of the European rivers. As an alternative, lakes harbouring unique and diversified benthic faunal assemblages have to be considered as potential lakes of reference even if they not exhibit pristine conditions. Co-inertia analysis can serve to identify such a lakes.

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