

**ICES Passive sampling trial survey for water and sediment (PSTS) 2006 – 2007.
Part 3: Preliminary interpretation of field data**

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Passive sampling of the water phase and sediment pore waters was carried out between October and December 2006 by thirteen laboratories at up to 31 locations through the PSTS project. The European locations covered estuarine and coastal environments from Norway to Portugal and west to Ireland and the Faeroe Islands. Also, two locations in Brisbane, Australia were sampled. The free dissolved or available concentrations of hydrophobic organic contaminants in the aqueous phases (water column and pore water) are estimated from the uptake by passive samplers.

Samplers made of silicone rubber sheets were exposed to water in the field for periods of around 6 weeks. Sediment samples were shaken for around 3 weeks in a bottle coated with a layer of silicone rubber in the laboratory environment. The exchange process of both sampler types was monitored using performance reference compounds spiked on the samplers. Some initial interpretation for polycyclic aromatic hydrocarbons (PAHs) and chlorobiphenyls (CBs) has been made.

Available concentrations for individual PAHs in water ranged over 3 orders of magnitude. Notably high concentrations were found in Norwegian areas close to aluminium smelters. A remarkable finding was that in the outer parts of the Scheldt, concentrations of lighter PAHs increased seawards, while heavier PAHs showed a decrease. Possibly this is related to atmospheric input that remains more in the water phase in open sea where in the estuarine water suspended particulate matter may bound the deposited PAHs.

Concentrations in sediment pore waters reflected known contamination of the Seine and the Scheldt with CBs, and the Elbe with hexachlorobenzene. Low concentrations were found in Norway and Scotland; these areas are likely to be remote from inputs of CBs.

Keywords: Passive sampling, PAH, CB, North Sea, water, sediment

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1 Introduction

The ICES Passive Sampling Trial Survey (PSTS) provided an opportunity for laboratories in the ICES community (and further afield) to gain experience in the use of passive samplers, to investigate sources of uncertainty in data from passive sampling, and to extend the geographical range of the validation of the use of passive samplers in both water and sediment (Smedes *et al.*, 2007). Twelve European laboratories took part in the programme, from Norway in the north to Portugal in the south, and samples were collected from sites known to be contaminated by hydrophobic organic contaminants such as PAHs and CBs, and also sites thought to represent relatively uncontaminated conditions. In doing so, data on the freely dissolved concentrations of contaminants in water and sediment pore water have been collected over a wide area, and range of environmental settings. The purpose of this paper is to present aspects of the field data, to explore whether the data are reasonable in the light of other knowledge of marine and estuarine environmental quality in Europe, and to indicate where the data may lead to new perspectives.

2 Materials and Methods

Details of the design of the PSTS programme are available in Smedes *et al.* (2007). In summary, duplicate sets of passive sampling equipment for water and sediment were distributed to the 13 participating laboratories in autumn 2006. The equipment used silicone rubber sheets as samplers in water, and silicone rubber film on the inside of glass bottles as samplers for sediment pore water. Samples of sediment were collected at approximately 30 locations, and water samplers were exposed at the same locations for around 6 weeks. The sediment was shaken in the coated bottles in the laboratory.

One of each of the duplicate sets of samples produced was analysed in the participating laboratories, while the other set of samples was returned to the reference laboratory (RIKZ, National Institute for Coastal and Marine Management, The Netherlands) for analysis. This paper reports the results of the analyses on passive sampling materials carried out by the reference laboratory on samples collected by the participants. Data on concentrations in mussels and sediment were produced by the participating laboratories.

The methods used to prepare the silicone rubber sampling material (pre-cleaning, spiking with Performance Reference Compounds, etc), deployment of the samplers, extraction of analytes from the exposed samplers, clean-up of the extracts were all consistent with the procedures described in the draft Guidelines on the use of silicone rubber passive samplers (WGMS, 2006, Annex 9). The final determinations of both polyaromatic hydrocarbons (PAHs) and chlorobiphenyl congeners (CBs) were carried out using routine GC-MS procedures.

3 Results

The dataset produced during the PSTS programme is large, and it is only possible to present a few of the prominent features of the data in this report.

3.1 Concentrations of contaminants in water

3.1.1 PAHs in water

- For all PAHs, the concentrations in water samples from the Karmoy site in southwest Norway are very much higher than all other locations (Figures 1 and 2). It is known that aluminium smelters in the area are sources of aqueous discharges containing PAHs, particularly the heavier compounds.
- There is a tendency for concentrations of the lighter PAHs (e.g. phenanthrene, fluoranthene) in far west stations (Scotland, Ireland, Faroe) to be as high as those in areas of the SE North Sea where concentrations might be expected to be higher. This could reflect high concentrations of suspended particulate matter (SPM) in the southern North Sea adsorbing PAHs and reducing the dissolved concentrations, whereas atmospheric inputs in the west occur into water with low SPM and under these conditions therefore higher concentrations might remain in solution. Concentrations of the heavier PAHs are lower at these stations than in the southern North Sea, except in relatively enclosed harbours such as Aberdeen (Scotland) and Dublin (Ireland) where dissolved concentrations are higher and may reflect local inputs.
- In the outer parts of the Scheldt, dissolved concentrations of lighter PAHs (e.g. phenanthrene, fluoranthene) in water increase seawards. This could also reflect the significance of atmospheric inputs of PAHs. Alternatively degradation of organic matter may cause PAHs to desorb from the solids, although this might be expected to increase the concentrations of heavier compounds more than the concentrations of light compounds. However, this process of significant degradation and desorption has not been demonstrated elsewhere. It is unlikely to be the reason, as the seawards increase in concentration is not found for heavier compounds (e.g. benzo[a]pyrene or CBs), which tend to show progressively decreasing concentrations towards the open sea.

3.1.2 CBs in water

- CB concentrations at sampling stations in Norway and western locations (e.g. Scotland, Ireland, Faroe) are all low in comparison to those found at sites on the southern coast of the North Sea (Figures 3 and 4). There are no large local inputs, and possibly no significant atmospheric inputs, in these areas.
- The high concentrations in the inner Scheldt decrease seawards. This could reflect dilution of river water by open sea water. Concentrations are also high in the Seine estuary (France).
- While concentrations of light CBs (e.g. CB52) are low at Vigo (Spain), concentrations of more heavily chlorinated CBs (e.g. CB153, CB187) are relatively high in comparison to concentrations at other sites.

3.1.3 HCB in water

- One very high concentration of HCB was found in the Elbe (Figure 4). Apart from that, there is a tendency for higher concentrations in western parts of the survey area, particularly in Faroe. This may reflect the effect of atmospheric transport and deposition in areas of low SPM.

3.2 Concentrations of contaminants in sediment pore water

3.2.1 PAHs in sediment pore water

- Concentrations are generally relatively high at stations in Norway (Figures 5 and 6). The pattern is widespread, and not just confined to heavier compounds (e.g. Indeno(1,2,3-cd)pyrene, Benzo(ghi)perylene, Benzo(a)pyrene, Benz(a)anthracene), or to areas that receive inputs of heavy PAHs from aluminium smelters (e.g. Karmoy).
- There is a tendency for higher concentrations of lighter compounds (e.g. acenaphthene, fluorene) in areas likely to receive petrogenic inputs, such as Aberdeen harbour and the Scheldt (Antwerp).
- In the Scheldt area, concentrations generally decrease in a westerly direction out of the estuary and away from riverine inputs. Although the decrease is less marked, it is also present for the lighter PAHs that showed an increase in dissolved concentrations in the water phase.

3.2.2 CBs in sediment pore water

- There are relatively high concentrations of CBs in the sediment pore waters in the Seine and Scheldt estuaries (where inputs are known to occur). Concentrations in the Scheldt pore waters generally decrease seawards, in the same way as was observed in the water phase.
- Concentrations in sediments from Norway and Scotland are low in comparison to other locations sampled, and these areas are likely to be remote from inputs.
- The CB concentrations in sediment pore waters at Vigo, Spain increase relative to those at other sites with increasing degree of chlorination (CB44, CB52, CB153, CB187). It may be that the source of CBs in the Vigo area is of a different bulk composition to that affecting other PSTS sampling sites

3.2.2 HCB in sediment pore water

- HCB concentrations are relatively high in 1 out of 2 samples from the Kiel area, but low in Western Scotland and Portugal. It should be noted that sediment analyses were not carried out on samples from the Elbe, where concentrations in water were found to be very high in comparison to other sites.

3.3 Relations between concentrations in water and pore water

The relative concentrations of contaminants in water and pore water will determine whether the sediments are acting as a diffusive source or sink for dissolved contaminants in the water column. Passive sampling can therefore be used to address questions regarding the potential for persistent diffusive exchange of organic contaminants between sediment and water column, and have direct application in the assessment and management of areas of contaminated sediment, such as areas used for the disposal of harbour dredgings.

The general nature of the relationships between water and pore water for four sites are shown in Figure 9. At the Tagues estuary site, concentrations of PAHs in water and pore water are broadly similar, while the concentrations of CBs tend to be higher in water than pore water. This may reflect inputs of CBs to the water column which will then be transferred to the sediment.

In Aberdeen harbour, the pore water is more heavily contaminated than the water column with some of the CBs, and PAHs lighter than fluoranthene. The sampling station at Zeebrugge was located close to shipping lane in a marine setting. Most compounds show very similar concentrations in water and pore water, indicating that the sediment and water are broadly in equilibrium for both PAHs and CBs. Only in the case of some of the lighter PAHs (naphthalene and acenaphthylene) is there a suggestion of higher concentrations in the sediment.

At Mosjon, the sediment was collected in the middle of the fjord at 350 meters depth and the sampler exposed to water about 1 km west. The sediment is clearly a source of the input of PAHs to the water column. The difference between concentrations in water column and porewater is smaller for lighter PAHs except anthracene. For CBs, the concentrations are about equal indicating diffuse sources. The only exception to this pattern in the CB data is for CB18. CB18 is recognised to present particular analytical difficulties.

3.4 Environmental validation of passive sampling – bioaccumulation factors in mussels

Passive sampling addresses the freely dissolved concentrations of contaminants in water. Contaminant concentrations in marine organisms will also be in equilibrium with the dissolved contaminants. Therefore an environmental validation of the silicon rubber passive sampling and extraction methods can be obtained through comparison of uptake by passive samplers with the concentrations found in organisms.

Within the PSTS programme, participating laboratories were encouraged to transplant mussels from reference areas for the period of deployment of the samplers or, if that was not feasible, to collect wild (native) mussels from the sampling locations. These mussels were analysed by participating laboratories for the same suite of contaminants as the passive samplers. These data allow calculation of the bioconcentration factors (BCF) calculated from the water concentrations found by the participating laboratories using the silicon rubber passive sampling method and the concentrations found in mussels at the same location.

The BCF is the ratio of the concentration of a compound in biological tissue and the freely dissolved concentration in the surrounding water. The 75% trimmed mean of the calculated BCFs for the PAH, HCB and CB compounds for mussels from the PSTS survey were plotted against the K_{ow} for these compounds (Figure 10). The linear relationship obtained appears to be consistent with the model ($\log BCF = 0.82 * \log K_{ow} - 0.52$) developed by Bergen *et al.* (1993) for bioaccumulation of chlordane and CBs in mussels. The PSTS data indicate that silicone rubber passive sampling of water can be used to predict the concentrations of CBs and PAHs in mussels over a range of K_{ow} from about 3.2 to 7.8.

3.5 Sediment/water partition coefficients

Passive sampling of sediment provides information on the freely dissolved concentrations of contaminants in pore water. It is therefore possible to combine these data with information on the total concentrations of contaminants in the sediment solids, and the organic carbon concentration in the sediment, to calculate an apparent partition coefficient between sediment organic matter and pore water (K_{oc}). K_{oc} are calculated from the concentrations in pore water

and the concentrations found in the sediment expressed on the organic carbon content of the sediment. The K_{oc} values are “apparent” because it is likely that not all of the total concentrations of contaminants present in the sediment will be equally available for exchange with the water phase (Smedes 2007).

Because added compounds are much more available, it is necessary to distinguish between two forms of organic contaminants in the sediment/passive sampler system. Firstly there are the native contaminants already present in the sediment in the field, and secondly there are the additional related contaminants (deuterated PAHs and CB congeners) added to the sampling system as PRCs.

The conventional model (e.g. diToro et al., 1991) for the relationship between octanol water partition coefficient (K_{ow}) and K_{oc} is:

$$\log K_{oc} = a * \log K_{ow} + b.$$

Well accepted values for the parameters of the regression are gradients close unity (i.e. $a = 1.0$) and a small negative intercept (e.g. $b = -0.1$ to -0.3) representing the ratio between the absorption capacity of octanol and the capacity of sediment organic matter represented by the organic carbon content. The PRC's (Figure 11a) closely follow the model described above, with perhaps a tendency for PAHs used as PRCs to show slightly higher $\log K_{oc}$ values than predicted by the model.

The native CB's also follow the model quite closely (Figure 11b) although the slight offset towards higher values of K_{oc} indicates that not all CBs held in the sediment is available for exchange with the water phase.

However, native PAHs show a much larger positive offset towards higher K_{oc} values, indicating that a large proportion ($> 90\%$) of the PAH held in the sediment does not directly participate in the exchange process with the pore water and is also likely to be unavailable to sediment-dwelling organisms. This process could lead to variations in apparent biota-sediment accumulation factors (BSAF) with differences in the nature of the organic carbon in sediment (Cornelissen and Gustafsson, 2005).

3.6 Detection of pesticides and other organic contaminants in water

The target groups of contaminants in the PSTS programme were PAHs and CBs. However, other environmental contaminants with $\log K_{ow}$ values that fall in the same range ($\log K_{ow}$ 3.2 to $\log K_{ow}$ 7.8) as shown by CBs and PAHs would also be accumulated by the samplers.

There is considerable current interest in relation to the implementation of the EU Water Framework Directive 2000/60/EC in sampling techniques that may alleviate some of the difficult analytical problems posed by the low concentrations being proposed in a daughter directive as Environmental Quality Standards for priority contaminants. Also, Working Groups of the Oslo and Paris Commission have identified the need for one-off surveys concerning the occurrence of organic contaminants that they have identified as being of particular importance.

The opportunity offered by the deployment of passive samples in water in locations distributed widely over European coasts was used to explore the possibility of using silicone

rubber passive samplers to sample for priority pesticides and other organic contaminants as defined by OSPAR and/or in the EU WFD. The data for a range of contaminants are presented in Figures 12 – 14. The silicone rubber/water partition coefficients (K_{sw}) for these compounds have not been measured, and therefore they were estimated from K_{ow} values. This gives great uncertainty (bias) to the actual calculated values. This is less for BDEs which are in the linear uptake phase at all stations and in that case the K_{sw} is not required. Nevertheless, data may be used in a comparative sense and the differences between stations are still meaningful.

3.6.1 Dissolved concentrations of g-HCH (lindane) in water (Figure 12)

Freely dissolved concentrations of g-HCH (lindane) in water ranged from 2 to over 1000 pg/l. Generally, concentrations were around 200 pg/l. Higher concentrations were found in Dutch and Belgian coastal waters while lower concentrations were found a station in the Baltic Sea, Seine Bay and one station in Brisbane, Australia. There was no marked gradient of concentrations in the Scheldt estuary.

3.6.2 Dissolved concentrations of chlorpyrifos in water (Figure 12)

Freely dissolved concentrations of chlorpyrifos in water ranged from 3 to over 800 pg/l. Generally, concentrations in coastal waters of Faroe, Scotland, Norway, W Ireland, Belgium, the Netherlands and in the Baltic Sea) were less than 200 pg/l. Higher concentrations were found at a number of scattered stations including the Taguies estuary (Portugal), Vigo, the Seine Bay, Antwerp, Dublin and the west coast of Denmark. There was no marked gradient in concentrations in the Scheldt estuary, apart from a high concentration in Antwerp. The distribution suggests chlorpyrifos distributions are strongly influenced by local inputs.

3.6.3 Dissolved concentrations of endosulphan-1 in water (Figure 13)

Freely dissolved concentrations of endosulphan-1 in water ranged from 0.1 to over 100 pg/l. Generally, concentrations were around 20 pg/l. Higher concentrations were found in Dutch and Belgian coastal waters and at one station in the east of Denmark. Lower concentrations were found at a station in the Baltic Sea, the Elbe, the Seine Bay and in Brisbane, Australia. There was no marked gradient in concentrations in the Scheldt estuary.

3.6.4 Dissolved concentrations of trifluralin in water (Figure 13)

Freely dissolved concentrations of trifluralin in water ranged less than 1 to over 1000 pg/l. Generally, concentrations were around 200 pg/l. Higher concentrations were found in Dutch and Belgian coastal waters while rather lower concentrations were found at stations in the Baltic Sea, Seine Bay and stations in Norway, Scotland, Ireland and Spain. Concentrations tended to increase seawards in the Scheldt estuary. The data suggest that inputs are concentrated in the southern and eastern North Sea.

3.6.5 Dissolved concentrations of BDE047 and BDE099 in water (Figure 14)

Freely dissolved concentrations of BDE047 in water ranged from 1 to over 50 pg/l. Concentrations of BDE099 were approximately 4 times less. Generally, relatively high

concentrations of both compounds were found in some harbours (e.g. Aberdeen, Dublin, Antwerp) but also at Karmoy, Stockholm, and Faroe. Concentrations at other stations in the Scheldt and adjacent coastal waters showed lower concentrations (1 – 10 pg/l of BDE047, and 0.5 – 2 pg/l of BDE099).

3.7 Multivariate statistical analysis of passive sampling data

The data on freely dissolved concentrations of CBs and PAHs in water from PSTS were analysed with the principal component analysis (PCA) component of the Statistica software package. In PCA, mutually non-correlated multivariate factors are identified that progressively account for the variance of the data in vector space (of variables and cases), according to the least squares criterion. For this analysis, the individual compounds were taken as variables and the locations as the cases. Missing data for any given variable was replaced by the mean for the respective variable. Calculations were based on a correlation matrix.

3.7.1 CBs in water

The CB data were normalised to CB153 and analysed PCA. The analysis shows 3 factors with Eigenvalues greater than 1 (Figure 15), which accounted for 50, 18 and 10% of the variance respectively. Only these three factors were considered during the subsequent analysis.

Projection of the variables on the factor-plane of the first two factors showed that CBs could be considered in two groups (Figure 16). One group consisted of the higher chlorinated PCBs i.e CBs 170, 180 and 187) which are very persistent and can be transported over long distances or come from a specific source. The other group contained the other CBs and was mostly governed by factor 2. When the factor scores for factors 1 and 2 were plotted on the factor plane for the sampling locations, a number of distinct clusters could be observed (Figure 17). The location NER01 stood out as it was negatively correlated with factor 1 and positively with factor 2 to an extent that set it apart from all others. The site was characterised by relatively high concentration of the lower chlorinated CBs. The second cluster consisted of the sites MII01, FRS01, NIV01 and NIV03 situated in Atlantic waters of the coasts of, respectively, Ireland, Scotland and Norway. These sites were characterised by relatively high concentrations of mainly the CBs 28, 52, 118 and 187. The cluster of the two stations of the Spanish coast (IEO01 and -02) were characterised by relatively high concentrations of the CBs 180 and 187, and low amounts of CB 101 and lesser chlorinated compounds. The other sites were clustered together (showed similar patterns of CBs) and could not be separated further on the basis of the characteristics of the sites.

3.7.2 PAHs in water

The initial PCA analysis included all stations, but the results were heavily biased by the sample from the site NIV03 (Karmoy). When the factor scores for factors 1 and 2 were plotted on the factor plane, it became immediately evident that this site alone was responsible for the major factor (Figure 18). This site was heavily contaminated by aluminium smelter discharges. For the follow-up analysis, both this station and the Australian stations UoQ01 and UoQ02 were excluded. The initial PCA analysis of this data set showed 3 factors with Eigenvalues greater than 1 (Figure 19), which accounted for 56, 20 and 11% of the variance respectively. Only these three factors were considered during the further analysis

Projection of the variables on the factor-plane of the first two factors showed that the PAHs could be divided in two groups (Figure 20). The lower group in the graph consisted of most of low molecular weight (MW) PAHs and the other group contained all other PAHs. Clearly this group correlates mainly with the first factor.

Figure 20 also shows the ratios of phenanthrene to anthracene (PA/Ant), and fluoranthene to Pyrene (Flu/Pyr) as supplementary variables. These variables have not taken part in the calculation but are projected onto the vector subspace generated by the factors. These ratios have been used to distinguish between pyrolytic and petrogenic sources (Readman *et al.*, 1982; Webster *et al.*, 2000). A PA/Ant ratio of less than 10 and a Flu/Pyr ratio of less than 1 are generally accepted as indicating a pyrolytic origin of the PAH mixture in the environment. The sites were classified according to these criteria, and a site was considered to be mainly influenced by pyrolytic sources if the PA/Ant ratio was less than 10 and a Flu/Pyr ratio was less than 1. All other sites were considered to be mainly influenced by petrogenic sources.

Figure 21 shows the scores for factors 1 and 2 plotted on the factor plane for the sampling locations. Factor 3 was not further considered as it is only related to the specific situation at station MMM02. The analysis revealed that all the sites that were predominantly influenced by petrogenic sources could all be found clustered together at the upper rightmost corner of the Figure. This was confirmed when the analysis was performed with the probable source of PAHs as a selection criterion for the variable. These are generally also the sites with the lowest concentrations and nearly all of them are situated on the Atlantic coast of Europe. Remarkably, the freely dissolved PAHs in water at harbour sites are predominantly influenced by pyrolytic sources. Apparently, exhaust fumes from ships and other harbour activities or even runoff from land are responsible for most of the PAH input and not accidental or deliberate oil spills. In contrast, the 2006 OSPAR (OSPAR, 2007) assessment of PAHs in sediments showed that the PAH contamination of harbour sediments seems to be mostly from petrogenic origin when the same ratios are used to make the assessment. If one assumes that sediments reflect past pollution and that the passive samplers are representative for the current situation, it would seem that the main cause for PAH pollution of the harbour area has switched from oil spills to combustion related sources. In any case, the statistical evaluation of the data gives results that are largely in line with what has been observed in the previous sections.

4 Conclusions

The PSTS programme has provided new information on the distribution of freely dissolved CBs and PAHs in water and sediment pore water over a wide geographical range. The broad features of the distributions of CBs and PAHs are interpretable in terms of current general understanding of the sources, transport mechanisms, and environmental chemistry of CBs and PAHs.

Environmental validation of passive sampling of water has been provided through parallel analyses of mussels. Bioconcentration factors linking concentrations in mussels with freely dissolved concentrations in water determined by passive sampling showed strong correlation with K_{OW} values, and closely matched a published model of the bioconcentration of organochlorine compounds in mussels.

Freely dissolved concentrations in sediment pore water were used to calculate sediment organic carbon – water partition coefficients (K_{OC}). K_{OC} values from passive sampling were

correlated with K_{OW} values. The data suggest that while most of the CBs present in the sediment are potentially available to the water phase, most of the PAH (>90%) are not available to take part in partitioning with water or organisms.

Passive samples of water were used to provide new data on the distribution of freely dissolved concentrations of some priority organic contaminants – data that would otherwise be difficult to obtain. Data are reported for lindane, chlorpyrifos, endosulphan-1, trifluralin, BDE047 and BDE099.

Principal Component Analysis of passive sampling data for freely dissolved contaminants in water demonstrated that sites showing different patterns of CB congeners or PAH compounds grouped together. The groupings could be interpreted in terms of differences in sources of contaminants experienced at different sampling locations.

5 Acknowledgements

The authors wish to acknowledge the contributions made by the participating laboratories in finding space within their programmes to undertake this work, and particularly staff at the RIKZ laboratory who undertook a large amount of analytical working when acting as the central reference laboratory.

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Figure 1: Concentrations of PAHs in water

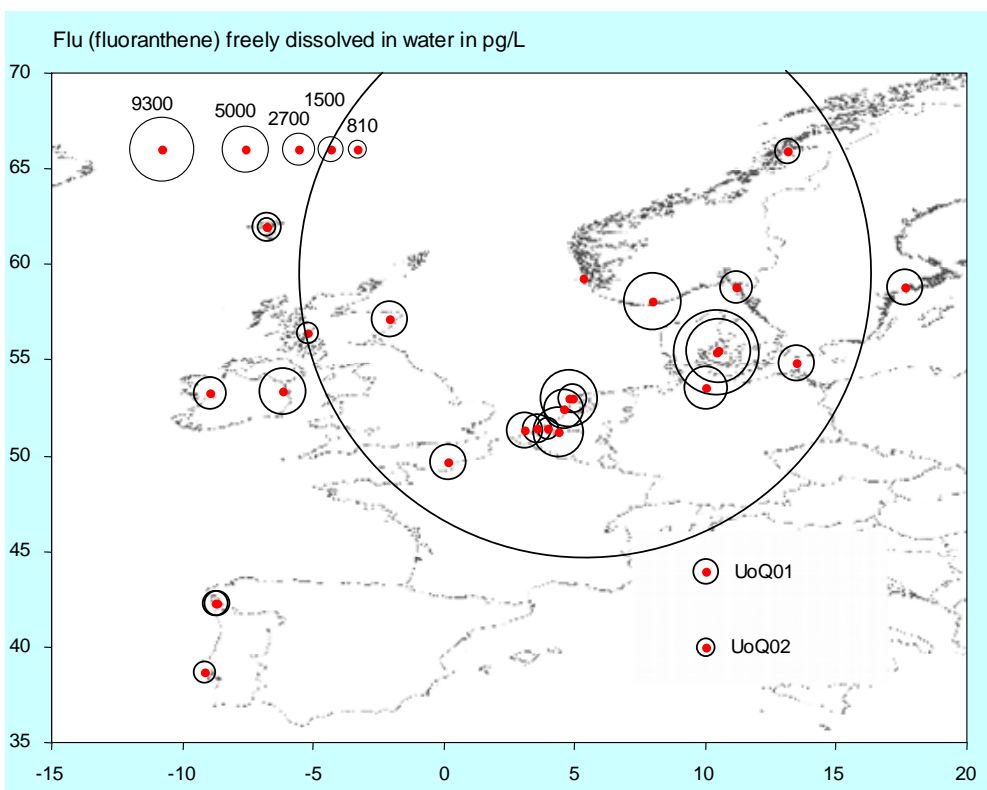
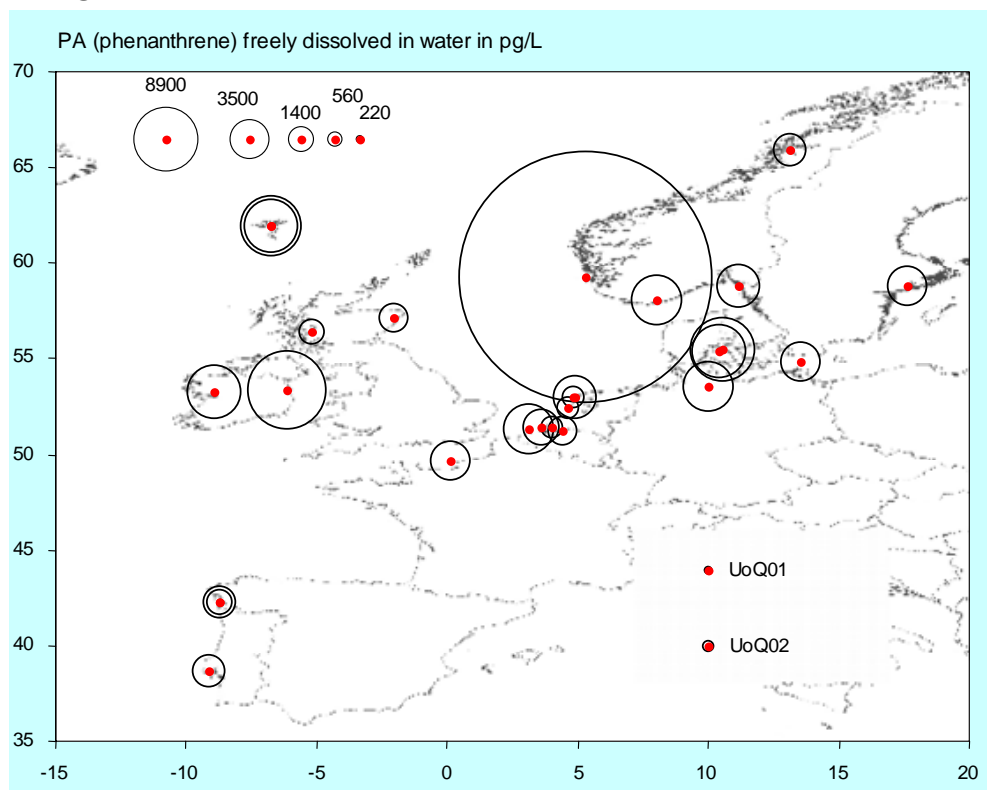


Figure 2: Concentrations of PAHs in water

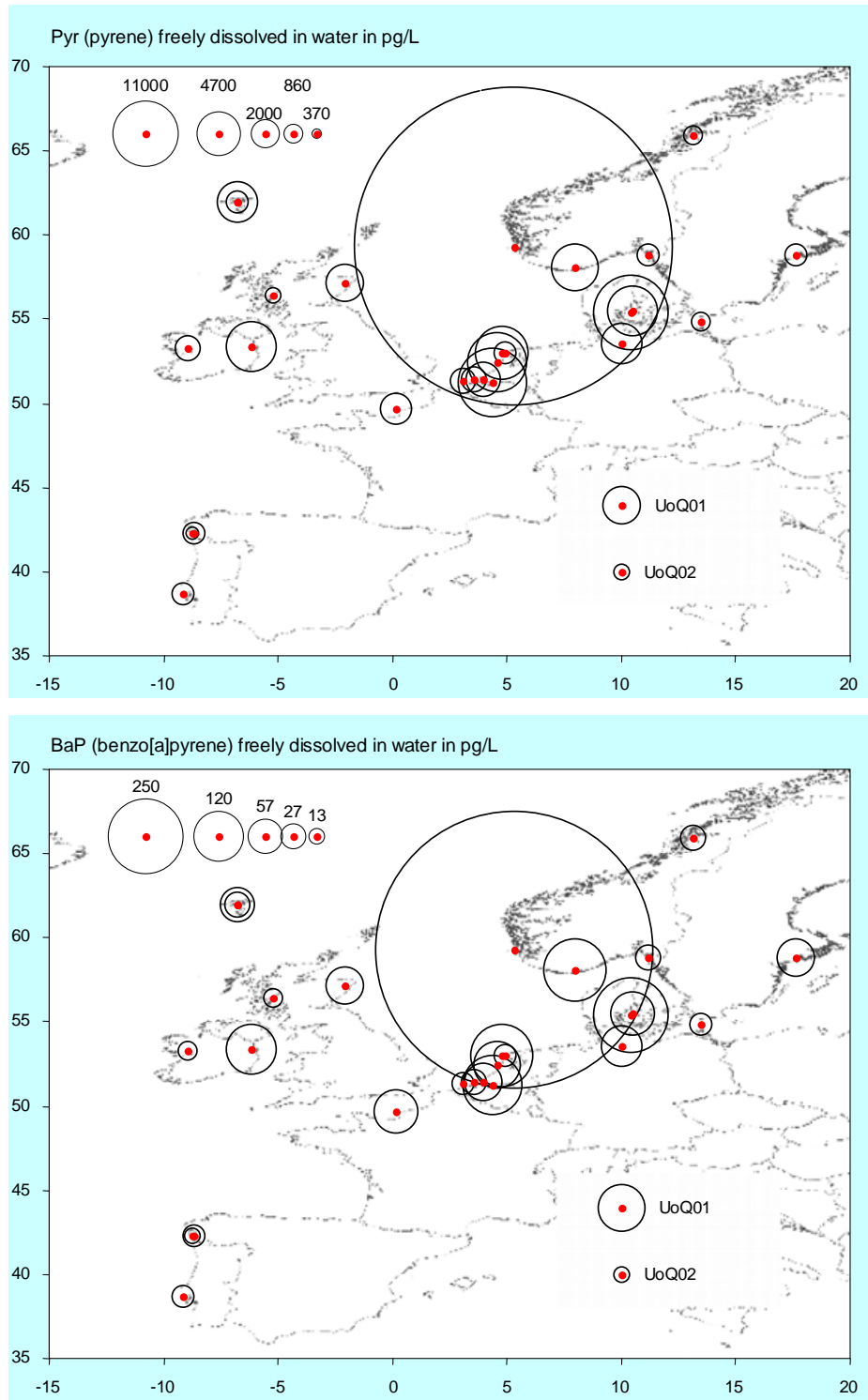


Figure 3: Concentrations of CBs in water

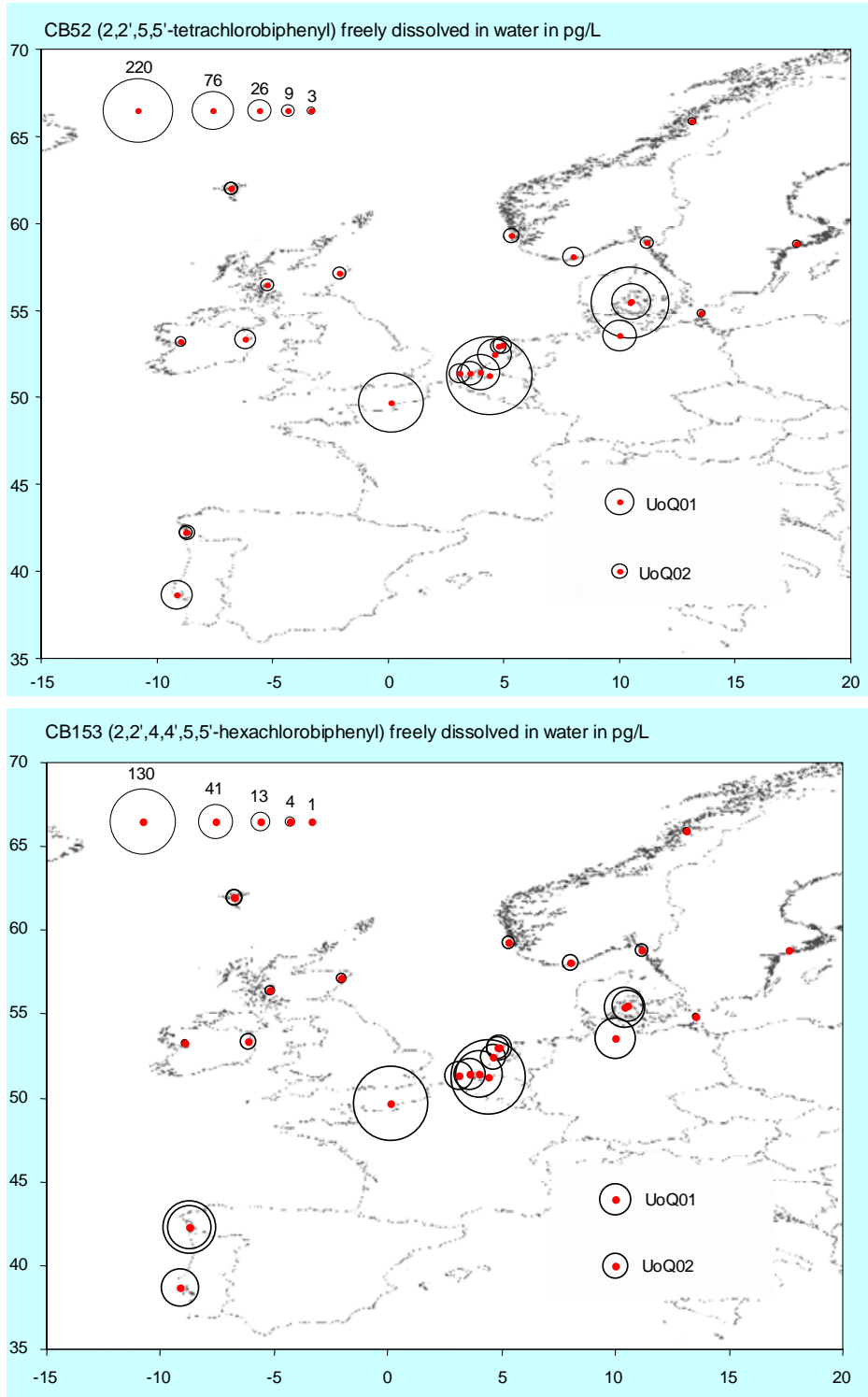


Figure 4: Concentrations of CB187 and HCB in water

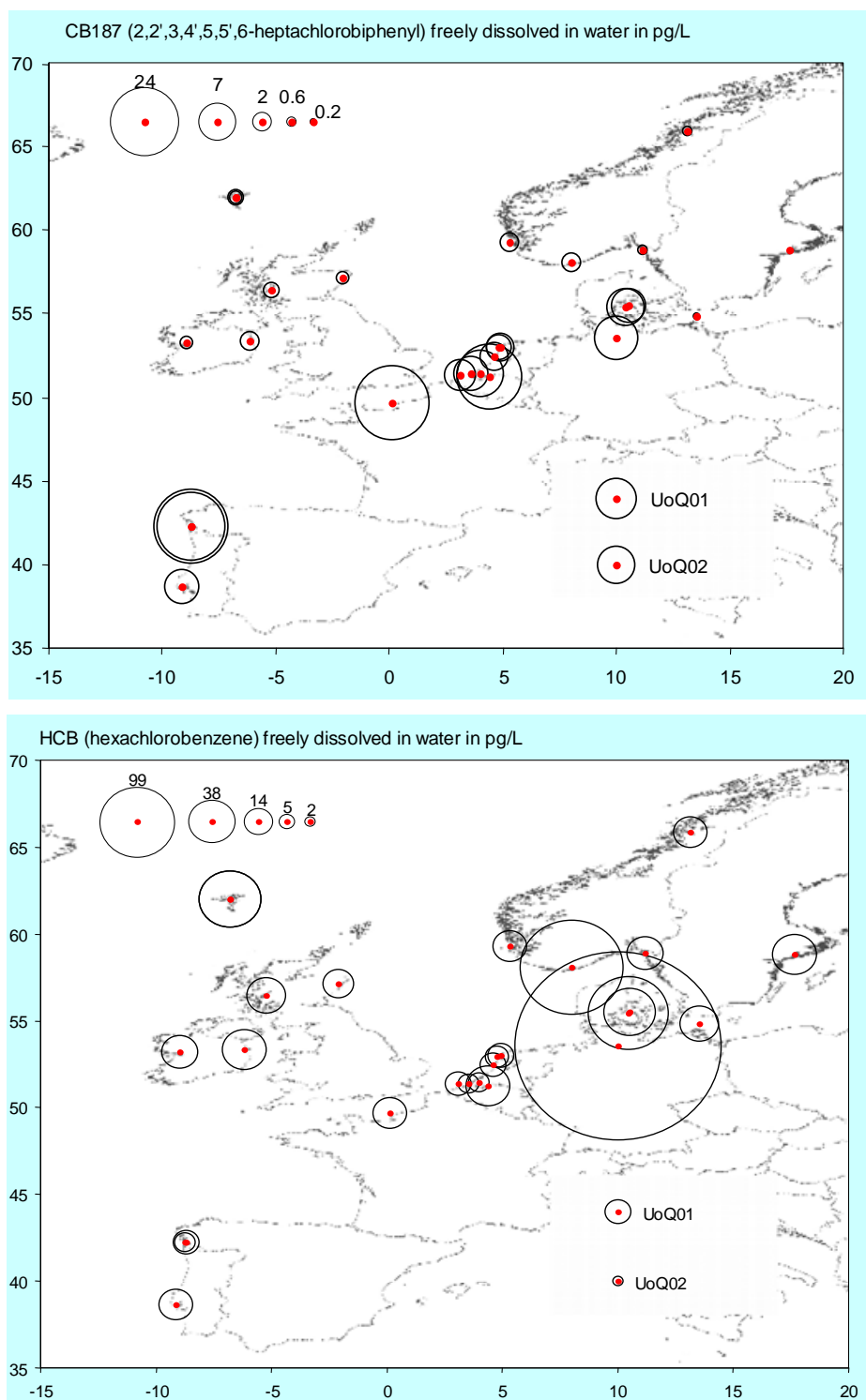


Figure 5: Concentrations of PAHs in sediment pore water

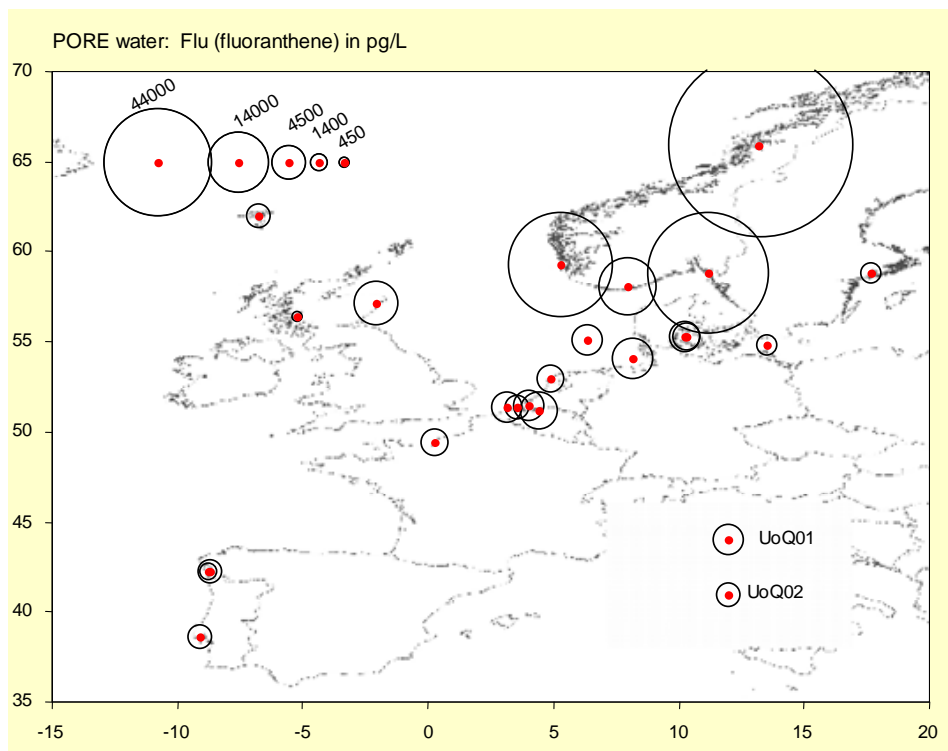
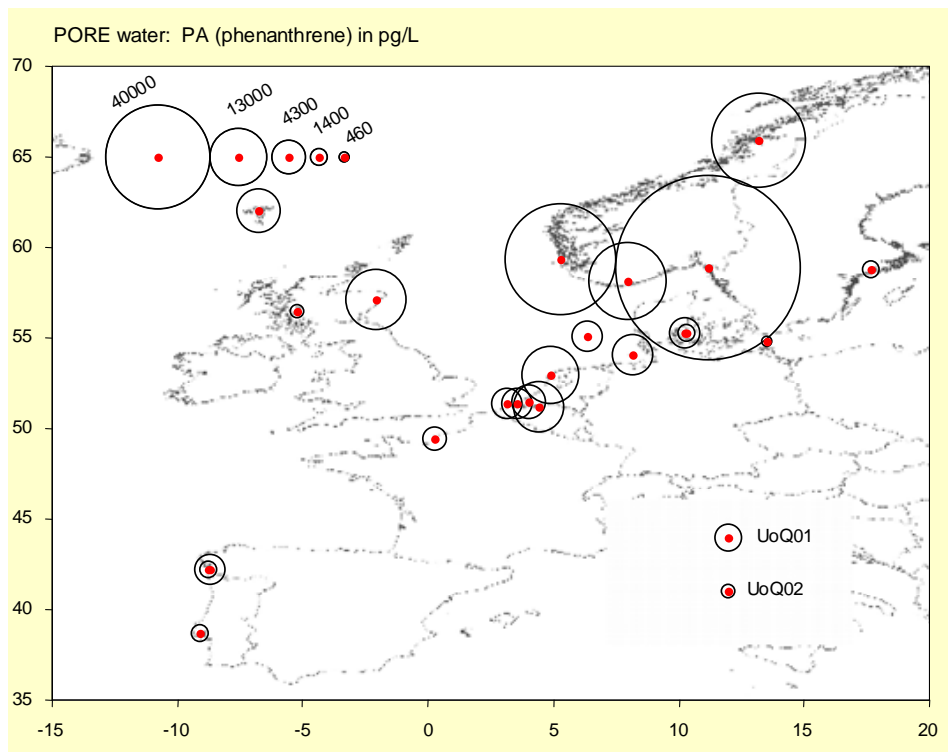


Figure 6: Concentrations of PAHs in sediment pore water

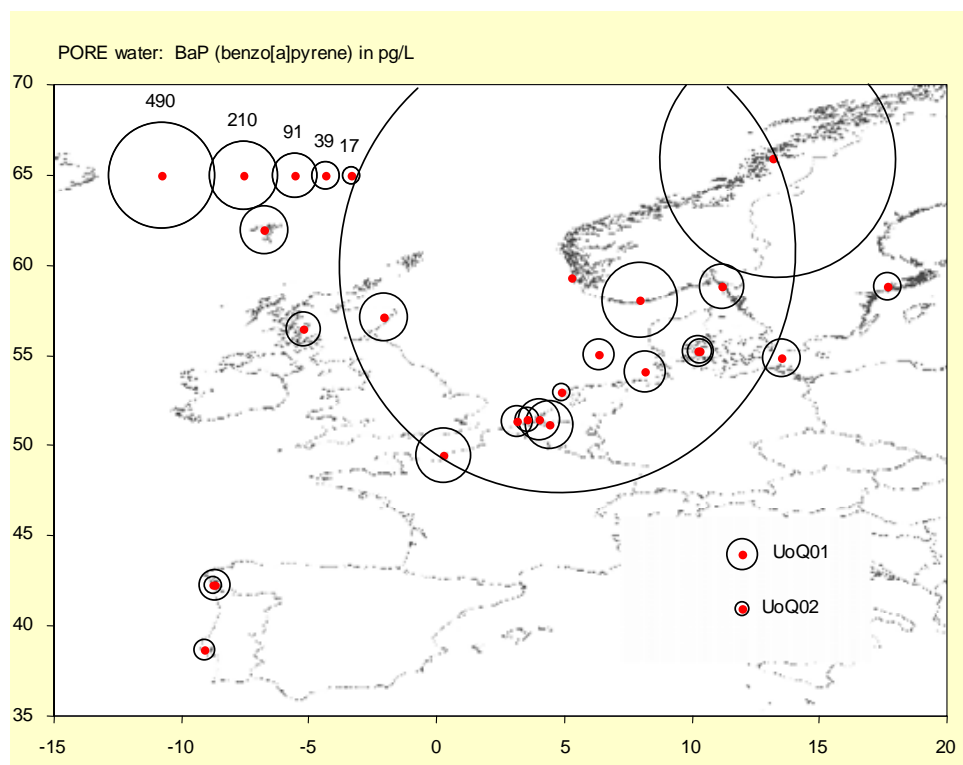
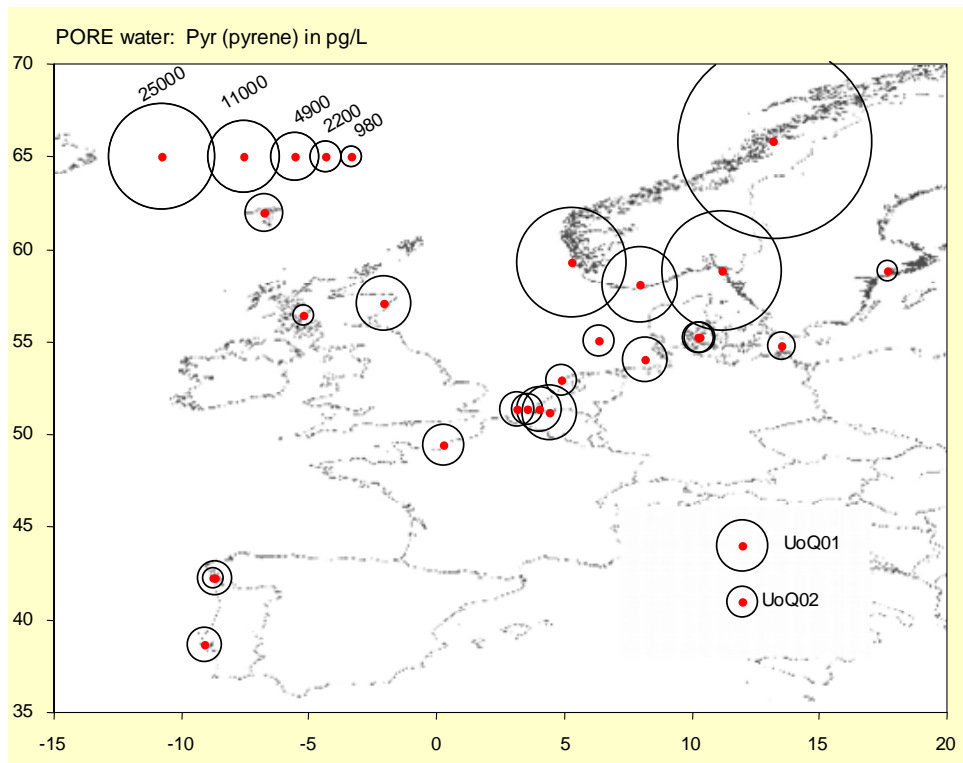


Figure 7: Concentrations of CBs in sediment pore water

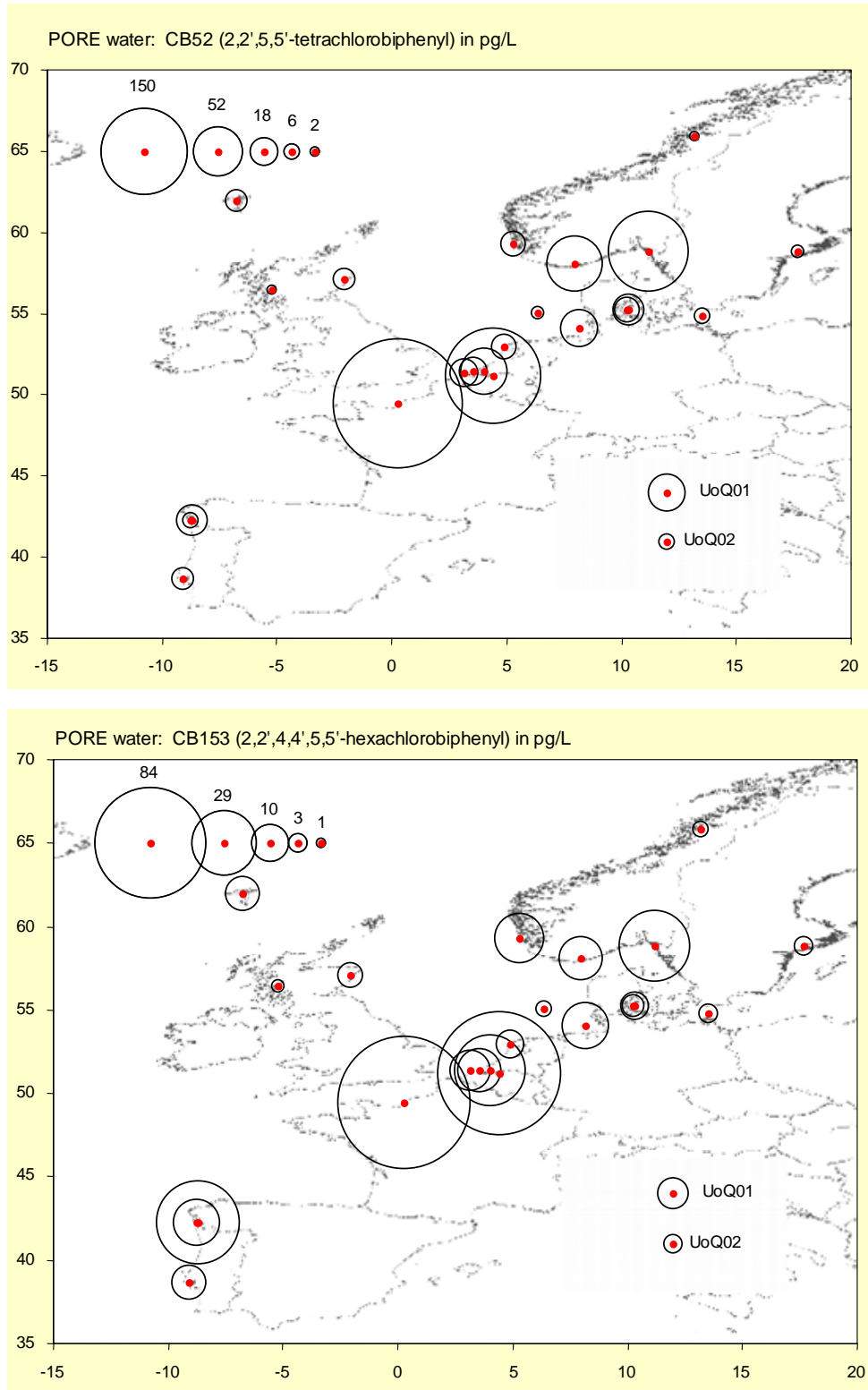


Figure 8: Concentrations of CB187 and HCB in sediment pore water

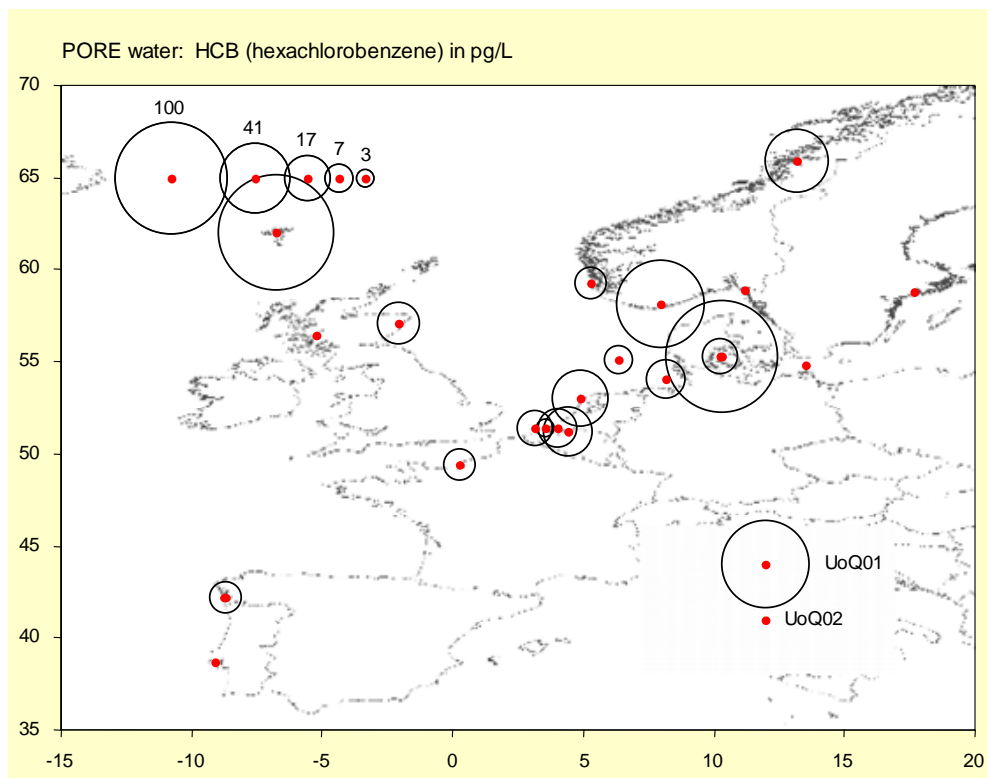
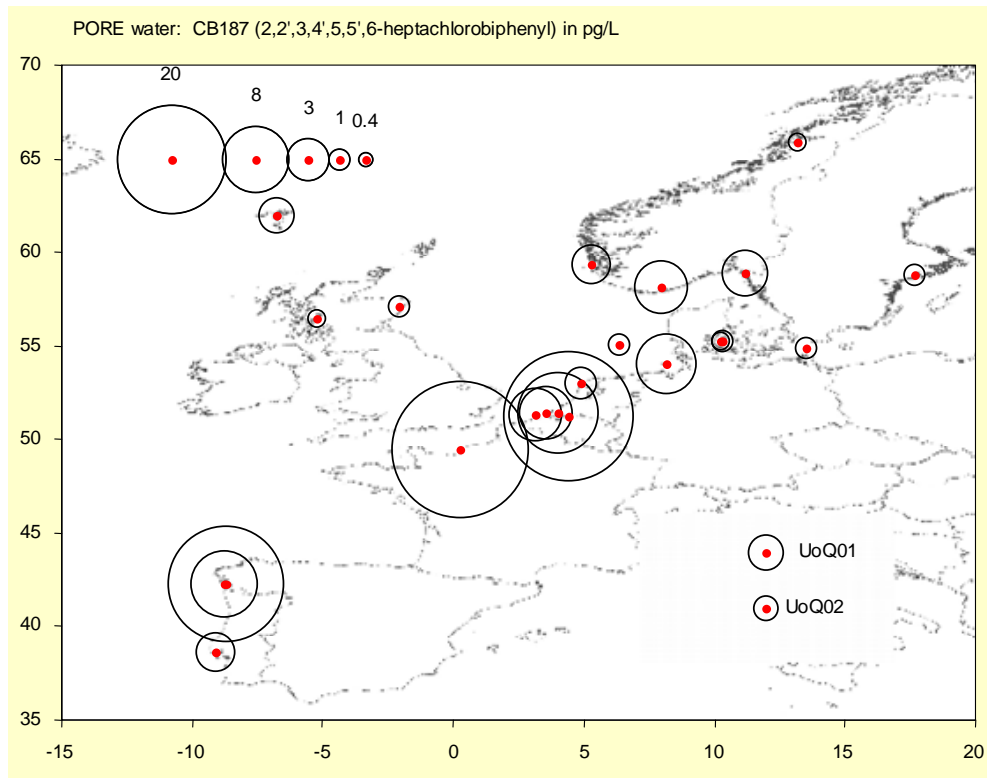


Figure 9: Relationships between concentrations of CBs and PAHs in sediment pore water and the overlying water column at four sampling stations

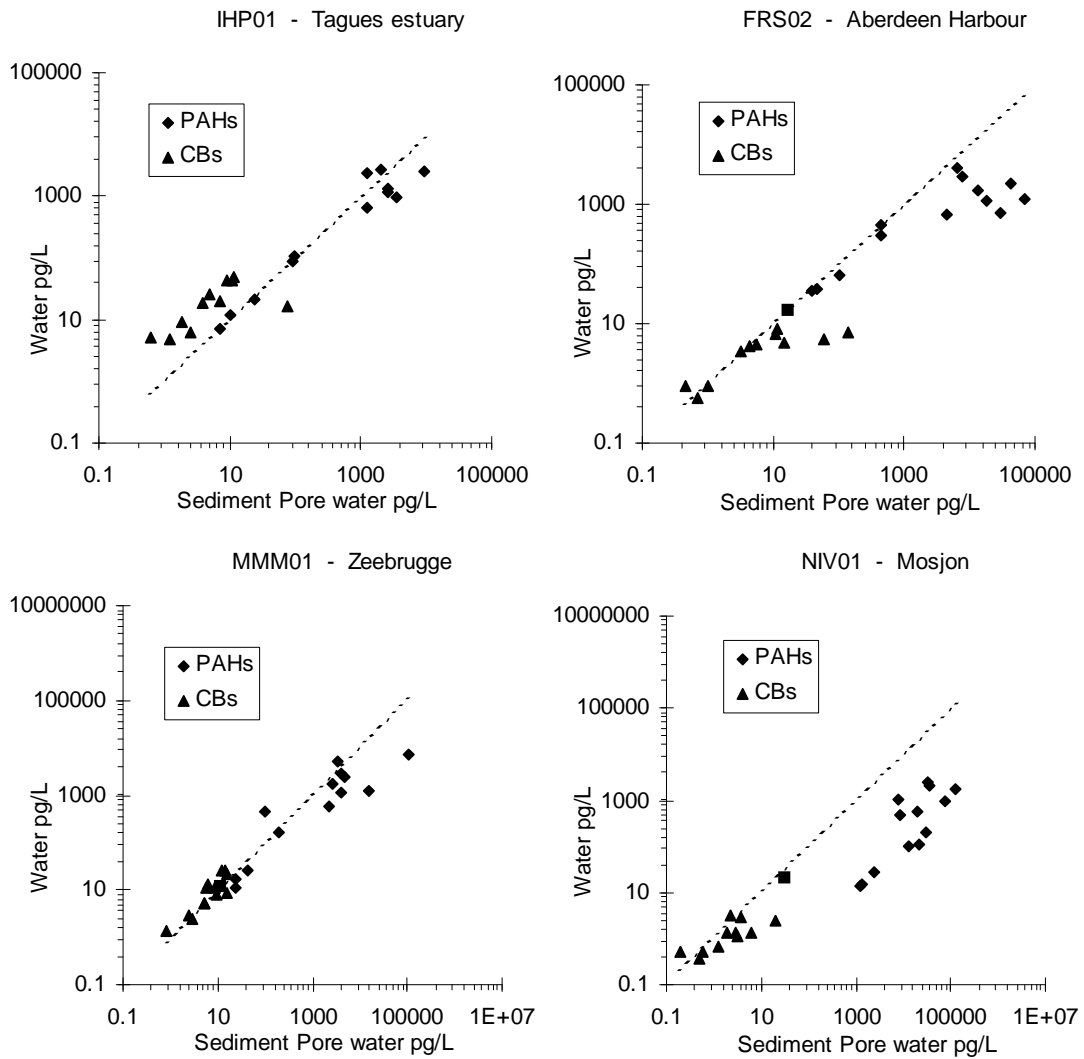


Figure 10: Relationship between bioconcentration factors calculated from freely dissolved concentrations of PAHs and CBs in water and concentrations in mussels, and log K_{ow}.

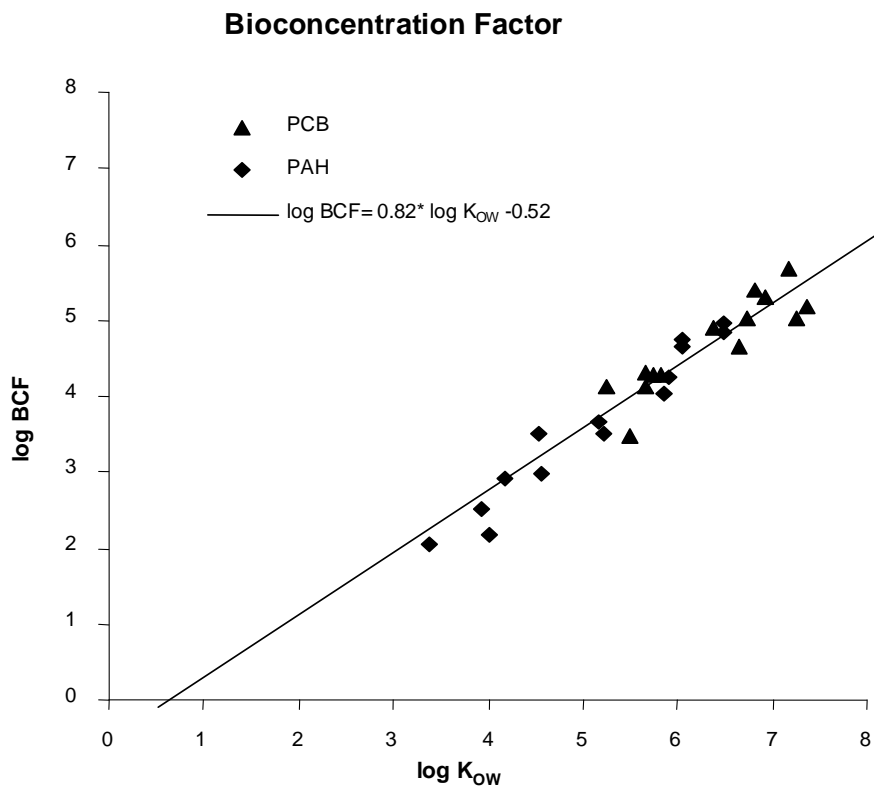


Figure 11: Sediment – pore water partition coefficients (log K_{oc}) for PAHs and CBs added to sediment samples as PRCs, and for PAHs and CBs present in the sediment in the field, related to log K_{ow} values.

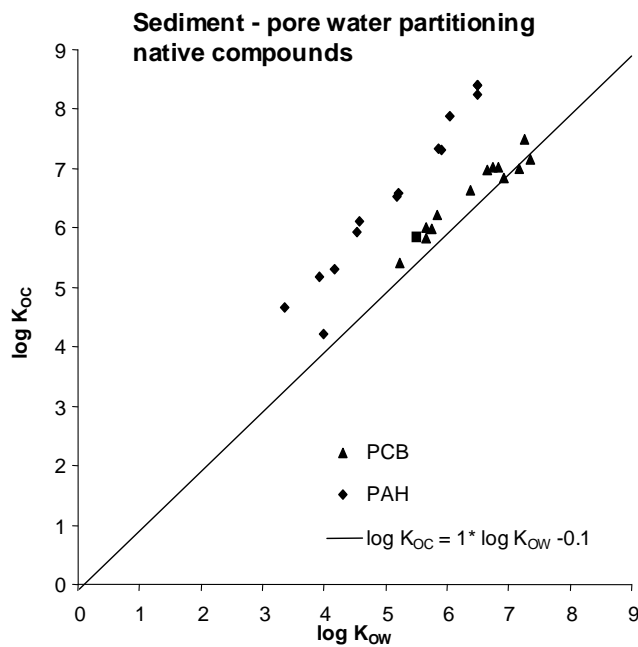
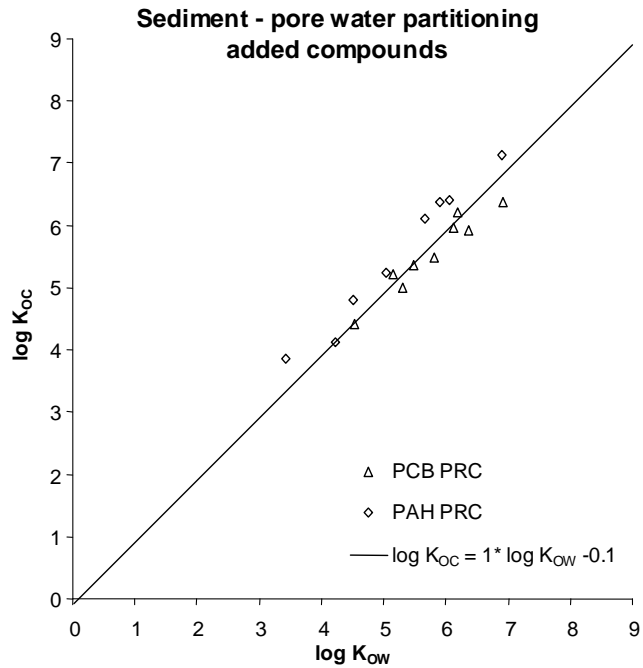


Figure 12: Estimated dissolved concentrations of g-HCH and chlorpyrifos in water.

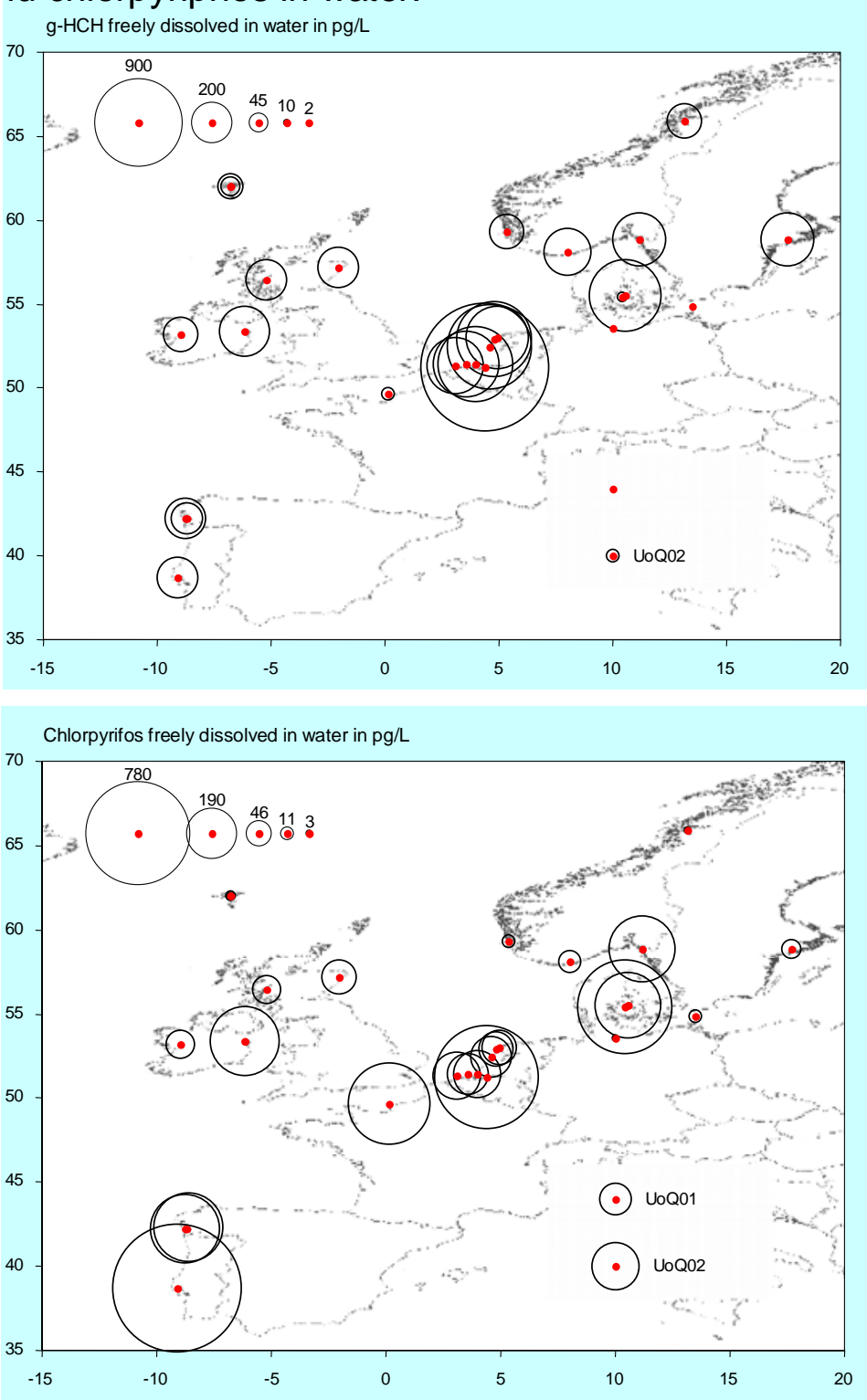


Figure 13: Estimated dissolved concentrations of endosulphan-1 and trifluralin in water.

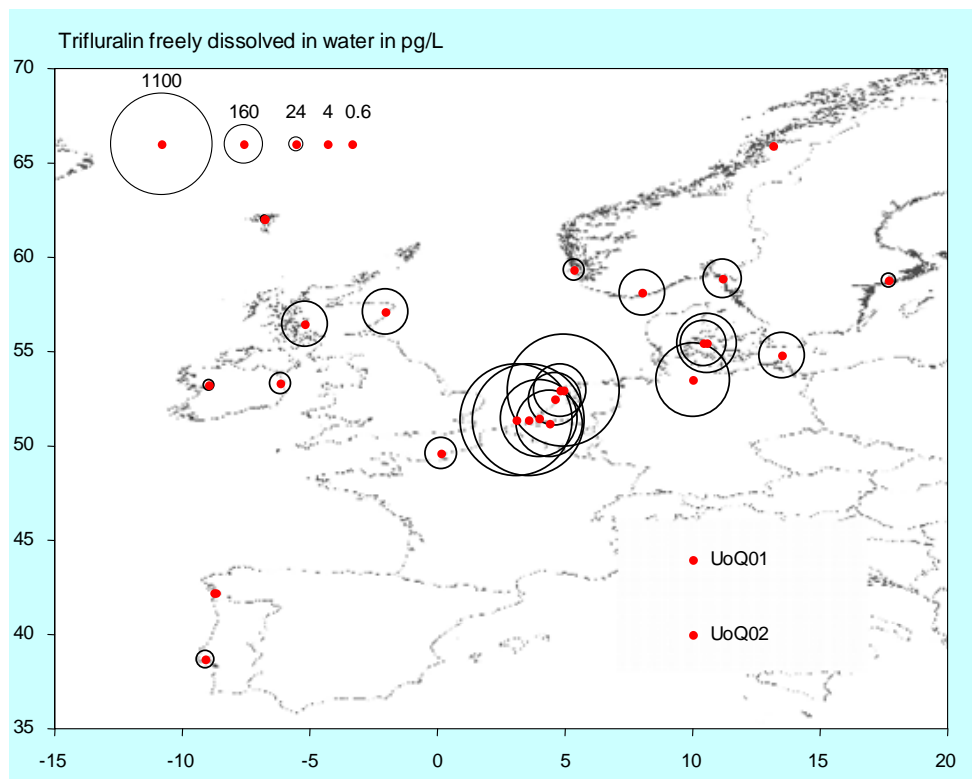
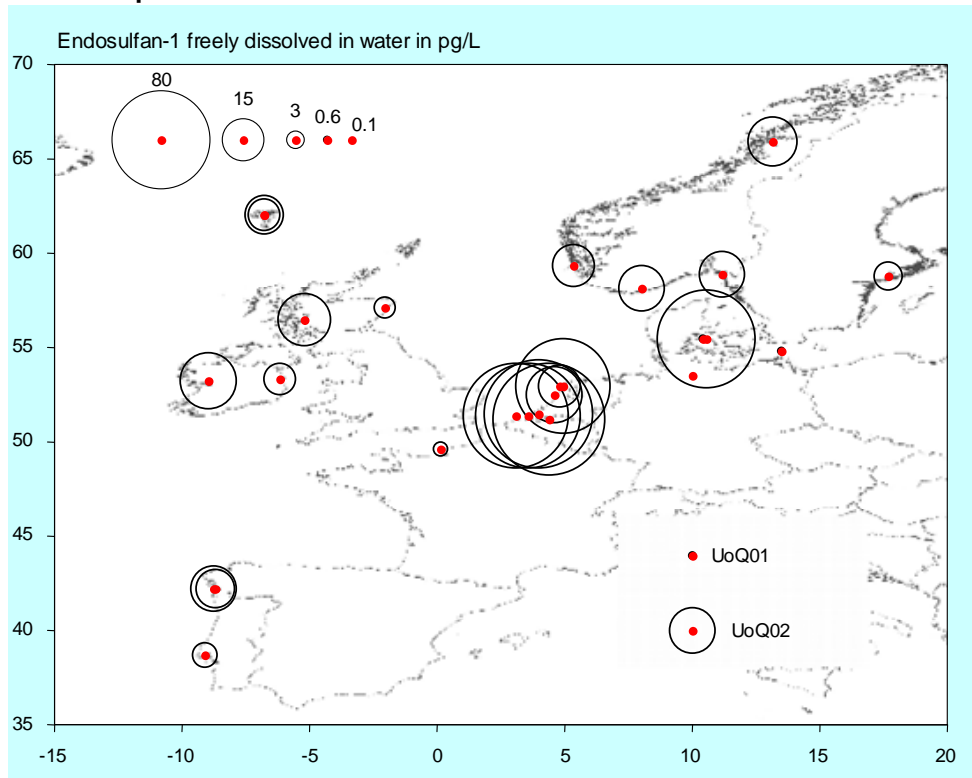
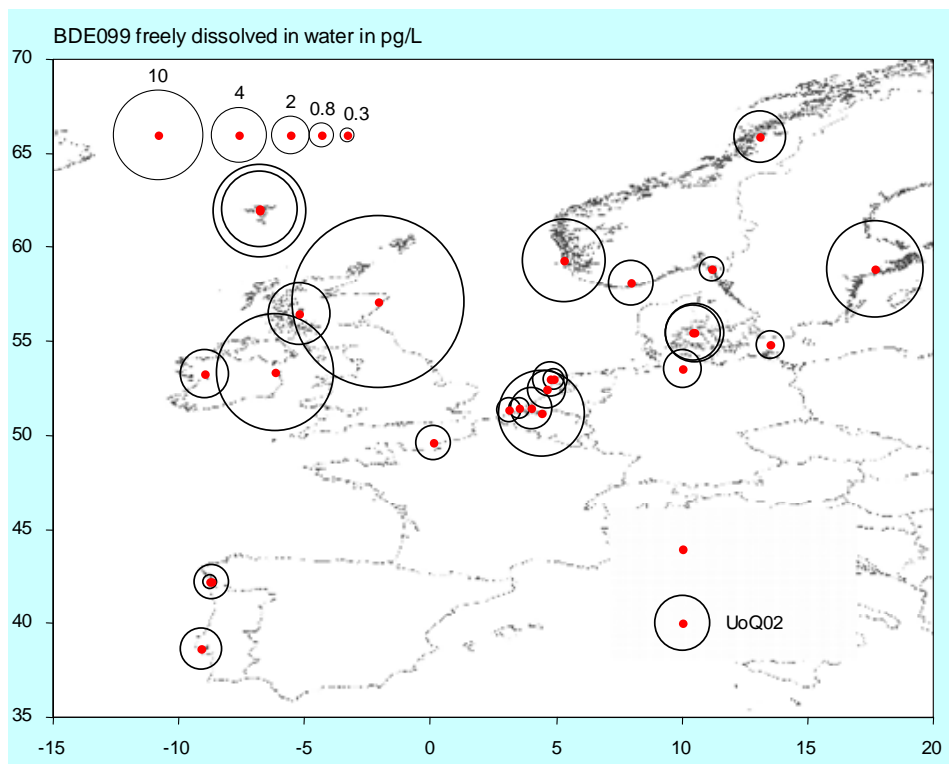
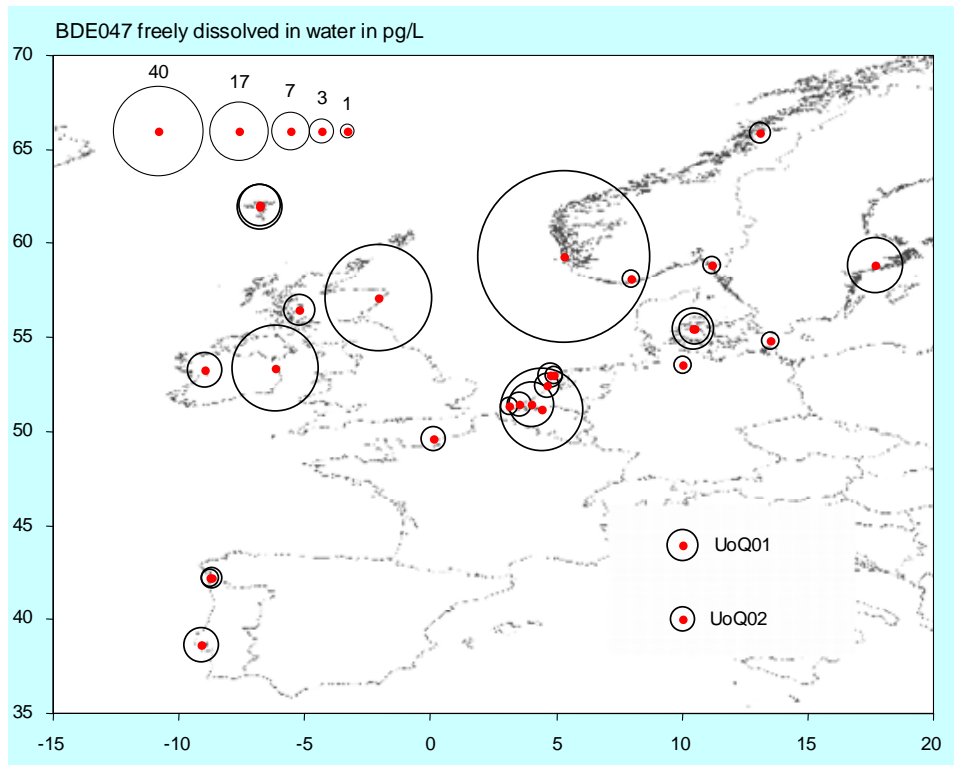


Figure 14: Estimated dissolved concentrations of BDE047 and BDE099 in water.



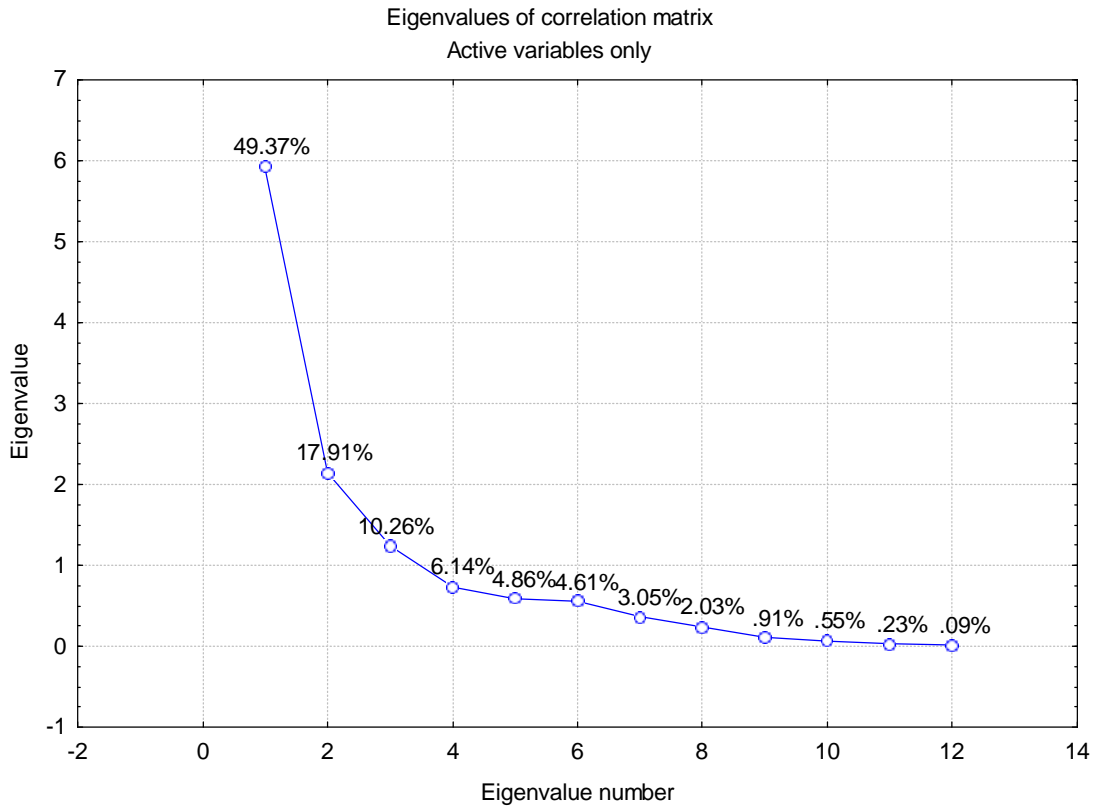


Figure 15: Eigenvalues of the correlation matrix for PCBs.

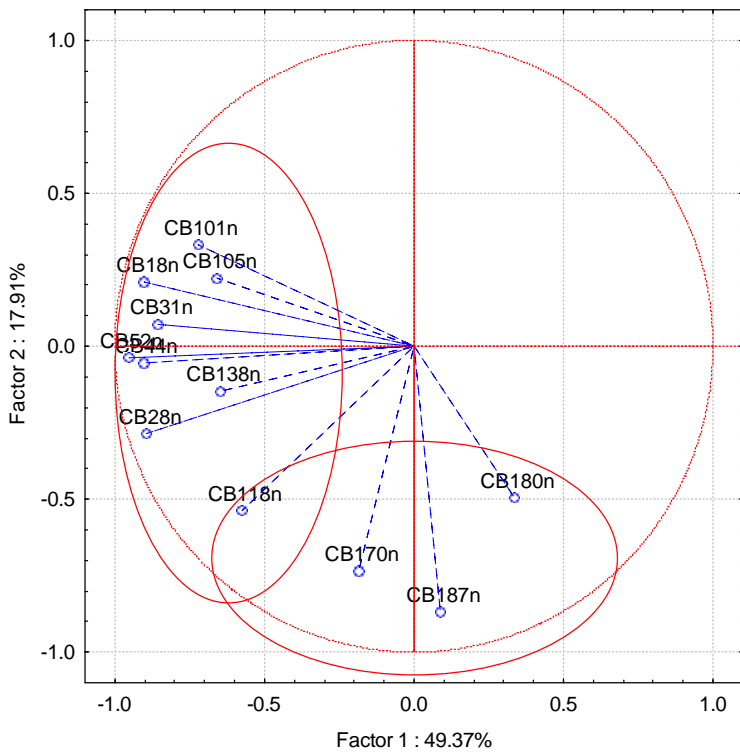


Figure 16: Projection of the factor scores of the PCBs on the factor-plane of the first two factors.

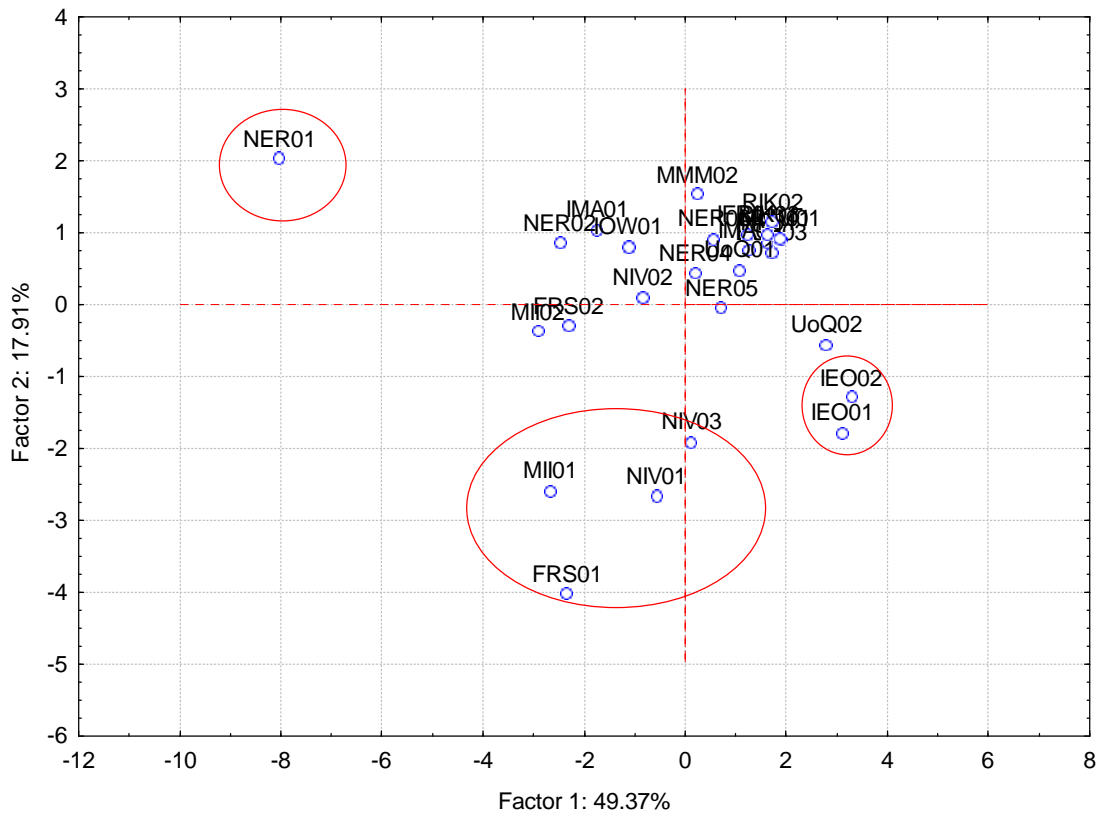


Figure 17: Projection of the factor scores for the different sites on the factor-plane of the first two factors.

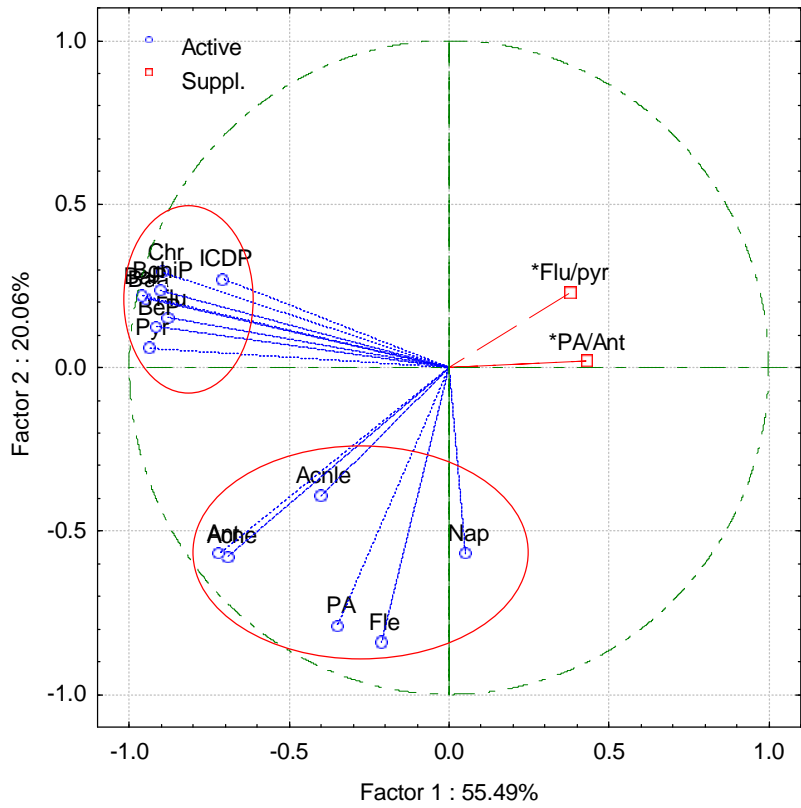


Figure 20: Projection of the factor scores of the PAHs on the factor-plane of the first two factors.

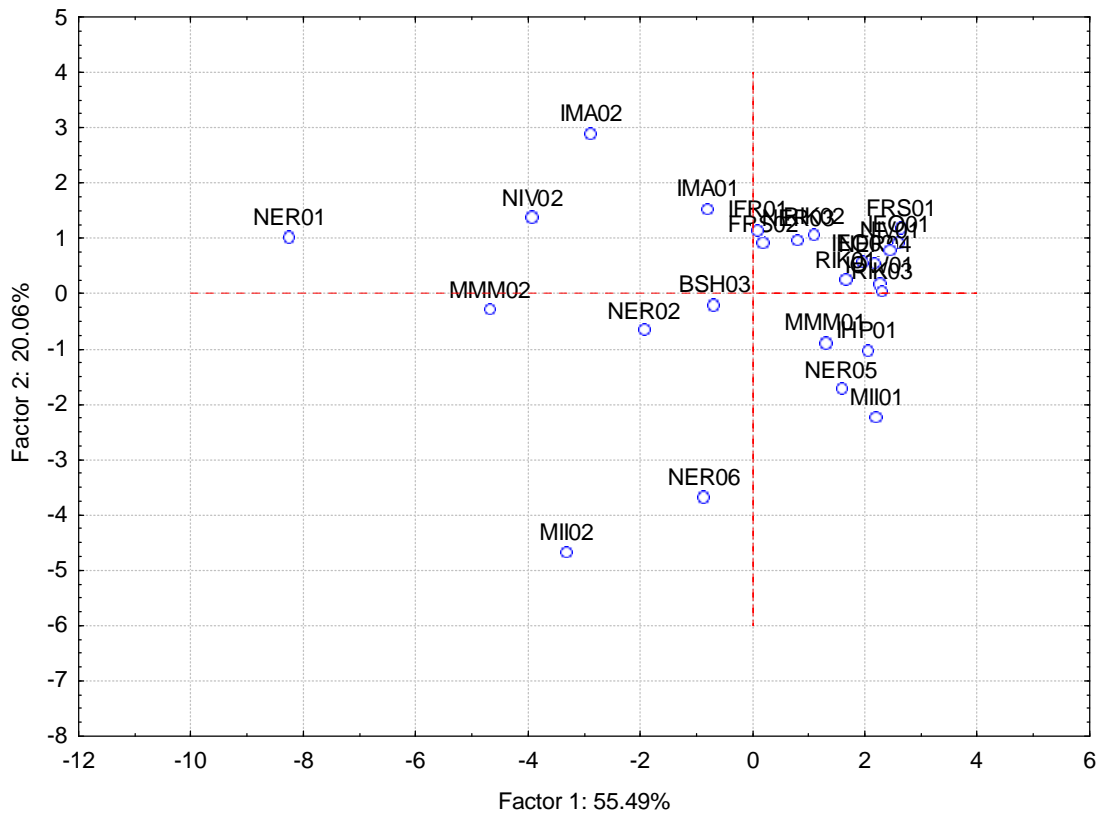


Figure 21: Projection of the factor scores for the different sites, excluding NIV03 and the Australian sites, on the factor-plane of the first two factors.