Assessment and Monitoring Series

2005 Assessment of data collected under the Co-ordinated Environmental Monitoring Programme (CEMP)

OSPAR Commission

2005

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l'Espagne.

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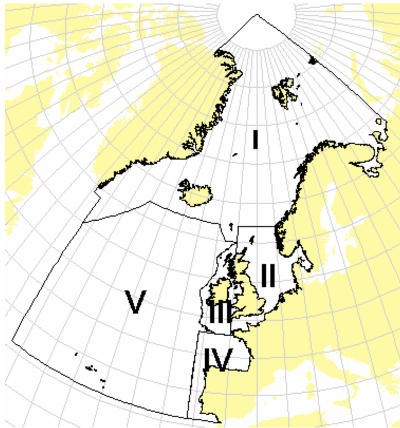
Executive Summary

Clear downward trends in Atlantic pollution

A scientific assessment of OSPAR[1] marine monitoring data shows widespread downward trends in the concentrations of hazardous substances in the North East Atlantic. Nevertheless, the majority of measurements show that concentrations of both naturally occurring and man-made contaminants remain above long-term targets[2]. Continued monitoring is needed to improve the number of time series where statistically significant trends can be detected. However, the assessment generally supports the conclusion that the work of OSPAR is having a substantial beneficial effect on the quality of the marine environment of the North-East Atlantic.

1. The ocean is a very dynamic medium, and there are strong seasonal patterns of change in both chemical and biological processes. These factors make it difficult to establish trends in marine monitoring data. Effective and reliable ocean monitoring requires consistent international co-operation supported by costly research vessels and sophisticated analytical equipment, and linked to sound data analysis. This assessment of the North-East Atlantic is the outcome of over 25 years' detailed international collaboration, involving all OSPAR coastal states. This collaboration is based on the Coordinated Environmental Monitoring Programme (CEMP).



OSPAR REGIONS

2. The assessment examined 2772 time series of observations of hazardous substances in biota (fish and shellfish), and 9151 time series of hazardous substances in sediments. These time series are drawn from data collected at widely spaced monitoring stations in OSPAR Regions I, II, III and IV, and varied in length from 3 to 25 years. Most stations were in Region II, but the results are similar in all four regions. The hazardous substances monitored include metals, polycyclic aromatic hydrocarbons (PAH), chlorinated biphenyl (CB) compounds, and selected pesticides.

3. Statistically significant trends, showing either increasing or decreasing concentrations, were found in 962 time series. The large majority (688 (72%)) showed downward trends. 274 (28%) showed increasing trends. The results are shown graphically in Figure A. The following results are particularly important for chemicals identified by OSPAR for priority action:

a. the large majority of the statistically significant trends of concentrations of mercury (28 out of 34), cadmium (53 out of 67) and lead (33 out of 37) in biota show decreasing concentrations;

b. all the statistically significant trends for lindane (56), and the large majority of those for CB 153 (representative of the CB group) (49 out of 51), in biota show decreasing concentrations. However, the rate at which concentrations of PCBs in biota are decreasing was less than that determined in the previous assessment suggesting that there may be a residual problem[3];

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[1] OSPAR (the Convention for the Protection of the Marine Environment of the North-East Atlantic) is the mechanism through which Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom, together with the European Community, co-operate to protect the North East-Atlantic. Finland, Luxembourg and Switzerland are not coastal States of the OSPAR area and have not taken part in this work.

[2] In 1998, the first OSPAR Ministerial Meeting adopted a long-term Hazardous Substances Strategy. This included "the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances".

[3] A possible explanation may lie in changing feeding habits, with more intake of food influenced by the seabed, where concentrations of contaminants in sediments can be significant.

c. the numbers of statistically significant increasing (33) and decreasing (54) trends for PAH compounds in biota did not show the clear move towards downward trends visible for other contaminants[4];

d. a substantial majority of the statistically significant trends of concentrations of metals in sediments were decreasing, particularly for cadmium (19 out of 23) and mercury (44 out of 44);

e. there were relatively fewer significant trends for organic compounds (PAH, CBs and lindane) in sediment, although a majority of those that were determined (15 out of 26) were in fact decreasing. Continued monitoring is needed to develop a more comprehensive picture.

4. For the large majority of time series, no statistically significant trends could yet be detected. The main reason for this is that the time series were too short: the dynamic nature of the marine environment produces much statistical "noise", which means that trends can only be detected over relatively long time series. Continued monitoring to extend the time series will help to clarify the position. Further monitoring is especially necessary to develop a more comprehensive picture in OSPAR Regions III and IV.

5. OSPAR has agreed a set of Background Concentrations, to represent the background levels of hazardous substances that would be expected in the absence of human-induced contamination. Comparison of the concentrations in the last year of each time series with these shows that in a large majority of cases concentrations of heavy metals are above background levels. For example:

biota

a. for lead and cadmium, over 85% of concentrations in blue mussels in the last year of each time series were above background levels;

b. for mercury, 99% of concentrations in blue mussels in the last year of each time series were above background levels, as were 79% of concentrations of mercury in fish;

sediments

c. for cadmium, 85% of concentrations in sediments in the last year of each time series were above background levels;

d. for lead and mercury, concentrations in sediments could only be assessed in the small number of cases where it was possible to normalise for aluminium. In these cases, concentrations were above background levels.

6. The picture was rather different for PAHs and CBs. For the various PAHs assessed, between 0% and 46% of concentrations in the latest year of biota time series were at background levels, depending on the PAH compound concerned. For concentrations in the latest year of sediment time series, between 0% and 59% of were at background levels. For CBs (which are man made synthetic substances), the ultimate OSPAR aim is concentrations close to zero. 11% of concentrations of CBs in blue mussels in the latest year of time series were close to zero. No concentrations of CBs in sediments in the latest year of sediment time series were close to zero.

7. Although a high proportion of the statistically significant trends show decreases, some notable upward trends were observed. for example:

biota

a. for PCBs in cod at some Norwegian and some UK sites[5];

sediments

b. for cadmium in the German Bight and off the Belgian coast;

c. for mercury in the inner German Bight;

d. for lead in the open North Sea and on the Belgian coast;

e. for PAHs in the North Sea, although further monitoring at a number of sites is needed to build a more comprehensive picture.

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[4] PAH compounds have a variety of sources, including wood-burning stoves, run-off from tarmac roads and municipal-waste incinerators.

[5] Again, this may be related to changes in feeding habits.

8. OSPAR has been particularly concerned about tributyltin, which has been used as an antifouling paint on ships, and which has an endocrine disrupting effect, particularly on shellfish. An initial assessment has been made of the monitoring of the biological effects of tributyltin in Denmark, Norway and UK. In these areas, strong effects were found in and around ports and related facilities, with much weaker effects in remote areas, for example in parts of northern Scotland and Norway. OSPAR aims to develop a more comprehensive assessment of this monitoring for publication in 2006.

9. This assessment shows that progress is being made towards the ultimate aim of the OSPAR Hazardous Substances Strategy of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man made, synthetic substances. The report has been produced as part of OSPAR's Joint Assessment and Monitoring Programme (JAMP), which aims at an overall evaluation of the success of OSPAR's strategies for the protection of the marine environment. It will contribute to the preparation of a new overall Quality Status Report in 2010. Recommendations are made for improving the assessment procedure, which will be taken into account in the preparation of further assessments of CEMP monitoring data during the period up to 2010.

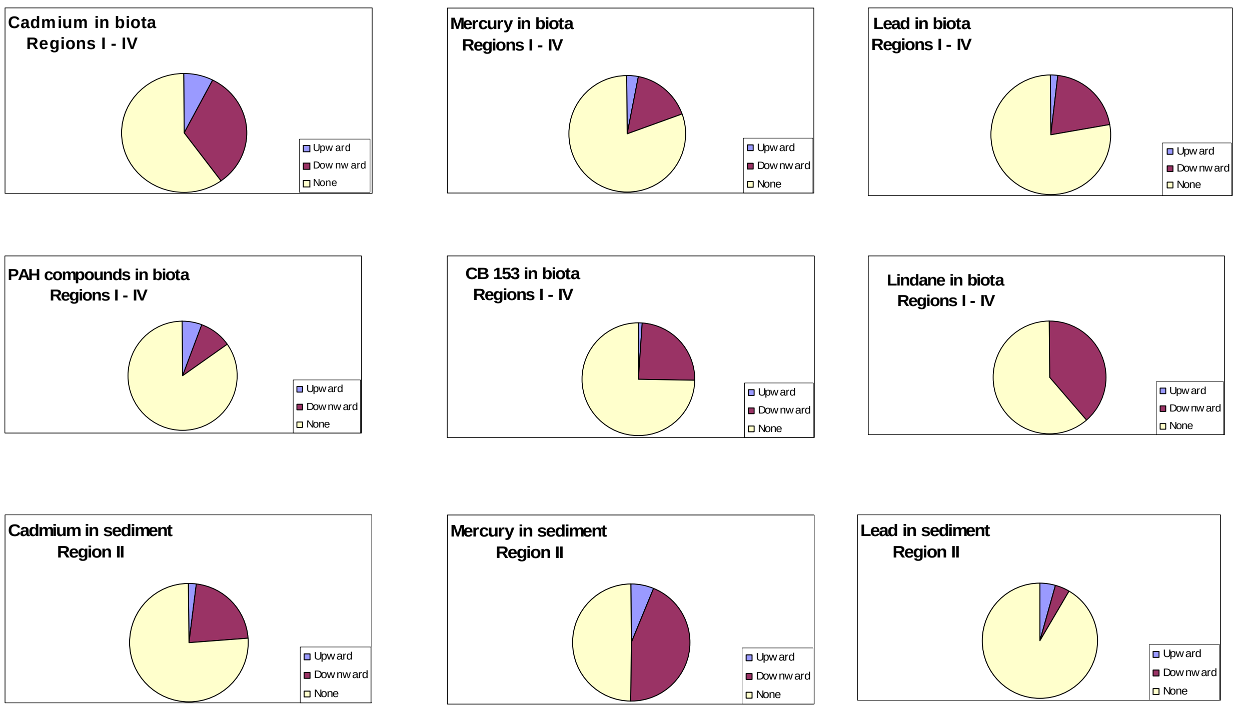


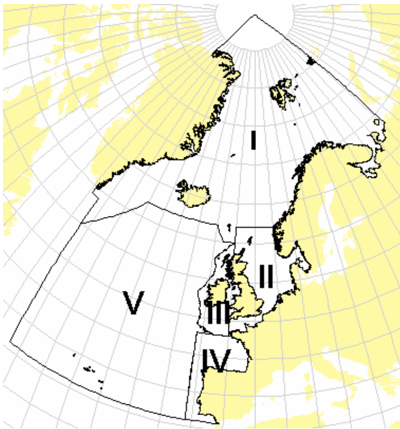
Figure A: Summary of the temporal trends in concentrations of hazardous substances (metals and organic contaminants) in fish, shellfish and sediments in the OSPAR area.

Récapitulatif

Nette tendance à la baisse de la pollution dans l'Atlantique

Selon une évaluation scientifique des données issues de la surveillance marine OSPAR[6] les teneurs en substances dangereuses dans l'Atlantique du Nord-Est sont en baisse dans l'ensemble. La plupart des mesures montrent néanmoins que les teneurs des contaminants aussi bien présents à l'état naturel que de synthèse sont toujours supérieures aux objectifs à long terme[7]. Il convient de poursuivre la surveillance continue afin d'accroître le nombre de séries temporelles qui permettent de détecter des tendances statistiquement significatives. D'une manière générale, l'évaluation étaye néanmoins la conclusion à savoir que les travaux d'OSPAR ont un effet salutaire considérable sur la qualité du milieu marin de l'Atlantique du Nord-Est.

1. L'océan est un milieu très dynamique qui présente d'importantes variations saisonnières tant en ce qui concerne les processus chimiques que biologiques. Ces facteurs rendent difficile la détection de tendances dans les données issues de la surveillance marine. Une coopération internationale constante, des navires de recherche coûteux, du matériel d'analyse sophistiqué ainsi qu'une analyse solide des données permettent une évaluation efficace et fiable de l'océan. La présente évaluation de l'Atlantique du Nord-Est est le résultat de plus de vingt-cinq années d'une collaboration internationale minutieuse entre les états riverains d'OSPAR. Cette collaboration se fonde sur le Programme coordonné de surveillance continue de l'environnement (CEMP).



RÉGIONS OSPAR

2. L'évaluation a étudié 2772 séries temporelles de substances dangereuses dans le milieu vivant (poisson et crustacés), et 9151 séries temporelles de substances dangereuses dans les sédiments. Ces séries temporelles découlent des données provenant de stations de surveillance espacées dans les Régions OSPAR I, II, III et IV, et couvrent des périodes allant de trois à vingt-cinq ans. Bien que la plupart des stations se situent dans la Région II, les résultats obtenus dans les quatre régions sont semblables. Les substances dangereuses surveillées comprennent les métaux, les hydrocarbures aromatiques polycycliques (HAP), les composés de chlorobiphényles (CB), et des pesticides sélectionnés.

3. Des tendances statistiquement significatives qui mettent en évidence des teneurs tant croissantes que décroissantes, ont été observées dans 962 séries temporelles. La plupart (688 (72%)) révèlent des tendances à la baisse alors que 274 (28%) révèlent des tendances à la hausse. La figure A comporte une représentation graphique des résultats. Les résultats suivant sont particulièrement importants pour les produits chimiques identifiés par OSPAR comme devant faire l'objet de mesures prioritaires:

a. la plupart des tendances statistiquement significatives sont à la baisse pour les teneurs en mercure (28 sur 34), cadmium (53 sur 67) et plomb (33 sur 37) dans le milieu vivant;

b. toutes les tendances statistiquement significatives pour les teneurs en lindane (56), et la plupart pour le CB153 (représentatif du groupe de CB) (49 sur 51), dans le milieu vivant sont à la

[6] OSPAR (Convention pour la protection du milieu marin de l'Atlantique du Nord-Est) est le mécanisme selon lequel l'Allemagne, la Belgique, le Danemark, l'Espagne, la Finlande, la France, l'Islande, l'Irlande, le Luxembourg , la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni, la Suède, et la Suisse ainsi que la Communauté européenne, co-opèrent à la protection de l'Atlantique du Nord-Est. La Finlande, le Luxembourg et la Suisse ne sont pas des états riverains de la zone OSPAR et n'ont pas participé aux travaux.

[7] La première réunion ministérielle d'OSPAR en 1998, a adopté une Stratégie à long terme visant les substances dangereuses. Son but est "en dernier ressort, de parvenir à des teneurs, dans l'environnement marin, qui soient proches des teneurs ambiantes dans le cas des substances présentes à l'état naturel et proches de zéro dans celui des substances de synthèse."

baisse. Les teneurs en PCB dans le milieu vivant diminuent moins rapidement, cependant, que prévu dans l'évaluation précédente, ce qui semble suggérer qu'un problème persiste[8];

c. les nombres de tendances statistiquement significatives à la hausse (33) et à la baisse (54) pour les composés de HAP dans le milieu vivant ne représentent pas une nette tendance à la baisse telle qu'observée dans le cas des autres contaminants[9];

d. la plupart des tendances statistiquement significatives pour les teneurs en métaux dans les sédiments sont à la baisse, en particulier en ce qui concerne le cadmium (19 sur 23) et le mercure (44 sur 44);

e. les composés organiques (HAP, CB et lindane) dans les sédiments, présentent relativement moins de tendances significatives, bien que la plupart de celles qui ont été déterminées (15 sur 26) soient à la baisse. Il convient de poursuivre la surveillance continue afin d'obtenir une vue d'ensemble plus complète.

4. Il n'est pas encore possible de déterminer des tendances significatives pour la plupart des séries temporelles, car ces séries sont trop courtes. La détermination des tendances doit se faire à partir de séries temporelles relativement longues du fait de la nature dynamique et changeante du milieu marin. Une surveillance continue suivie, permettant d'obtenir des séries temporelles plus longues, permettra de clarifier la situation. Il convient en particulier de poursuivre la surveillance continue afin d'obtenir une vue d'ensemble plus complète pour les Régions III et IV d'OSPAR.

5. OSPAR est convenue d'une série de teneurs ambiantes qui représentent les niveaux ambiants de substances dangereuses auxquels on peut s'attendre en l'absence de contamination anthropique. Si l'on compare ces teneurs ambiantes aux teneurs relevées lors de la dernière année de la série on s'aperçoit que dans la plupart des cas les teneurs en métaux lourds sont supérieures aux teneurs ambiantes, par exemple:

milieu vivant

a. pour le plomb et le cadmium, plus de 85% des teneurs dans la moule sont supérieures aux teneurs ambiantes;

b. pour le mercure, 99% des teneurs dans la moule ainsi que 79% des teneurs dans le poisson sont supérieures aux teneurs ambiantes;

sédiments

c. pour le cadmium, 85% des teneurs dans les sédiments, sont supérieures aux teneurs ambiantes;

d. pour le plomb et le mercure, il n'a été possible d'évaluer les teneurs dans les sédiments que dans un petit nombre de cas où il a été possible de normaliser pour l'aluminium. Dans ces cas les teneurs étaient supérieures aux teneurs ambiantes.

6. La situation est différente en ce qui concerne les HAP et les CB. Suivant le composé de HAP étudié, entre 0% et 46% des teneurs dans le milieu vivant pour les divers HAP évalués sont égales aux teneurs ambiantes au cours de la dernière année de la série temporelle. En ce qui concerne les teneurs dans les sédiments au cours de la dernière année de la série temporelle, entre 0% et 59% étaient égales aux teneurs ambiantes. Dans le cas des CB (qui sont des substances synthétiques), l'ultime objectif d'OSPAR est de parvenir à des teneurs proches de zéro. 11% des teneurs en CB dans la moule étaient proches de zéro au cours de la dernière année de la série temporelle. Aucune teneur en CB dans les sédiments n'était proche de zéro au cours de la dernière année de la série temporelle.

7. Bien qu'un grand nombre de tendances statistiquement significatives soient à la baisse, on a également noté des tendances à la hausse importantes, par exemple:

milieu vivant

a. pour les PCB dans le cabillaud dans certains sites de Norvège et du Royaume-Uni[10];

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[8] Ceci pourrait être dû à des modifications de l'alimentation, telles qu'une augmentation des aliments provenant du fond de la mer où les teneurs en contaminants dans les sédiments peuvent être considérables.

[9] Les composés de HAP proviennent de diverses sources, notamment les poêles à bois, les déchets du revêtement des routes goudronnées et les incinérateurs de déchets municipaux.

[10] Ceci peut de nouveau être dû à des modifications de l'alimentation.

sédiments

b. pour le cadmium dans le German Bight et près de la côte belge;

c. pour le mercure à l'intérieur du German Bight;

d. pour le plomb au large de la mer du Nord et sur la côte belge;

e. pour les HAP dans la mer du Nord. Il convient cependant de poursuivre la surveillance continue dans certains sites afin d'obtenir une vue d'ensemble plus complète.

8. Le tributylétain préoccupe particulièrement OSPAR. Il est utilisé dans les peintures antisalissures pour navires et a pour effet de perturber le système endocrinien, des crustacés en particulier. Une évaluation préliminaire de la surveillance continue des effets biologiques du tributylétain a été effectuée au Danemark, en Norvège et au Royaume-Uni. Dans ces zones les effets sont importants dans les ports et leur voisinage et beaucoup plus faibles dans les zones éloignées comme par exemple au nord de l'Ecosse et en Norvège. L'objectif d'OSPAR est d'effectuer une évaluation plus complète de cette surveillance en vue de sa publication en 2006.

9. La présente évaluation illustre les progrès accomplis dans le sens de l'ultime objectif de la Stratégie OSPAR visant les substances dangereuses, de parvenir à des teneurs, dans l'environnement marin, qui soient proches des teneurs ambiantes dans le cas des substances présentes à l'état naturel et proches de zéro dans celui des substances de synthèse. Le rapport est élaboré dans le cadre du Programme conjoint OSPAR d'évaluation et de surveillance continue (JAMP), dont l'objectif est une évaluation globale des résultats obtenus dans le cadre des stratégies OSPAR pour la protection du milieu marin. Ce rapport contribuera aux préparatifs d'un nouveau Bilan de santé global (QSR) en 2010. L'élaboration de nouvelles évaluations des données issues de la surveillance continue dans le cadre du CEMP couvrant la période jusqu'à 2010, tiendra compte des recommandations portant sur l'amélioration de la procédure d'évaluation.

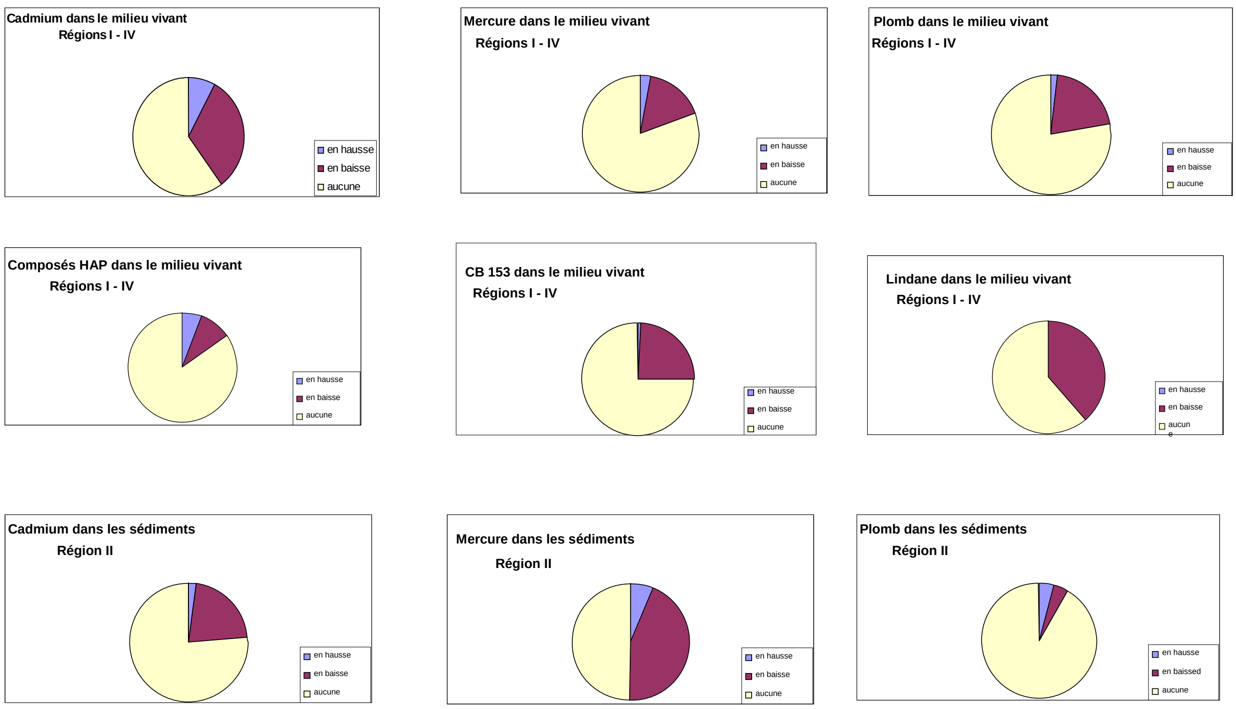


Figure A: Vue d'ensemble des tendances temporelles des substances dangereuses (métaux et contaminants organiques) dans le poisson, les crustacés et les sédiments dans la zone OSPAR

1. Introduction

This report presents an assessment of trends in the concentrations of metals and organic contaminants in sediments and the tissues of various fish species and in the soft tissue of bivalves determined under the OSPAR Coordinated Environmental Monitoring Programme (CEMP). The assessment has been produced as part of the OSPAR Joint Assessment and Monitoring Programme (JAMP) as a contribution to JAMP Product HA-1: assessments by 2005 of temporal trends and (where relevant/feasible) spatial distribution for the hazardous substances, where periodic sampling and analysis are undertaken under the Comprehensive Study on Riverine Inputs and Direct Discharges (RID), the Comprehensive Atmospheric Monitoring Programme (CAMP) and the CEMP.

The report assesses data on following metals and organic contaminants monitored in biota and sediments under the CEMP on a mandatory basis: cadmium (Cd), mercury (Hg) and lead (Pb), polycyclic aromatic hydrocarbons (PAHs) (anthracene, benz[a]anthracene, benzo[a]pyrene, benzo[g,h,i]perylene, chrysene, fluoranthene, indeno[1,2,3-cd]pyrene, phenanthrene, pyrene), polychlorinated biphenyls (ΣCB_7, CB 153). Data for the following contaminants reported on a voluntary basis was also assessed: arsenic (As), chromium (Cr), copper (Cu), nickel (Ni) and zinc (Zn), dieldrin and lindane (γ-HCH)). The assessments are based on data up to and including 2003 and were prepared during the 2004 meeting of the OSPAR Working Group on Monitoring (MON 2004). The preparations of assessment products were overseen by a MON intersessional group (MIG) and carried out in collaboration with the International Council for the Exploration of the Sea (ICES), which acts as the OSPAR data centre for CEMP monitoring data.

Data were selected from the OSPAR CEMP data held in environmental databases managed by ICES. Data were included in the assessment if:

- the time series were $\geq$ 3 years long;
- the data included at least 1 observation later than 1996.

A total of 2772 time series $\geq$ 3 years for metals and organic contaminants in bivalves and fish were available for assessment. time series for 3506 contaminant/location combinations for sediment were assessed, and considered after application of up to 3 normalisation procedures. The time series varied in length within the period 1978-2003. The sites monitored ranged from Spain to the north of Norway and Iceland. The vast majority of the sites monitored fell within Region II (the Greater North Sea) of the OSPAR Convention area.

A total of 1967 time series $\geq$ 5 years in length for contaminants in biota were suitable for a statistical analysis of linear trends, once those containing many observations below the detection limit or containing large gaps in monitoring had been excluded. The availability of several alternative approaches to normalisation of contaminant concentrations in sediment led to the assessment of 9152 time series of contaminants in sediment.

The results from the last monitoring year were compared to assessment tools representing background concentrations (BCs or BRCs) and concentrations that would be of potential concerns to marine species (EACs).

An initial attempt to integrate information on temporal trends of contaminant concentrations in sediments and biota with the assessment of data from the Comprehensive Study on Riverine Inputs and Direct Discharges (RID) study on changes in inputs of Hg, Cd, Pb to the North Sea via riverine inputs and direct discharges, which is being assessed in parallel by the OSPAR Working Group on Inputs to the Marine Environment (INPUT). A preliminary qualitative assessment of the trends in CEMP and RID data is presented in section 9 of this report. A further parallel assessment is taking place of the data on atmospheric deposition to the North Sea collected under the CAMP. The CAMP assessment was not sufficiently progressed at the time of preparation of this assessment for a comparison between trends in CEMP and CAMP data to be made.

The JAMP also scheduled an initial assessment of the biological effects of hazardous substances in the marine environment for 2005 to be published in conjunction with this report. In preparing this assessment it became clear that there was insufficient data in the ICES database on biological effects to support such an assessment of these biological effects. Further consideration of the availability of appropriate data to prepare such an assessment will be made in 2005/2006.

2. Data screening

The deadline for the submission of data for inclusion in the assessment was 1 August 2004. A total of 197 data submissions (data files) were processed from Belgium, Denmark, France, Germany, Iceland, Ireland, Netherlands, Norway, Spain, Sweden and the United Kingdom. Of these submissions 89 were received before the agreed deadline, while 16 were received after. The 16 late arrivals were for imposex and other biological effects data. The status of biological effects data was evaluated by MIG by 15 September 2004 at which time it was decided that these could not be included in this assessment. Between 1 August and 3 December 2004, 66 data submissions were resubmitted at the request of ICES due to errors which were found in the preliminary assessment.

A total of 2965 files containing Quality Assurance of Information for Marine Environmental Monitoring in Europe (QUASIMEME) participation results were received from 50 laboratories, 10 of which could not be identified. There are still a number of laboratories which have not sent in their results, as well as a number that have deleted the results of certain QUASIMEME exercises.

3. Quality assurance of analytical data

The preparations for previous temporal trend assessments, such as that prepared by MON in 1996, included the formation of an expert steering group to undertake an assessment of the analytical quality of the contaminant data held in the ICES database.

The approach taken (described in detail in the report of the 1996 assessment) was to establish criteria for the acceptability of data. These criteria set out that data that failed to meet the criteria for acceptability were excluded from the assessment. This would have resulted, depending on the country concerned, in the exclusion of 1-23% of the data on metals in biota, and 67-100% of the data on organic contaminants. MON 1995 decided that these levels of loss were acceptable for metals and most CBs, but that all data for some other organic contaminants should be included, as a second group of determinands, irrespective of the QA assessor's advice.

Over subsequent years a more detailed analysis of the sources of variance in time series of field data (Nicholson *et al.* 2001) has revealed that, generally, the analytical variance is a small component of the total variance, and that field variance (e.g. between year variance) is more important. It was therefore agreed that the process of accepting/excluding data should be modified, and that data should be weighted according to the apparent quality as indicated by the supporting QA information. No data would be excluded, but data of good quality would be weighted more strongly (weight 1,0) than data with poor or absent QA information (weight 0,2). Details of this procedure are provided in Appendix 4.

Other consequences of adopting this approach include elimination of the need to take account of data inclusion/exclusion policies used in previous assessments. This is particularly important in relation to early data in long data series, submitted to ICES when there was no requirement for accompanying QA information. All these data would now be included in the assessment.

Furthermore, the continuation and expansion of the scope of international laboratory performance studies (LPS) (e.g. QUASIMEME), and of the accreditation of analytical laboratories, allows more emphasis to be given to performance in such studies in reaching a conclusion as to overall analytical quality.

As for previous assessments, the QA information consisted mainly of:

- QUASIMEME z-scores, as supplied to ICES by analytical laboratories, by means of the collations of laboratory performance study (LPS) results distributed to participating laboratories on CD by QUASIMEME in summer 2004;
- QUASIMEME z-scores previously held in the ICES QA database – these are also taken to be acceptable if < 2 in absolute magnitude;
- Certified Reference Material (CRM) values – these are taken to be acceptable if the CRM laboratory concentration is within 25% of the CRM true concentration;
- Information in national comment documents.

In most cases, the assessment of data quality could be carried out without reference back to national data coordinators. The provision by analytical laboratories of comprehensive information on their performance in

QUASIMEME exercise, through forwarding copies of summary CDs prepared by QUASIMEME was a significant move forward in both the scope and reliability of QA information held at ICES. The continuation of this co-operation is important to the future developments of assessments.

A number of difficulties were encountered in making use of CRM analyses as supporting QA information. Firstly, a large number of different CRMs have been used by the laboratories for the same compartment/contaminant combination, and laboratories rarely used the same CRM for more than a few years.

Evaluation of the reported values against the certified (target) values should have been straightforward, but in 16% of the cases the laboratories had clearly reported values using the wrong units. The resulting large deviations should have caused concern in the laboratories, and caused them to review their data prior to submission, but this does not seem to have occurred.

In the large majority of cases (87%), once gross errors have been corrected, the laboratories reported satisfactory data for CRM analyses. This suggests that using CRM analyses as a simple indicator of data quality may not have great value. The target concentrations are usually known to the laboratory staff, and therefore CRM analyses do not provide the same rigour of tests as LPS which use test unknown materials. However, CRM analyses can contribute to in-house estimates of analytical uncertainty, and laboratories are encouraged to continue to use them. The observation that in a minority of cases laboratories are reporting unsatisfactory CRM data suggests that these laboratories should be aware of problems with their methods, but have been unable to solve them. The reporting of unsatisfactory CRM data to ICES/OSPAR is a strong indication of potential unreliability of field sample data. Further details of the analysis underlying this discussion are given in Appendix 4.

It is recommended that greater weight be given to LPS data than to CRM data and also that ICES explore the feasibility and scientific merit of requiring data submissions to be accompanied by expressions of analytical uncertainty.

4. Choice of bases

The choice of bases aimed to meet several considerations: scientific validity, uniformity for groups of contaminants for particular tissues and a minimum loss of data. As to the latter, the choice of bases might affect the number of data that could be treated in the statistical analyses, depending on available information of dry weights (dw), wet weights (ww) and lipid weights (lw). The bases preferred for biota were:

- dry weights for metals, organochlorines and PAHs in bivalves soft body tissues;
- wet weights for metals and organochlorines in fish muscle, including tail muscle (crustaceans), and metals in fish liver;
- lipid weights for organochlorines in fish liver, and;
- sediment expressed on a dry weight basis.

This selection meant a 0,3-3% loss of data (Appendix 3).

5. Statistical methodology

As in previous assessments, trends were assessed using a smoother, a non-parametric curve fitted to time series of annual contaminant indices. A graphical presentation was supported by formal statistical tests of the significance of the fitted smoother and of the linear and non-linear components of the trend. The theory and methodology are described in detail in Fryer & Nicholson (1999). A review of the assumptions in the method and a list of revisions in the current method are described in Appendix 4.

For time series with 5 or 6 years, a simpler analysis was made focusing only on evidence of a linear trend.

For time series with 3 or 4 years, the data were simply summarised by their mean. These assessments only provide information about the average level and are mainly of interest where they can be compared to assessment criteria.

For biota, the annual contaminant index was the median log concentration. For sediment, the annual contaminant index was a weighted mean log concentration.

The assessment also compared current concentrations to the BAC or EAC by calculating the ratio of the upper 95% confidence limit of the fitted estimate for the most recent sampled year to the BAC or EAC. This is referred to as the BAC or EAC ratio. Ratios < 1 indicate that mean concentrations are significantly below the BAC or EAC. This is in accordance with the precautionary approach to environmental management. Note that the ratios take no account of the uncertainty in setting the BAC/BRC/EACs. Further discussion is given in Appendix 4.

The output from the analyses is summarised in a standard format in sections 7 and 8. This includes the '10-year detectable trend' i.e., the percentage change that would be detected with a 90% power at a 5% significance level by a 10-year monitoring programme. Further discussion of the methods is given in Appendix 4.

6. Assessment criteria

6.1 Background concentrations and environmental assessment criteria

Background Reference Concentrations (BRCs) for contaminants in sea water, sediment and biota and EACs for trace metals, PCBs, PAHs, TBT and some organochlorine pesticides (*OSPAR agreements 1997-14 and 1997-15*) [11] were originally adopted by OSPAR 1997 as assessment tools for use in preparing the previous CEMP assessment and the Quality Status Report 2000 (OSPAR Commission 2000). In adopting these criteria OSPAR agreed that:

a. BRC values should be updated after the QSR 2000 (i.e. before subsequent assessments), taking into account increasing knowledge about the environment of the OSPAR maritime area;

b. EACs needed to be further refined and updated at periodic intervals (every 5-10 years, for example), in order to take account of changes to the JAMP (e.g. in the parameter list) and changes in the availability of new marine toxicity data.

In order to facilitate the updating of the assessment criteria the Netherlands held an OSPAR/ICES workshop on the evaluation and update of BRCs and EACs and on how these assessment tools should be used in assessing contaminants in water, sediment and biota from 9-13 February 2004. The workshop proposed changes to the nomenclature for OSPAR assessment criteria with BRCs being replaced by Background Concentrations (BCs) and EACs becoming Environmental Assessment Criteria. Following the workshop, proposals were developed for updated assessment criteria in the form of BCs for metals in sediment and PAHs and PCBs in sediment and biota and Environmental Assessment Criteria for metals, PAHs and selected organochlorine pesticides were prepared. The workshop also proposed that testing of whether mean observed concentrations can be considered to be near background concentrations should be carried out through the use of "Background Assessment Criteria" (BACs). These are statistical tools defined in relation to the background concentrations (BCs) on the basis of the variability within the monitoring dataset. A set of provisional BACs based on the variability within the UK monitoring dataset were also developed following the workshop.

In preparing this assessment a trial application of the proposed BCs and EACs was made. However, for certain parameters no updated BCs or EACs had been proposed and where this was the case the BRC and EACs values from the 1997 agreements were applied. To test mean observed concentrations against the proposed BCs, the provisional BAC values calculated on the basis of the variability in UK monitoring data were applied.

In relation to the use of the criteria used in the assessment it should be noted that:

a. France has emphasised that:

(i) the BAC values are dependent upon the variability of the dataset used to their construction and to be representative of all CEMP monitoring data, the BAC values should be calculated using the variability of the whole CEMP dataset, and not only on a part of it as it has been done in preparing the provisional BACs. The provisional BAC values used in this assessment were not acceptable to France as official OSPAR BACs;

[11] Following preparation of this assessment a new OSPAR agreement on background concentrations for contaminants in seawater, biota and sediment was adopted (*OSPAR agreement 2005-06*) superseding OSPAR agreement 1997-14, and taking up the BC values proposed following the 2004 workshop. Further work on the development of the proposed EAC values is taking place.

(ii) the proposed BC in mussel for Hg appears too low and note should be taken of proposals made by France to the OSPAR SIME working group in2001 for a revised BRC for Hg;

b. Iceland has drawn attention to the fact that the QSR 2000 reports higher BCs for some metals in the western parts of Region I than in other parts of the OSPAR maritime area. No anthropogenic point sources of these metals in the western parts of Region I are known, and the higher levels can only been explained by natural factors such as sediments of different geological origin and different physical/chemical conditions. This implies that the proposed BC ranges for some metals are not valid for this part of Region I;

c. Spain has drawn attention to the high concentrations in Cd found in wild mussel in pristine areas from the Galician coast from the National Monitoring Programme for the Spanish Atlantic coast (Besada *et al* 2002). Analyses of samples from these areas have since 1991 consistently given high concentrations for Cd but very low for Hg and Pb, which agree with the low population density and the level of industrialisation of the area. Therefore, the high Cd values might be due to the oceanic upwelling in this area, which has been well documented. Research results have been describing transports of Cd to the sea surface when upwelling occurs (Chester, R. (2000)). The upwelling presents its maximum intensity near Finisterre and Cabo Vilano. In view of these results, Spain suggests that for this area the maximum value for the BAC range should be considered to be 0,5 mg/kg (ww).

Tables 6.1 and 6.2 show the assessment criteria used in the assessment. In cases where a proposal for a BC or EAC has not been made, BRCs or EACs from the 1997 agreements have been used.

Table 6.1 Background concentration (BC), environmental assessment criteria (EACS) values for metals in sediment, blue mussel and fish. Provisional BACs values used in the assessment are also indicated

Parameter	SEDIMENT (mg kg-1 dw; normalised to 5% Al for BC/BAC)			BIOTA – blue mussel (µg kg-1 ww)			BIOTA – fish (µg kg-1 ww)		
	BC	BAC	EAC	BRC*	BAC	EAC	BRC-fillet*	BAC-fillet	EAC-whole
As	15	22	0,71						
Cd	0,2	0,31	0,06	110*		55,9			7,35*
Cr	60	76	21						
Cu	20	31	0,22	1100*					
Hg	0,05	0,08	0,22	10*		1,7 3	50* 1 70* 2		3,5 3
Ni	45	70	2,8						
Pb	25	34	2,22	190*		1690 3			300 3
Zn	90	116	1,48	30000*					

1 Roundfish fillet
2 Flatfish and herring fillet
3 Provisional EAC for secondary poisoning, whole fish
* Values from OSPAR agreement 1997-14 on BRCs (now superseded by OSPAR agreement 2005-06) or OSPAR agreement 1997-15 on EACs have been used

For sediment, the BCs and EAC proposed in 2004 have been applied with the BC being applied using provisional BACs calculated on the basis of variability in UK monitoring data. For blue mussel no BC has been proposed in 2004 for metals or PCBs, therefore the maximum of the ranges of BRCs in OSPAR agreement 1997-14 (now superseded) have been applied as BCs. The EAC value used for Cd in blue mussel was the value proposed for direct toxicity in 2004. The EACs for Hg and Pb in mussel were for those proposed for secondary poisoning in 2004. No assessment criteria were available for bivalve molluscs other than blue mussel.

For fish the maximum of the BRC ranges in OSPAR agreement 1997-14 (now superseded) was used as a BC for Hg. The EAC applied for Cd in fish was the value proposed in 2004 for direct toxicity. The EACs for Hg and Pb in fish were those proposed in 2004 for secondary poisoning.

Table 6.2 Background concentration, and environmental assessment criteria values for organochlorines and PAHs in sediment, blue mussel and fish. Provisional BACs values used in the assessment are also indicated

Parameter	SEDIMENT (µg kg-1 dw normalised to 2,5% carbon)			BIOTA – blue mussel (µg kg-1 ww)			BIOTA – fish (µg kg-1 ww)		
	BC	BAC	EAC	BC	BAC	EAC	BC-liver	BAC-liver	EAC-whole
DDE			4			10*			50*
Dieldrin			19,75			10*			50*
Lindane			2,75			0,29			1,1
TBT			0,025			2,4			
CB 153	0	0,5		0	0,4	2,5*	0	0,2	2,5*
ΣCB_7 [1]	0	1,3		0	0,7	10*	0	1,2	10*
Naphthalene	5	11	95	0,2	1,1	91			
Phenanthrene	17	41		0,9	4,9				
Anthracene	3	8		0,2	0,4				
3 rings (PA+ANT)			77,5			1290			
Fluoranthene	20	44		1,4	2,5				
Pyrene	13	28		1,1	1,8				
Benz[a]anthracene	9	22		0,3	1,1				
Chrysene	11	29		1,3	3,4				
4 rings (FLU+PYR+BAA+CHR)			352,5			6900			
Benoz[a]pyrene	15	56		0,2	0,7				
5 rings (BAP+BKF)			52,5			1069			
Benzo[ghi]perylene	45	140		0,5	2,7				
Indeno[123-cd]pyrene	50	128		0,4	1,6				
6 rings (BGHIP+ICDP)			9,25			73			

1. Sum of CB 28, CB 52, CB 101, CB 118, CB 138, CB 153, CB 180
* Values from OSPAR agreement 1997-14 on BRCs (now superseded by OSPAR agreement 2005-06) or OSPAR agreement 1997-15 on EACs have been used

For organochlorines and PAHs in sediment, the BCs and EACs proposed in 2004 have been applied, with the BCs being applied through use of provisional BACs calculated on the basis of variability in UK monitoring data.

For PAHs in blue mussel the BC and BAC values were taken from the 2004 proposed values. The EAC values for DDE, dieldrin, CB 153, and ΣCB_7 in blue mussel were taken from the OSPAR agreement 1997-15. The EACs for lindane, TBT and PAHs in blue mussel were the 2004 proposed values for direct toxicity for bivalves.

For fish the BCs and BACs for CB 153, and ΣCB_7 proposed in 2004 have been applied. The EAC values for DDE, dieldrin, CB 153, and ΣCB_7 in fish were taken from the OSPAR agreement 1997-15. The EAC for lindane in fish was the value proposed in 2004 for direct toxicity.

6.2 Conversion of assessment criteria to preferred bases

The proposed assessment criteria (BRCs, EACs) were expressed on bases which differ from the preferred bases used in this assessment. In order to use the assessment criteria, it was necessary to convert between bases, for example from wet weight to dry weight or lipid weight. A comprehensive set of conversion factors were developed during the 1996 assessment of biota data, making use of data in the ICES database. The factors were reassessed (see Appendix 5) and for the current assessment the same conversion factors to change the bases of expression of the assessment criteria were used. Factors were also used to convert whole fish EACs to individual tissue based values, where necessary.

The same conversions were necessary to ensure that maximum use was made of the field data in the ICES database. Conversion was only done if the contaminant data for the sample were accompanied by the necessary specific conversion information (e.g. a measured value for % dry weight).

The general factors used to convert the values of assessment criteria were based on the mean dry weights and lipid weights relating to the samples screened (Appendix 5).

By applying the conversion factors, the assessment criteria for bivalves were converted to the preferred bases (table 6.3). The conversion of EACs for fish fillet or fish liver required first a conversion from fish (whole carcass) to these tissues (table 6.4). By using the mean lipid weight concentrations in liver for the different species (Appendix 3) the EACs for these were estimated (table 6.5).

Table 6.3 Conversion to the preferred bases in biota

The bases used in this assessment are highlighted in bold (see also tables 6.1, 6.2, 6.4 and 6.5).

Contaminant	Species tissue	Conversion type	Factor	ww µg/kg	dw µg/kg
BRC/BAC					
Cd	blue mussel	wt to dw	5x	110	**550**
Cu	blue mussel	wt to dw	5x	1100	**5500**
Hg	blue mussel	wt to dw	5x	10	**50**
Pb	blue mussel	wt to dw	5x	190	**950**
Zn	blue mussel	wt to dw	5x	30000	**150000**
CB 153	blue mussel	wt to dw	5x	0,4	**2**
ΣCB_7	blue mussel	wt to dw	5x	0,7	**3,5**
Hg 2	roundfish[1]			**50**	
Hg 2	flatfish			**70** [4]	
EAC					
Cd	blue mussel	wt to dw	5x	55,9	**279,5**
Hg	blue mussel	wt to dw	5x	1,7	**8,5**
Pb	blue mussel	wt to dw	5x	1690	**8450**
DDE	blue mussel	wt to dw	5x	10	**50**
Dieldrin	blue mussel	wt to dw	5x	10	**50**
γ-HCH	blue mussel	wt to dw	5x	0,29	**1,45**
TBT	blue mussel	wt to dw	5x	2,4	**12**
CB 153	blue mussel	wt to dw	5x	2,5	**12,5** [5]
ΣCB_7	blue mussel	wt to dw	5x	10	**50**
Naphthalene	blue mussel	wt to dw	5x	91	**445**
3 rings (PA+ANT)	blue mussel	wt to dw	5x	1290	**6450**
4 rings (FLU+PYR+BAA+CHR)	blue mussel	wt to dw	5x	6900	**34500**
5 rings (BAP+BKF)	blue mussel	wt to dw	5x	1069	**5345**
6 rings (BGHIP+ICDP)	blue mussel	wt to dw	5x	73	**365**
Cd	fish[3]			**7,35**	
Hg	fish[3]			**3,5**	
Pb	fish[3]			**300**	
DDE	fish[3]			**50**	
Dieldrin	fish[3]			**50**	
γ-HCH	fish[3]			**1,1**	
CB 153	fish[3]			**2,5** [5]	
ΣCB_7	fish[3]			**10**	

1 Assumed applicable for whiting
2 BRC for Hg only applied to fish fillet
3 Concerns the whole fish
4 Assumed applicable for herring.
5 Assumed to be 25% of ΣCB_7
6 See section 6.2.1

Table 6.4 The EACs for organochlorines for fish, and suggested EACs for fish liver, flatfish fillet and roundfish fillet

(See also table 6.3)

Contaminant	"Fish" µg/kg ww	Fish liver µg/kg ww (="Fish"*10)	Flatfish fillet µg/kg ww (="Fish")	Roundfish fillet µg/kg ww (="Fish"/10)
DDE	50	500	50	5
Dieldrin	50	500	50	5
Lindane	1,1	11	1,1	0,11
CB 153 [1]	2,5	25	2,5	0,25
ΣCB_7 [2]	10	100	10	1

1 Assumed to be 25% of ΣCB_7
2 CB 28, CB 52, CB 101, CB 118, CB 138, CB 153, CB 180

Table 6.5 Estimated EACs for fish liver on lipid weight basis
(See also table 6.4 and conversion factors in Appendix 3)

Contaminant	Species	Fish liver µg/kg ww	Conversion factor	Fish liver µg/kg lw
DDE, dieldrin	Cod/whiting	500	2	1000
γ-HCH		11		22
CB 153 [1]		25		50
ΣCB_7 2		100		200
DDE, dieldrin	Dab	500	7	3500
γ-HCH		11		77
CB 153 [1]		25		175
ΣCB_7 2		100		700
DDE, dieldrin	Flounder/plaice	500	9	4500
γ-HCH		11		99
CB 153 [1]		25		225
ΣCB_7 2		100		900
DDE, dieldrin	Megrim	500	5	2500
γ-HCH		11		55
CB 153 [1]		25		125
ΣCB_7 [2]		100		500

1 Assumed to be 25% of ΣCB_7
2 CB 28, CB 52, CB 101, CB 118, CB 138, CB 153, CB 180

For ΣCB_7, firm EACs are available for mussels and whole fish (*OSPAR agreement 1997-15*), and provisional EACs are available for fish liver and muscle. These values were recalculated for CB 153 assuming that CB 153 constitutes about 25% of this sum. The uncertainty introduced by this recalculation was considered negligible.

6.3 Assessment of monitoring data against assessment criteria (e.g. EACs, BACs)

Comparisons are made in this assessment report between the upper bound of the 95% confidence interval about the fitted value for the final year (UCL) in time series and assessment criteria (BCs and EACs as appropriate). These comparisons are based upon calculations of the ratio between the UCL and each assessment criterion.

Some care is required in interpreting the significance with regard to potential ecological consequences of these ratios. In the case of EACs, which have been developed in relation to ecological or toxicological information, the higher the value of the UCL/EAC ratio, the greater the potential for biological effects. However, such interpretations disregard a wide range of factors such as bioavailability of contaminants (from sediments) and synergistic/antagonistic effects.

Ratios to BACs are not linked to the potential for biological impact. It should be noted that ratios > 1 do not necessarily indicate a likely adverse effect on the biota. BACs are set using information from areas with no known natural or anthropogenic sources of contaminants, and levels above the BRCs or BACs could be caused by local natural sources (e.g. volcanic activities in the Icelandic area affecting metal concentrations), as well as by anthropogenic sources.

Furthermore, BACs have been developed as assessment criteria from BCs, using the variance typical in monitoring programmes. As noted above, the variance estimates used to date have been derived from UK data only, and other values may be more widely applicable. It may be that further research will lead to modifications of the BCs or BACs, which would alter the values of the UCL/BAC ratios. These ratios therefore have no significance beyond indicating the degree to which the field data exceed, or fall below, our current best estimates of BACs. No proposals are made as to how high a UCL/BAC ratio may be ecologically “acceptable”.

7. Assessment of metals and organic contaminants in biota

7.1 Overview of available data for contaminants in biota

Over 22000 data (yearly medians of contaminant concentrations) were assessed during this exercise (Appendix 7). Data were received from 11 countries: Belgium, Denmark, France, Germany, Iceland, Ireland, Netherlands, Norway, Spain, Sweden and the United Kingdom and the amount of data contributed varied greatly: from 210 to about 8500 medians.

7.2 Trace metal trends in biota

7.2.1 General introduction

The alterations in the assessment procedure for QA data, and the inclusion of new data submitted to ICES since the last assessment increased the amount of assessed data on contaminants in biota by a factor of 2 in comparison to the previous assessment exercise. Only datasets with 7 or more years of information were assessed for both linear and non-linear temporal trends. Linear trends only were fitted to datasets of 5-6 years, whereas datasets of only 3-4 years were summarised as means. The results presented in this report cover data from Regions I to IV, but generally there were relatively few data from Region I.

Some metals (e.g. Cu and Zn) are known to be bioregulated which make temporal trend and spatial assessments difficult. Partly for this reason and because temporal trend survey strategies can differ between countries, it is not appropriate to compare different regions using different tissues. Spatial comparison, however, is not in the design of this aspect of the JAMP programme.

In addition to the assessment of temporal trends in bivalves and fish, the UCLs of the fitted concentrations in the final year of each data series were compared to assessment criteria, where available (table 6.1). For blue mussel and fish, the UCLs were compared to the maximum of the ranges of BRCs in OSPAR agreement 1997-14 (now superseded). The EACs for Cd were those proposed in 2004 for direct toxicity. The EACs for Hg and Pb were those proposed in 2004 for secondary poisoning.

The ratio of the UCL to the BRC or EAC are known as BRC or EAC ratios respectively. BRC ratios < 1 indicated that concentrations are 'close to background'. However, It should be noted that BRC ratios > 1 do not necessarily indicate an adverse effect on the biota. BRCs are set for areas with no known natural or anthropogenic sources of metals, and levels above the BRCs could be caused by local natural sources (e.g. volcanic activities in the Icelandic area), as well as by anthropogenic sources. Generally, the BRC ratios for metals were > 1. No suggestions were made as to how high a ratio might be ecologically acceptable, and such a "maximum" ratio could be site specific. However, the ultimate aim of the OSPAR Hazardous Substances Strategy is to achieve concentrations in the marine environment near BCs for naturally occurring substances and close to zero for man made synthetic substances.

Plots have been prepared of all temporal trend series, for all contaminants (Appendix 11). Where available, the assessment criteria (BRCs, EACs) have been included in the plots. The relationships with assessment criteria are summarised in tables and figures in the main text, and shown in more detail in Appendix 12. Comments are made in the main text concerning the relationship between the fitted concentrations in the final year and the assessment criteria. The geographical distributions of sampling stations and temporal trends are shown in maps in Appendix 9. Throughout, significance has been assessed at the 5% level. A complete list of stations where biota samples were collected is given in Appendix 8. A list of species for which monitoring data was available is presented in Appendix 2.

The assessment has presented the opportunity to review the power of the monitoring programmes to detect temporal trends in concentrations. The main body of the report considers the 10-year detectable trend; the % yearly change in concentration that would be detected by a 10-year monitoring programme with 90% power at the 5% significance level (Nicholson *et al*. 1997) (see also Appendix 4D). An alternative approach, as used in assessments of data from the Baltic Sea area, is presented in Appendix 4E.

7.2.2 Arsenic

Available data

Concentrations were assessed in 32 mussel datasets (table 7.1), of which 20 had data from 5 or more years. Concentrations were also assessed in 27 fish datasets: 8 liver datasets all with 5 or more years, and 19 muscle datasets, 6 of which had 5 or more years. The datasets were submitted by Iceland (11 mussel time series), Belgium (1 mussel time series), Germany (7 mussel time series and 8 fish time series) and the UK (13 mussel time series and 19 fish time series). There are no BRCs or EACs for As.

Table 7.1 Arsenic in biota - Extent of the dataset

Region	Year category	Blue mussel	Common dab	Flounder	Plaice	Whiting	Total
I	3-4	1					1
	5-6	5					5
	7+	5					5
II	3-4	3		7	1		11
	5-6	1		2	2		5
	7+	7		7			14
III	3-4	8		1	3	1	13
	5-6	2	1	1	1		5
Total		32	1	18	7	1	59

Time trend analysis

There were 34 datasets of 5 years or more for which trends could be assessed. There were 4 significant upward linear trends and 6 significant downward linear trends. There was a significant non linear component in 7 time series.

Table 7.2 Arsenic in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
I	3-4			1	1
	5-6	1		4	5
	7+			5	5
II	3-4			11	11
	5-6		1	4	5
	7+	3	5	6	14
III	3-4			13	13
	5-6			5	5
Total		4	6	49	59

Region I

A significant upward linear trend was observed for blue mussel at Dvergasteinn Alftafjördur (IS).

Region II

There were significant downward linear trends for blue mussel at Norderney (DE) and Elbe Outer (DE), for flounder liver at Borkum (DE), Baltrum (DE), Weser Outer (DE) and Elbe Outer (DE). Significant non-linear trends were also observed for flounder liver at Weser Outer (DE) and Elbe Outer (DE). Significant upward linear and non-linear trends were observed for blue mussel at Suedfall (DE), Norderaue (DE) and Helgoland (DE).

Region III

No significant trends were detected.

Ten-year detectable trend

The 10-year detectable trend varied between 2 and 25% with a median of 8 % for time series ≥ 5 years.

Conclusion

There were 34 time series assessed for temporal trends. There were 10 significant linear trends: 4 upward and 6 downward. Of the 10 time series with significant linear trends, 5 also showed significant non-linear trends: 3 upward and 2 downward.

7.2.3 Cadmium

Available data

A total of 230 time series were available (table 7.3): 117 in blue mussel, 2 in Mediterranean mussel, 22 in dab, 31 in flounder, 10 in cod, 13 in plaice, 2 in herring, 1 in megrim, 29 in Pacific oyster; 1 in sand gaper, 1 in shrimp and 1 in whiting. Datasets for these time series were submitted by Belgium (4), France (61), Denmark (23), Germany (16), Iceland (12), Ireland (5), the Netherlands (8), Norway (39), Spain (8), Sweden (4), and UK (50). Information on QA was available for all these datasets. The datasets covered 3-23 years of data. For some of the locations time series were also studied during the last trend assessment for data up to 1991.

Table 7.3 Cadmium in biota - Extent of the dataset

Region	Year categ	Blue mussel	Cod	Common dab	Flounder	Herring	Mediter. mussel	Megrim	Pacific oyster	Plaice	Sand gaper	Shrimp (crangon)	Whiting	Total
I	3-4	4												4
	5-6	3								1				4
	7+	11	2							1				14
II	3-4	19		5	8		1			3	1			37
	5-6	6		3	5				1	1				16
	7+	42	8	7	16	2	1	1	6	2		1		86
III	3-4	10		2	1					5			1	19
	5-6	3		5	1									9
	7+	1												1
IV	3-4	4												4
	7+	14							22					36
Total		117	10	22	31	2	2	1	29	13	1	1	1	230

Time trend analysis

There were 166 datasets of 5 years or more for which trends could be assessed. There were 14 significant downward linear trends and 53 significant upward linear trends. There was a significant non linear component in 15 time series.

Table 7.4 Cadmium in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
I	3-4			4	4
	5-6			4	4
	7+	3	3	8	14
II	3-4			37	37
	5-6	1	1	14	16
	7+	9	32	45	86
III	3-4			19	19
	5-6		1	8	9
	7+		1		1
IV	3-4			4	4
	7+	1	15	20	36
Total		14	53	163	230

Region I

There were 6 significant linear trends: 3 upward and 3 downward. These datasets concern blue mussel and cod liver. The shape of the time series graphs indicate that the increase in Cd concentrations is steady in Hvalfjördur area (IS) with annual changes of 6-10% over a 12 year period.

Region II

There were 43 significant linear trends: 10 upward and 33 downward. There were 12 time series with a significant non-linear trend. Among the downward trends, a particular region (4 stations in the Bay of Seine, FR) depicted a typical pattern of the effect of regulation of industrial discharge (See e.g. Appendix 11 Antifer Digue). Indeed, discharging of Cd rich phosphogypsum (wastes of phosphoric acid fabrication) occurred in the Seine estuary until the beginning of the nineties and then completely stopped. This seems to explain the downward trends of Cd concentrations in the blue mussel over the last 10 years in this area, with annual decreases of between 13 and 23%. Other locations also showed large annual decreases in concentrations in flounder liver over the last 7 years: Borkum and Jade Outer (DE), with 20 and 29 % respectively; Strandebarm (NO) with a decrease of 48%. Conversely, a significant increase was registered in blue mussel at Roskilde Fjord (DK), with an annual increase of 19% in the last 10 years.

Region III

There were 2 significant downward linear trends, including 1 for blue mussel in Dublin Bay (IE) with an annual decrease of 11% .

Region IV

There were 16 significant linear trends: 1 upward and 15 downward. There was also 1 significant non-linear trend. Downward trends were found along the French coast, with annual decreases ranging from 4 to 6%. For the Ria of Vigo (ES), there was a significant linear increase of 6% per year over the last 10 years.

Comparisons with BRCs and EACs

The only BRC for Cd is for blue mussel (based on the upper limit of the 1997 BRC) with a value of 550 µg/kg (dw). On the 117 datasets of blue mussel, 14 were significantly below the BRC, almost all from Region II (Figure 7.1). The highest levels (UCL/BRC ratios > 15) were found in Region I (Dvergasteinn Alftafjödur and Ulfsá Skutulsfjördur, IS) and in Region II (5 stations in NO).

Table 7.5 Cadmium in biota - Comparison with BRCs and EACs by region

	BRC (blue mussel)		EAC (blue mussel)		EAC (fish)	
Region	Above	Below	Above	Below	Above	Below
I	18		18		4	
II	54	13	64	3	59	
III	14		14		15	
IV	17	1	18			
Total	103	14	114	3	78	0

Figure 7.1 Cadmium in biota - Summary plots of BRC and EAC ratios in blue mussel

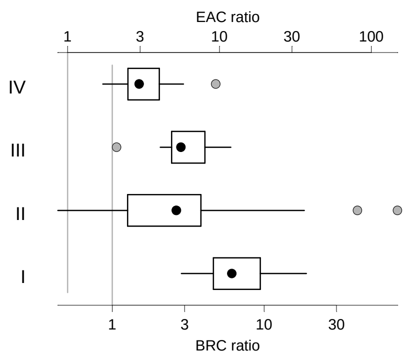
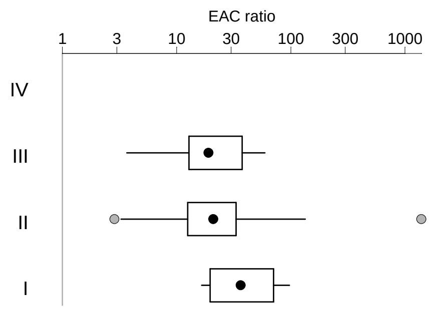


Figure 7.2 Cadmium in biota - Summary plots of EAC ratios in fish



Ten-year detectable trend

The 10-year detectable trend varied from 3 to 40% with a median of 10% for time series ≥ 5 years. 77% of the long term time series (≥ 10 years) had a 10-year detectable trend of ≤ 15%.

Conclusion

There were 166 time series assessed for temporal trends. There were 67 significant linear trends: 14 upward and 53 downward. Downward trends were mainly in Regions II and IV. Most time series for Cd are suitable for detecting annual trends between 5 and 15%. 12% of blue mussel time series were significantly below the BRC.

7.2.4 Chromium

Available data

There were 40 datasets available. Data were available from Region II (DE, SE and UK) and Region III (IE and UK). The time series comprised 28 blue mussel datasets, 8 flounder liver and 2 herring liver time series and 1 time series each for plaice and cod liver. 21 time series had over 3 years of adequate QA information. There were 17 datasets of 7 or more years, 5 datasets were from 5 to 6 years in length and 18 were between 3 and 4 years. There are no BRCs or EACs for Cr.

Table 7.6 Chromium in biota - Extent of the dataset

Region	Year category	Blue mussel	Cod	Flounder	Herring	Plaice	Total
II	3-4	7					7
	5-6	1		1			2
	7+	6	1	7	2		16
III	3-4	10				1	11
	5-6	3					3
	7+	1					1
Total		28	1	8	2	1	40

Time trend analysis

There were 22 datasets of 5 years or more for which trends could be assessed. There were 0 significant upward linear trends and 4 significant downward linear trends. There was a significant non-linear component in 2 time series.

Table 7.7 Chromium in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
II	3-4	0	0	7	7
	5-6	0	0	2	2
	7+	0	3	13	16
III	3-4	0	0	11	11
	5-6	0	1	2	3
	7+	0	0	1	1
Total		0	4	36	40

Region II

The 3 significant downward linear trends were at 2 German locations, 1 each for blue mussel (Elbe Outer) and for flounder liver (Borkum) and at 1 location in Sweden (Fladen) for herring liver. The previous assessment indicated that in some cases, the German data were based on cultured sub-littoral mussels from other places, as well as different length groups used in north and east Frisia. It was suggested that values tend to decrease with increasing length of mussel. Therefore, there were difficulties in comparing concentrations between sites. From the trends detected it was apparent that concentrations in the northern part of Germany were lower than concentrations in other areas, with concentrations near the Elbe being still the most elevated.

Region III

There was a significant downward linear trend at UK NMMP Site 768 (St Bees Cumbria coast) for blue mussel.

Ten-year detectable trend

The 10-year detectable trend varied from 5 to 49% with a median of 27% for time series ≥ 5 years.

Conclusion

There were 22 time series assessed for temporal trends. There were 4 significant linear trends, all downward.

7.2.5 Copper

Available data

There were 188 time series available (table 7.8): 113 in blue mussel, 2 in Mediterranean mussel, 7 in dab, 15 in flounder, 9 in cod, 8 in plaice, 2 in herring, 1 in megrim, 29 in Pacific oyster, 1 in sand gaper, and 1 in shrimp. The datasets were submitted by Belgium (2), France (61), Denmark (23), Germany (16), Iceland (9), Ireland (5), the Netherlands (5), Norway (39), Spain (8), Sweden (4), and UK (16). The datasets covered 3-23 years of data. For some locations, time series were also studied during the last trend assessment for data up to 1991.

Table 7.8 Copper in biota - Extent of the dataset

Region	Year categ	Blue mussel	Cod	Common dab	Flounder	Herring	Mediter. mussel	Megrim	Pacific oyster	Plaice	Sand gaper	Shrimp (crangon)	Total
I	3-4	5											5
	5-6	1								1			2
	7+	9	2							1			12
II	3-4	21			1		1			1	1		25
	5-6	5			2				1	1			9
	7+	41	7	7	12	2	1	1	6	3		1	81
III	3-4	9								1			10
	5-6	3											3
	7+	1											1
IV	3-4	4											4
	7+	14							22				36
Total		113	9	7	15	2	2	1	29	8	1	1	188

Time trend analysis

There were 144 datasets of 5 years or more for which trends could be assessed. There were 15 significant upward linear trends and 6 significant downward linear trends. There was a significant non linear component in 10 time series.

Table 7.9 Copper in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
I	3-4			5	5
	5-6			2	2
	7+	1	1	10	12
II	3-4			25	25
	5-6	1		8	9
	7+	1	11	69	81
III	3-4			10	10
	5-6			3	3
	7+			1	1
IV	3-4			4	4
	7+	3	3	30	36
Total		6	15	167	188

Region I

On the Norwegian coast 2 significant linear trends were found (1 with an additional significant non-linear component). One of these showed an upward trend (98A Svolvær with an annual rate of 5%) and the other was downward (Varanger Fjord with an annual rate of 10%).

Region II
There were 13 significant linear trends: 2 upward and 11 downward. 3 of these (Jade and Elbe on the German coast and Færder area, NO) showed a non-linear component which reflects a complex temporal evolution visible in both mussel and fish. The other 10 trends showed low annual decreases: 1 to 8% at Norderney, (DE).

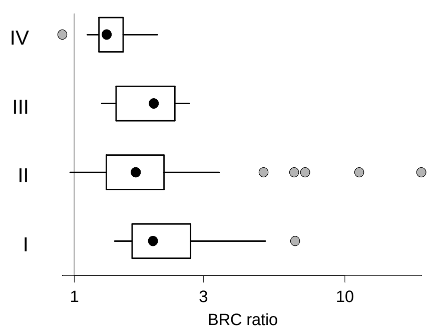
Region IV
There were 6 significant linear trends (1 with an additional significant non-linear component). There were 3 upward linear trends with annual rates < 5% (Gironde and Arcachon, FR). The 3 others were downward with annual rates ranging from 2 to 14% at Hendaye (FR).

Comparisons with BRCs and EACs
The only BRC for Cu is for blue mussel and is based on the upper limit of the range of 1997 BRC with a value of 5550 µg/kg (dw). Of the 113 datasets for blue mussel, only 3 were significantly below the BRC. These were from Regions II and IV. The highest levels (UCL/BRC ratios > 5) were found in Region I (Dvergasteinn Alftafjödur and Mjófjördur, IS) and Region II (4 stations along the Denmark coasts and at station UK NMMP station 555 (Tamar Warren Point)).

Table 7.10 Copper in biota - Comparison with BRCs by region for blue mussel

Region	Above	Below
I	15	
II	65	2
III	13	
IV	17	1
Total	110	3

Figure 7.3 Copper in biota - Summary plots of BRC ratios in blue mussel



Ten-year detectable trend

The 10 year detectable trend varied from 3 to 66% with a median of 8% for time series ≥ 5 years.

Conclusion
There were 144 time series assessed for temporal trends. There were 21 significant linear trends: 6 upward and 15 downward. Most of the linear trends corresponded to annual increases or decreases of less than 5%. 3% of blue mussel time series were significantly below the BRC.

7.2.6 Nickel

Available data
There were 45 time series available in different species/tissues (table 7.11). All time series were from Region II (78%) and Region III (22%). Information on QA was available for the entire period for 36 datasets, for 3 datasets since 1993, and missing in the database for 6 datasets. The span of the time series ranged from 3 to 15 years with about 35% of time series ≥5 years. There were no BCs and EACs for Ni.

Table 7.11 Nickel in biota - Extent of the dataset

Region	Year categ	Blue mussel	Cod	Common dab	Flounder	Herring	Mediter. mussel	Megrim	Pacific oyster	Plaice	Sand gaper	Shrimp (crangon)	Total
II	3-4	18								1	1		20
	5-6	6			3								9
	7+	3	1			2							6
III	3-4	9											9
	5-6	1											1
Total		37	1		3	2				1	1		45

Time trend analysis

There were 16 datasets of 5 years or more for which trends could be assessed. There were 0 significant upward trends and 3 significant downward trends. There was a significant non linear component in 1 time series.

Table 7.12 Nickel in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
II	3-4			20	20
	5-6		1	8	9
	7+		2	4	6
III	3-4			9	9
	5-6			1	1
	7+				0
Total			3	42	45

Region II

There were significant downward linear trends at 1 blue mussel site Little Belt (DK) and for herring from 2 fishing sites on the Swedish west coast (Väderöarna and Fladen). Estimated trends were downward, but non-significant, in a further 8 datasets, 5 of them for blue mussel, 2 for flounder and 1 for a cod fishing area. All blue mussel time series are from stations in the north Frisian and Danish Wadden Sea area and on the Isle of Heligoland, influenced by the Elbe River. There were no significant upward trends. For 4 sites, the estimated trend was upward, but non significant.

Region III

There were no significant trends.

Ten-year detectable trend

The 10-year detectable trend varied between 7 and 40% with a median of 12% for time series ≥ 5 years.

Conclusion

There were 16 time series assessed for temporal trends, mostly from Region II. There were 3 significant linear trends, all downward.

7.2.7 Mercury

Available data

There were 237 datasets available for the assessment in biota. Data were available from Regions I (22), II (144), III (31) and IV (40). Region II provided most of the datasets. With regards to QA, 198 time series had more than 3 years of sufficient information.

Table 7.13 Mercury in biota - Extent of the dataset

Region	Year categ	Blue mussel	Cod	Common dab	Flounder	Herring	Mediter. mussel	Megrim	Pacific oyster	Plaice	Sand gaper	Shrimp (crangon)	Whiting	Total
I	3-4	4												4
	5-6	3								1				4
	7+	11	2							1				14
II	3-4	19		5	9		1			3	1			38
	5-6	6		4	7				1	3				21
	7+	42	8	7	15	2	1	1	6	2		1		85
III	3-4	10		1	1					5			1	18
	5-6	4		7	1					1				13
IV	3-4	4												4
	7+	14							22					36
Total		117	10	24	33	2	2	1	29	16	1	1	1	237

Time trend analysis

There were 171 datasets of 5 years or more for which trends could be assessed. Blue mussel (61), Pacific oyster (29) and flounder (23) provided most of the data, with 3 flounder datasets relating to liver tissue. There were 6 significant upward trends and 28 significant downward trends. There was a significant non linear component in 18 time series.

Table 7.14 Mercury in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
I	3-4			4	4
	5-6		1	3	4
	7+		1	13	14
II	3-4			38	38
	5-6	1		20	21
	7+	4	20	61	85
III	3-4			18	18
	5-6	1		12	13
IV	3-4			4	4
	7+		6	30	36
Total		6	28	203	237

Region I

There were 2 downward linear trends at Varangerfjorden (Norwegian station 10B) in cod muscle and at Skogerøy (station 10F, NO) in plaice muscle.

Region II

There were 25 significant linear trends: 5 upward and 20 downward. German data for flounder and blue mussel, especially in the Elbe region, and data from the Netherlands for flounder and dab show significant downward linear trends. Data from Norway, Sweden and Denmark indicate upward linear trends for a small number of assessed species (3). French data from Region II show downward trends in blue mussel concentrations at 2 stations. Concentrations in flounder muscle at the Dutch station DDOVBMDN have decreased.

Region III

There was only 1 significant linear trend, upward, at UK NMMP station 796 (Morecambe Bay Offshore).

Region IV

A total of 36 time series were assessed for Region IV, 29 from France and 7 from Spain. 3 French stations (Riec sur Belon, Hendaye – Chingoudy and Arcachon-Les Jacquets) for Pacific mussel show significant downward linear trends and 3 Spanish blue mussel stations at Pontevedra, Arosa and La Coruña also showed a significant linear downward trend.

Comparisons with BRCs and EACs

For blue mussels, a BRC of 50 µg kg-1(dw) was used based on the upper limit of the 1997 BRC. Of the 117 datasets for blue mussel, only 1 was significantly below the BRC. This was from Region II. The highest levels (UCL/BRC ratios > 10) were found in Region II (Wadden Sea (DK); Byrkjenes, Kvalnes, Inner Sørdfjord (NO) and Region III (UK NMMP station 767 (Morecambe Bay north Bay)). The maximum UCL/ BRC ratio was 115 found in Byrkjenes (NO). For fish muscle, a BRC of 50 µg kg-1(ww) was used for roundfish and 70 µg kg-1 (ww) for flatfish (including herring). Of the 82 datasets, 17 were significantly below the BRC. EACs of 8,5 µg kg-1(dw) and 3,5 µg kg-1ww were proposed for blue mussel and fish respectively. All the UCL/EAC ratios exceeded the proposed EACs.

Table 7.15 Mercury in biota - Comparison with BRCs and EACs by region

	BRC (blue mussel)		EAC (blue mussel)		BRC (fish)		EAC (fish)	
Region	Above	Below	Above	Below	Above	Below	Above	Below
I	18		18		2	2	4	
II	66	1	67		47	15	66	
III	14		14		16		17	
IV	18		18					
Total	116	1	117	0	65	17	87	0

Figure 7.4 Mercury in biota - Summary plots of BRC and EAC ratios in blue mussel

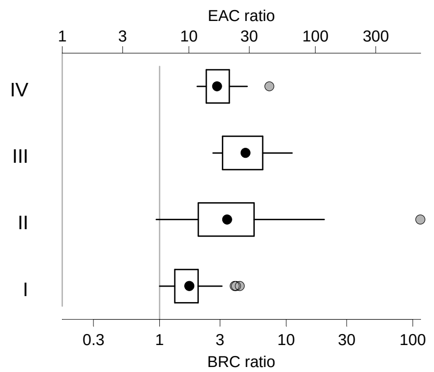
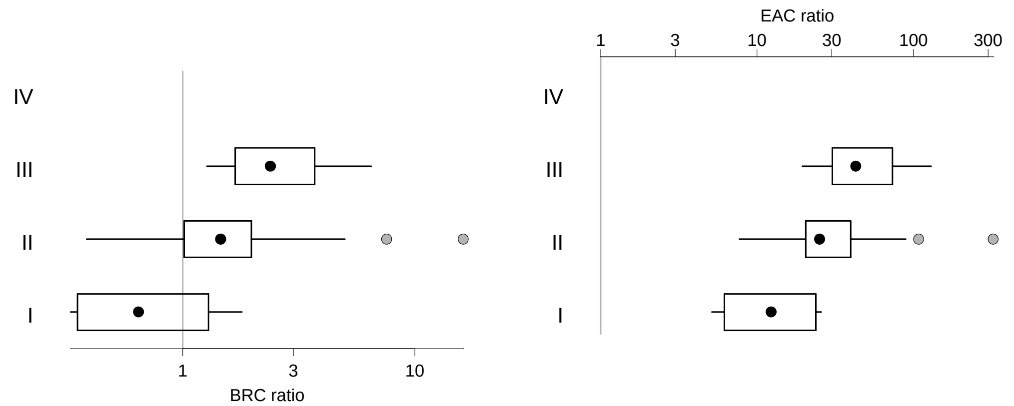


Figure 7.5 Mercury in biota - Summary plots of BRC and EAC ratios in fin fish



Ten-year detectable trend

The 10-year detectable trend varied from 3 to 40% with a median of 11% for time series ≥ 5 years. Of the long time series (≥ 10 years) 82% had a 10-year detectable trend of ≤ 15%.

Conclusion

There were 171 time series assessed for temporal trends. There were 34 significant linear trends: 6 upward and 28 downward. 1% of blue mussel time series were significantly below the BRC; 21% of fish time series were significantly below the BRC. All UCL/EAC ratios were > 1.

7.2.8 Lead

Available data

There were 229 time series available for the assessment of Pb (table 7.16): 118 in blue mussel, 2 in Mediterranean mussel, 22 in dab, 28 in flounder, 10 in cod, 12 in plaice, and 2 in herring, 1 in megrim, 29 in Pacific oyster, 3 in sand gaper, 1 in shrimp and 1 in whiting. The datasets were submitted by Belgium (4), France (61), Denmark (27), Germany (16), Iceland (11), Ireland (5), the Netherlands (5), Norway (39), Spain (8), Sweden (4), and UK (49). Information on QA was available for all these datasets. The datasets covered 3-23 years of data. For some locations, time series were also studied during the last trend assessment for data up to 1991.

Table 7.16 Lead in biota - Extent of the dataset

Region	Year categ	Blue mussel	Cod	Common dab	Flounder	Herring	Mediter. mussel	Megrim	Pacific oyster	Plaice	Sand gaper	Shrimp (crangon)	Whiting	Total
I	3-4	5												5
	5-6	3								1				4
	7+	9	2							1				12
II	3-4	22		5	9		1			3	2			42
	5-6	6		3	5				1	1	1			17
	7+	42	8	7	12	2	1	1	6	1		1		81
III	3-4	9		2	1					5			1	18
	5-6	3		5	1									9
	7+	1												1
IV	3-4	4												4
	7+	14							22					36
Total		118	10	22	28	2	2	1	29	12	3	1	1	229

Time trend analysis

There were 160 datasets of 5 years or more for which trends could be assessed. There were 4 significant upward linear trends and 33 significant downward linear trends. There was a significant non linear component in 16 time series.

Table 7.17 Lead in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
I	3-4			5	5
	5-6		1	3	4
	7+		2	10	12
II	3-4			42	42
	5-6	3		14	17
	7+	1	21	59	81
III	3-4			18	18
	5-6		2	7	9
	7+			1	1
IV	3-4			4	4
	7+		7	29	36
Total		4	33	192	229

Region I

Significant linear downward trends were found in blue mussel at Straumur-Straumsvik and Grimsey (IS), and in plaice liver at Skogerøy (NO), the annual decreases being around 15%.

Region II

There were 25 significant linear trends: 4 upward and 21 downward. 3 of the 4 upward trends were in stations along the Danish coast (Wadden Sea (2), Roskilde fjord). A slight increase was detected in the Baie de la Seine (FR). The 21 significant downward linear trends included all 11 Norwegian time series, 6 of which also had a significant non-linear component. 3 of these downward trends had annual decreases greater than 10% (up to 39% at Strandebarm, NO). The rate of decrease appeared to have slowed in recent years.

Region III

There were 2 significant downward linear trends found for fish liver at UK stations with annual decreases of 46 and 59% (UK NMMP stations 765 (Mersey Channel) and 766 (Ribble 11 mile post)).

Region IV

There were 7 significant linear trends, all downward with an annual decrease in concentration of between 2 and 11%. 2 of these time series also had a significant non-linear component.

Comparisons with BRCs and EACs

The only BRC is for blue mussel (based on the upper limit of the 1997 BRC) with a value of 950 µg/kg (dw). Of the 118 datasets for blue mussel, 16 were significantly below the BRC. The highest levels (UCL/BRC ratios > 40) were found on the Norwegian coast (Byrkjenes, Eitrheimsneset, Kvalnes), in the UK (NMMP stations 455 (Thames Mucking), 555 (Tamar Warren Point), 567 (Poole Harbour Wytch), 690 (Dee Mostyn Bank)), and in Region III (Cork west passage, IE).

Table 7.18 Lead in biota - Comparison with BCs and EACs by region

	BRC (blue mussel)		EAC (blue mussel)		EAC (fish)	
Region	Above	Below	Above	Below	Above	Below
I	8	9		17		4
II	64	6	8	62	12	43
III	13		4	9	5	10
IV	18		1	17		
Total	103	15	13	105	17	57

Figure 7.6 Lead in biota - summary plots of BRC and EAC ratios in blue mussel

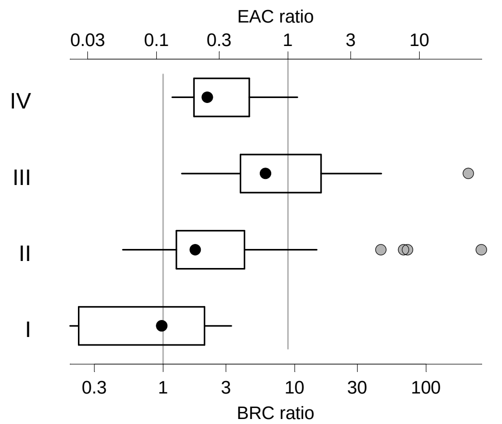
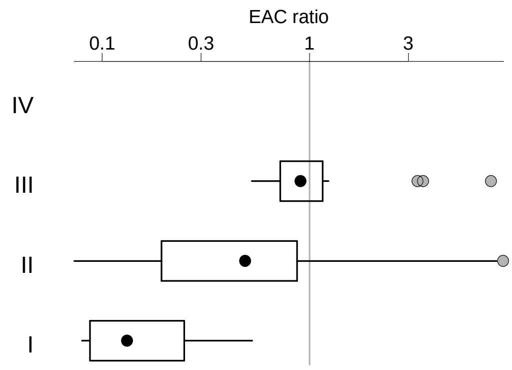


Figure 7.7 Lead in biota - Summary plots of EAC ratios in finfish



Ten-year detectable trend

The 10-year detectable trend varied from 3 to 66% with a median value of 12% for time series ≥ 5 years. Of the long time series (≥ 10 years) 64% had a 10-year detectable trend of ≤ 15%.

Conclusion

There were 160 time series assessed for temporal trends. There were 37 significant linear trends: 4 upward and 33 downward. There were downward trends in all 4 regions. Most time series are suitable for detecting annual trends between 5 and 15%. Of blue mussel time series, 14% were significantly below the BRC and 89% significantly below the EAC. 77% of fish time series were significantly below the EAC.

7.2.9 Zinc

Available data

Concentrations were assessed in 149 datasets for bivalves. Of these, 117 were mussel datasets, with 79 having data from 5 or more years; 29 were Pacific oyster datasets of 5 or more years; 2 Mediterranean mussel datasets of which 1 contained data from 5 or more years; and 1 sand gaper dataset < 4 years (table 7.19). There was a crustacean dataset for shrimp with a time series of 7 years.

Concentrations were also assessed in 42 fish datasets. Of these 33 were liver datasets, with 30 having time series ≥ 5 years, and 9 were muscle datasets with time series ≥ 5 years.

Table 7.19 Zinc in biota - Extent of the dataset

Region	Year categ	Blue mussel	Cod	Common dab	Flounder	Herring	Mediterr. mussel	Megrim	Pacific oyster	Plaice	Sand gaper	Shrimp (crangon)	Total
I	3-4	4											4
	5-6	3								1			4
	7+	11	2							1			14
II	3-4	20			1		1			1	1		24
	5-6	6			2				1	1			10
	7+	41	7	7	12	2	1	1	6	3		1	81
III	3-4	10								1			11
	5-6	3											3
	7+	1											1
IV	3-4	4											4
	7+	14							22				36
Total		117	9	7	15	2	2	1	29	8	1	1	192

Time trend analysis

There were 149 datasets of 5 years or more for which trends could be assessed. There were 10 significant upward linear trends and 12 significant downward linear trends. There was a significant non linear component in 15 time series.

Table 7.20 Zinc in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
I	3-4			4	4
	5-6			4	4
	7+			14	14
II	3-4			24	24
	5-6	1		9	10
	7+	9	11	61	81
III	3-4			11	11
	5-6			3	3
	7+			1	1
IV	3-4			4	4
	7+		1	35	36
Total		10	12	170	192

Region I

No significant trends were detected.

Region II

There were significant downward linear trends in 8 mussel datasets at Seine Villerville (FR), Baie de la Fresnaye (FR), Suedfall (DE), Helgoland (DE), 63A Ranaskjær (NO), 57A Krossanes (NO), 56A Kvalnes (NO) and 52A Eitrheimsneset (NO). Significant downward linear trends were also observed for 2 time series for common dab liver at IJMDWT80 (NL) and BORKND30 (NL) and for 1 flounder liver dataset at 33B Sande (east side) (NO). 3 time series showed an additional significant non-linear component, blue mussel at Helgoland (DE) and Seine Villerville (FR) and common dab liver at BORKND30 (NL). There were 10 datasets showing significant upward linear trends: 4 for blue mussel at Roskilde Fjord 65 (DE), Elbe Outer (DE), 36A Færder (NO) and Fladen (SE), 2 for flounder muscle at Weser Inner (DE) and Borkum (DE) (up to 1998 as no data were available since then), 1 for shrimp at BCP (BE), 1 for common dab liver at TERSLNWT40 (NL), 1 for cod liver at 53B Inner Sørfjord (NO) and 1 for herring liver at Fladen (SE). 3 time series showed an additional significant non-linear component, blue mussel in Fladen (SE), 36A Færder (NO) and Elbe Outer (DE).

Region III

No significant trends were detected.

Region IV

A single significant downward linear trend was observed for the Pacific oyster at Hendaye – Chingoudy (FR).

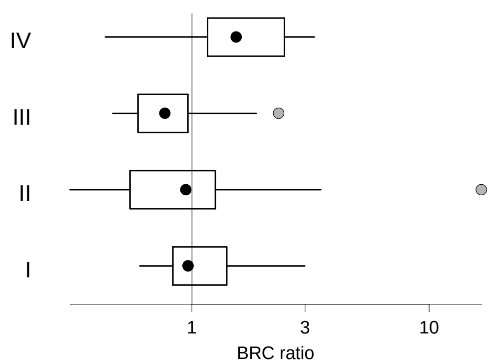
Comparisons with BRCs and EACs

The only BRC available was for blue mussel (based on the upper limit of the 1997 BRC) with a value of 150000 µg/kg (dw). In Region 1 the UCL/BRC ratios were between 0,6 and 3, with 10 of the 18 time series significantly below the BRC. In Region II, 41 of the 67 time series were significantly below the BRC. The remaining UCL/BRC ratios were around 1 except for 51A Byrkjenes (2.21) (N), NMMP455 (Thames Mucking) (3.46) (UK), NMMP555 (Tamar Warren Point) (3,49) (UK) and Elbe Outer (16,58) (D). In Region III, 11 of the 14 time series were significantly below the BRC. In Region IV, 4 of the 18 time series were significantly below the BRC. In contrast to other metals, UCL/BRC ratios were, in general, much closer to 1 in the OSPAR maritime area.

Table 7.21 Zinc in biota - Comparison with BRCs for blue mussel by region

Region	Above	Below
I	8	10
II	27	40
III	3	11
IV	14	4
Total	52	65

Figure 7.8 Zinc in biota - Summary plots of BRC ratios in blue mussel



Ten-year detectable trend

The 10-year detectable trend varied between 1 and 50% with a median of 7% for time series ≥ 5 years.

Conclusion

There were 149 time series assessed for temporal trends. There were 22 significant linear trends: 10 upward and 12 downward. 56% of blue mussel time series were significantly below the BRC.

7.2.10 Selenium

Available data

There were 12 time series available for blue mussel (table 7.22) of which 10 contained data for 5 or more years. All the datasets were submitted by Iceland (Region I). No BRCs or EACs are available for Se in blue mussel.

Table 7.22 Selenium in biota - Extent of the dataset

Region	Year category	Blue mussel	Total
I	3-4	2	2
	5-6	2	2
	7+	8	8
Total		12	12

Time trend analysis

There were 10 datasets of 5 years or more for which trends could be assessed. No significant trends were detected.

Ten-year detectabe trend

The 10-year detectable trend varied between 4 and 18% with a median of 13% for time series ≥ 5 years.

Conclusion

There were 10 time series assessed for temporal trends, all from Region I, but no significant trend were detected.

7.3 Organic contaminant trends in biota

7.3.1 General introduction

Compared to the previous assessment, the number of available datasets and the length of appropriate time series increased considerably. Datasets of PAH compounds were available from 5 countries, and of organochlorine compounds from all 11 countries (Belgium, Denmark, France, Germany, Iceland, Ireland, Netherlands, Norway, Spain, Sweden and the United Kingdom). The assessment covered both individual PAH compounds and grouped parameters according to ring numbers. CBs were assessed as CB 153 and as ΣCB_7.

In contrast to the difficulties that had been experienced in QA assessments of organic contaminants in previous assessment exercises, the new procedure (Appendix 4) leading to differential weighting of data points rather than their rejection resulted in the inclusion of all available data in the assessment.

Only datasets with 7 or more years of information were assessed for both linear and non-linear temporal trends. Linear trends only were fitted to datasets of 5-6 years, whereas datasets of only 3-4 years were summarised as means.

In addition to the assessment of temporal trends in bivalves and fish, the UCL of the fitted concentrations in the final year of each data series were compared (table 6.2) to assessment criteria, where available. BACs were available for 12 organic contaminant parameters in blue mussel, and EACs for 11 parameters. BACs were also available for 2 determinands in fish liver (CB 153, ΣCB_7), and EACs for 5 organochlorine parameters in whole fish.

The ratios of the UCLs to the BAC or EAC are referred to as BAC or EAC ratios respectively. BAC ratios < 1 indicate that concentrations are close to background. However, BAC ratios > 1 do not necessarily indicate an adverse effect on the biota. BACs are set for areas with no known significant anthropogenic sources, and levels above the BACs could be caused by local natural sources (e.g. volcanic activities in the Icelandic area), as well as by anthropogenic sources. No suggestions were made as to how high a ratio might be ecologically acceptable, and such a "maximum" ratio could be site specific. However, OSPAR has a long term aim that concentrations of contaminants should be at, or close to, BCs.

Plots have been prepared of all temporal trend series, for all contaminants (Appendix 11). Where available, the assessment criteria (BACs, EACs) have been included in the plots. The relationships with assessment criteria are summarised in tables and figure s in the main text, and shown in more detail in Appendix 12 Comments are made in the main text concerning the relationship between the fitted concentrations in the final year and the assessment criteria. The geographical distributions of sampling stations and temporal trends are shown in maps in Appendix 9. Throughout, significance has been assessed at the 5% level.

Advantage has been taken of the opportunity presented by this assessment to review the power of the monitoring programmes to detect temporal trends in concentrations. Two approaches have been used, firstly as described by Nicholson *et al*. (1997) (see Appendix 4D), and secondly as employed in discussion of data from the Baltic Sea area (Appendix 4E).

7.3.2 PAHs

Anthracene

Available data

There were 84 time series available, 53 in blue mussel, 2 in Mediterranean mussel and 29 in Pacific oyster (table 7.23). The datasets were submitted by Denmark (13), France (61), Norway (1), UK (2) and Spain (7). The datasets covered between 3 and 9 years of data. For most of the datasets < 3 years of good QA data were available.

Table 7.23 Anthracene in biota - Extent of the dataset

Region	Year category	Blue mussel	Mediterranean mussel	Pacific oyster	Total
II	3-4	14	1	1	16
	5-6	1			1
	7+	19	1	6	26
III	3-4	2			2
IV	3-4	10			10
	5-6			2	2
	7+	7		20	27
Total		53	2	29	84

Time trend analysis

There were 56 datasets of 5 years or more for which trends could be assessed. There was 1 significant downward linear trend and 22 significant upward linear trends. There was a significant non linear component in 8 time series.

Table 7.24 Anthracene in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
II	3-4			16	16
	5-6			1	1
	7+	1	8	17	26
III	3-4			2	2
IV	3-4			10	10
	5-6			2	2
	7+		14	13	27
Total		1	22	61	84

Regions II and IV

There were 23 significant linear trends, 1 upward and 22 downward, all from France. For blue mussel there were downward linear trends at Saint Vaast-Le Moulard, Ouest Cotentin-Breville, Cancale-Le Vivier sur Mer, Baie des Veys Gefosse, Baie de la Fresnaye, Vilaine-Er Fosse and Loire-Pointe de Chemoulin and an upward linear trend (also with a non-linear component) at Calvados Ouistreham. For Mediterranean mussel a downward linear trend was detected at Saint Brieuc-Pointe de Rosel. Finally, for Pacific oyster there were downward linear trends at Paimpol-Beg Nod, Brest-Aulne rive droite, Riec sur Belon, Pertuis Breton-Rive doux, Morbihan-Locmariaquer, Morbihan-Arradon, Marennes-Mus de Loup, Gironde-Pontaillal, Gironde-Bonne Anse, Chatelaillon, Bourgneuf-Coupelasse, Baie de l'Aiguillion, Arcachon-Cap Ferret, and Adour. However, a detailed analysis of the time series plots strongly suggests that some of the changes in concentrations could not be interpreted as a regular trend. They strongly suggest some event in the field or during the data acquisition process.

Region III

There were no time series long enough for trend analysis.

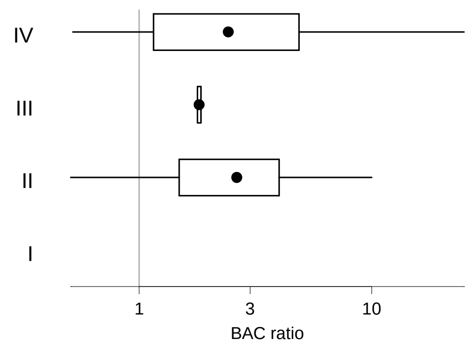
Comparisons with BAC and EAC

A BAC has been proposed for anthracene in blue mussel (2 µg kg-1, dw) but not for the other bivalves assessed. There is a proposed EAC for Σ3-rings PAHs. Of the 34 blue mussel time series in Region II, 7 were significantly below the BAC; the remaining UCL/BAC ratios were > 1 with a maximum of 10. The UCL/BAC ratios of the 2 time series in Region III were about 1,8. In Region IV, 4 blue mussel time series were significantly below the BAC; the remaining UCL/BAC ratios were > 1 with a maximum of 25.

Table 7.25 Anthracene in biota - Comparison with BAC by region

Region	Above	Below
II	27	7
III	2	
IV	13	4
Total	42	11

Figure 7.9 Anthracene in biota - Summary plots of BAC ratios in blue mussel



Ten-year detectable trend

The 10-year detectable trend varied from 2 to 41% with a median of 14% for time series ≥ 5 years. The 10-year detectable trend was ≤ 10% in 34% of time series.

Conclusion

There were 56 time series assessed for temporal trends, mostly from Regions II and IV. There were 23 significant linear trends: 1 upward and 22 downward. Doubts were expressed about the validity of some of the trends. 21% of blue mussel time series were significantly below the BAC.

Benz[a]anthracene

Available data

There were 88 time series available: 56 in blue mussel; 2 in Mediterranean mussel, 29 in Pacific oyster and 1 in sand gaper (table 7.26). The datasets were submitted by Denmark (16), France (61), Norway (1), Spain (7) and UK (3). Information on QA was available for all these datasets. The datasets covered 3-9 years of data.

Table 7.26 Benzo[a]anthracene in biota - Extent of the dataset

Region	Year categ	Blue mussel	Mediterranean mussel	Pacific oyster	Sand gaper	Total
II	3-4	16	1	1	1	19
	5-6	1				1
	7+	19	1	6		26
III	3-4	1				1
	5-6	2				2
IV	3-4	10				10
	5-6			2		2
	7+	7		20		27
Total		56	2	29	1	88

Time trend analysis

There were 58 datasets of 5 years or more for which trends could be assessed. There were 0 significant upward linear trends and 1 significant downward linear trend. There was a significant non linear component in 2 time series.

Table 7.27 Benzo[a]anthracene in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
II	3-4			19	19
	5-6			1	1
	7+		1	25	26
III	3-4			1	1
	5-6			2	2
IV	3-4			10	10
	5-6			2	2
	7+			27	27
Total			1	87	88

Region II

There was a significant downward linear trend for mussels from Calvados Port de Bessin (France), with an annual decrease of 21% since 1995.

Regions III and IV

No significant trends were detected.

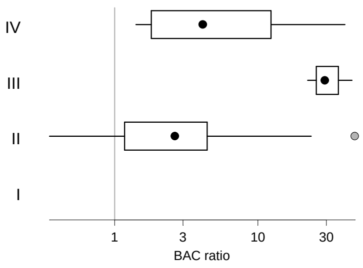
Comparisons with BACs and EACs

A BAC has been proposed for benzo[a]anthracene (5,5 µg kg-1, dw) in blue mussel but not for the other bivalves assessed. There is a proposed EAC for Σ4 ring PAHs. Of the 56 blue mussel time series, 7 were significantly below the BAC, all from Region II. The highest levels (UCL/BAC ratios > 20) were found in Region II (Roskilde Fjord (DK), Cap de la Hève (FR)), in Region III (NMMP765 (Mersey Channel), 767(Morecambe Bay north Bay) and 768 (Cumbria Coast St Bees) in UK) and in Region IV (Bay of Vilaine (FR), and Santander Pantalan (ES)).

Table 7.28 Benzo[a]anthracene in biota - Comparison with BAC by region

Region	Above	Below
II	29	7
III	3	
IV	17	
Total	49	7

Figure 7.10 Benzo[a]anthracene in biota - Summary plots of BAC ratios in blue mussel



Ten-year detectable trend

The 10-year detectable trend varied from 5 to 39% with a median of 15% for time series ≥ 5 years.

Conclusion

There were 58 time series assessed for temporal trends, mostly from Region II and IV. There was 1 significant linear trend: downward in Region II. 12% of blue mussel time series were significantly below the BAC.

Benzo[a]pyrene

Available data

There were 84 time series available: 52 in blue mussel; 2 in Mediterranean mussel, 29 in Pacific oyster, and 1 in sand gaper (table 7.29). The datasets were submitted by Denmark (12), France (61), Norway (1), Spain (7), and UK (3). Information on QA was available for all these datasets. The datasets covered 3-9 years of data.

Table 7.29 Benzo[a]pyrene in biota - Extent of the dataset

Region	Year categ	Blue mussel	Mediterranean mussel	Pacific oyster	Sand gaper	Total
II	3-4	12	1	1	1	15
	5-6	1				1
	7+	19	1	6		26
III	3-4	1				1
	5-6	2				2
IV	3-4	10				10
	5-6			2		2
	7+	7		20		27
Total		52	2	29	1	84

Time trend analysis

There were 58 datasets of 5 years or more for which trends could be assessed. There were 3 significant upward linear trends and 5 significant downward linear trends. There was a significant non linear component in 4 time series.

Table 7.30 Benzo[a]pyrene in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
II	3-4			15	15
	5-6			1	1
	7+	1		25	26
III	3-4			1	1
	5-6			2	2
IV	3-4			10	10
	5-6			2	2
	7+	2	5	20	27
Total		3	5	76	84

Regions II and IV

There were 8 significant linear trends: 3 upward and 5 downward, all in French data. (1 of the time series also had a significant non-linear component.) However, a detailed analysis of the time series plots strongly suggests that the changes in concentrations could not be interpreted as a regular trend. They strongly suggest some event in the field or during the data acquisition process.

Region III

No significant trends were detected.

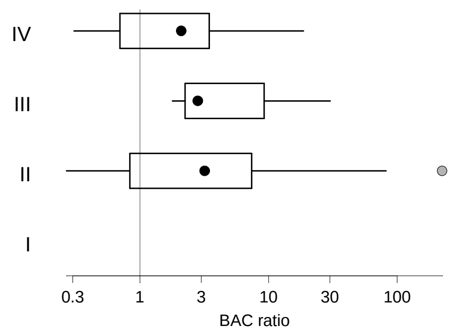
Comparisons BACs and EACs

A BAC has been proposed for blue mussel (3,5 µg kg-1, dw) but not for the other bivalves assessed. There is a proposed EAC for Σ5 ring PAHs. Of the 52 blue mussel time series, 14 were significantly below the BAC, the latter being from Regions II and IV. High levels (UCL/BAC ratios > 20) were found in Region II (Roskilde Fjord (DK) and Cap de la Hève (FR)) and in Region III (UK NMMP station 765 (Mersey Channel)).

Table 7.31 Benzo[a]pyrene in biota - Comparison with BAC by region

Region	Above	Below
II	23	9
III	3	
IV	12	5
Total	38	14

Figure 7.11 Benzo[a]pyrene in biota - Summary plots of BAC and EAC ratios in blue mussel



Ten-year detectable trend

The 10-year detectable trend varied from 3 to 69% with a median of 11% for time series ≥ 5 years.

Conclusion

There were 58 time series assessed for temporal trends, mostly from Regions II and IV. There were 8 significant linear trends: 3 upward and 5 downward. Doubts were expressed about the validity of some of the trends. 27% of blue mussel time series were significantly below the BAC.

Benzo[g,h,i]perylene

Available data

There were 86 time series available: 54 in blue mussel; 2 in Mediterranean mussel, 29 in Pacific oyster, and 1 sand gaper (table 7.32). The datasets were submitted by Denmark (10), France (61), Norway (1), Spain (7), and UK (7). Information on QA was available for all these datasets. The datasets covered 3-9 years of data.

Table 7.32 Benzo[g,h,i]perylene in biota - Extent of the dataset

Region	Year category	Blue mussel	Mediterranean mussel	Pacific oyster	Sand gaper	Total
II	3-4	15	1	1	1	18
	5-6	1				1
	7+	19	1	6		26
III	3-4	2				2
IV	3-4	10				10
	5-6			2		2
	7+	7		20		27
Total		54	2	29	1	86

Time trend analysis and comparison with BACs and EACs

There were 56 datasets of 5 years or more for which trends could be assessed. There were 12 significant upward linear trends and 0 significant downward linear trends. There was a significant non linear component in 2 time series.

Table 7.33 Benzo[g,h,i]perylene in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
II	3-4			18	18
	5-6			1	1
	7+	7		19	26
III	3-4			2	2
IV	3-4			10	10
	5-6			2	2
	7+	5		22	27
Total		12		74	86

Regions II and IV

There were 12 significant linear trends, all upward and from the French coast. However, a detailed analysis of the time series plots strongly suggests that the changes in concentrations could not be interpreted as a regular trend. They strongly suggest some event in the field or during the data acquisition process. However, in the Baie de Vilaine (Pen Bé, Region IV, FR) an annual increase of 29% seems to be quite steady over 8 years.

Region III

No significant trends were detected.

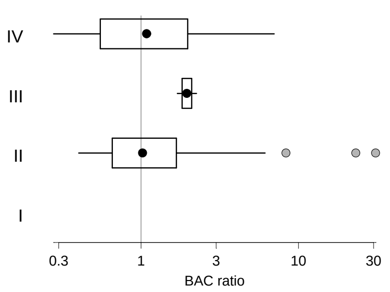
Comparisons with BACs and EACs

A BAC has been proposed for blue mussel (13,5 µg kg-1, dw) but not for the other bivalves assessed. There is a proposed EAC for Σ6 ring PAHs. Of the 54 blue mussel time series, 25 are significantly below the BAC. High levels (UCL/BAC ratios > 5) were found in Region II (Lynetten and Skovshoved Sounds (DK), NMMP445 (Thames Muicking) and 555 (Tamar Warrren Point) in UK) and in Region IV (Santander Pantalan, ES).

Table 7.34 Benzo[g,h,i]perylene in biota - Comparison with BAC by region

Region	Above	Below
II	18	17
III	2	
IV	9	8
Total	29	25

Figure 7.12 Benzo[g,h,i]perylene in biota - Summary plots of BAC ratios in blue mussel



Ten-year detectable trend

The 10-year detectable trend varied from 5 to 37% with a median of 14% for time series ≥ 5 years.

Conclusion

There were 56 time series assessed for temporal trends, mostly from Regions II and IV. There were 12 significant linear trends, all upward. Doubts were expressed about the validity of some of the trends. 46% of blue mussel time series were significantly below the BAC.

Chrysene

Available data

There were 91 time series available: 59 in blue mussel; 2 in Mediterranean mussel, 29 in Pacific oyster, and 1 in sand gaper (table 7.35). The datasets were submitted by Denmark (16), France (60), Norway (1), Spain (7), and UK (7). Information on QA was available for all these datasets. The datasets covered 3-9 years of data.

Table 7.35 Chrysene in biota - Extent of the dataset

Region	Year category	Blue mussel	Mediterranean mussel	Pacific oyster	Sand gaper	Total
II	3-4	20	1	1	1	23
	5-6	3				3
	7+	17	1	6		24
III	3-4	2				2
IV	3-4	10		1		11
	5-6	1		3		4
	7+	6		18		24
Total		59	2	29	1	91

Time trend analysis

There were 55 datasets of 5 years or more for which trends could be assessed. There were 2 significant upward linear trends and 2 significant downward linear trends. There was a significant non linear component in 8 time series. Trend analyses were carried out on 55 datasets, which correspond to time series ≥ 5 years (table 7.36).

Table 7.36 Chrysene in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
II	3-4			23	23
	5-6			3	3
	7+	1	2	21	24
III	3-4			2	2
IV	3-4			11	11
	5-6			4	4
	7+	1		23	24
Total		2	2	87	91

Regions II and IV

There were 4 significant linear trends: 2 upward in Regions II and IV (France), and 2 downward in Region II (FR and NO). A detailed inspection of the graph from the Norwegian site (30A Gressholmen, inner Oslofjord) indicated that the changes in concentrations occurred abruptly in the last 2 years. This strongly suggested some recent event in the field or change during the data acquisition process. The other trends were steadier over a 7 years period, with an annual increase of 39% at Baie de la Fresnaye and an annual decrease of 10% at Port en Bessin (FR).

Region III

No significant trends were detected.

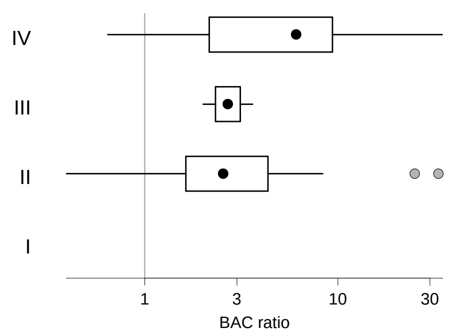
Comparisons with BACs and EACs

A BAC has been proposed for chrysene in blue mussel (17 µg kg-1, dw) but not for the other bivalves assessed. There is a proposed EAC for Σ4-rings PAHs. Of the 59 blue mussel time series, 6 were significantly below the BAC. High levels (UCL/BAC ratios > 10) were found in Region II (NMMP555 (Tamar Warrren Point), 567 (Poole Harbour Wytch) in UK), and Region IV (Loire estuary and Baie de Vilaine (FR), and Santander Pantalan, ES).

Table 7.37 Chrysene in biota - Comparison with BAC by region

Region	Above	Below
II	35	5
III	2	
IV	16	1
Total	53	6

Figure 7.13 Chrysene in biota - Summary plots of BAC ratios in blue mussel



Ten-year detectable trend

The 10-year detectable trend varied from 8 to 46% with a median of 19% for time series ≥ 5 years.

Conclusion

There were 55 time series assessed for temporal trends, mostly from Regions II and IV. There were 4 significant linear trends: 2 upward and 2 downward. Doubts were expressed about the validity of some of the trends. 10% of blue mussel time series were significantly below the BAC.

Fluoranthene

Available data

There were 91 time series available: 60 in blue mussel; 2 in Mediterranean mussel; and 29 in Pacific oyster (table 7.38). The datasets were submitted by Denmark (13), France (61), Norway (1), UK (9) and Spain (7). The datasets covered 3-9 years of data. For most of the datasets < 3 years of good QA information were available.

Table 7.38 Fluoranthene in biota - Extent of the dataset

Region	Year category	Blue mussel	Mediterranean mussel	Pacific oyster	Total
II	3-4	18	1	1	20
	5-6	2			2
	7+	19	1	6	26
III	3-4	2			2
	5-6	2			2
IV	3-4	10			10
	5-6			2	2
	7+	7		20	27
Total		60	2	29	91

Time trend analysis

There were 59 datasets of 5 years or more for which trends could be assessed. There was 1 significant upward linear trend and 4 significant downward linear trends. There was a significant non-linear component in 3 time series.

Table 7.39 Fluoranthene in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
II	3-4			20	20
	5-6	1		1	2
	7+		3	23	26
III	3-4			2	2
	5-6			2	2
IV	3-4			10	10
	5-6			2	2
	7+		1	26	27
Total		1	4	86	91

Region II

There were 3 significant trends: 1 upward was observed at Roskilde Fjord 65 (DE).and 3 downward for blue mussel in France (Lannion-Saint Michel en Grev; Calais-Dunkerque-Oye Plage and Baie des Veys Gefosse).

Region III

There were no significant trends.

Region IV

There was 1 significant downward linear trend, at Vendée-Talmont in France.

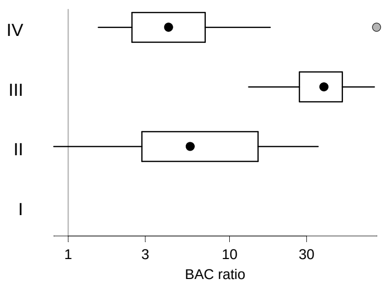
Comparisons with BACs and EACs

A BAC has been proposed for fluoranthene in blue mussel (12,5 µg kg-1 dw) but not for the other bivalves assessed. There is a proposed EAC for Σ4-rings PAHs. Of the 60 blue mussel time series, only 2 were significantly below the BAC, both in Region II. UCL/BAC ratios of up to 80 were recorded.

Table 7.40 Fluoranthene in biota - Comparison with BAC by region

Region	Above	Below
II	37	2
III	4	
IV	17	
Total	58	2

Figure 7.14 Fluoranthene in biota - Summary plots of BAC ratios for in blue mussel



Ten-year detectable trend

The 10-year detectable trend varied between 5 and 38 % with a median of 14% for time series ≥ 5 years. The 10-year detectable trend was ≤ 10% in 39% of time series.

Conclusion

There were 59 time series assessed for temporal trends, mostly from Region II and IV. There were 5 significant linear trends: 1 upward and 4 downward. 3% of blue mussel time series were significantly below the BAC.

Indeno[1,2,3-cd]pyrene

Available data

There were 82 time series available: 50 in blue mussel, 29 in Pacific oyster, 2 in Mediterranean mussel and 1 in sand gaper (table 7.41). The datasets were submitted by Denmark (10), France (61), Norway (1), Spain (7) and the UK (3). The datasets covered 3-9 years of data. For most of the datasets < 3 year of good quality QA information was available.

Table 7.41 Indeno[1,2,3-cd]pyrene in biota - Extent of dataset

Region	Year category	Blue mussel	Mediterranean mussel	Pacific oyster	Sand gaper	Total
II	3-4	11	1	1	1	14
	7+	19	1	6		26
III	3-4	1				1
	5-6	2				2
IV	3-4	10				10
	5-6			2		2
	7+	7		20		27
Total		50	2	29	1	82

Time trend analysis

There were 57 datasets of 5 years or more for which trends could be assessed. There were 13 significant upward linear trends and 0 significant downward linear trends. There were no significant non-linear components.

Table 7.42 Indeno[1,2,3-cd]pyrene in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
II	3-4			14	14
	7+	10		16	26
III	3-4			1	1
	5-6			2	2
IV	3-4			10	10
	5-6			2	2
	7+	3		24	27
Total		13		69	82

Regions II and IV

There were 13 significant linear trends, all upwards and all from France. For blue mussel they were at Ouest Cotentin-Pirou Nord, Ouest Cotentin – Breville, Lannion-Saint Michel en Grev, Dieppe – Varengeville, Calvados Ouistreham, Baie de la Fresnaye, Antifer Digue, Vilaine-Pen Be and Lorient-La Potée de Beure. For Mediterranean mussel there was 1 significant upward linear trend at Saint Brieuc-Pointe de Rosel. For Pacific oyster there were 3 significant upward linear trends at Paimpol-Beg Nod, Brest-Baie de Roscanvel, and Morbihan–Locmariaquer. However, a detailed analysis of the time series plots strongly suggests that some of the changes in concentrations could not be interpreted as a regular trend. They strongly suggest some event in the field or during the data acquisition process.

Region III

There were no significant trends.

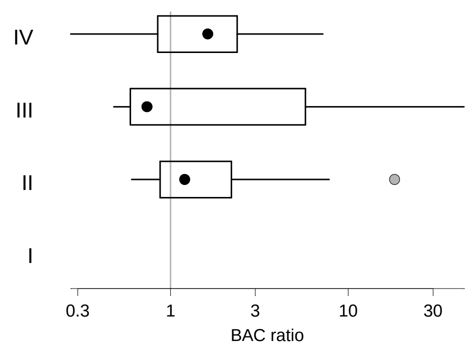
Comparisons with BACs and EACs

A BAC has been proposed for indeno[1,2,3-cd]pyrene in blue mussel (8 µg kg-1 dw) but not for the other bivalves assessed. There is a proposed EAC for Σ6-rings PAHs. Of the 50 blue mussel time series, 18 were significantly below the BAC.

Table 7.43 Indeno[1,2,3-cd]pyrene in biota - Comparison with BAC by region

Region	Above	Below
II	20	10
III	1	2
IV	11	6
Total	32	18

Figure 7.15 Indeno[1,2,3-cd]pyrene in biota - Summary plots of BAC ratios in blue mussel



Ten-year detectable trend

The 10-year detectable trend varied between 1 and 42% with a median of 17% for time series ≥ 5 years. The 10-year detectable trend was ≤ 10% in 24 % of time series.

Conclusion

There were 57 time series assessed for temporal trends, mostly from Regions II and IV. There were 13 significant linear trends, all downward. Doubts were expressed about the validity of some of the trends. 36% of blue mussel time series were significantly below the BAC.

Naphthalene

Available data

There were 74 time series available: 43 in blue mussel, 2 in Mediterranean mussel, and 29 in Pacific oyster (table 7.44). The datasets were submitted by Denmark (12), France (61) and Norway (1). Information on QA was available for all these datasets. The datasets covered 3-9 years of data.

Table 7.44 Naphthalene in biota - Extent of the dataset

Region	Year category	Blue mussel	Mediterranean mussel	Pacific oyster	Total
II	3-4	13	1	1	15
	5-6	1			1
	7+	19	1	6	26
IV	3-4	3			3
	5-6			2	2
	7+	7		20	27
Total		43	2	29	74

Time trend analysis

There were 56 datasets of 5 years or more for which trends could be assessed. There were no significant trends.

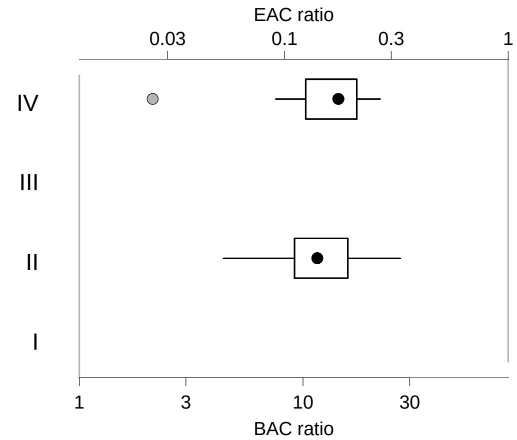
Comparisons with BACs and EACs

A BAC has been proposed for benzo[a]pyrene in blue mussel (5,5 µg kg-1 dw) but not for the other bivalves assessed. There is an EAC of 445 µg kg-1 dw for blue mussel. All UCL/BAC ratios were > 1, and were typically > 5. Particularly high UCL/BAC ratios (> 20) were found in Region II (Roskilde Fjord, Cancale and Douardenez, FR) and Region IV (Cap Breton, FR). All blue mussel time series were significantly below the EAC.

Table 7.45 Naphthalene in biota - Comparison with BAC by region

Region	Above	Below
II	33	
IV	10	
Total	43	

Figure 7.16 Naphthalene in biota - Summary plots of BAC and EAC ratios in blue mussel



Ten-year detectable trend

The 10-year detectable trend varied from 28 to 93% with a median of 57% for time series ≥ 5 years.

Conclusion

There were 56 time series assessed for temporal trends, mostly from Regions II and IV. There were no significant trends. No blue mussel time series were significantly below the BAC, but all were significantly below the EAC.

Phenanthrene

Available data

A total of 94 time series were available: 62 in blue mussel; 2 in Mediterranean mussel, 29 in Pacific oyster, and 1 in sand gaper (table 7.46). The datasets were submitted by Denmark (16), France (61), Norway (1), Spain (7), and the UK (9). Information on QA was available for all these datasets. The datasets covered 3-9 years of data.

Table 7.46 Phenanthrene in biota - Extent of the dataset

Region	Year category	Blue mussel	Mediterranean mussel	Pacific oyster	Sand gaper	Total
II	3-4	21	1	1	1	24
	5-6	1				1
	7+	19	1	6		26
III	3-4	2				2
	5-6	2				2
IV	3-4	10				10
	5-6			2		2
	7+	7		20		27
Total		62	2	29	1	94

Time trend analysis

There were 58 datasets of 5 years or more for which trends could be assessed. There were 0 significant upward trends and 19 significant downward trends. There was a significant non-linear component in 7 time series.

Table 7.47 Phenanthrene in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
II	3-4			24	24
	5-6			1	1
	7+		7	19	26
III	3-4			2	2
	5-6			2	2
IV	3-4			10	10
	5-6			2	2
	7+		12	15	27
Total			19	75	94

Regions II and IV

There were 19 significant linear trends, all downward and all from the French coast. The annual rates of decrease were all > 13% and reached the rate of 43% on Noirmoutier Island (Region IV, FR) over a period of 8 years.

Region III

No significant linear trends were detected.

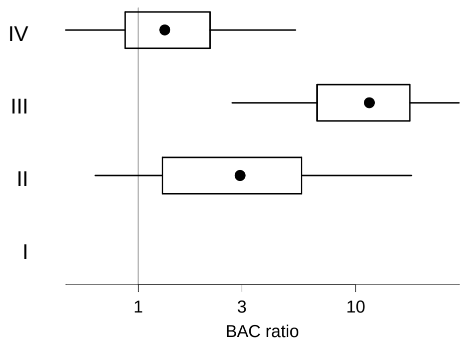
Comparisons with BACs and EACs

A BAC has been proposed for phenanthrene in blue mussel (24,5 µg kg-1 dw) but not for the other bivalves assessed. An EAC is proposed for Σ3 ring PAHs. Of the 62 blue mussel time series, 9 were significantly below the BAC. High UCL/BAC ratios > 10 were found in Region II (Nivå Bugt 31 (DK) and NMMP567 (Poole Harbour Wytch) (UK) and in Region III (NMMP690 (Dee Mostyn Bank) and 768 (St Bees Cumbria Coast) (UK).

Table 7.48 Phenanthrene in biota - Comparison with BAC by region

Region	Above	Below
II	37	4
III	4	
IV	12	5
Total	53	9

Figure 7.17 Phenanthrene in biota - Summary plots of BAC ratios in blue mussel



Ten-year detectable trend

The 10-year detectable trend varied from 7 to 49% with a median of 14% for time series ≥ 5 years.

Conclusion

There were 58 time series assessed for temporal trends, mostly from Region II and IV. There were 19 significant linear trends, all downward. 15% of blue mussel time series were significantly below the BAC.

Pyrene

Available data

There were 93 time series available: 61 in blue mussel; 29 in Pacific oyster; 2 in Mediterranean mussel; and 1 in sand graper (table 7.49). The datasets were submitted by Denmark (16), France (61), Norway (1), Spain (7) and the UK (8). The datasets covered 3-9 years of data. For most of the datasets < 3 years of good quality QA information was available.

Table 7.49 Pyrene in biota - Extent of the dataset

Region	Year category	Blue mussel	Mediterranean mussel	Pacific oyster	Sand gaper	Total
II	3-4	20	1	1	1	23
	5-6	2				2
	7+	19	1	6		26
III	3-4	1				1
	5-6	2				2
IV	3-4	10				10
	5-6			2		2
	7+	7		20		27
Total		61	2	29	1	93

Time trend analysis

There were 59 datasets of 5 years or more for which trends could be assessed. There was 1 significant upward linear trend and 1 significant downward linear trend. There was a significant non-linear component in 4 time series.

Table 7.50 Pyrene in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
II	3-4			23	23
	5-6			2	2
	7+			26	26
III	3-4			1	1
	5-6			2	2
IV	3-4			10	10
	5-6			2	2
	7+	1	1	25	27
Total		1	1	91	93

Regions II and III

There were no significant linear trends.

Region IV

For Pacific oyster, there was 1 significant upward linear trend at Hendaye–Chingoudy and 1 significant downward linear trend at Vendée-Talmont.

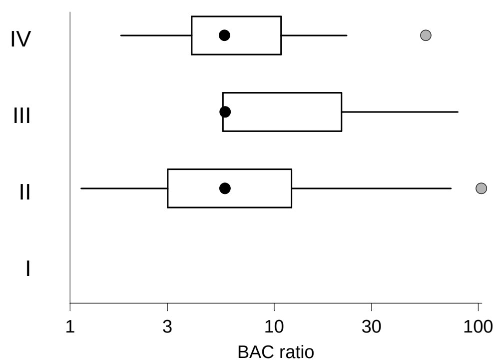
Comparisons with BACs and EACs

A BAC has been proposed for blue mussel (9 µg kg-1 dw) but not for the other bivalves assessed. There is a proposed EAC for Σ4-rings PAHs. All UCL/BAC ratios were > 1.

Table 7.51 Pyrene in biota - Comparison with BACs by region

Region	Above	Below
II	41	
III	3	
IV	17	
Total	61	0

Figure 7.18 Pyrene in biota - Summary plots of BAC ratios in blue mussel



Ten-year detectable trend

The 10-year detectable trend varied between 5 and 28% with a median of 10% for time series ≥ 5 years. The 10-year detectable trend was ≤ 10% in 53% of time series.

Conclusion

There were 59 time series assessed for temporal trends, mostly from Region II and IV. There were 2 significant linear trends: 1 upward and 1 downward. No blue mussel time series were significantly below the BAC.

7.3.3 PCBs (CB 153 and ΣCB_7)

Available data

CB 153

A total of 242 time series were available: bivalves (146), flatfish (68), roundfish (27) and crustaceans (1) (table 7.52). There were 26 time series from Region I (11%), 153 time series from Region II (63%), 24 time series from Region III (10%) and 39 time series from Region IV (16%). Between 50-60% of the data for Regions I-III were from time series for bivalves, whereas time series from Region IV were exclusively for bivalves. For fish, the majority of time series were from flatfish data (72%).

ΣCB_7

A total of 244 time series available for ΣCB_7 (CBs 28, 52, 101, 118, 138, 153 and 180). Of these 240 were from samples identical to CB 153. For an additional 4 stations in Region III (mussel, UK) only ΣCB_7 time series were available. For 2 time series in Region IV no ΣCB_7 time series were extracted from the data base.

Table 7.52 CB 153 in biota - Extent of the dataset

Region	Year categ	Blue mussel	Cod	Common dab	Flounder	Herring	Mediter. mussel	Megrim	Pacific oyster	Plaice	Sand gaper	Shrimp (crangon)	Whiting	Total
I	3-4	3												3
	5-6	4								2				6
	7+	11	4							2				17
II	3-4	19		3	10		1		1	3	2			39
	5-6	11		3	3		1		2	2	1			23
	7+	38	15	9	20	2		2	4			1		91
III	3-4	4		3	1					2			1	11
	5-6	7		3	1					1				12
	7+	1												1
IV	3-4	3												3
	5-6	2							4					6
	7+	12							18					30
Total		115	19	21	35	2	2	2	29	12	3	1	1	242

Table 7.53 ΣCB_7 in biota - Extent of the dataset

Region	Year categ	Blue mussel	Cod	Common dab	Flounder	Herring	Mediter mussel	Megrim	Pacific oyster	Plaice	Sand gaper	Shrimp (crangon)	Whiting	Total
I	3-4	3												3
	5-6	5								3				8
	7+	10	4							1				15
II	3-4	22		3	10		1		1	3	2			42
	5-6	23		3	5				6	2	1			40
	7+	23	15	9	19	2		2				1		71
III	3-4	7		3	1					2			1	14
	5-6	7		4	1					1				13
	7+	1												1
IV	3-4	2							3					5
	5-6	3							16					19
	7+	10							3					13
Total		116	19	22	36	2	1	2	29	12	3	1	1	244

Time trend analysis

CB 153

There were 186 datasets of 5 years or more for which trends could be assessed. There were 2 significant upward linear trends and 45 significant downward linear trends. There was a significant non-linear component in 12 time series.

ΣCB_7

There were 180 datasets of 5 years or more for which trends could be assessed. There were 2 significant upward linear trends and 49 significant downward linear trends. There was a significant non-linear component in 12 time series.

Table 7.54 CB 153 in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
I	3-4			3	3
	5-6			6	6
	7+		6	11	17
II	3-4			39	39
	5-6		2	21	23
	7+	2	23	66	91
III	3-4			11	11
	5-6			12	12
	7+			1	1
IV	3-4			3	3
	5-6			6	6
	7+		14	16	30
Total		2	45	195	242

Table 7.55 ΣCB_7 in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
I	3-4			3	3
	5-6			8	8
	7+		3	12	15
II	3-4			42	42
	5-6	1	5	34	40
	7+	1	23	47	71
III	3-4			14	14
	5-6		1	12	13
	7+		1		1
IV	3-4			5	5
	5-6		5	14	19
	7+		11	2	13
Total		2	49	193	244

Region I

For CB 153, there were 6 significant downward linear trends: 4 from Iceland and 2 from Norway. For 2 of these time series (blue mussel from Eyri Hvalfjördur (IS) and cod from station 10B Varangerfjorden, NO) there was also a significant non-linear component. No corresponding downward trends were detected for ΣCB_7 at the four Icelandic stations, possibly due to low concentrations. For most time series, the estimated trend was downward, even if it was not significant. The exceptions were blue mussel time series from two Icelandic sites (Mjófjördur, Vestmannaeyjar).

Region II

There were 25 and 28 significant downward linear trends for CB 153 and ΣCB_7 respectively. Trends were detected for herring (Fladen, SE), cod (Færder area, NO), blue mussel and flatfish (dab, flounder) from sites from Norway, Sweden and the southern North Sea coastal area (DK, DE, NL and BE). Particularly in the Wadden Sea area, concentrations have decreased over the entire period at most sites, but in many cases the downward trend stopped in the mid nineties and has been relatively constant or even slightly upwards in most recent years. Significant upward linear trends in CB 153 were detected for cod liver and cod muscle from Oslo city area (NO) and in ΣCB_7 for cod liver from Oslo city area and for plaice liver at UK station NMMP105 (Moray Firth Offshore).

Region III

There were only 2 significant linear trends, both downwards and both for ΣCB_7. One of these was for blue mussel from the Irish site at Cork west passage/ Ringaskiddy.

Region IV

There were 14 and 16 significant downward linear trends for CB 153 and ΣCB_7 respectively, from along the French and Spanish coasts. Of these, 2 also had a significant non-linear component. For most time series, the estimated trend was downwards, even if it was not significant.

Comparisons with BACs and EACs

BACs for CB 153 and ΣCB_7 are only available for blue mussel and fish liver. Of blue mussel time series, 9% and 11% were significantly below the BACs for CB 153 and ΣCB_7 respectively. All UCL/BAC ratios for fish liver were > 1, with most ratios > 30. EACs are only available for blue mussel and fish (muscle and liver). Of blue mussel time series, 47% and 63% were significantly below the EACs for CB 153 and ΣCB_7 respectively. Of fish time series, 27% and 44% were significantly below the EACs for CB 153 and ΣCB_7 respectively. In Region I, UCL/EAC ratios for CB 153 were > 1 for blue mussel from Elenheimsundet (NO) and Norwegian cod time series. UCL/EAC ratios for ΣCB_7 were > 1 for all Icelandic blue mussel time series and Norwegian cod time series. In Region II, blue mussel time series at Norwegian sites covering ≥ 10 years and 2 UK sites starting in 1999 were significantly below the BAC. There is no clear correspondence in UCL/BAC ratios or UCL/EAC ratios between species or areas for most time series, except cod from Norwegian sites, with UCL/EAC ratios > 1 for both liver and muscle.

Table 7.56 CB 153 in biota - Comparison with BACs and EACs by region

	BRC (blue mussel)		EAC (blue mussel)		BRC (fish)		EAC (fish)	
Region	Above	Below	Above	Below	Above	Below	Above	Below
I	10	8	1	17	2		4	4
II	66	2	41	27	44		53	19
III	12		6	6	11		10	2
IV	17		13	4				
Total	105	10	61	54	57	0	67	25

Figure 7.19 CB 153 in biota - Summary plots of BAC and EAC ratios in blue mussel

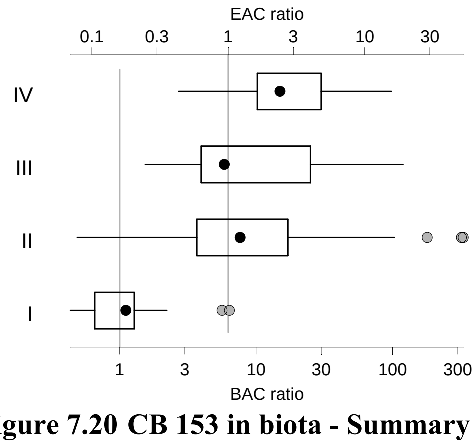


Figure 7.20 CB 153 in biota - Summary plots of BAC and EAC ratios in fin fish

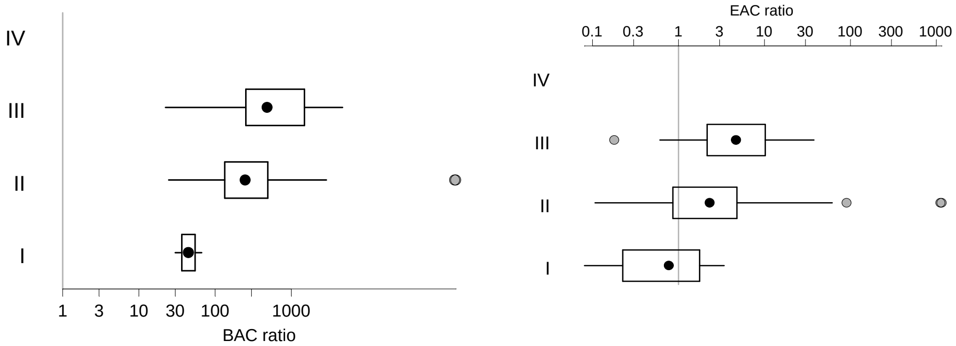


Table 7.57 ΣCB_7 in biota - Comparison with BACs and EACs by region

	BRC (blue mussel)		EAC (blue mussel)		BRC (fish)		EAC (fish)	
Region	Above	Below	Above	Below	Above	Below	Above	Below
I	15	5	1	17	2		4	4
II	60	8	28	40	45		41	32
III	15		4	11	12		8	5
IV	15		10	5				
Total	103	13	43	73	59	0	53	41

Figure 7.21 ΣCB_7 in biota - Summary plots of BAC and EAC ratios for in blue mussel

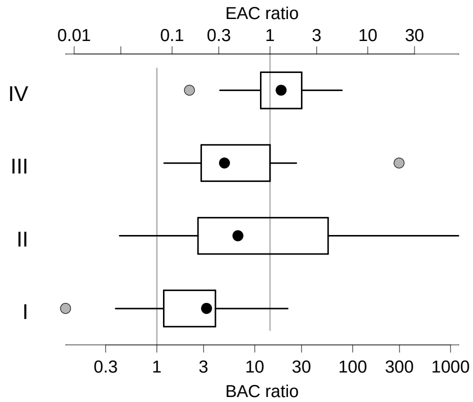
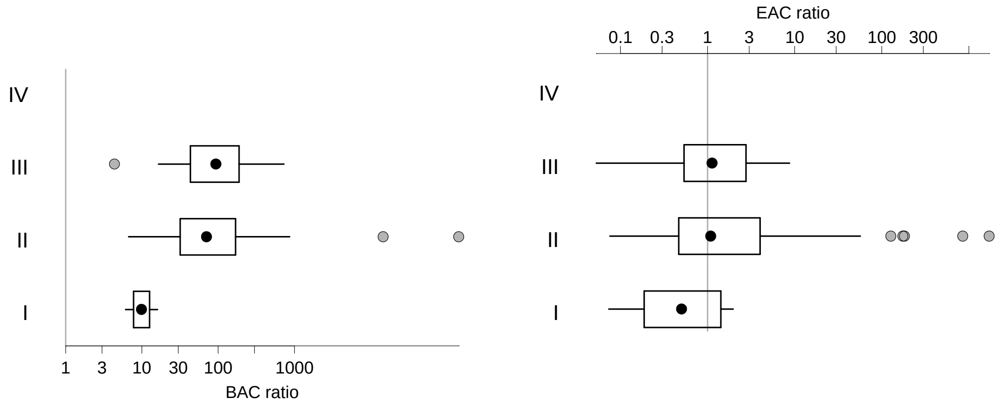


Figure 7.22 ΣCB_7 in biota - Summary plots of BAC and EAC ratios in finfish



Ten-year detectable trend

For both CB 153 and ΣCB_7, the 10-year detectable trend varied between 3 and about 67% with a median of 13% for time series ≥ 5 years.

Conclusion

For CB 153, 186 time series were assessed for temporal trends. There were 47 significant linear trends: 2 upward and 25 downward. For ΣCB_7, 180 time series were assessed for temporal trends. There were 51 significant linear trends: 2 upward and 49 downward. There is evidence that CB concentrations are generally decreasing over the assessed time period. But compared to the last assessment, for many of the long time series concentrations are not decreasing further and vary at a relatively constant concentration level. In some cases a slight increase could be recognised in the recent years. Increasing concentrations resulting in a significant upward trend could be detected for cod samples at some Norwegian sites. 9% and 11% of blue mussel time series were significantly below the BACs for CB 153 and ΣCB_7 respectively. All UCL/BAC ratios for fish liver were > 1, with most ratios > 30. 47% and 63% of blue mussel time series were significantly below the EACs for CB 153 and ΣCB_7 respectively. 27% and 44% of fish time series were significantly below the EACs for CB 153 and ΣCB_7 respectively.

7.3.4 Organochlorine pesticides trends in biota

γ-HCH

Available data

There were 179 datasets available. Data were available from Regions I (n=25), II (n=120), III (n=3) and IV (n=31). Region II provided most of the datasets within the assessment (table 7.58). 148 time series in excess of 5 years were available for assessment of which 67 were blue mussel, 29 Pacific oyster and 19 flounder, for which liver tissue compose the majority of the datasets. 79 time series had over 3 years of sufficient QA information but 8 possible shifts in datasets were noted, possibly arising from persistent bias in the data.

Table 7.58 γ-HCH in biota - Extent of the dataset

Region	Year categ	Blue mussel	Cod	Common dab	Flounder	Herring	Mediter. mussel	Megrim	Pacific oyster	Plaice	Sand gaper	Shrimp (crangon)	Total
I	3-4	4											4
	5-6	5								2			8
	7+	6	4							2			13
II	3-4	16			3		1			2	2		24
	5-6	6			2				2				10
	7+	39	15	4	17	2	1	2	5			1	86
III	3-4	1											1
	5-6	1											1
	7+	1											1
IV	3-4	2											2
	5-6								1				1
	7+	7							21				28
Total		90	19	4	22	2	2	2	29	6	2	1	179

Time trend analysis

There were 148 datasets of 5 years or more for which trends could be assessed. There were 0 significant upward linear trends and 56 significant downward linear trends. There was a significant non-linear component in 18 time series.

Table 7.59 γ-HCH in biota - Temporal trend assessment

Region	Year category	Upward	Downward	None	Total
I	3-4			4	4
	5-6			8	8
	7+		5	8	13
II	3-4			24	24
	5-6		2	8	10
	7+		43	43	86
III	3-4			1	1
	5-6		1		1
	7+		1		1
IV	3-4			2	2
	5-6			1	1
	7+		4	24	28
Total			56	123	179

Region I

There were 5 significant linear trends, all downwards: 1 in Icelandic blue mussels, 2 in Norwegian cod liver and 1 each for Norwegian plaice liver and muscle tissues. Overall the trend within the region appears to be gradually downward.

Region II

There were 45 significant linear trends, all downward. In general concentrations are fairly conserved throughout the region but areas such as the Elbe and Jade river (DE) tend to be more elevated than at other locations. The 5 time series within the Elbe, however, show significant downward trends. 4 Belgian time series, especially for shrimp from station BCP, indicate a general and significant downward trend within the region. Flounder and cod tissues from Belgium do not show the general trend as clearly. time series from Danish waters showed a significant downward trend with blue mussel from the Wadden Sea and the Little belt providing further evidence of this direction. Swedish herring muscle and cod liver also suggest the downward pattern in the region.

Region III

The 2 time series long enough to be assessed both showed a significant downward trend: in blue mussel in Cork and Dublin harbours.

Region IV

There were 4 significant linear trends, all downward, at blue mussel stations Marennes-Mus de Loup, Marennes – Boyardville, Gironde – Pontaillal and Gironde-Bonne Anse. The downward trend at Marennes-Mus de Loup also showed a significant non-linear component. Trends are not as visible compared to other more northern latitudes.

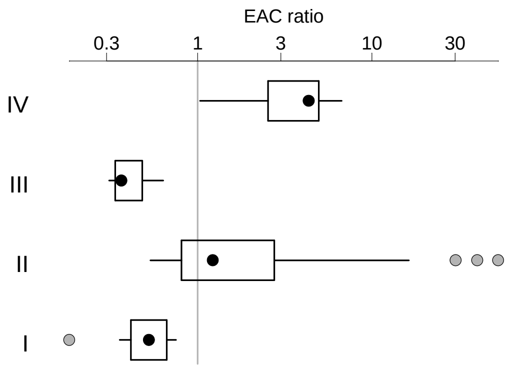
BACs and EACs

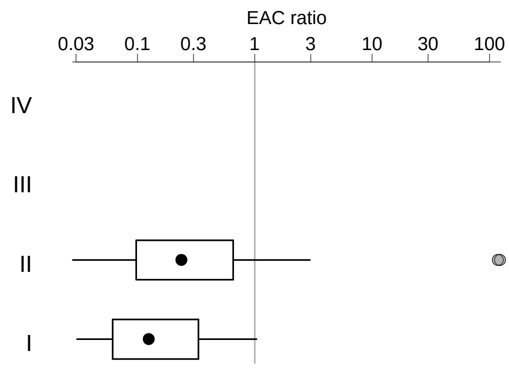
A BC of 0 is proposed for γ-HCH for all biota, but no BAC was available for assessment purposes. EACs of 1,45 (blue mussel), 99 (plaice and flounder liver), 1,1 (plaice and flounder muscle), 22 (cod liver), 0,11 (cod muscle, 70 (plaice and flounder muscle), 55 (megrim liver) and 77 for common dab liver are proposed. 65% of time series were significantly below the EAC, including all but 1 time series from Regions I and III.

Table 7.60 γ-HCH in biota - Comparison with EACs by region

Region	Above	Below
I	1	24
II	41	67
III	0	3
IV	9	0
Total	51	94

Figure 7.23 γ-HCH in biota - Summary plots of EAC ratios in blue mussel (left) and fish (right)





Ten-year detectable trend

The 10-year detectable trend varied between 6 and 71% with a median of 18% for time series ≥ 5 years.

Conclusion

There were 148 time series assessed for temporal trends. There were 56 significant linear trends, all downward. 65% of time series were significantly below the EAC, including all but 1 time series from Regions I and III.

Dieldrin

Available data

There were 8 time series available: 2 in fish liver, 2 in fish muscle, 3 in blue mussel and 1 in shrimp (table 7.61). time series for Region II were all from Belgium (6) on cod liver and muscle, flounder liver and muscle, blue mussel and shrimp from 1 site. time series for Region III were from the UK for blue mussel from 2 sites.

Table 7.61 Dieldrin in biota - Extent of the dataset

Region	Year category	Blue mussel	Cod	Flounder	Shrimp	Total
II	7+	1	2	2	1	6
III	5-6	2				2
Total		3	2	2	1	8

Time trend analysis and comparison with EACs and BRCs

There were 8 datasets of 5 years or more for which trends could be assessed. There were no significant linear trends and 1 significant non-linear component.

Region II

There was a significant non-linear trend in a cod liver time series, which showed a minimum in the period 1995-1997, increasing to levels comparable to the years 1990 and 1992.

Region III

There were no significant trends.

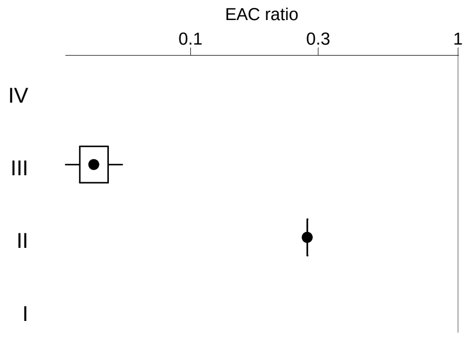
BACs and EACs

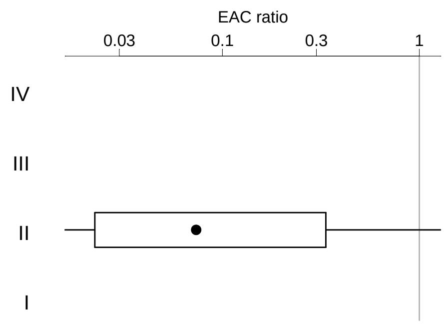
No BACs were available for dieldrin. Despite the different matrices involved, comparison of biota concentrations with EACs showed consistent results (table 7.62). All but 1 time series, a cod liver time series from Belgium, were significantly below the EAC.

Table 7.62 Dieldrin in biota - Comparison with EAC by region

Region	Above	Below
II	1	4
III		2
Total	1	6

Figure 7.24 Dieldrin in biota - Summary plots of EAC ratios in blue mussel (left) and fish (right)





Ten-year detectable trend

The 10-year detectable trend varied between 19 and 66% with a median of 30% for time series ≥ 5 years.

Conclusion

There were 8 time series assessed for temporal trends. There were no significant linear trends. All but 1 time series were significantly below

8. Assessment of metals and organic contaminants in sediment

8.1 General introduction

Sediments were analysed in the measured fraction, which was either sieved sample at 20 or 63 µm (FS20 or FS63) or unsieved "total" sample at < 2000 µm (US2000). For each of these fractions, different normalisation procedures have been used, depending on the availability of normalisation parameters: Li or Al indicators for clay content, and total organic carbon (TOC) for the organic carbon content (C_{org}). Thus each dataset may contribute up to 4 time-trends, 1 for each normalising method and 1 for the reported concentration (unnormalised). These trends may be in different directions. It should be noted that not all normalisation parameters were available for all datasets.

Only datasets with 7 or more years of information were assessed for both linear and non-linear temporal trends. Linear trends only were fitted to datasets of 5-6 years, whereas datasets of only 3-4 years were summarised as means. The results presented in this report cover data from Regions I-IV.

In addition to the assessment of temporal trends in sediments, the UCL of the fitted concentrations in the final year of each data series were compared to available assessment criteria (table 6.1). BACs were available for 8 elements (Hg, Cd, Pb, Cu, Zn, Ni, As, Cr), 2 CB parameters (CB 153, and ΣCB_7), and 10 PAH compounds. EACs were available for 3 organochlorine compounds, TBT, and 5 grouped PAH parameters.

The ratios of the UCLs to the BAC or EAC are known as BAC or EAC ratios respectively. BAC ratios < 1 indicated that concentrations are 'close to BCs'. However, BAC ratios > 1 do not necessarily indicate an adverse effect on biota. BACs are set from data from areas with no known significant anthropogenic sources, and levels above the BACs could be caused by local natural sources (e.g. volcanic activities in the Icelandic area), as well as by anthropogenic sources. Generally, the BAC ratios were > 1. No suggestions were made as to how high a ratio might be ecologically acceptable, and such a "maximum" ratio could be site specific. However, OSPAR has a long term aim that concentrations of contaminants should be at, or close to, BCs.

Plots have been prepared of all temporal trend series, for all contaminants (Appendix 13). Where available, the assessment criteria (BACs, EACs) have been included in the plots. The relationships with assessment criteria are summarised in tables and figures in the main text, and shown in more detail in Appendix 12. Comments are made in the main text concerning the relationship between the fitted concentrations in the final year and the assessment criteria. The geographical distributions of sampling stations and temporal trends are shown in maps in Appendix 9. A complete list of stations where sediment samples were collected is given in Appendix 8. Throughout, significance is assessed at the 5% level.

Advantage has been taken of the opportunity presented by this assessment to review the power of the monitoring programmes to detect temporal trends in concentrations. Two approaches have been used, firstly as described by Nicholson *et al*. (1997) (see Appendix 4D), and secondly as employed in discussion of data from the Baltic Sea area (Appendix 4E).

8.2 Overview of available data

Belgium

About 16 time series were available for metals and CBs with yearly measurements, starting in 1987. From 1990 onwards measurements were performed in sieved fraction. However, the data fields of the reporting format were completed very inconsistently and a considerable amount of revision was necessary to make the results accessible. For example, sieve fractions of 62µm instead of 63µm were used in some years, 3 types of total sample of 500, 1000 and 2000µm were used, etc. Except for 1990 no C_{org} results were used and also other cofactors were only scarcely available. In that respect Al is the most frequently available cofactor. Using the station information held by ICES most stations could be named as always nominal codes were reported to ICES. After 2002 this policy probably changed and (in several cases) other (actual) coordinates were reported. PAH were reported from 2001 onwards.

Denmark

The monitoring program which started in 1998 has now run through 2 cycles. Most of the data originate from 2000 and 2003. Baseline data from other stations with very little overlap in coordinates were sampled in 1985 or 1990. Only 1 station with data for 3 years was included in the assessment.

France

In 1991, an extensive survey with 65 stations was carried out in which total and sieved samples (< 63µm) were analyzed for CBs, Al, Cu, Pb and Zn, although not all determinands were reported for all samples. No C_{org} was determined. Instead loss on ignition (LO_{IGN}) was determined in total samples only. In 1999 and 2001 complete datasets for total samples were reported (Al, Li and C_{org} CBs and PAHs). However of the 65 stations visited in 1991 only 13 were visited again in 1999 and 1 in 2001.

Germany

About 40 time series with more than 10 data points were available for metals in fractionated sediment (< 20µm). About 10 time series for total sediment, were available for metals and CBs. For PAH only 3 time series had a length of more than 10 years. When shorter time series are considered about 70 time series become available. Contaminant data were in many cases accompanied by cofactors like C_{org} and Al. There were many data for which it was not possible to assign a station name or co-ordinates. It was possible to add these data to existing locations if they fell in a certain co-ordinates window. In addition to surface sediment data, data from 2 cores (0-6 cm) were reported.

Iceland

Data were only available from the ICES database for 1990. These were 14 samples taken at sites around the whole of Iceland. Cofactors and heavy metals were analyzed in sieved fractions. In a few total samples the PCBs were determined (no C_{org} available).

The Netherlands

Data exist from a number of locations from 1987 with up to 8 years of measurement until 2003. Locations could perhaps be screened with a view to combining them to create longer time series. Al was only measured in 1993 but C_{org} was consequently reported in all subsequent years except in 1999. Nevertheless, there were many odd results noted that needed to be checked and/or adjusted. Also the use of sample identification fields was not consistent.

Norway

The data held in the ICES database are numerous. This is mainly because of the detailed slicing of cores. For the proposed trend assessment surface sediments have been considered together with the information below. Therefore the assessment is restricted to the upper slices of the cores. The earliest data available are from the Oslo and Trondheim fjords starting from 1986. In 1990 a large survey was performed in the south western waters of Norway. This also included sieved samples. In 1992 the mid section of Norwegian waters were sampled, and in 1994, the upper northern waters. In 1996/1997 the southern waters were sampled again. However, most stations were sampled once only. About 6 stations were sampled twice (1990 and 1997). Near Oslo, 3 stations were sampled 3 times over the period 1986-1996 with multiple samples taken (2-4). However, the interpretation of these data is difficult. Cofactors and metals were determined in 1 cm slices and the organic compounds in the 0-2 cm slice. Using information under the ICES database fields SEQNO, SUBNO and REPNO it was not possible to conclude on which C_{org} should belong to which sample for the organics.

Spain

Only a limited amount of data were available dating from 1990. These comprised Cd, Cu, Ni, Pb and Zn in sieved fractions (63µm). For digestion HF was applied.

Portugal

No data were available after 1990. There were few metal data available dating from before 1990.

Sweden

Data were available only for 1990 from 10 stations on the west coast of Sweden. An extensive set of parameters were reported, including grain size distribution. Of the other cofactors only C_{org} was determined.

United Kingdom

Data from an extensive survey in 1990/1991 are available in the ICES database including metal data and for some locations CBs. From 1999 onwards, the UK reported data on metals, CBs and PAHs in sieved samples (< 63µm) collected under a monitoring program comprising about 80 stations, and applying multiple sampling (3-5 samples). These stations were mostly situated in coastal areas and none of the stations matched those used for the survey in 1990/1991. About 20 stations have a time series of 4 years for metals, about 15 for CBs and 10 for PAHs. Unfortunately no results of C_{org} were reported for any of the samples.

8.3 Trace metal trends in sediments

8.3.1 Arsenic

Available data

There were 646 datasets from 228 sediment stations available (table 8.1). The stations were split into 3 groups according to length of the time series: 3-4 years (99), 5-6 years (75) and 7-18 years (54). Of the 646 time series, 200 were normalised to Al, 130 to C_{org} and 88 to Li.

Table 8.1 Arsenic in sediment - Summary of assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	1	13	5	19	1	3		0
		AL	6	1	0	7	0	0	1	
		LI	3	3	0	6	0	0		
		C_{org}	11	5	3	19	0	0		
	FS63	none	77	38	16	131	0	2		0
		AL	93	24	11	128	0	2	23	
		LI	16	14	0	30	0	1		
		C_{org}	59	14	0	73	4	0		
	FS20	none	3	13	33	49	6	4		0
		AL	3	16	20	39	3	0	1	
		LI	6	13	17	36	3	0		
		C_{org}	6	10	22	38	8	0		
III	FS63	none	18	11	0	29	0	0		0
		AL	15	11	0	26	0	0	16	
		LI	13	3	0	16	0	0		
Total all			330	189	127	646	25	12	41	0
Total none[1]			99	75	54	228	7	9		

1 Sum of "none" from each fraction and corresponds to the number of sediment stations
2 Only applies to time series normalised to AL
3 Only applies to non-normalised time series

Time trend analysis

There were 25 significant upward trends and 12 significant downward trends.

Region II

Data were available for the fractions FS20 (49), FS63 (131) and US2000 (19). For these datasets, normalisation parameters Al (174), C_{org} (130) and Li (72) were available. There were 37 significant trends: 25 upwards and 12 downwards. Upward trends were found in 7 non-normalised time series, 3 normalised to Al, 3 to Li and 12 to C_{org}. Downward trends were found in 9 non-normalised time series, 2 normalised to Al, 1 to Li and 0 to C_{org}. 2 significant non-linear components were associated with the upward trends. For German site EL-S7 all 4 normalisers corresponded (i.e. showed a significant trend in the same direction). For sites EL-S1, EL-S7, EL-S9 and EL-S11 3 of the 4 normalisers corresponded. For another 3 stations, 2 normalisations corresponded, and for 4 Dutch stations significant upward trends were only found when normalising to C_{org}. In the case of NMMP435 Thames Woolwich (E) the 3 normalisers available (Al, Li, none) corresponded, and for 1 station FS20 and US2000 non-normalised corresponded.

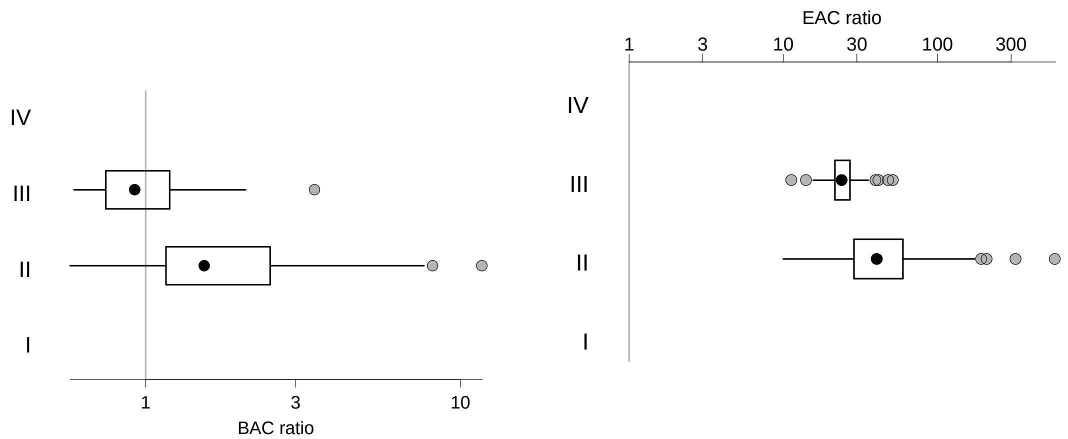
Region III

There were 71 time series datasets from UK available for FS63 fraction. Al and Li normalisers were available in 26 and 16 of these datasets respectively. No significant trends were found.

Comparison with BAC and EAC

The proposed BAC of 22 mg kg^{-1} was applied to time series normalised to Al. An EAC of 0,71 mg kg^{-1} was applied to non-normalised sediments. For Region II, 14% of the time series were significantly below the BAC (i.e. UCL/BAC ratios < 1), but all UCL/EAC ratios were > 10. The proposal of an EAC much smaller than the BAC is queried. For Region III, 62% of the time series were significantly below the BAC. Again, all the UCL/EAC ratios were > 10. UCLs exceeding the proposed BAC and EAC by up to 12 and 577 times respectively were recorded.

Figure 8.1 Arsenic in sediments - Summary plots of BRC and EAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 2 and 47% with a median of 13% for time series $\geq$ 5 years.

Conclusion

There were 646 time series assessed from Regions II and III. There were 37 significant trends: 25 upward and 12 downward, all from Region II. 20% of time series were significantly below the BRC. All UCL/EAC ratios were > 10. Downward trends were observed in the UK and in Belgian and western German coastal waters. Along the coastline of the Netherlands and in the German Bight, upward trends were evident. In general though, concentrations in the open North Sea and in Belgian offshore areas were above the BAC, and trends were upward. In the German Bight the levels were close to or below BAC, and some increasing trends were evident. Due to the high natural occurrence of As, it was difficult to observe anthropogenic impact on this element.

8.3.2 Cadmium

Available data

There were 662 datasets from 229 sediment stations available for Cd (table 8.2). The stations were split into 3 groups according to length of the time series: 3-4 years (110), 5-6 years (67) and 7-18 years (52). Of the 662 time series, 202 were normalised to Al, 132 to C_{org} and 99 to Li.

Table 8.2 Cadmium in sediment - Summary of assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	1	14	3	18	0	2		0
		AL	4	1	0	5	0	0	0	
		LI	1	4	0	5	2	0		
		C_{org}	11	4	3	18	1	0		
	FS63	none	85	25	13	123	2	8		0
		AL	91	19	13	123	0	2	17	
		LI	17	13	0	30	0	1		
		C_{org}	65	2	0	67	0	1		
	FS20	none	7	15	36	58	1	9		0
		AL	8	17	21	46	1	10	10	
		LI	15	11	21	47	1	3		
		C_{org}	9	8	30	47	2	6		
III	FS63	none	17	13	0	30	1	0		0
		AL	16	12	0	28	0	0	6	
		LI	14	3	0	17	0	0		
Total all			361	161	140	662	11	42	33	0
Total none[1]			110	67	52	229	4	19		

1 Sum of "none" from each fraction and corresponds to the number of sediment stations
2 Only applies to time series normalised to AL
3 Only applies to non-normalised time series

Time trend analysis

There were 11 significant upward trends and 42 significant downward trends.

Region II

Data were available for the fractions FS20 (58), FS63 (123) and US2000 (18). For these 199 datasets, normalisation parameters were available as follows: Al (174), C_{org} (132) and Li (82). There were 52 significant time trends: 10 upward and 42 downward. Only 1 time series normalised for Al had a significant upward trend; 3 time series for each of the other normalisation methods had significant upward trends. Only German station UE70 was consistent between C_{org} and NONE, but not AL and LI. For the remaining 8 upward time series, the Belgian B08 and S09 Al normalised time series were not significant, and for the Belgian UE20 and German EL-S4, 7, 8, 9 and 13 up to 7 other combinations of sieved and normalisation methods did not give any significant trends. As regards the time series with downward trends, mainly non-normalised but sieved samples were significant, and many stations showed consistently downward trends between different normalisation methods and non-normalised time series. 11 of the downward time series were only for 1 normalisation method/sieving combination, the remaining 31 time series represent 11 stations with 2-4 combinations of normalisation methods/sieving all showing downwards trends.

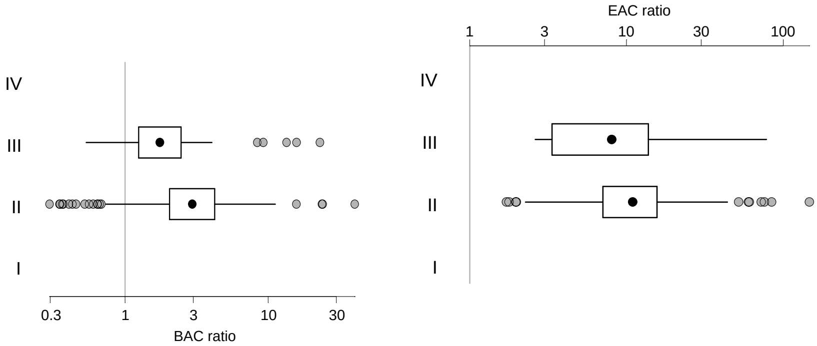
Region III

There were 30 time series from UK available, all FS63. Al and Li normalisers were available for 28 and 17 time series respectively. There was 1 significant upward trend: Milford Haven FS63 fraction with no normalisation.

Comparison with BAC and EAC

The proposed BAC of 0,31 mg kg^{-1} was applied to time series normalised to Al. An EAC of 0,06 mg kg^{-1} was applied to non-normalised sediments. For Region II, 16% of the time series were significantly below the BAC, but all the UCL/EAC ratios were > 1. For Region II, 21% of the time series were significantly below the BAC, but all of the UCL/EAC ratios were > 1. The proposal for an EAC which is one fifth of the BAC was queried. It seems to be intuitively wrong that the BAC is above the EAC, since this implies that nature itself would be harmful. UCLs exceeding the proposed BAC and EAC by up to 40 and 147 times respectively were recorded.

Figure 8.2 Cadmium in sediments - Summary plots of BRC and EAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 3 and 37% with a median of 9% for time series ≥ 5 years.

Conclusion

There were 662 time series from 229 stations assessed from Regions II and III. There were 53 significant trends at 23 stations: 10 upward trends and 42 downward trends in Region II and 1 upward trend in Region III. 16% of the time series were significantly below the BAC. All UCL/EAC ratios > 1. For some coastal areas, downward trends were observed, but in general concentrations near shore were above BAC, and in the open areas below BAC. Time trends in most of the offshore areas in the German Bight and in the Schelde estuary showed a downward trend. Close to shore under the influence of the River Elbe in the German Bight and at the southern Belgian coast upward trends were detected. The general downward trend in the sediment reflects the decreasing load from rivers, which are the dominant source compared to direct discharges.

8.3.3 Copper

Available data

There were 700 datasets from 244 sediment stations available (table 8.3). The stations were split into 3 groups according to the length of the time series: 3-4 years (104), 5-6 years (80) and 7-18 years (60). Of the 244 time series, 210 were normalised to Al, 140 to C_{org} and 106 to Li.

Table 8.3 Copper in sediment - Summary of assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	4	15	5	24	0	0		0
		AL	6	1	0	7	0	0	1	
		LI	3	4	0	7	0	0		
		C_{org}	14	3	3	20	0	0		
	FS63	none	76	36	19	131	0	3		0
		AL	93	22	14	129	0	2	50	
		LI	17	15	0	32	0	1		
		C_{org}	59	14	0	73	1	1		
	FS20	none	7	15	36	58	0	23		0
		AL	8	17	21	46	0	19	30	
		LI	15	11	21	47	0	10		
		C_{org}	9	8	30	47	1	12		
III	FS63	none	17	14	0	31	1	0		0
		AL	15	13	0	28	0	0	2	
		LI	17	3	0	20	1	0		
Total all			360	191	149	700	4	71	83	0
Total none[1]			104	80	60	244	1	26		

[1] Sum of "none" from each fraction and corresponds to the number of sediment stations
[2] Only applies to time series normalised to AL
[3] Only applies to non-normalised time series

Time trend analysis

There were 4 significant upwards trends and 71 significant downward trends.

Region II

Data were available for the fractions FS20 (58), FS63 (131) and US2000 (24). For these datasets, normalisation parameters Al (182), C_{org} (140) and Li (86) were available. There were 73 significant trends: 2 upward and 71 downward. Both the upward trends were in time series normalised to C_{org}. Downward trends were identified in 26 non-normalised time series, 21 normalised to Al, 11 to Li and 13 to C_{org}. In 10 cases, 3 types of normalisation corresponded and for German WB1, WB2, L1, L2 and TIiArea all 4 normalisation types resulted in downward trends. Only in 13 cases were significant trends found for only 1 type of normalisation. 2 significant non-linear components were associated with the detected trends.

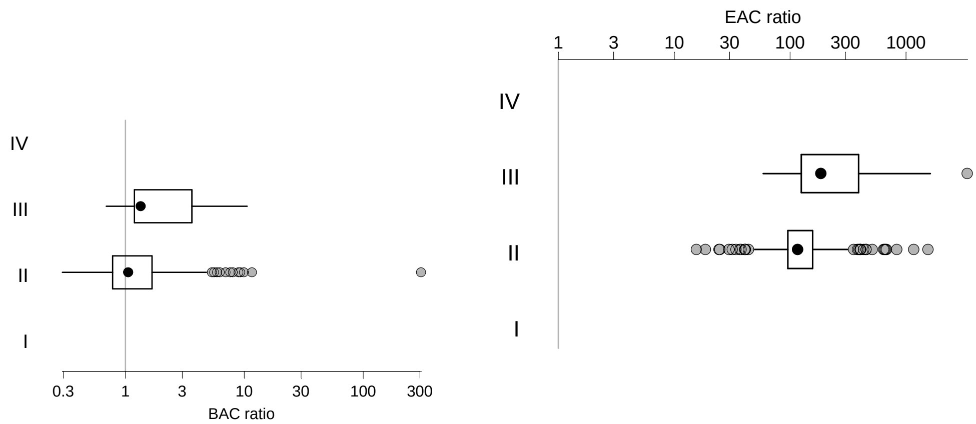
Region III

There were 79 time series from UK available for FS63 fraction. Al and Li normalisation data were available in 28 and 20 of these datasets respectively. Two significant upwards trends were found, both for NMMP646 Milford Haven Cesteston Point normalised to Li and non-normalised.

Comparison with BAC and EAC

The proposed BAC of 31 mg kg^{-1} was applied to time series normalised to Al. An EAC of 0,22 mg kg^{-1} was applied to non-normalised sediments. For Region II, 45% of the time series were significantly below the BAC, but all the UCL/EAC ratios > 10. The proposal of an EAC value much smaller than the BAC is queried. For Region III, 7% of the time series were significantly below the BAC and all the UCL/EAC ratios > 10. UCLs exceeding the proposed BAC and EAC by up to 300 and 3300 times respectively were recorded.

Figure 8.3 Copper in sediments - Summary plots of BAC and EAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 1 and 110% with a median of 5% for time series ≥ 5 years.

Conclusion

There were 700 time series assessed from Regions II and III. There were 75 significant trends: 2 upward and 71 downward in Region II and 2 upward in Region III. 40% of time series were significantly below the BAC. All the UCL/EAC ratios > 10. Downward trends were observed in most of the area. In general though, concentrations in the open North Sea and in Belgian offshore areas were above the BAC, and trends were upward. In the German Bight the levels were close to or below BAC. Upwards trends were only evident at Milford Haven, NOORDWK2 and EL-S13 near the Elbe. In spite of the high natural occurrence of Cu, it seems possible to observe a general decline in anthropogenic impact on this element. Cu has many uses, for example in plumbing products, electrical goods, and is a major part of most antifouling paints. It was not possible from the data available to suggest whether inputs arising from one or more particular uses have led to these downward trends.

8.3.4 Chromium

Available data

There were 682 datasets from 240 sediment stations available Cr (table 8.4). The stations were split into 3 groups according to the length of the time series: 3-4 years (102), 5-6 years (77) and 7-18 years (61). Of the 682 time series, 207 were normalised to Al, 135 to C_{org} and 100 to Li.

Table 8.4 Chromium in sediment - Summary of assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	2	15	6	23	1	1		4
		AL	5	1	0	6	0	0	0	
		LI	2	4	0	6	0	0		
		C_{org}	11	2	5	18	0	0		
	FS63	none	76	35	20	131	2	2		0
		AL	93	20	15	128	2	4	2	
		LI	16	15	0	31	1	0		
		C_{org}	59	14	0	73	2	0		
	FS20	none	6	14	35	55	11	3		0
		AL	7	17	21	45	5	1	1	
		Li	12	11	21	44	1	1		
		C_{org}	7	12	25	44	7	0		
III	FS63	None	18	13	0	31	3	1		0
		Al	16	12	0	28	0	1	0	
		Li	16	3	0	19	1	0		
Total all			346	188	148	682	36	14	3	4
Total none[1]			102	77	61	240	17	7		

[1] Sum of "none" from each fraction and corresponds to the number of sediment stations
[2] Only applies to time series normalised to AL
[3] Only applies to non-normalised time series

Time trend analysis

There were 36 significant upward trends and 14 significant downward trends.

Region II

Data were available for the fractions FS20 (55), FS63 (131) and US2000 (23). For these datasets, normalisation parameters Al (179), C_{org} (135) and Li (81) were available. There were 44 significant trends: 32 upward and 12 downward. Upward trends were found in 14 non-normalised time series, 7 normalised to Al, 2 to Li and 9 to C_{org}. Upward trends in the German KSArea, UE 11 and WB1 time series corresponded for 3 normalisers, and 4 other stations corresponded for 2 normalisers. Downward trends were identified in 6 non-normalised time series, 5 normalised to Al, 1 to Li and 0 to C_{org}. In the German UE67 case, Al, Li and non-normalised time series corresponded and for Belgian S18 and NMMP435 Thames Woolwich Al and non-normalised time series corresponded in downward trends. There were 6 and 3 significant non-linear components respectively associated with the upward and downward trends.

Region III

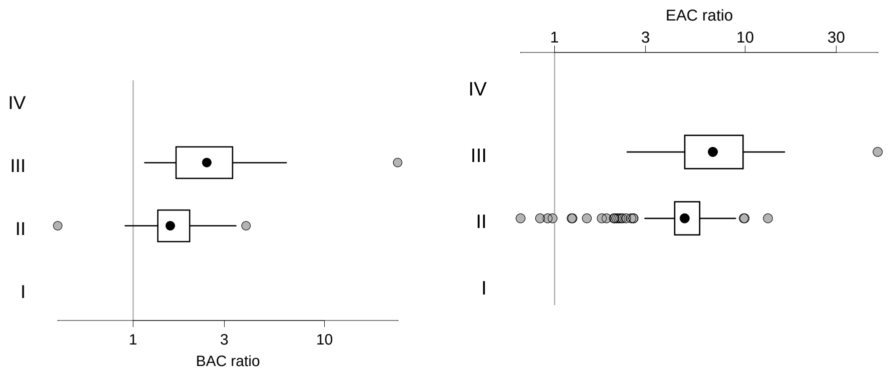
There were 78 time series from UK available for FS63 fraction. Al and Li normalisers were available in 28 and 19 of these datasets respectively. 4 significant upward trends were found, NMPP645 Severn Peterstone, NMMP808 Irish Sea Buoy and both Li and non-normalised NMMP646 Milford Haven Cesteston Point. 2 significant downward trends were found, both at NMMP820 Bann Estuary, non-normalised and normalised to Al.

Comparison with BAC and EAC

The proposed BAC of 76 mg kg^{-1} was applied to time series normalised for Al. An EAC of 21 mg kg^{-1} was applied to non-normalised sediments. For Region II, 2% of the time series were significantly below the BAC, and 2% were significantly below the EAC. The proposal of an EAC one third of the BAC is queried. For

Region III, no time series was significantly below either the BAC or EAC. UCLs exceeding the proposed BAC and EAC by up to 24 and 50 times respectively were recorded.

Figure 8.4 Chromium in sediments - Summary plots of BAC and EAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 1 and 30% with a median of 4% for time series ≥ 5 years.

Conclusion

There were 682 time series assessed from Regions II and III. There were 50 significant trends: 32 upward and 12 downward from Region II and 4 upward and 2 downward from Region III. 1% of time series were significantly below the BAC and 2% of time series were significantly below the EAC. In general, upward trends were observed along the coast of UK, Germany and the Netherlands, but also in the Open North Sea. Only some coastal areas around Belgium and in the German Bight, north of Ireland and in the Thames area together with one open North Sea location was observed to be downward. Due to the high natural occurrence of Cr, it was difficult to observe anthropogenic impact on this element.

8.3.5 Mercury

Available data

There were 634 datasets from 220 sediment stations available (table 8.5). The stations were split into 3 groups according to the length of time series: 3-4 years (103), 5-6 years (63) and 7-18 years (54). Of the 634 time series, 188 were normalised to Al, 132 to C_{org} and 94 to Li.

Table 8.5 Mercury in sediment - Summary of assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	3	13	4	20	0	2		8
		AL	4	1	0	5	0	0	0	
		LI	2	4	0	6	2	0		
		C_{org}	13	3	4	20	1	0		
	FS63	none	77	30	16	123	0	9		23
		AL	87	18	14	119	2	3	0	
		LI	17	12	0	29	0	0		
		C_{org}	57	13	0	70	0	3		
	FS20	none	7	16	34	57	0	32		15
		AL	9	18	19	46	3	20	4	
		LI	15	11	20	46	2	17		
		C_{org}	10	7	25	42	1	14		
III	FS63	none	16	4	0	20	0	1		6
		AL	15	3	0	18	0	1	0	
		LI	10	3	0	13	0	0		
Total all			342	156	136	634	11	102	4	52
Total none[1]			103	63	54	220	0	44		

1 Sum of "none" from each fraction and corresponds to the number of sediment stations
2 Only applies to time series normalised to AL
3 Only applies to non-normalised time series

Time trend analysis

There were 11 significant upward trends and 102 significant downward trends.

Region II

Data were available for the fractions FS20 (57), FS63 (123) and US2000 (20). For these 200 datasets, normalisation parameters Al (170), C_{org} (132) and Li (81) were available. There were 111 significant trends: 11 upward and 100 downward. Upward trends were found in no non-normalised time series, 5 normalised to Al, 4 to Li and 2 to C_{org}. Downward trends were found in 43 non-normalised time series, 23 normalised to Al, 17 to Li and 17 to C_{org}. In most cases where normalisation parameters were available, all indicated the same downward trend, but in some cases a non-normalised downward trend could be reversed by normalisation to e.g. Li. None of the upward trends had significant non-linear components, whereas 14 of the downward trends (7 non-normalised, 4 Al-normalised and 3 C_{org} normalised), had a non-linear component associated with the trend.

The time series from EL-S3 in the river Elbe in the sieved sample (20 µm) was a good example of what can happen when normalising the data. Without normalisation, the trend was significantly downward (P=0,001, -12% annual change). When normalising to C_{org}, the trend had a non-linear component (P=0,012) and the linear trend disappeared for the last 10 years. Finally, normalising to Al changed the trend to being significant upward (p=0,021, +17% annual change). Assuming the Al content was indicative of the clay content of recent suspension load, this meant that the clay content of recent sedimentation was very low (e.g. sandy sediment), which “diluted” the metal content of the sample. The ratio of organic content to Hg was also changing, to account for the non-linear component when normalising to C_{org} that stopped the decrease. This indicated that the sediment type was changing over the last decade, and made use of non-normalised data inappropriate. The same tendency was observed for 1 other stations in the Elbe EL-S9 indicating that the hydrography was changing, and thereby the environmental impact of riverine transport of metals fixed to suspended matter. For the rest of the time series all significant trends was in the same direction. In 22 cases 2-3 combinations of normaliser/sieving, and in 9 cases for 4 combinations of sieving/normaliser.

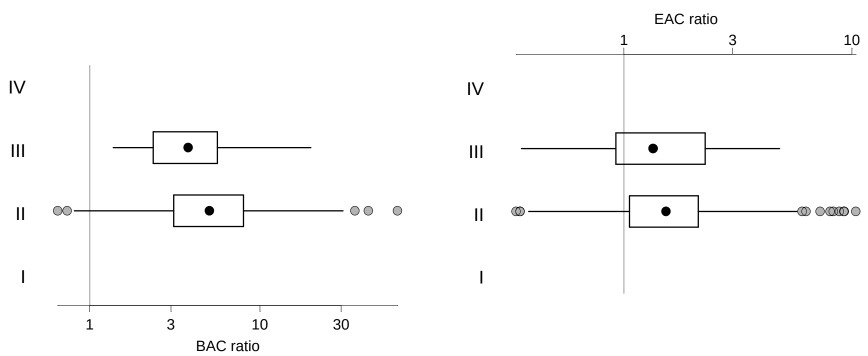
Region III

There were 30 time series datasets from UK available for the FS63 fraction. Al and Li normalisers were available in 28 and 17 of these datasets respectively. There were 2 significant downward trends: Severn Bedwin (UK) FS63 fraction without normalisation and normalised to Al.

Comparison to BAC and EAC

The proposed BAC of 0,08 mg kg^{-1} was applied to time series normalised for Al. An EAC of 0,22 mg kg^{-1} was applied to non-normalised sediments. For Region II, 2% of the time series were significantly below the BAC and 21% were significantly below the EAC. For Region III none of the time series were significantly below the BAC, but 30% were significantly below the EAC. UCLs exceeding the proposed BAC and EAC by up to 60 and 10 times respectively were recorded.

Figure 8.5 Mercury in sediments - Summary plots of BRC and EAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between < 1 and 50% with a median of 7% for time series ≥ 5 years.

Conclusion

There were 634 time series from 220 stations assessed from Regions II and III. There were 113 significant trends at 52 stations: 11 upward and 100 downward in Regions II and 2 downward in Region III. 2% of time series were significantly below the BAC and 24% were significantly below the EAC. The Hg level in the open North Sea was found to be decreasing, but at most stations was still above the proposed BAC value. Close to shore some upward trends were found in the inner German Bight.

8.3.6 Nickel

Available data

There were 693 datasets from 242 sediment stations available (table 8.6). The stations were split into 3 groups according to the length of the time series: 3-4 years (105), 5-6 years (77) and 7-18 years (60). Of the 693 time series, 209 were normalised to Al, 139 to C_{org} and 103 to Li.

Table 8.6 Nickel in sediment - Summary of assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	2	15	5	22	1	1		0
		AL	7	1	0	8	0	0	7	
		LI	3	4	0	7	0	0		
		C_{org}	11	4	5	20	0	0		
	FS63	none	78	34	20	132	6	0		0
		AL	92	20	15	127	1	1	118	
		LI	16	15	0	31	1	0		
		C_{org}	59	14	0	73	2	0		
	FS20	none	8	14	35	57	11	0		0
		AL	9	16	21	46	11	0	41	
		LI	14	11	21	46	0	0		
		C_{org}	9	8	29	46	12	0		
III	FS63	none	17	14	0	31	1	0		0
		AL	15	13	0	28	1	0	17	
		LI	16	3	0	19	0	0		
Total all			356	186	151	693	47	2	183	0
Total none[1]			105	77	60	242	19	1		

1 Sum of "none" from each fraction and corresponds to the number of sediment stations
2 Only applies to time series normalised to AL
3 Only applies to non-normalised time series

Time trend analysis

There were 47 significant upward trends and 2 significant downward trends.

Region II

Data were available for the fractions FS20 (57), FS63 (132) and US2000 (22). For these datasets, normalisation parameters Al (181), C_{org} (139) and Li (84) were available. There were 47 significant trends: 45 upward and 2 downward. Upward trends were found in 18 non-normalised time series, 12 normalised to Al, 1 to Li and 14 to C_{org}. The downward trends were found in 1 non-normalised and 1 Al normalised time series. In the case of German station L1, all 4 normalisation methods indicated upward trends, and for KSArea, L2 and TiArea, 3 of the 4 indicated upward trends. Finally 5 incidences where 2 normalisation methods indicated upward trends were identified. Significant non-linear components were associated with the detected trends for L1, L2 and TiArea as well as 6 other significant upward trends, and the long downward trend at Belgian S18.

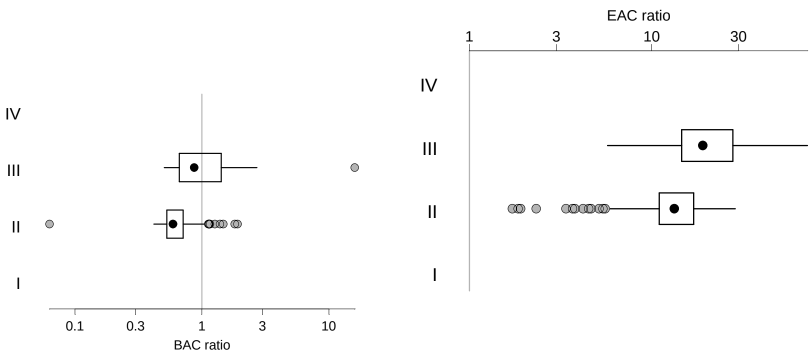
Region III

There were 31 time series from UK available for FS63 fraction. Al and Li normalisers were available in 28 and 19 of these datasets respectively. There were 2 significant upward trends, at NMMP645 Severn Peterstone (E) normalised to Al and NMMP815 (Dundrum Bay) non-normalised.

Comparison with BAC and EAC

The proposed BAC of 40 mg kg-1 was applied to time series normalised for Al. An EAC of 2,8 mg kg-1 was applied to non-normalised sediments. For Region II, 92% of the time series were significantly below the BAC, and all UCL/EAC ratios > 1. The proposal of an EAC much less than the BAC is queried. For Region III, 61% of the time series were significantly below the BAC, and all the UCL/EAC ratios > 1. UCLs exceeding the proposed BAC and EAC by up to 16 and 70 times respectively were recorded.

Figure 8.6 Nickel in sediments - Summary plots of BRC and EAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 1 and 37% with a median of 6% for time series ≥ 5 years.

Conclusion

There were 693 time series assessed from Regions II and III. There were 49 significant trends: 45 upward and 2 downward in Region II and 2 upward in Region III. 88% of time series were significantly below the BAC. All UCL/EAC ratios were > 1. Upward trends were observed offshore in the German Bight. In general though, concentrations in the open North Sea and in Belgian offshore areas were below the BAC, and trends were upward. In the German Bight the levels were close to or below BAC, and some upward trends were evident. Due to the high natural occurrence of Ni, it was difficult to observe anthropogenic impact on this element.

8.3.7 Lead

Available data

There were 700 datasets from 244 sediment stations available (table 8.7). The stations were split into 3 groups according to the length of the time series: 3-4 years (102), 5-6 years (81) and 7-18 years (61). Of the 700 time series, 211 were normalised to Al, 140 to C_{org} and 105 to Li.

Table 8.7 Lead in sediment - Summary of assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	2	17	5	24	0	1		0
		AL	8	1	0	9	0	0	1	
		LI	4	3	0	7	0	0		
		C_{org}	13	4	3	20	0	0		
	FS63	none	76	35	20	131	2	3		0
		AL	93	20	15	128	2	2	2	
		LI	16	15	0	31	0	1		
		C_{org}	59	14	0	73	2	2		
	FS20	none	7	15	36	58	3	5		0
		AL	8	17	21	46	2	2	0	
		LI	15	11	21	47	0	1		
		C_{org}	9	8	30	47	3	3		

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
III	FS63	none	17	14	0	31	0	0		0
		AL	15	13	0	28	0	0	1	
		LI	17	3	0	20	0	0		
Total all			359	190	151	700	14	20	4	0
Total none[1]			102	81	61	244	5	9		

1 Sum of "none" from each fraction and corresponds to the number of sediment stations
2 Only applies to time series normalised to AL
3 Only applies to non-normalised time series

Time trend analysis

There were 14 significant upward trends and 20 significant downward trends.

Region II

Data were available for the fractions FS20 (58), FS63 (131) and US2000 (24). For these datasets, normalisation parameters Al (183), C_{org} (140) and Li (85) were available. There were 34 significant trends: 14 upward and 20 downward. Upward trends were found in 5 non-normalised time series, 4 normalised to Al, 0 to Li and 5 to C_{org}. 2 of the non-normalised upward trends corresponded to normalised trends. Downward trends were found in 9 non-normalised time series, 4 normalised to Al, 2 to Li, and 5 to C_{org}. In 2 cases, Al and non-normalised time series corresponded and for BL14 all 4 normalisation types resulted in downward trends. No significant non-linear components were associated with the detected trends.

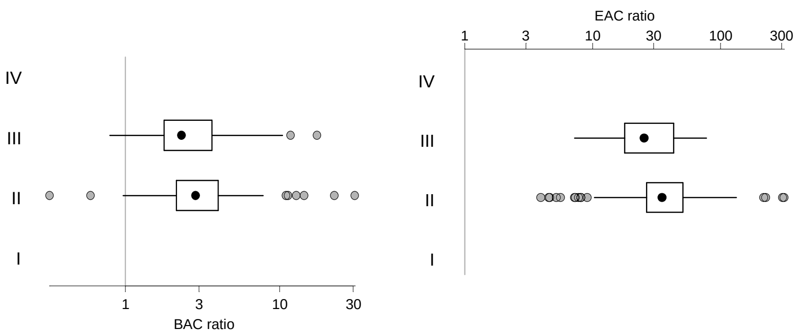
Region III

There were 79 time series from UK available for FS63 fraction. Al and Li normalisers were available in 28 and 20 of these datasets respectively. No significant trends were found.

Comparison with BAC and EAC

The proposed BAC of 34 mg kg^{-1} was applied to time series normalised to Al. An EAC of 2,22 mg kg^{-1} was applied to non-normalised sediments. For Region II, 2% of the time series were significantly below the BAC, and all UCL/EAC ratios > 1. The proposal for an EAC lower than the BAC is queried. For Region III, 4% of the time series were significantly below the BAC, and all UCL/EAC ratios > 1. UCLs exceeding the proposed BAC and EAC by up to 30 and 300 times respectively were recorded.

Figure 8.7 Lead in sediments - Summary plots of BRC and EAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 1 and 42% with a median of 7% for time series ≥ 5 years.

Conclusion

There were 700 time series assessed from Regions II and III. There were 34 significant trends: 14 upward and 20 downward, all from Region II. 2% of time series were significantly below the BAC. All UCL/EAC ratios were > 1. Downward trends were observed in the north of the UK and offshore in the German Bight. In general though, concentrations in the open North Sea and in Belgian offshore areas were above the BAC, and trends were upward. In the German Bight the levels were close to or below BAC, and some upward trends were evident. Due to the high natural occurrence of Pb, it was difficult to observe anthropogenic impact on this element.

8.3.8 Zinc

Available data

There were 698 datasets for 244 sediment stations available (table 8.8). The stations were split into 3 groups according to the length of the time series: 3-4 years (102), 5-6 years (80) and 7-15 years (62). Of the 244 time series, 209 could be normalised to Al, 140 to C_{org} and 105 to Li.

Table 8.8 Zinc in sediment - Summary of assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	2	16	6	24	2	1		0
		AL	6	1	0	7	0	0	0	
		LI	3	4	0	7	1	0		
		C_{org}	11	4	5	20	2	0		
	FS63	none	76	35	20	131	1	3		0
		AL	93	20	15	128	1	1	12	
		LI	16	15	0	31	0	1		
		C_{org}	59	14	0	73	1	0		
	FS20	none	7	15	36	58	2	4		0
		AL	8	17	21	46	4	5	2	
		LI	15	11	21	47	1	2		
		C_{org}	9	8	30	47	6	3		
III	FS63	none	17	14	0	31	0	1		0
		AL	15	13	0	28	0	0	0	
		LI	17	3	0	20	0	1		
Total all			354	190	154	698	21	22	14	0
Total none[1]			102	80	62	244	5	9		

1 Sum of "none" from each fraction and corresponds to the number of sediment stations
2 Only applies to time series normalised to AL
3 Only applies to non-normalised time series

Time trend analysis

There were 21 significant upward trends and 22 significant downward trends.

Region II

Data were available for the fractions FS20 (131), FS63 (58) and US2000 (24). For these datasets, normalisation parameters Al (181), C_{org} (140) and Li (85) were available. There were 41 significant trends: 21 upward and 20 downward. Upward trends were found in 5 non-normalised time series, 5 normalised to Al, 2 to Li and 9 to C_{org}. 2 of the non-normalised upward trends corresponded to normalised trends. In the German stations EL-S3, EL-S4 and EL-S7 3 of 4 normalisers corresponded, for 2 others 2 of 4 corresponded and the remaining 6 stations only 1 normalisation method gave a significant trend. Downward trends were found in 8 non-normalised time series, 6 normalised to Al, 3 to Li, and 3 to C_{org}. In 2 cases, German stations BL 14 and WB5, time series corresponded for 3 normalisers and for 2 Al and non-normalised corresponded. In the remaining 11 cases only one normalisation type resulted in downward trends. 3 significant non-linear components were associated with the detected trends, 2 downward and 1 upward.

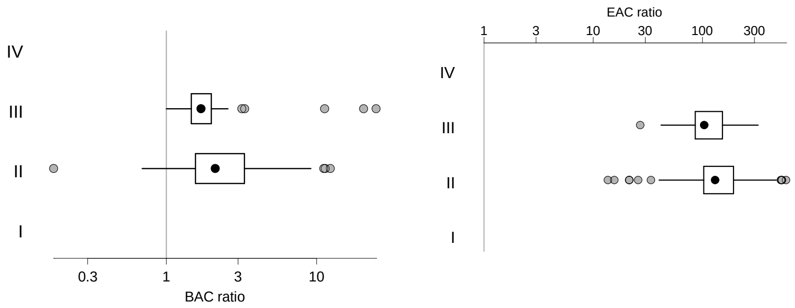
Region III

There were 79 time series datasets available from UK for FS63 fraction. Al and Li normalisers were available in 28 and 20 of these datasets respectively. There were 2 significant downward trends.

Comparison with BAC and EAC

The proposed BAC of 116 mg kg^{-1} was applied to time series normalised for Al. An EAC of 1,48 mg kg^{-1} was applied to non-normalised sediments. For Region II, 8% of the time series were significantly below the BAC, and all UCL/BAC ratios > 10. The proposal for an EAC much lower than the BAC is queried. For Region III, none of the time series were significantly below the BAC ratios, and the UCL/EAC ratios > 10. UCLs exceeding the proposed BAC and EAC by up to 25 and 580 times respectively were recorded.

Figure 8.8 Zinc in sediments - Summary plots of BAC and EAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 1 and 71% with a median of 6% for time series ≥ 5 years.

Conclusion

There were 698 time series assessed from Regions II and III. There were 43 significant trends: 21 upward and 20 downward in Region II and 2 downward in Region III. 6% of time series were significantly below the BAC. All UCL/EAC ratios were > 10. Downward trends were observed in the Irish Sea and Thames estuary as well as in most areas in the open North Sea and away from the coast line, and even close to the German shores at Jadebussen. Upward trends were observed in the Tamar Hoza south-west of UK, the German Bight and Oland close to shore and on the coast of the Netherlands (NOORDWK and DANTZGZD). Due to the high natural occurrence of Zn, it was difficult to observe anthropogenic impact on this element.

8.4 Organic contaminant trends in biota

8.4.1 PAHs

For mussel, only a subset of the many possible PAHs were assessed: anthracene, benz[a]anthracene, benzo[a]pyrene, benzo[g,h,i]perylene, chrysene, fluoranthene, indeno[1,2,3-cd]pyrene, phenanthrene, and pyrene. Trends in PAHs were found at only 11 stations, often for only 1 or 2 individual PAHs. At 2 Dutch and 1 UK stations several individual PAHs decreased (ROTTMPT3 in the open North Sea, TERSLG235 at the north coast of the Netherlands and NMMP95 in north UK Moray Firth), and concentrations were generally significantly below the BAC. At 1 Dutch station to the south (NOORDWK2), several PAHs increased, and UCL/BAC ratios generally > 1.

Anthracene

Available data

There were 285 datasets from 122 sediment stations available (table 8.9). The stations were split into 3 groups according to the length of the time series: 3-4 years (91), 5-6 years (26) and 7-8 years (5). Of the 285 time series, 70 were normalised to Al and 93 to C_{org}.

Table 8.9 Anthracene in sediment - Summary of assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	22	14	1	37	0	0		
		C_{org}	28	0	1	29	0	0	0	
	FS63	none	58	8	4	70	2	0		
		AL	70	0	0	70	0	0		
		C_{org}	45	10	0	55	1	0	0	
III	US2000	none	11	4	0	15	1	0		
		C_{org}	9	0	0	9	0	0	0	
Total all			243	36	6	285	4	0	0	
Total none[1]			91	26	5	122	3	0		

1 Sum of “none” from each fraction and corresponds to the number of sediment stations
2 Only applies to time series normalised to C_{org}
3 No EAC

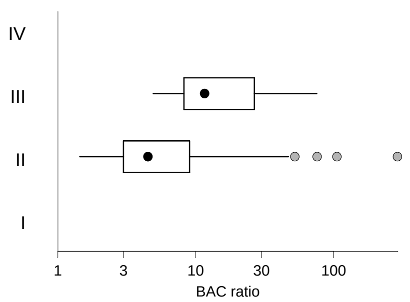
Time trend analysis
There were 4 significant upward trends.

Region II
Data were available for the fractions FS63 (70) and US2000 (37). For these datasets, normalisation parameters Al (70) and C_{org} (84) were available. There were 3 significant trends, all upward. The trends were in 2 non-normalised time series and 1 normalised to C_{org}. The non-normalised time series did not correspond to the normalised time series.

Region III
There were 15 time series from UK available for unsieved fraction. C_{org} normalisation were available in 9 of these datasets. There was 1 significant upward trend in a non-normalised time series.

Comparisons with BAC and EAC
The proposed BAC of 8 µg kg-1 was applied to time series normalised to C_{org}. All UCL/BAC ratios > 1, with ratios up to 290 being recorded. No EAC has been defined for anthracene.

Figure 8.9 Anthracene in sediments - Summary plots of BAC ratios



Ten-year detectable trend
The 10-year detectable trend varied between < 1 and 38% with a median of 10% for time series $\geq$ 5 years.

Conclusion
There were 285 time series assessed from Regions II and III. There were 4 significant trends: 3 upward in Region II and 1 upward in Region III. No time series were significantly below the BAC. Upwards trends were observed for Bristol Channel in Region III and areas north and west of the Netherlands. In general concentrations in the North Sea were above the BAC and monitoring has not been carried out long enough to evaluate trends for most sampling sites.

Benzo(a)anthracene
Available data
There were 349 datasets from 153 sediment stations available (table 8.10,). The stations were split into 3 groups according to the length of the time series: 3-4 years (113), 5-6 years (32) and 7-8 years (8). Of the 349 time series, 87 were normalised to Al and 109 to C_{org}.

Table 8.10 Benzo[a]anthracene in sediments - Summary of assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	32	19	3	54	1	0		
		C_{org}	28	1	4	33	0	0	0	
	FS63	none	68	10	5	83	0	0		
		AL	87	0	0	87	0	0		
		C_{org}	55	13	0	68	1	2	3	

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
III	US2000	none	13	3	0	16	0	0		
		C_{org}	8	0	0	8	0	0	0	
Total all			291	46	12	349	2	2	3	
Total none[1]			113	32	8	153	1	0		

1 Sum of "none" from each fraction and corresponds to the number of sediment stations
2 Only applies to time series normalised to C_{org}
3 No EAC

Time trend analysis

There were 2 significant upward trends and 2 significant downward trends.

Region II

Data were available for the fractions FS63 (87) and US2000 (54). For these datasets, normalisation parameters Al (87) and C_{org} (101) were available. There were 4 significant trends: 2 upward and 2 downward. 3 of these time series, from the Netherlands, showed similar trends in benzo(a)pyrene, fluoranthene and pyrene. The upward trends were in FS63, C_{org}-normalised sediments from the southern coast of the Netherlands and non-normalised sediment at the eastern coast of central UK. The downward trends were in FS63, C_{org}-normalised sediments in the open North Sea and one closer to the northern shores of the Netherlands.

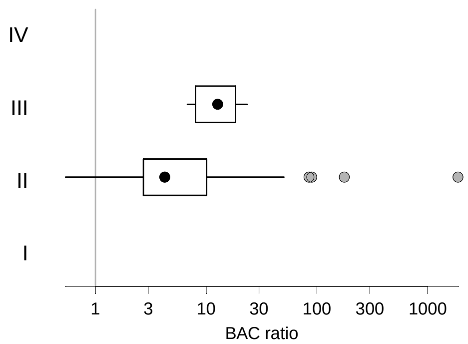
Region III

There were 24 time series from UK available for unsieved fraction. C_{org} normalisation were available in 8 of these datasets. There were no significant trends.

Comparison with BAC and EAC

The proposed BAC of 22 µg kg^{-1} was applied to time series normalised to C_{org}. No EAC has been defined for benzo(a)anthracene. For Region II, 3% of the time series were significantly below the BAC. Both time series with a downward trend were significantly below the BAC. For Region III, all the UCL/BAC ratios > 1. A UCL exceeding the proposed BAC by up to 1000 times was recorded.

Figure 8.10 Benzo[a]anthracene sediments - Summary plots of BAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 2 and 68% with a median of 10% for time series ≥ 5 years.

Conclusion

There were 349 time series assessed from Regions II and III. There were 4 significant trends: 2 upward and 2 downward, all from Region II. 3% of time series were significantly below the BAC. 2 downward trends were observed: in the open North Sea and north of the Netherlands. One upward trend was observed near the southern coast of the Netherlands. In general though, concentrations in the North Sea were above the BAC.

Benzo[a]pyrene

Available data

There were 353 datasets from 152 sediment stations available (table 8.11). The stations were split into 3 groups according to the length of the time series: 3-4 years (114), 5-6 years (30) and 7-8 years (8). Of the 353 time series, 87 could be normalised to Al and 114 to C_{org}.

Table 8.11 Benzo[a]pyrene in sediments - Summary of the assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	30	16	3	49	1	2		
		C_{org}	28	2	4	34	0	0	0	
	FS63	none	71	11	5	87	0	0		
		AL	87	0	0	87	0	0		
		C_{org}	57	14	0	71	1	2	10	
III	US2000	none	13	3	0	16	1	0		
		C_{org}	9	0	0	9	0	0	0	
Total all			295	46	12	353	3	4	10	
Total none[1]			114	30	8	152	2	2		

1. Sum of "none" from each fraction and corresponds to the number of sediment stations
2. Only applies to time series normalised to C_{org}
3. No EAC

Time trend analysis

There were 3 significant upward trends and 4 significant downward trends.

Region II

Data were available for the fractions FS63 (87) and US2000 (49). For many of these 136 datasets, normalisation parameters Al (87) and C_{org} (105) were available. There were 6 significant trends: 2 upward and 4 downward. 3 of these trends were from time series where there was a similar trend for benzo(a)anthracene, fluoranthene and pyrene. 1 of the upward trends was in FS63, C_{org}-normalised sediments from the southern coast of the Netherlands (Terheijde). The downward trends were in FS63, C_{org}-normalised sediments in the open North Sea and closer to the northern shores of the Netherlands, and in 2 non-normalised time series in NMMP435 Thames Woolwich (E) and NMMP95 Moray Firth.

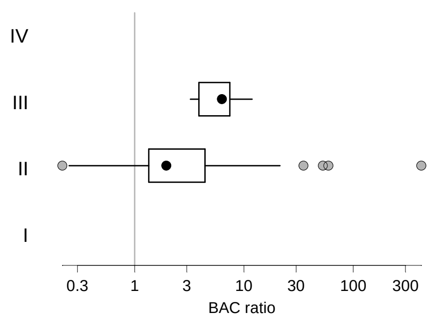
Region III

There were 25 time series from UK available for unsieved fraction. C_{org} normalisation was available in 9 of these datasets. 1 significant upward trend was found at NMMP645 Severn Peterstone (E).

Comparison with BAC and EAC

The proposed BAC of 56 µg kg^{-1} was applied to time series normalised to C_{org}. No EAC has been defined for benzo[a]pyrene. For Region II, 10% of the time series were significantly below the BAC. For Region III, all the UCL/BAC ratios > 1. A UCL exceeding the proposed BAC by up to 400 times were recorded.

Figure 8.11 Benzo[a]pyrene sediments - Summary plots of BAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 1 and 49% with a median of 11% for time series $\geq$ 5 years.

Conclusion

There were 353 time series assessed from Regions II and III. There were 7 significant trends: 3 upward and 4 downward in Region II and 1 upward in Region III. 9% of time series were significantly below the BAC. The downward trends were in the open North Sea (ROTTMPT3), north of the Netherlands (TERSLG235), in north-east Scotland (NMMP95 Moray Firth) and at NMMP435 Thames Woolwich (E). One of the upward trends was near the southern coast of the Netherlands. In general though, concentrations in the North Sea were above the BAC.

Benzo[g,h,i]perylene

Available data

There were 344 datasets from 156 sediment stations available (table 8.12). The stations were split into 3 groups according to the length of the time series: 3-4 years (135), 5-6 years (12) and 7-8 years (9). Of the 344 time series, 87 could be normalised to Al and 101 to C_{org}.

Table 8.12 Benzo[g,h,i]perylene in sediments - Summary of assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	48	1	4	53	0	0		
		C_{org}	18	1	4	23	0	0	4	
	FS63	none	71	11	5	87	0	0		
		AL	87	0	0	87	0	0		
		C_{org}	58	14	0	72	1	1	55	
III	US2000	none	16	0	0	16	0	0		
		C_{org}	6	0	0	6	0	0	1	
Total all			304	27	13	344	1	1	60	
Total none[1]			135	12	9	156	0	0		

1. Sum of "none" from each fraction and corresponds to the number of sediment stations
2. Only applies to time series normalised to C_{org}
3. No EAC

Time trend analysis

There was 1 significant upward trend and 1 significant downward trend.

Region II

Data were available for the fractions FS63 (87) and US2000 (53). For these datasets, normalisation parameters Al (87) and C_{org} (95) were available. There were 2 significant trends: 1 upward and 1 downward. The upward trend was in FS63, C_{org} normalised sediments from the southern coast of the Netherlands, and the downward trend was in FS63, C_{org} normalised sediments in ROTTMPT3.

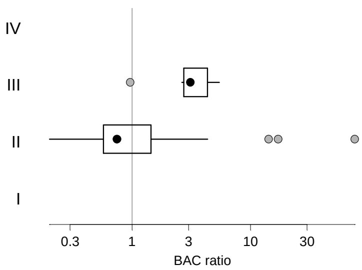
Region III

There were 22 time series datasets available from UK for unsieved fraction. C_{org} normalisation was available in 6 of these datasets. There were no significant trends.

Comparison with BAC and EAC

The proposed BAC of 140 µg kg^{-1} was applied to time series normalised to C_{org}. No EAC has been defined for benzo[g,h,i]perylene. For Region II, 62% of the time series were significantly below the BAC. For Region III, 17% of the time series were significantly below the BAC. A UCL exceeding the proposed BAC by up to 70 times was recorded.

Figure 8.12 Benzo[g,h,i]perylene sediments-Summary plots of BAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 3 and 25% with a median of 9% for time series $\geq$ 5 years.

Conclusion

There were 344 time series assessed from Regions II and III. There were 2 significant trends: one upward and 1 downward, both from Region II. 59% of time series were significantly below the BAC. The downward trend was observed in the open North Sea, north of the Netherlands, and the upward trend was observed near the southern coast of the Netherlands. In general though, concentrations in the North Sea were below the BAC.

Chrysene

Available data

There were 271 datasets from 105 sediment stations available (table 8.12). The stations were split into 3 groups according to the length of the time series: 3-4 years (89), 5-6 years (11) and 7 years (5). Of the 271 time series, 87 were normalised to Al and 79 to C_{org}. Only data from Region II were available.

Table 8.13 Chrysene in sediments - Extent of the dataset for three year classes

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	20	0	0	20	0	0		
		C_{org}	7	0	0	7	0	0	0	
	FS63	none	69	11	5	85	0	0		
		AL	87	0	0	87	0	0		
		C_{org}	58	14	0	72	0	2	5	
III	US2000	none	0	0	0	0				
		C_{org}	0	0	0	0				
Total all			241	25	5	271	0	2	5	
Total none[1]			89	11	5	105				

1. Sum of “none” from each fraction and corresponds to the number of sediment stations
2. Only applies to time series normalised to C_{org}
3. No EAC

Time trend analysis

There were 2 significant downward trends.

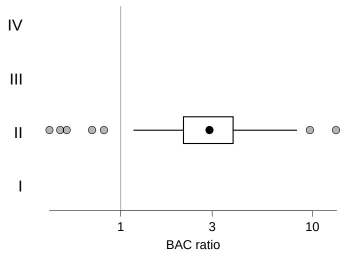
Region II

Data were available for the fractions FS63 (85) and US2000 (20). For these datasets, normalisation parameters Al (87) and C_{org} (79) were available. There were 2 significant trends, both downward. These were from time series where there were also significant downward trends in benzo(a)anthracene, benzo(a)pyrene, fluoranthene, etc. The trends were in FS63, C_{org}-normalised sediments in the open North Sea and closer to the northern shores of the Netherlands.

Comparison with BAC and EAC

The proposed BAC of 29 µg kg^{-1} was applied to time series normalised to C_{org}. No EAC has been defined for chrysene. For Region II, 6% of the time series were significantly below the BAC. Both time series with downward trends were significantly below the BAC. A UCL exceeding the proposed BAC by up to 13 times was recorded.

Figure 8.13 Chrysene in sediments - Summary plots of BAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 1 and 28% with a median of 11% for time series $\geq$ 5.

Conclusion

There were 271 time series assessed from Region II. There were 2 significant trends, both downward. 6% of the time series were significantly below the BAC. Downward trends were observed in the open North Sea and near the north coast of the Netherlands. In general, concentrations in the North Sea were above the BAC.

Fluoranthene

Available data

There were 368 datasets from 163 sediment stations available (table 8.14). The stations were split into 3 groups according to the length of the time series: 3-4 years (119), 5-6 years (35) and 7-8 years (9). Of the 368 time series, 87 were normalised to Al and 118 to C_{org}.

Table 8.14 Fluoranthene in sediments - Summary of the assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	32	21	4	57	0	1		
		C_{org}	29	2	4	35	0	0	0	
	FS63	none	72	11	5	88	0	0		
		AL	87	0	0	87	0	0		
		C_{org}	59	14	0	73	1	2	5	
III	US2000	none	15	3	0	18	0	0		
		C_{org}	10	0	0	10	0	0	0	
Total all			304	51	13	368	1	3	5	
Total none[1]			119	35	9	163	0	1		

1. Sum of "none" from each fraction and corresponds to the number of sediment stations
2. Only applies to time series normalised to C_{org}
3. No EAC

Time trend analysis

There was 1 significant upward trend and 3 significant downward trends.

Region II

Data were available for the fractions FS63 (88) and US2000 (57). For these datasets, normalisation parameters Al (87) and C_{org} (108) were available. There were 4 significant trends: 1 upward and 3 downward. 3 of these trends were from Dutch time series where there were similar trends in benzo(a)anthracene, benzo(a)pyrene and pyrene. The upward trend was in FS63, C_{org}-normalised sediments from the southern coast of the Netherlands. The downward trends were in FS63, C_{org}-normalised sediments in the open North Sea and closer to the northern shores of the Netherlands and one non-normalised time series in Moray Firth, Scotland.

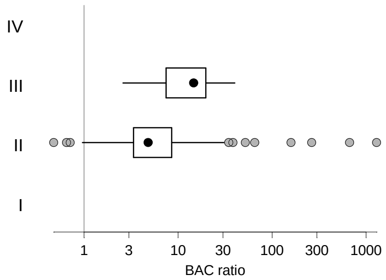
Region III

There were 28 time series from UK available for unsieved fraction. C_{org} normalisation was available in 10 of these datasets. There were no significant trends.

Comparison with BAC and EAC

The proposed BAC of 44 µg kg^{-1} was applied to time series normalised to C_{org}. No EAC has been defined for fluoranthene. For Region II, 5% of the time series were significantly below the BAC. All the time series with downward trends were significantly below the BAC. For Region III, all UCL/BAC ratios > 1. A UCL exceeding the proposed BAC by up to 1000 times was recorded.

Figure 8.14 Fluoranthene sediments - Summary plots of BAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 2 and 48% with a median of 12% for time series ≥ 5 years.

Conclusion

There were 368 time series assessed from Regions II and III. There were 4 significant trends: 1 upward and 3 downward, all from Region II. 4% of time series were significantly below the BAC. 3 downward trends were observed in the open North Sea (Netherlands, ROTTMPT3), north of the Netherlands (TERSLG235) and north-east of Scotland [NMMP95, Moray Firth). In general, concentrations in the North Sea were above the BAC.

Indeno[1,2,3-cd]pyrene

Available data

There were 356 datasets from 154 sediment stations available (table 8.15). The stations were split into 3 groups according to the length of the time series: 3-4 years (113), 5-6 years (32) and 7-8 years (9). Of the 356 time series, 87 were normalised to Al and 115 to C_{org}.

Table 8.15 Indeno[1,2,3-cd]pyrene in sediments - Summary of assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	32	17	4	53	0	0		
		C_{org}	27	2	4	33	0	0	1	
	FS63	none	71	11	5	87	0	0		
		AL	87	0	0	87	0	0		
		C_{org}	58	14	0	72	1	0	41	
III	US2000	none	10	4	0	14	0	0		
		C_{org}	10	0	0	10	0	0	2	
Total all			295	48	13	356	1	0	44	
Total none[1]			113	32	9	154	0	0		

1. Sum of "none" from each fraction and corresponds to the number of sediment stations
2. Only applies to time series normalised to C_{org}
3. No EAC

Time trend analysis

There was 1 significant upward trend.

Region II

Data were available for the fractions FS63 (87) and US2000 (53). For these datasets, normalisation parameters Al (87) and C_{org} (105) were available. There was 1 significant upward trend, in FS63, C_{org} normalised sediments from the southern coast of the Netherlands. This trend was from a time series with similar upward trends for benzo(a)anthracene, benzo(a)pyrene, fluoranthene etc.

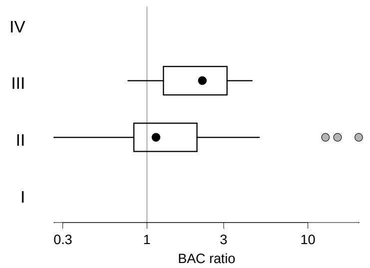
Region III

There were 24 time series datasets from UK available for unsieved fraction. C_{org} normalisation was available in 10 of these datasets. There were no significant trends.

Comparison with BAC and EAC

The proposed BAC of 128 µg kg^{-1} was applied to time series normalised to C_{org}. No EAC has been defined for indeno [1,2,3-cd]pyrene. For Region II, 39% of the time series were significantly below the BAC. For Region III, 20% of the time series were significantly below the BAC. A UCL exceeding the proposed BAC by up to 20 times was recorded.

Figure 8.15 Indeno[1,2,3-cd]pyrene sediments - Summary plots of BAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 3 and 43% with a median of 10% for time series $\geq$ 5 years.

Conclusion

There were 356 time series assessed from Regions II and III. There was 1 significant upward trend from the southern coast of the Netherlands. 38% of the time series were significantly below the BAC.

Phenanthrene

Available data

There were 339 datasets from 148 sediment stations available (table 8.16). The stations were split into 3 groups according to the length of the time series: 3-4 years (107), 5-6 years (32) and 7-8 years (9). Of the 339 time series, 75 were normalised to Al and 116 to C_{org}.

Table 8.16 Phenanthrene in sediments - Summary of the assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	35	18	4	57	0	0		
		C_{org}	29	2	4	35	0	0	0	
	FS63	none	58	11	5	74	0	0		
		AL	75	0	0	75	0	0		
		C_{org}	59	14	0	73	0	2	7	
III	US2000	none	14	3	0	17	0	0		
		C_{org}	8	0	0	8	0	0	0	
Total all			278	48	13	339	0	2	7	
Total none[1]			107	32	9	148	0	0		

1. Sum of “none” from each fraction and corresponds to the number of sediment stations
2. Only applies to time series normalised to C_{org}
3. No EAC

Time trend analysis

There were 2 significant downward trends.

Region II

Data were available for the fractions FS63 (74) and US2000 (57). For these datasets, normalisation parameters Al (75) and C_{org} (108) were available. There were 2 significant trends, both downward. Both trends were in FS63, C_{org}-normalised sediments from the Netherlands, 1 in the open North Sea and 1 closer to the northern shores. These were the same time series where downward trends were observed for benzo(a)anthracene, benzo(a)pyrene, fluoranthene etc.

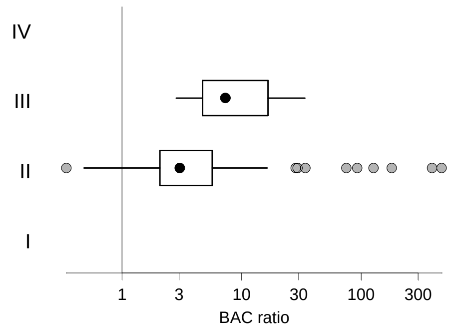
Region III

There were 17 time series datasets from UK available for unsieved fraction. C_{org} normalisation were available in 8 of these datasets. There were no significant trends.

Comparison with BAC and EAC

The proposed BAC of 41 µg kg^{-1} was applied to time series normalised to C_{org}. No EAC has been defined for phenanthrene. For Region II, 6% of the time series were significantly below the BAC. For Region III, all UCL/BAC ratios > 1. A UCL exceeding the proposed BAC by up to 450 times was recorded.

Figure 8.16 Phenanthrene sediments - Summary plots of BAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 1 and 54% with a median of 11% for time series $\geq$ 5 years.

Conclusion

There were 339 time series assessed from Regions II and III. There were 2 significant trends, both downward from Region II, observed in the open North Sea (Netherlands, ROTTMPT3) and north of the Netherlands (TERSLG235). 6% of time series were significantly below the BAC.

Pyrene

Available data

There were 363 datasets from 158 sediment stations available (table 8.17). The stations were split into 3 groups according to the length of the time series: 3-4 years (115), 5-6 years (34) and 7-8 years (9). Of the 363 time series, 87 could be normalised to Al and 118 to C_{org}.

Table 8.17 Pyrene in sediments - Extent of the dataset for three year classes

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	29	19	4	52	0	1		
		C_{org}	29	2	4	35	0	0	0	
	FS63	none	72	11	5	88	0	0		
		AL	87	0	0	87	0	0		
		C_{org}	58	14	0	72	1	2	4	
III	US2000	none	14	4	0	18	0	0		
		C_{org}	11	0	0	11	0	0	0	
Total all			300	50	13	363	1	3	4	
Total none[1]			115	34	9	158	0	1		

1. Sum of "none" from each fraction and corresponds to the number of sediment stations
2. Only applies to time series normalised to C_{org}
3. No EAC

Time trend analysis

There was 1 significant upward trend and 3 significant downward trends.

Region II

Data were available for the fractions FS63 (88) and US2000 (52). For these datasets, normalisation parameters Al (87) and C_{org} (107) were available. There were 4 significant trends: one upward and 3 downward. 3 of these trends were from Dutch time series with similar trends in benzo(a)anthracene, benzo(a)pyrene, and fluoranthene. The upward time series was in FS63, C_{org}-normalised sediments from the southern coast of the Netherlands. The downward trends were in FS63, C_{org}-normalised sediments in the open North Sea and closer to the northern shores of the Netherlands and in a non-normalised time series in Moray Firth, Scotland.

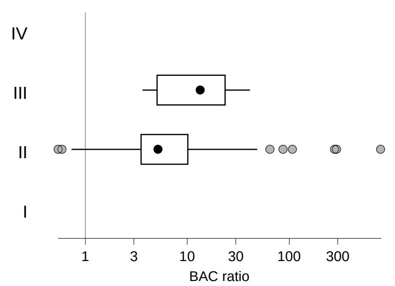
Region III

There were 18 time series from UK available for unsieved fraction. C_{org} normalisation was available in 11 of these datasets. There were no significant trends.

Comparison with BAC and EAC

The proposed BAC of 28 µg kg^{-1} was applied to time series normalised to C_{org}. No EAC has been defined for pyrene. For Region II, 4% of the time series were significantly below the BAC. 2 of the 3 time series with downward trends were significantly below the BAC. For Region III, all UCL/BAC ratios > 1. A UCL exceeding the proposed BAC by up to 750 times was recorded.

Figure 8.17 Pyrene in sediments - Summary plots of BAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 2 and 48% with a median of 10% for series ≥ 5 years.

Conclusion

There were 368 time series assessed from Regions II and III. There were 4 significant trends: 1 upward and 3 downward, all from Region II. 3% of time series were significantly below the BAC. 3 downward trends were observed in the open North Sea (Netherlands, ROTTMPT3), north of the Netherlands (TERSLG235) and the north-east of Scotland (NMMP95, Moray Firth). 1 upward trend was observed in the southern coast of the Netherlands. In general, concentrations in the North Sea were above the BAC.

8.4.2 PCBs

As with mussels, of the many possible CB congeners IUPAC Nos. CB 28, CB 52, CB 101, CB 118, CB 138, CB 153 and CB 180 are usually reported to ICES. The same shortcomings as discussed for mussel exist for sediments. In particular, the number of datasets is smaller for ΣCBs than for individual CBs (see CB 153 below), as all 7 CBs should be present to be included in the assessment. In the following ΣPCB_7 is taken to mean the sum of the 7 mentioned CBs.

CB 153

There were 396 datasets from 170 sediment stations available (table 8.18). The stations were split into 3 groups according to the length of the time series: 3-4 years (86), 5-6 years (56) and 7-12 years (28). Of the 396 time series, 91 were normalised to Al, 134 to C_{org} and 1 to Li.

Table 8.18 CB 153 in sediments - Summary of the assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	13	33	11	57	3	5		
		AL	1	0	0	1	0	0		
		LI	1	0	0	1	0	0		
		C_{org}	29	11	10	50	0	0	2	
	FS63	none	54	16	17	87	2	5		
		AL	74	5	11	90	0	0		
		C_{org}	55	14	0	69	1	4	7	
III	US2000	none	19	7	0	26	0	0		
		C_{org}	15	0	0	15	0	0	3	
Total all			261	86	49	396	6	14	12	
Total none[1]			86	56	28	170	5	10		

1. Sum of "none" from each fraction and corresponds to the number of sediment stations
2. Only applies to time series normalised to C_{org}
3. No EAC

Time trend analysis

There were 6 significant upward trends and 14 significant downward trends.

Region II

Data were available for the fractions FS63 (87) and US2000 (57). For these datasets, normalisation parameters Al (91), C_{org} (119) and Li (1) were available. There were 20 significant trends: 6 upward and 14 downward. Upward trends were found in 5 non-normalised time series, and 1 normalised to C_{org}. The normalised trend did not correspond to any of the non-normalised trends. Downward trends were found in 10 non-normalised time series and 4 normalised to C_{org}. In 2 cases, normalised and non-normalised time series corresponded, both Netherlands stations DOOVBWT and WALCRN70.

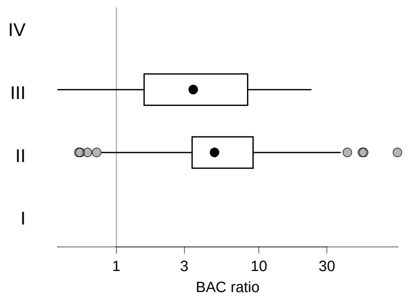
Region III

There were 26 time series from UK available for unsieved fraction. C_{org} normalisation were available in 15 of these datasets. There were no significant trends.

Comparison with BAC and EAC

The proposed BAC of 0,5 µg kg^{-1} was applied to time series normalised to C_{org}. No EAC has been defined for CB 153. For Region II, 8% of the time series were significantly below the BAC. For Region III, 20% of the time series were significantly below the BAC. A UCL exceeding the proposed BAC by up to 90 times was recorded.

Figure 8.18 CB 153 sediments - Summary plots of BAC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 1 and 62% with a median of 17% for time series $\geq$ 5 years.

Conclusion

There were 396 time series assessed from Regions II and III. There were 20 significant trends: 6 upward and 14 downward, all from Region II. 9% of time series were significantly below the BAC. Trends for CB 153 are in accordance with the trends observed for ΣPCB_7. Most areas along the coast from Belgium to Germany, showed downward trends. Upward trends were observed in the west of Belgium and the northern part of the German coastline. Also in the Thames estuary, a downward trend was observed, as for ΣPCB_7. There are only anthropogenic inputs of CB 153, and only downward trends should be expected as legislation has been introduced in the OSPAR area against the use of PCBs. The general BAC ratio > 1 was, however, indicative of a residual problem for these substances.

ΣCB_7

Available data

There were 308 datasets from 131 sediment stations available (table 8.18). The stations were split into 3 groups according to the length of the time: 3-4 years (77), 5-6 years (37) and 7-12 years (17). Of the 308 time series, 78 were normalised to Al, 98 to C_{org} and 1 to Li.

Table 8.19 ΣCB_7 in sediments - Summary of the assessment

Region	Fraction	Normaliser	Number of time series				Trends		UCL below	
			3-4	5-6	7+	Total	Up	Down	BAC[2]	EAC[3]
II	US2000	none	16	15	5	36	3	2		
		AL	1	0	0	1	0	0		
		LI	1	0	0	1	0	0		
		C_{org}	18	4	7	29	0	0	0	
	FS63	none	47	18	12	77	1	5		
		AL	61	5	11	77	0	0		
		C_{org}	48	10	0	58	0	3	0	
III	US2000	none	14	4	0	18	1	0		
		C_{org}	11	0	0	11	0	0	0	
Total all			217	56	35	308	5	10	0	
Total none[1]			77	37	17	131	5	7		

1. Sum of "none" from each fraction and corresponds to the number of sediment stations
2. Only applies to time series normalised to C_{org}
3. No EAC

Time trend analysis

There were 5 significant upward trends and 10 significant downward trends.

Region II

Data were available for the fractions FS63 (77) and US2000 (36). For these datasets, normalisation parameters Al (78), C_{org} (87) and Li (1) were available. There were 14 significant trends: 4 upward and 10 downward. The 4 upward trends were all in non-normalised sediments. Downward trends were found in 7 non-normalised time series and 3 normalised to C_{org}. In no cases did the trends in normalised and non-normalised time series correspond.

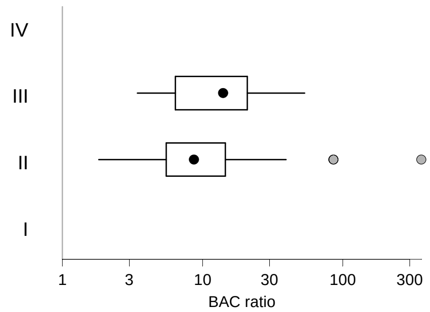
Region III

There were 17 time series datasets from UK available for unsieved fraction. C_{org} normalisation was available in 11 of these datasets. There was 1 significant upward trend.

Comparison with BAC and EAC

The proposed BAC of 1,3 µg kg^{-1} was applied to time series normalised to C_{org}. No EAC has been defined for ΣCB_7. All the UCL/BAC ratios > 1. A UCL exceeding the proposed BAC by up to 360 times was recorded.

Figure 8.19 ΣCB_7 sediments - Summary plots of BRC ratios



Ten-year detectable trend

The 10-year detectable trend varied between 2 and 48% with a median of 13% for time series ≥ 5 years.

Conclusion

There were 308 time series assessed from Regions II and III. There were 15 significant trends: 4 upward and 10 downward in Region II and 1 upward in Region III. No time series was significantly below the BAC. Downward trends were observed in most areas along the coast from Belgium to Germany, except in the west of Belgium and the northern part of the German coastline, where trends were upward. A downward trend was also observed in the Thames estuary, while an upward trend was observed at Severn Peterston. There were only anthropogenic inputs of ΣPCB_7, and downward trends could be expected following the introduction of controls in the OSPAR maritime area against the use of PCBs. However, the general BAC ratio > 1 was also indicative of a residual problem for these substances.

9. Comparison of RID and CEMP assessments

In parallel with this assessment of data collected under the CEMP, an assessment was also being made of data collected under the RID study by the OSPAR Working group on Inputs to the Marine Environment (INPUT). The assessment of RID data covered the period 1990-2002 and distinguished between 5 sub-regions of Region II. An analysis of the results of the RID assessment for Cd, Hg and Pb is given in Appendix 14 and table 9.1.

Table 9.1 Aggregated results (direct discharge + riverine input) where a significant (p< 0,05) downward or upward trend is indicated

RID assessment	Region I (UK north)	Region II (UK south)	Region III (B, NL)	Region IV (DE, DK)	Region V (N)
Cd	downward [1] (61%)	downward [1] (55%)	nt	downward [2] (40%)	nt
Hg	downward [1] (55%)	downward [1] (64%)	upward (67%)	upward [3] (68%)	nt
Pb	nt	nt	nt	nt	upward (72%)

1 Direct flow rates lacking
2 Adjustment lacking
3. Data gaps
The percentage of total decrease or increase over 12-year period is indicated in brackets
"nt" indicates that no significant trend was observed

The CEMP assessment produced time trends for sediments and biota for locations in the 5 sub-regions, many of which were downward (table 9.2). It should be noted that the percentages in the RID and CEMP tables cannot be compared directly. However, a significantly decreasing riverine inputs and direct discharges of a particular substance could be expected to lead to CEMP sediment and biota time series showing predominantly downward trends.

Table 9.2 Percentage of significant downward trends found in sediment and biota

CEMP		Regions I+II (UK)	Region IV (B, NL)	Region IV (DE, DK)	Region V (N)
Biota	Cd	na	67%	88%	53%
	Hg	0%	100%	89%	50%
	Pb	na	100%	25%	100%
Sediment	Cd	100%	71%	90%	nd
	Hg	100%	100%	100%	nd
	Pb	100%	33%	63%	nd

na: not applicable since there were no significant trends
nd: no data

The discussion that follows focuses on the significant RID trends.

Regions I and II (UK)

Comparison for biota was difficult as there was only 1 significant trend for Hg which was upward. For sediments, all significant trends for Cd and Hg were downward which fits well with the downward RID trends.

Region III (Belgium and the Netherlands)

There was only 1 significant RID trend for Hg which was downward. The CEMP assessment of Hg in biota identified 7 significant trends, which were all downward. The CEMP assessment of Hg in sediments also identified 7 significant trends which were also all downward. Thus, it seems that in this case the RID and CEMP assessments compare very well, and the decrease in Hg input from rivers and direct discharges is reflected in the downward trends in sediments and biota.

Region IV (Germany and Denmark)

There were significant downward RID trends for Cd and Hg. As in Region III, this was reflected in the proportion of significant downward trends in biota, which was 88% for Cd and 89% for Hg. The downward

RID trends were also reflected in the proportion of significant downward trends in sediments, which was 90% for Cd and 100% for Hg.

Region V (Norway)

There was a significant downward RID trend for Pb. This was reflected in the CEMP assessment of Pb in biota which showed 11 significant trends, which were all downward. Unfortunately, there were no Norwegian data for metals in sediments.

Conclusion

The inputs of Cd, Hg and Pb from direct discharges and rivers has mainly decreased over the period 1990-2002. This is consistent with the CEMP sediment and biota time series, which are predominantly downward for the concentrations of these metals.

10. Assessment of organotin specific biological effects in Denmark, Norway and United Kingdom

10.1 Introduction

Contamination of the marine environment by tributyltin (TBT) has long been known to cause the development of imposex amongst female neogastropods and of intersex in female Littorinid gastropods. Recognition of these effects has led to a range of legislative actions in different countries to prohibit or restrict the use of the TBT-based antifoulants on the hulls of vessels and in aquaculture.

These effects also form the basis for OSPAR Guidelines on TBT specific biological effects monitoring. The imposex/intersex response in marine gastropods is sensitive, contaminant specific and can be directly related to the reproductive potential of the population. An OSPAR workshop was held in The Hague in 2004 to define assessment criteria for TBT specific effects in a range of gastropod species (table 10.1). The biological equivalence of the assessment classes to *Nucella lapillus* are described in table 10.2. External quality assurance is available through QUASIMEME.

Table 10.1 OSPAR biological effect assessment criteria for TBT

Assessment criteria for imposex in *Nucella lapillus* are presented alongside equivalent VDSI/ISI /PCI values for sympatric populations of other relevant species.

Assessment class	*Nucella*	*Nassarius*	*Buccinum~*	*Neptunea#*	*Littorina*
	VDSI	VDSI	PCI	VDSI	ISI
A	< 0,3	< 0,3	< 0,3	< 0,3	< 0,3
B	0,3-< 2,0			0,3-< 2,0	
C	2,0 < 4,0	0,3-2,0	0,3-2,0	2,0-4,0	
D	4,0-5,0	2,0-3,5	2,0-3,5	4,0 ^	0,3-< 0,5
E	> 5,0	> 3,5	> 3,5		0,5-1,2
F	-				> 1,2
			Stroben *et al*., 1995, and ~ No correlation established	# field evidence that *Neptunea* has similar sensitivity as *Nucella* , ^ highest value possible	

Table 10.2 Biological interpretation of assessment classes to *Nucella lapillus*

Assessment class	Biological interpretation
A	Close to zero effects
B	Response caused by TBT concentrations below the EAC
C	Level of response where females are not expected to be sterile
D	Sterile females are present in the population, but reproductively capable females remain
E	Populations are unable to reproduce
F	Populations of *Nucella* have expired

During the preparation for the current assessment, Contracting Parties were encouraged to submit TBT-effects monitoring data to ICES so that they might be available for assessment. Only 3 Contracting Parties submitted data, although the submissions included observations from all North Sea countries, and Ireland. Pressure of time on MIG/ICES, and the status of the development of the ICES database systems, made it impractical to undertake a data assessment in the same way as has been done for contaminant concentrations in sediment and biota. It was therefore agreed to make an interim presentation of national TBT-effects monitoring activity in 3 countries, with a view to developing a more comprehensive report at MON 2005 as part of the preparation for JAMP Product HA-4, due in 2009.

10.2 United Kingdom

Monitoring for imposex/intersex in gastropods has been undertaken in the UK since the late 1980s to assess the biological effects of TBT contamination. Particularly over the last decade, monitoring authorities in the UK have collected a large quantity of data on the biological effects of TBT contamination from a number of spatial and temporal surveys of different gastropod species, in accordance with the relevant OSPAR guideline.

Projects have included wide scale surveys of the east and south coasts of the UK in 1992/93 and 1998/99 at sites not associated with known point sources of TBT (Figure 10.1). Western coastlines were surveyed in 1997/98 in more detail, including sites expected to be subject to ‘background’ levels of contamination and groups of stations positioned either side of known TBT point sources (Davies *et al*, 1998).

In addition, around 40 stations along the coast of Northern Ireland have been sampled between 1994 and 2003 (at approximately 2 year intervals), and further 65 sites (approximately) around Scotland have been sampled during annual surveys between 1998 and 2003.

The Sullom Voe oil terminal in Shetland has provided a unique opportunity to monitor the spatial and long-term temporal trends of effects of TBT from antifoulants on oil tankers visiting the terminal. The area has been surveyed approximately every 2 years since 1987.

Some offshore areas (‘background’ sites, anchorages and shipping lanes) have been covered by surveys of effects in whelks (*Buccinum undatum* and *Neptunea antiqua*), but the data are not reported here.

Data assessment has used OSPAR assessment criteria. VDSI/ISI data from shoreline surveys of *Nucella* and *Littorina* have been used to assign each station surveyed between 1994 and 2003 to an assessment class, by comparison with OSPAR assessment criteria.

United Kingdom results

In general, the VDSI values in *Nucella* from the UK open coastal sites not close to likely inputs of TBT surveyed between 1994 and 2003 were low and gave no cause for concern for the health of the populations or individuals (OSPAR assessment classes A-C). Data from more detailed surveys of *Nucella* imposex carried out in and immediately around ports, marinas, etc, which are recognised as potential sources of TBT, showed that the maximum intensity of imposex differed considerably between sampling areas. This is likely to be a result of the types of vessel using facilities and the capacity of the receiving waters to dilute and disperse the TBT. In general, *Nucella* VDSI was > 4 (OSPAR assessment class D) only at sites within a few hundred metres of input areas.

Sites in the east and south of the UK, surveyed in both 1992/3 and 1998/9 showed that populations from all sites showed some degree of imposex development, and in most cases all females were affected. Small numbers of sterile females were found at around 15% of the sites sampled. The intensity of imposex development had declined between 1992 and 1998 at most of the sites sampled while only 2 sites showed increasing VDSI.

Data from the 2001 survey of Sullom Voe (Figure 10.2) show that VDSI values are typically high (4,0-4,42, OSPAR assessment class D) inside Sullom Voe and around the oil terminal jetties and low (0,17-1,88, class A & B) in the adjacent open waters of Yell Sound. The VDSI values for the populations at sites in the Sullom Voe where VDSI was > 4 in early surveys, and at less strongly impacted sites outside the Voe, have generally decreased with time. This has occurred in parallel with a reduction in the number of vessels using the oil terminal, and a change from free association to co-polymer paints with lower TBT leaching rates.

All monitoring data from shoreline surveys between 1994 and 2003 are presented according to OSPAR assessment class in Figure 10.3. This includes all data from UK national surveys, Sullom Voe surveys, Northern Ireland and Scotland surveys for both *Nucella* and *Littorina*. A total of 490 station samples are represented in this figure . The results show that the majority of UK data have been obtained from *Nucella*, and that most sites surveyed fall into assessment classes B-D. Only data from *Littorina* provide information on assessment classes E or F. These data should not be used to determine temporal trends, since the data represented came from multiple surveys covering different geographical areas and undertaken in different years.

Figure 10.1 Geographical coverage of stations sampled during UK national shoreline surveys 1992 – 1998

Additional stations in Northern Ireland and Scotland were sampled during this time period by the Department of the Environment Northern Ireland and the Scottish Environment Protection Agency respectively.

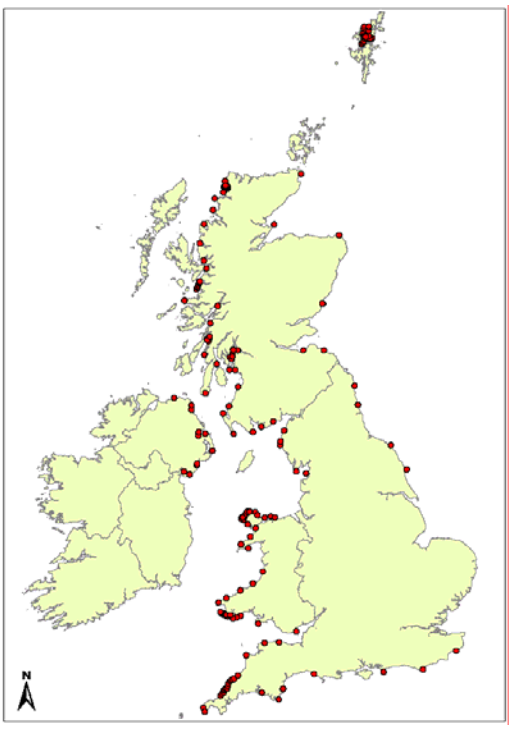


Figure 10.2 Assessment of 2001 VDSI data from *Nucella* sampled from sites around Sullom Voe, Shetland oil terminal

Data are presented in accordance with OSPAR assessment classes A – D (see table 10.1 for description)

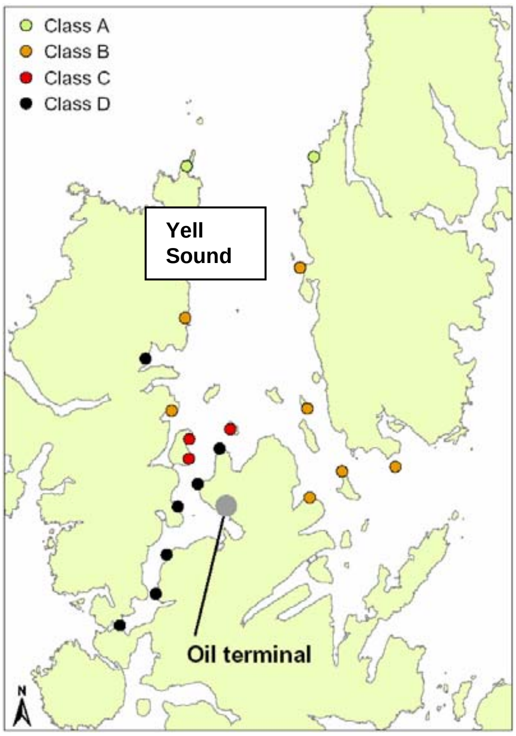
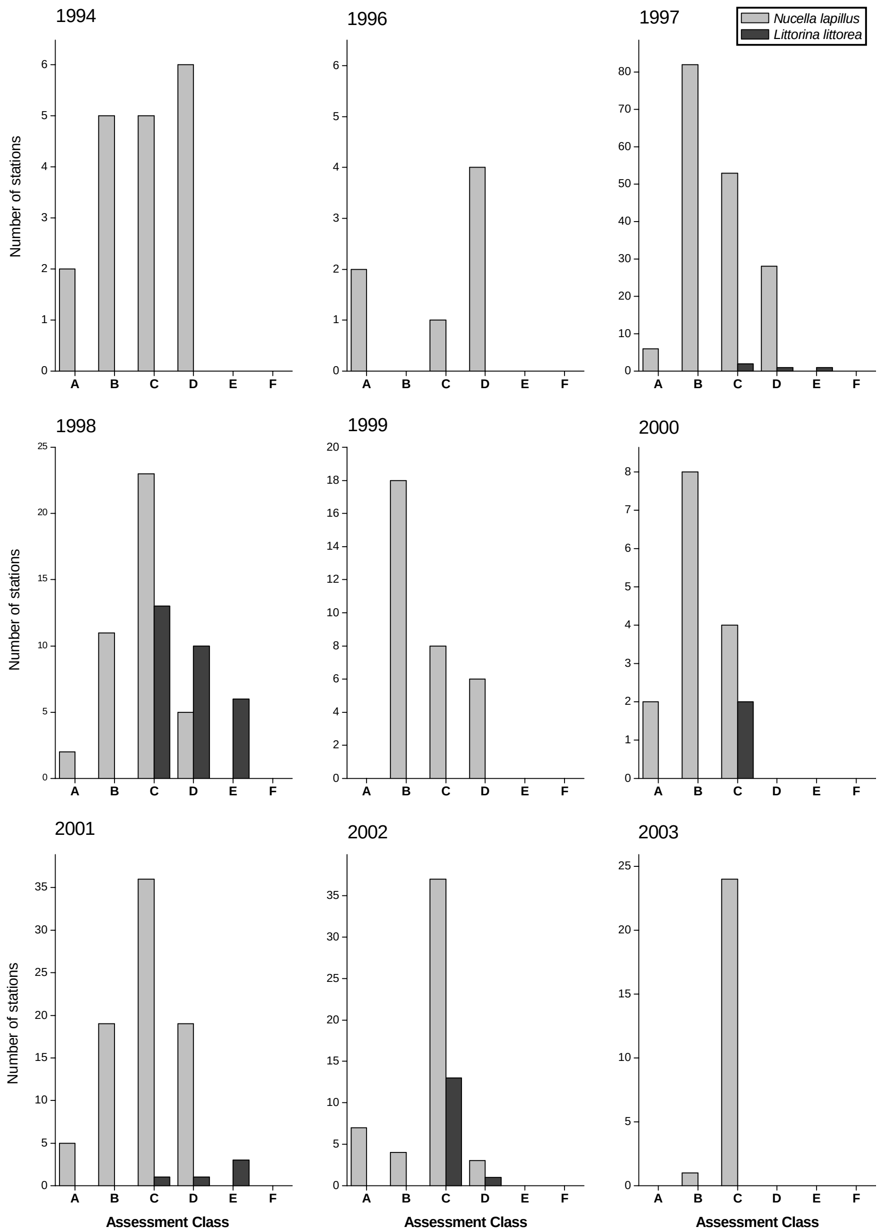


Figure 10.3 UK organotin effects monitoring data obtained from shoreline surveys of imposex in *Nucella* and intersex in *Littorina* from 1994-2003

Data are presented as number of sites surveyed falling into OSPAR assessment classes A-F according to VDSI or ISI determinations (see table 10.1 for description of OSPAR assessment classes).



10.3 Norwegian studies of the effects and concentrations of organotin compounds

Introduction

Effects from organotin in *Nucella* and concentrations in *Nucella* and *Mytilus edulis* were investigated in 9 and 14 locations along the coast of Norway in September-October 2003, respectively (cf. Green *et al*. 2004 (for methods and maps) and Green *et al*. in publ.). Imposex (VDSI and RPSI), was analysed according to OSPAR JAMP guidelines (OSPAR agreement 2003-10). Detailed information about the chemical analyses of the animals is given in Følsvik *et al*. (1999).

Nucella lapillus

Evident effects from organotin were observed in 2003 at all stations, except for 11X in northern Norway. Concentrations of organotin were relatively low (≤ 50 µg Sn/kg d.w.) at the coastal locations in the southwest of Norway, but lowest at the northern locations. Most heavily affected were snails from western Norway and the Haugesund location (st. 227G, VDSI=4,1) and the highest organotin levels were also found at Haugesund (median 360µg Sn/kg d.w.) (Figure 10.4). This is the highest concentration measured at this station in the period 1997-2003 (Figure 10.5). Except for western Norway (22G) and Haugesund (227G), concentrations had generally decreased compared to 2002 (cf. Green *et al.* in publ.). However, no statistically significant temporal trends for the period 1997-2003 were found at Haugesund (227G) or Færder (36G).

The results for 1997-2003 indicate higher concentrations and imposex indexes at the near harbour station Haugesund (227G) compared to the more remote station Færder (36G) in the outer Oslofjord (Figure 10.6).

At Færder (36G) the VDSI values for 1993-2003 are lower (better) than 1991 (Figure 10.6). The values for Haugesund area (227G) are slightly worse in 1991 and 2000-2002 than for other years.

Figure 10.4 Concentrations of TBT (µg Sn/kg d.w.; circles) and imposex (VDSI; columns) in *Nucella lapillus* from 9 stations along the coast of Norway in 2003

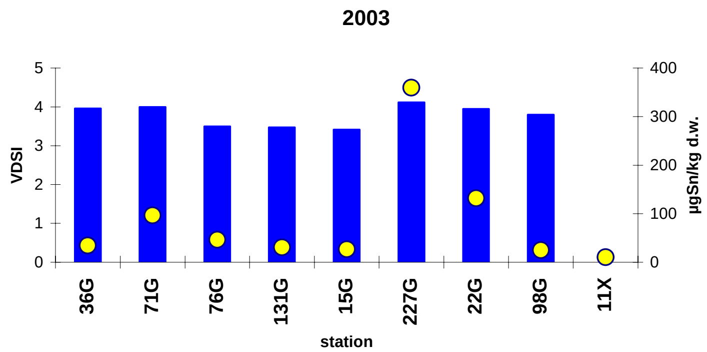
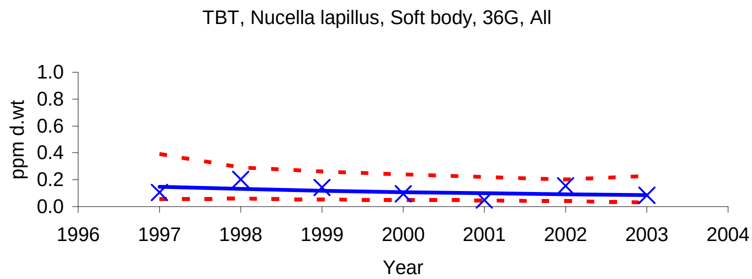


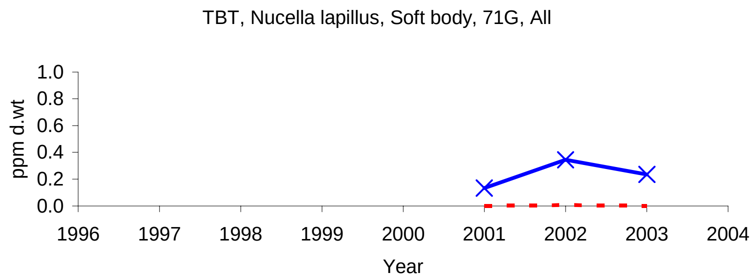
Figure 10.5 Median tributyltin concentration in *Nucella lapillus* from outer Oslofjord (st.36G), Langesundsfjord (west of Oslofjord) (st.71G) and Haugesund (St.227G)

(Note: TBT concentration on formulation-basis). For some years the upper confidence interval line is off-scale in figure s A and B.

A



B



C

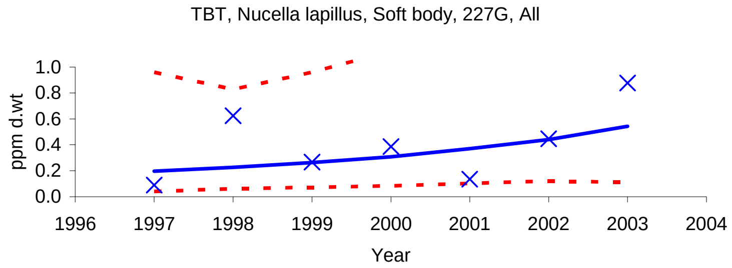
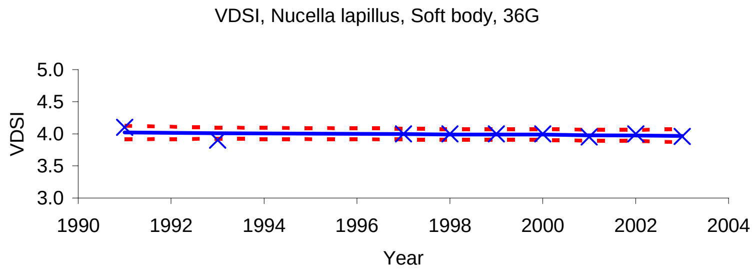


Figure 10.6 Imposex (VDSI) in *Nucella lapillus* at 2 stations in southern Norway; Færder (36G) and Haugesund (227G)

Data from 1991 (Harding *et al*. (1992) and 1993 (Walday *et al*. 1997).

A



B

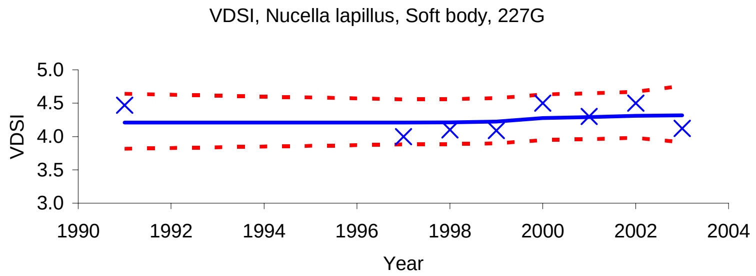
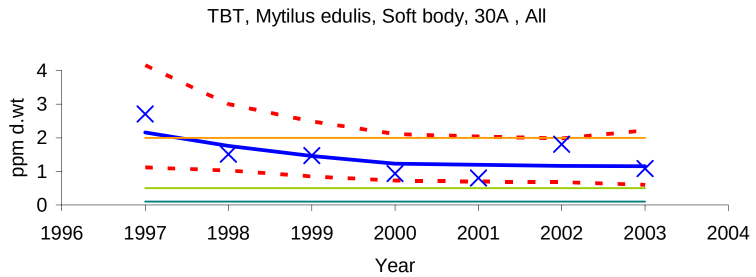


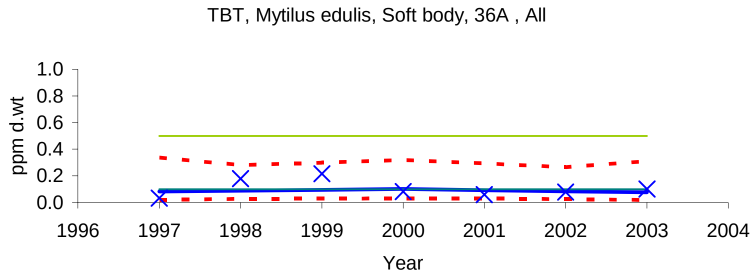
Figure 10.7 Levels of TBT (mg Sn/kg d.w.) in *Mytilus edulis* from inner (st.30A) to outer (st.36A) Oslofjord, Langesundsfjord (west of Oslofjord) (st.71A) and Haugesund (St.227X).

Note: for some years the upper confidence interval line is off scale in figure s A and B. Horizontal lines indicate SFT Classes I slightly (nearest x-axis), II moderate III marked.

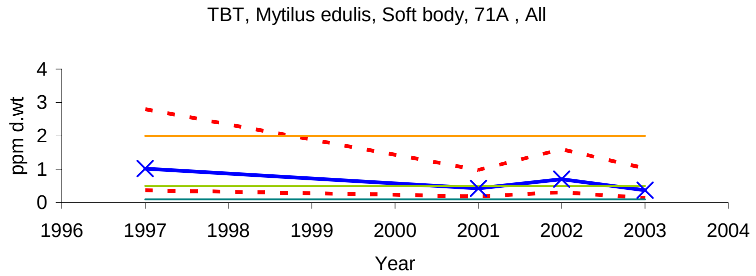
A



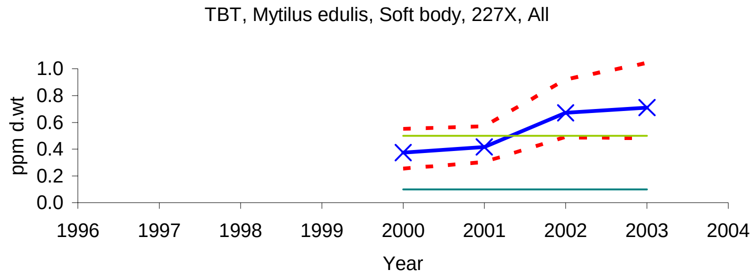
B



C



D



Mussel

Concentrations of organotin in mussel were high in the near harbour stations (301, 30A, 712, 713 and 227A) and western Norway (22A), while they were low at the northern stations (10A, 11X) and at Farsund (15A). Levels (median) ranged between 0,005 and 0,891 mg Sn/kg (dw). According to the Norwegian classification of environmental quality (Molvær *et al.* 1997) inner Oslofjord (st. 301) was severely polluted (Class V) by TBT, while the other inner Oslofjord station (30A), the Breviksfjord (712, 713), Espevær (22A) and Haugesund (227X) were markedly polluted (Class III) by TBT. The northern stations (10A, 11X) and the Lista area (15A) were only slightly polluted (Class I), while the rest of the samples were moderately polluted (Class II). Compared to previous years, most concentrations were lower in 2003, but an increase was observed at near harbour station in Haugesund (227A) (Figure 10.7) and Espevær, western Norway (st. 22A). Also the remote Færder station (36A) had concentrations somewhat higher than in 2002. However, no significant temporal trends for the period 1997-2003 were found at this station or Færder (36A).

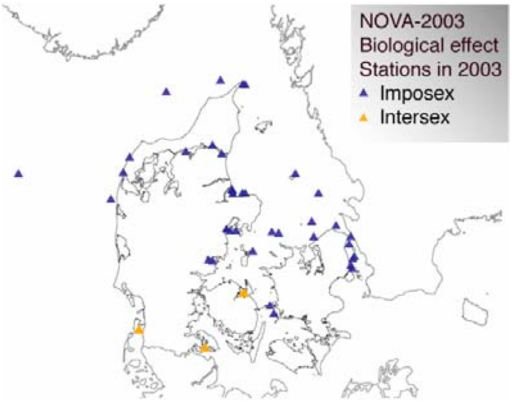
Conclusion

The presence of organotin (as TBT) in Norwegian waters still exceeded acceptable levels in 2003, in particular close to harbours. Concentrations of organotin in mussels and *Nucella* were elevated, and biological effects from TBT were found in *Nucella* from all of the investigated areas, except 1 northern station. No significant trends were found, however TBT concentrations in mussel were mostly lower than in 2002. It is a cause for concern that the ban on the use of TBT in antifouling on boats < 25 m of length has not lead to a clear improvement in the investigated areas.

10.4 Imposex in Denmark

Monitoring of the biological effects of TBT in the form of intersex and imposex has been part of the Danish national monitoring programme since 1998. The samples are taken from the Sound and the Belt Sea all the way out into the open North Sea. A station map of the latest monitoring year is shown in Figure 10.7. In the revised monitoring programme, NOVANA 2009, the number of stations are slightly reduced. Imposex is studied in more pristine areas using different whelk species or, near harbours, using intersex in *Littorina littorea*.

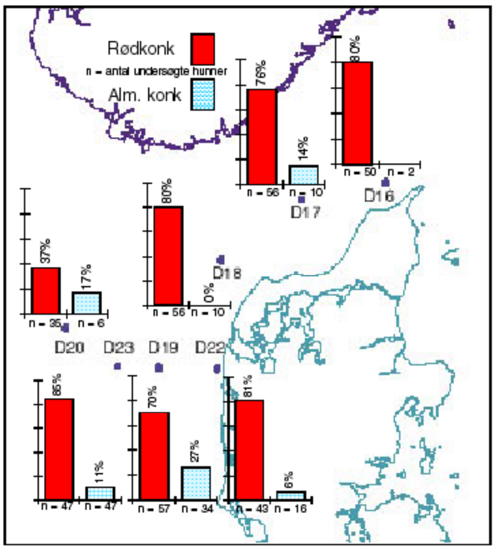
Figure 10.8 Sampling stations for imposex and intersex in the Danish Monitoring Programme NOVA 2003.



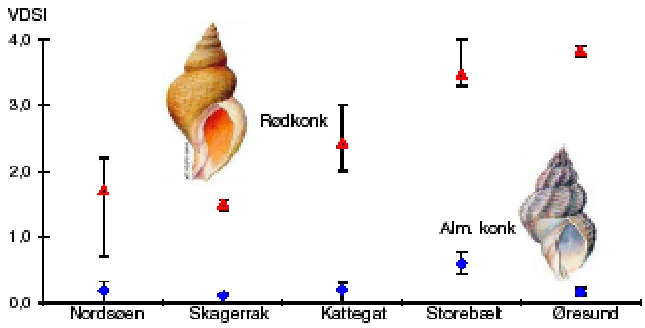
Buccinum undatum and *Neptunea antiqua* were the preferred species, and some extra samples in the North Sea showed that imposex was widespread even in this area (Figure 10.8) (Strand, 2002)

In the latest survey, (Strand, 2004), 11-79% of *Neptunea antiqua* in the North Sea and Skagerrak had developed VDSI of 0,1-1,5 and 15-31% of *Buccinum undatum* (VDSI=0,2-0,3) in the same area had developed imposex. In the inner Danish waters, 99% (VDSI 2,5 –4,0) of *Neptunea antiqua* and 2-52% (VDSI 0,02-0,6) of *Buccinum undatum* had developed imposex, with the highest levels found in the Great Belt and the Sound area (Figure 10.9).

Figure 10.9 Imposex in Danish waters

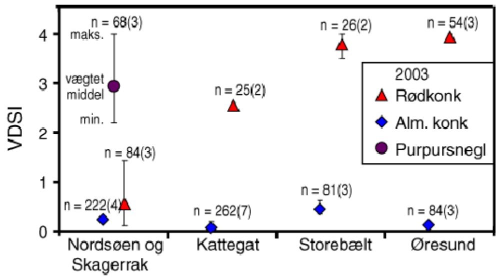


A. % of females with imposex development in *Neptunea antiqua* and *Buccinum undatum* in 2001



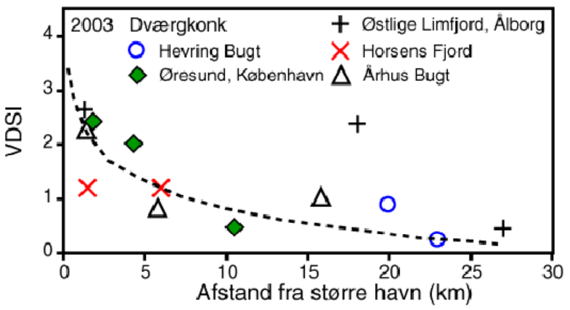
B Geographical distribution: VDSI in *Neptunea antiqua* and *Buccinum undatum*. (Strand, (2002)

Figure 10.10 VDSI in different regions of Denmark (2003 data), including a weighed average, minimum and maximum of different species



Buccinum undatum was also sampled at 3 dredging sites in the Kattegat, in the Frederiksborg and Aarhus areas. No raised levels of imposex were found compared to the monitoring programme (VDSI 0,0-0,4). Within a distance of 5 km from harbours, 85-100% of *Nassarius reticulata* (VDSI 1,2-2,7) were found compared to 25-57% (VDSI 0,2-1,2) at distances > 5 km (Figure 10.10).

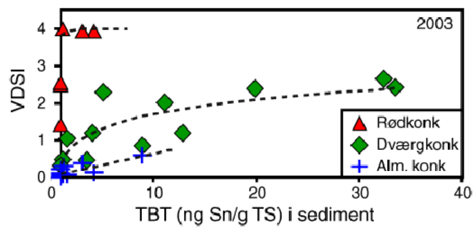
Figure 10.11 Correlation of distance to larger harbour and VDSI for 5 different locations in Denmark. The unusual high VDSI from Østlige Limfjord, Ålborg at 18 km is ascribed to high shipping intensity in the Limfjord at the sampling site



TBT concentrations in sediments in 2003 were also correlated with imposex development for whelks collected in the vicinity of the sediment stations. Results are depicted in Figure 10.11. *Neptunea antiqua* is more sensitive to TBT than the analytical method employed, whereas fair correlation is obtained for *Buccinum undatum* and *Nassarius reticulata*.

Figure 10.12 Correlation of VDSI in different species with concentration in sediments

It is clear that the species have different sensitivity to TBT.



Note red triangle = *Neptunea antiqua*
green square = *Nassarius reticulata*,
blue cross = *Buccinum undatum*

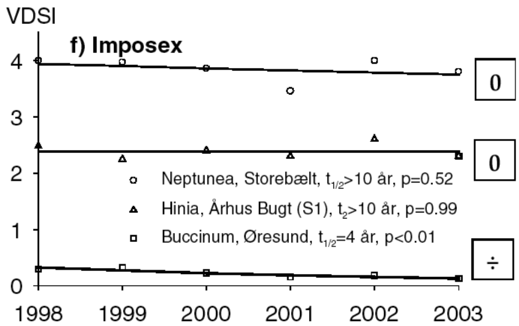
At the end of the NOVA 2003 programme, the power and time trends of the imposex monitoring programme were investigated for 25 stations, the results are shown in Figure 10.12 and table 10.3. Only 3 stations showed significant trends, but on average the power to detect an annual 10% change with 80% confidence was 10 years. With only 6 years of monitoring this result was expected, and it is hoped that the ban on TBT in larger ships will result in measurable (significant) decreases in the inner Danish water within the NOVANA programme, running until 2009.

Table 10.3 Time trend analysis of Danish imposex stations

The number of stations with no upward or downward trends are given. In the column strength, the % detectable annual trend is indicated, together with the number of years to obtain 80% power with a 10% annual change.

No trend	Increase	Decrease	Strength	Power analysis # years to 80%
22	1	2	31% (3-100%)	10 (5-20)

Figure 10.13 Time trend of Danish imposex stations. *Neptunea antiqua.* at Great Belt (Store Bælt, open circles), *Hinia reticulata* in Aarhus Bay and *Buccinum undatum* in the Sound



10.5 Overall conclusions

As stated in the introduction to this section, a full analysis of imposex data from the OSPAR Convention area was not possible. Only a preliminary assessment could be undertaken at this time. The data and supporting information presented and discussed here, and a cursory review of the scope of data submitted to ICES during 2004, indicated that imposex data are available, or being collected, for large parts of the OSPAR Convention area. The work is generally being carried out in accordance with the OSPAR Guidelines for TBT specific biological effects measurements. In some cases, for example UK data from Sullom Voe and data from some stations in Norway, the populations have been sampled repeatedly and regularly, using standard methodology. There is therefore good evidence that a reliable broad scale spatial assessment could be carried out at MON 2005, utilising data from several countries, and that data from some locations would be suitable for temporal trend assessment.

11. Conclusions and recommendations

11.1 Temporal assessment of metals in biota

The results of the assessments of metals in biota are summarised in table 11.1. The number of datasets for each region differed, with over 60% being from Region II. Of the 1232 time series considered, 359 were too short to make an assessment of any trends. Of the remaining 873 data series, 677 showed no significant linear trends. 42 time series showed significant upward trends, and 154 significant downward trends. Therefore, although most time series showed no significant trends, most (79%) of the significant trends were downward. Relatively more trends were found for Pb and Cd and fewer for Zn and Cu. Zn and Cu can be bioregulated, which may account for the fewer detected trends. The number of downward trends greatly exceeds the number of upward trends in Regions II, III, and IV. The numbers of upward and downward trends were more similar in Region I, although there were still more downward than upward trends.

Table 11.1 Linear significant trends for metals in the different regions for year category 5-6 and 7+ years and total number of datasets including year category 3-4 years

Metal	Trend	Region I	Region II	Region III	Region IV	Total
As	Upward	1	3	0	nd	4
	Downward	0	6	0	nd	6
	None	9	10	5	nd	24
	Total datasets	11	30	18	nd	59
Cd	Upward	3	10	0	0	13
	Downward	3	33	2	15	53
	None	12	59	8	20	99
	Total datasets	22	139	29	40	230
Cr	Upward	nd	0	0	nd	0
	Downward	nd	3	1	nd	4
	None	nd	15	3	nd	18
	Total datasets	nd	25	15	nd	40
Cu	Upward	1	2	0	3	6
	Downward	1	11	0	3	15
	None	12	77	4	30	123
	Total datasets	19	115	14	40	188
Hg	Upward	0	5	1	0	6
	Downward	2	20	0	6	28
	None	16	81	12	30	139
	Total datasets	22	144	31	40	237
Ni	Upward	nd	0	0	nd	0
	Downward	nd	3	0	nd	3
	None	nd	12	1	nd	13
	Total datasets	nd	35	10	nd	45
Pb	Upward	0	3	0	0	3
	Downward	3	21	2	7	33
	None	13	74	8	29	124
	Total datasets	21	140	28	40	229
Se	Upward	0	nd	nd	nd	0
	Downward	0	nd	nd	nd	0
	None	10	nd	nd	nd	10
	Total datasets	12	nd	nd	nd	12
Zn	Upward	0	10	0	0	10
	Downward	0	11	0	1	12
	None	18	70	4	35	127
	Total datasets	22	115	15	40	192
TOTAL	Upward	5	33	1	3	42
	Downward	9	108	5	32	154
	None	90	198	45	144	677
	Total datasets	129	743	160	200	1232

nd = no data available

11.2 Temporal assessment of organics in biota

The results of the assessments of organics in biota are summarised in table 11.2. The number of datasets for each region differed with over 60% from Region II (table 11.2). Of the 1540 time series considered, 446 were too short to make an assessment of any trends. Of the remaining 1094 data series, 852 showed no significant linear trends. 37 time series showed significant upward trends, and 207 significant downward trends. Therefore, most time series showed no significant trends. Most (> 80%) of the significant trends were downward.

94 of the downward trends were found for either CB 153, or for ΣCB_7. A further 57 downward trends were found for γ-HCH (lindane). Relatively few downward trends were therefore found for the range of 10 PAH compounds assessed.

It was not possible in the time available to make a detailed assessment of the possible underlying reasons for the observed temporal trends in either metals or organic contaminants in biota. However, locations noted in the preceding text sections where trends for metals in biota were found are summarised in Appendix 15. The interpretation of the temporal trend data in relation to local conditions, contaminant discharges, etc. is an important further step which should be taken as part of future CEMP assessments to determine the reasons for the patterns of change observed.

Table 11.2 Linear significant trends for organics in the different regions for year category 5-6 and 7+ years and total number of datasets including year category 3-4 years

Contaminant	Trend	Region I	Region II	Region III	Region IV	Total
Anthracene	Upward	nd	1	0	0	1
	Downward	nd	8	0	14	22
	None	nd	18	0	15	33
	Total datasets	nd	43	2	39	84
Benz[a]anthracene	Upward	nd	0	0	0	0
	Downward	nd	1	0	0	1
	None	nd	26	2	29	57
	Total datasets	nd	46	3	39	88
Benzo[a]pyrene	Upward	nd	1	0	2	3
	Downward	nd	0	0	5	5
	None	nd	26	2	22	50
	Total datasets	nd	42	3	39	84
Benzo[g,h,i]perylene	Upward	nd	7	0	5	12
	Downward	nd	0	0	0	0
	None	nd	20	0	24	44
	Total datasets	nd	45	2	39	86
Chrysene	Upward	nd	1	0	1	2
	Downward	nd	2	0	0	2
	None	nd	24	0	27	51
	Total datasets	nd	50	2	39	91
Fluoranthene	Upward	nd	1	0	0	1
	Downward	nd	3	0	1	4
	None	nd	24	2	28	54
	Total datasets	nd	48	4	39	91
Indeno[1,2,3-Cd]pyrene	Upward	nd	10	0	3	13
	Downward	nd	0	0	0	0
	None	nd	16	2	26	44
	Total datasets	nd	40	3	39	82

Contaminant	Trend	Region I	Region II	Region III	Region IV	Total
Naphthalene	Upward	nd	0	nd	0	0
	Downward	nd	0	nd	0	0
	None	nd	27	nd	29	56
	Total datasets	nd	42	nd	32	74
Phenanthrene	Upward	nd	0	0	0	0
	Downward	nd	7	0	12	19
	None	nd	20	2	17	39
	Total datasets	nd	51	4	39	94
Pyrene	Upward	nd	0	0	1	1
	Downward	nd	0	0	1	1
	None	nd	28	2	27	57
	Total datasets	nd	51	3	39	93
CB 153	Upward	0	2	0	0	2
	Downward	6	25	0	14	45
	None	17	87	13	22	139
	Total datasets	26	153	24	39	242
ΣCB_7	Upward	0	2	0	0	2
	Downward	3	28	2	16	49
	None	20	81	12	16	129
	Total datasets	26	153	28	37	244
γ-HCH	Upward	0	0	0	0	0
	Downward	5	45	2	5	57
	None	16	51	0	24	91
	Total datasets	25	120	3	31	179
Dieldrin	Upward	nd	0	0	nd	0
	Downward	nd	0	0	nd	0
	None	nd	6	2	nd	8
	Total datasets	nd	6	2	nd	8
TOTAL	Upward	0	25	0	12	37
	Downward	14	119	4	68	205
	None	53	454	39	306	852
	Total datasets	77	890	83	490	1540

nd = no data available

11.3 Temporal assessment of metals in sediment

An important aspect of the preparation of this report was the selection of the most appropriate normalisation methods to use to compensate for variations in the particle size distribution between samples. In some cases, contaminant analyses were accompanied by data for appropriate normalisation parameters, for example Al or Li with metallic contaminants. In these cases, the trends were analysed using both elements as normalisation parameters. In other cases, metals analysis was carried out on sieved fractions, for example < 63 or < 20µm fractions. This is a direct physical form of normalisation, and therefore gives confidence that trends could be investigated in the raw data without further normalisation, although further normalisation was carried out if appropriate normalisation parameters were available. The efficacity of normalisation is demonstrated in the improved power of normalised data to detect trends (Appendix 4B). In most, the conclusions regarding trends were the same whether metals were normalised to Al or Li.

The results of the temporal trend assessment of metals in sediment is summarised in table 11.3. The assessment generally showed very few significant trends in normalised analyses of unfractionated sediments, or in fractionated (63µm) sediment from Region III. The detection of a few trends in non-normalised unfractionated sediment data implies a trend in the particle size of the sediment at the sampling point.

Most of the significant trends were found in analyses of fractionated (63µm or 20µm) sediment from Region II. The greatest numbers of significant trends were found for Cd, Cu, Hg (and to a lesser extent, Pb). There were approximately twice as many downward trends as upward trends.

It may be noted that in Region II, where most of the significant trends were found, that there were more significant trends in the non-normalised data from fractionated sediment than in the normalised data. This may appear unexpected, as normalisation is applied to reduce the variance of data, particularly in unsieved samples. In the case of fractionated sediment, the bulk of the normalisation has been accomplished by the sieving. The inclusion of a second determinand, namely the normalisation parameter, and a pivot value, will introduce additional uncertainty in the normalised value, and thereby tend to reduce the power of the programme to detect changes. These data suggest that analysis of fine grained (sieved) fractions may be a more effective approach than whole (< 2 mm) sediment analysis to temporal trend studies of metals in sediment.

Table 11.3 Linear significant trends for metals in sediments in Regions II and III for year category 7+ years

Fraction: Ux= unfractionated, 6x = 63µ, 2x = 20µ; normaliser: Xn = none, Xa = Al, Xl = Li, Xc = organic carbon.

Metal	Trend	II	II	II	II	II	II	II	II	II	II	II	II	III	III	III	III
		Un	Ua	Ul	Uc	6n	6a	6l	6c	2n	2a	2l	2c	6n	6a	6l	6c
As	Upward	1	0	0	0	0	0	0	4	6	3	3	8	0	0	0	nd
	Downward	3	0	0	0	2	2	1	0	4	0	0	0	0	0	0	nd
	None	15	7	6	19	129	126	29	69	39	36	33	30	29	26	16	nd
	Total datasets	19	7	6	19	131	128	30	73	49	39	36	38	29	26	16	nd
Cd	Upward	0	0	2	1	2	0	0	0	1	1	1	2	1	0	0	nd
	Downward	2	0	0	0	8	2	2	1	9	10	3	6	0	0	0	nd
	None	16	5	3	17	113	121	28	66	48	35	43	39	29	28	17	nd
	Total datasets	18	5	5	18	123	123	30	67	58	46	47	47	30	28	17	nd
Cr	Upward	1	0	0	0	2	3	1	2	11	5	1	7	3	0	1	nd
	Downward	1	0	0	0	2	4	0	0	3	1	1	0	1	1	0	nd
	None	21	6	6	18	127	121	30	71	41	39	42	37	27	27	18	nd
	Total datasets	23	6	6	18	131	128	31	73	55	45	44	44	31	28	19	nd
Cu	Upward	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	nd
	Downward	0	0	0	0	3	2	1	2	23	19	10	12	0	0	0	nd
	None	24	7	7	20	128	127	31	70	35	27	37	34	30	28	19	nd
	Total datasets	24	7	7	20	131	129	32	73	58	46	47	47	31	28	20	nd
Hg	Upward	0	0	2	1	0	2	0	0	0	3	2	1	0	0	0	nd
	Downward	2	0	0	0	9	3	0	3	32	20	17	14	1	1	0	nd
	None	18	5	4	19	114	114	29	67	25	23	27	27	19	17	13	nd
	Total datasets	20	5	6	20	123	119	29	70	57	46	46	42	20	18	13	nd
Nil	Upward	1	0	0	0	6	1	1	2	11	11	1	12	1	1	0	nd
	Downward	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	nd
	None	20	8	7	20	126	125	30	71	46	35	45	34	30	27	19	nd
	Total datasets	22	8	7	20	132	127	31	73	57	46	46	46	31	28	19	nd
Pb	Upward	0	0	0	0	2	2	0	2	3	2	0	3	0	0	0	nd
	Downward	1	0	0	0	3	2	1	2	5	2	1	3	0	0	0	nd
	None	23	9	7	20	126	124	30	69	50	42	46	41	31	28	20	nd
	Total datasets	24	9	7	20	131	128	31	73	58	46	47	47	31	28	20	nd
Zn	Upward	2	0	1	2	2	4	1	6	1	1	0	1	0	0	0	nd
	Downward	1	0	0	0	5	5	2	3	3	1	1	0	1	0	1	nd
	None	21	7	6	18	51	37	44	38	127	126	30	72	30	28	19	nd
	Total datasets	24	7	7	20	58	46	47	47	131	128	31	73	31	28	20	nd
TOT.	Upward	5	0	5	4	14	12	3	17	33	26	8	35	6	1	2	nd
	Downward	11	0	0	0	32	20	7	11	79	53	33	35	3	2	1	nd
	None	158	54	46	151	914	895	251	521	411	363	303	314	225	209	141	nd
	Total datasets	174	54	51	155	960	928	261	549	523	442	344	384	234	212	144	nd

Table 11.4 Linear significant trends for organic contaminants in sediments in Regions II and III for year category 7+ years

Fraction: Ux= unfractionated, 6x = 63µ, 2x = 20µ; normaliser: Xn = none, Xa = Al, Xl = Li, Xc = organic carbon.

Org.	Trend	II	II	II	II	II	II	II	II	II	II	II	II	III	III	III	III
		Un	Ua	Ul	Uc	6n	6a	6l	6c	2n	2a	2l	2c	6n	6a	6l	6c
ANT	Upward	0	nd	nd	0	2	nd	0	1	nd	nd	nd	nd	1	nd	nd	0
	Downward	0	nd	nd	0	0	nd	0	0	nd	nd	nd	nd	1	nd	nd	0
	None	37	nd	nd	29	68	nd	70	54	nd	nd	nd	nd	13	nd	nd	9
	Total datasets	37	nd	nd	29	70	nd	70	55	nd	nd	nd	nd	15	nd	nd	9
BAA	Upward	1	nd	nd	0	0	nd	0	1	nd	nd	nd	nd	0	nd	nd	0
	Downward	0	nd	nd	0	0	nd	0	2	nd	nd	nd	nd	0	nd	nd	0
	None	53	nd	nd	33	83	nd	87	65	nd	nd	nd	nd	16	nd	nd	8
	Total datasets	54	nd	nd	33	83	nd	87	68	nd	nd	nd	nd	16	nd	nd	8
BAP	Upward	1	nd	nd	0	0	nd	0	1	nd	nd	nd	nd	1	nd	nd	0
	Downward	2	nd	nd	0	0	nd	0	2	nd	nd	nd	nd	0	nd	nd	0
	None	46	nd	nd	34	87	nd	87	68	nd	nd	nd	nd	15	nd	nd	9
	Total datasets	49	nd	nd	34	87	nd	87	71	nd	nd	nd	nd	16	nd	nd	9
Bghi P	Upward	0	nd	nd	0	0	nd	0	1	nd	nd	nd	nd	0	nd	nd	0
	Downward	0	nd	nd	0	0	nd	0	1	nd	nd	nd	nd	0	nd	nd	0
	None	53	nd	nd	23	87	nd	87	70	nd	nd	nd	nd	16	nd	nd	6
	Total datasets	53	nd	nd	23	87	nd	87	72	nd	nd	nd	nd	16	nd	nd	6
CHR	Upward	0	nd	nd	0	0	nd	0	0	nd	nd	nd	nd	nd	nd	nd	nd
	Downward	0	nd	nd	0	0	nd	0	2	nd	nd	nd	nd	nd	nd	nd	nd
	None	20	nd	nd	7	85	nd	87	70	nd	nd	nd	nd	nd	nd	nd	nd
	Total datasets	20	nd	nd	7	85	nd	87	72	nd	nd	nd	nd	nd	nd	nd	nd
FLU	Upward	0	nd	nd	0	0	nd	0	1	nd	nd	nd	nd	0	nd	nd	0
	Downward	1	nd	nd	0	0	nd	0	2	nd	nd	nd	nd	0	nd	nd	0
	None	56	nd	nd	35	88	nd	87	70	nd	nd	nd	nd	18	nd	nd	10
	Total datasets	57	nd	nd	35	88	nd	87	73	nd	nd	nd	nd	18	nd	nd	10
IcdP	Upward	0	nd	nd	0	0	nd	0	1	nd	nd	nd	nd	0	nd	nd	0
	Downward	0	nd	nd	0	0	nd	0	0	nd	nd	nd	nd	0	nd	nd	0
	None	53	nd	nd	33	87	nd	87	71	nd	nd	nd	nd	14	nd	nd	10
	Total datasets	53	nd	nd	33	87	nd	87	72	nd	nd	nd	nd	14	nd	nd	10
PA	Upward	0	nd	nd	0	0	nd	0	0	nd	nd	nd	nd	0	nd	nd	0
	Downward	0	nd	nd	0	0	nd	0	2	nd	nd	nd	nd	0	nd	nd	0
	None	57	nd	nd	35	74	nd	75	71	nd	nd	nd	nd	17	nd	nd	8
	Total datasets	57	nd	nd	35	74	nd	75	73	nd	nd	nd	nd	17	nd	nd	8

Org.	Trend	II	II	II	II	II	II	II	II	II	II	II	II	III	III	III	III
PYR	Upward	0	nd	nd	0	0	nd	0	1	nd	nd	nd	nd	0	nd	nd	0
	Downward	1	nd	nd	0	0	nd	0	2	nd	nd	nd	nd	0	nd	nd	0
	None	51	nd	nd	35	88	nd	87	69	nd	nd	nd	nd	21	nd	nd	13
	Total datasets	52	nd	nd	35	88	nd	87	72	nd	nd	nd	nd	21	nd	nd	13
CB 153	Upward	3	0	0	0	2	nd	0	1	nd	nd	nd	nd	0	nd	nd	0
	Downward	5	0	0	0	5	nd	0	4	nd	nd	nd	nd	0	nd	nd	0
	None	49	1	1	50	80	nd	90	64	nd	nd	nd	nd	26	nd	nd	15
	Total datasets	57	1	1	50	87	nd	90	69	nd	nd	nd	nd	26	nd	nd	15
ΣCB_7	Upward	3	0	0	0	1	nd	0	0	nd	nd	nd	nd	1	nd	nd	0
	Downward	2	0	0	0	5	nd	0	3	nd	nd	nd	nd	0	nd	nd	0
	None	31	1	1	29	71	nd	77	55	nd	nd	nd	nd	17	nd	nd	11
	Total datasets	36	1	1	29	77	nd	77	58	nd	nd	nd	nd	18	nd	nd	11
TOT.	Upward	8	0	0	0	5	nd	0	8	nd	nd	nd	nd	3	nd	nd	0
	Downward	11	0	0	0	10	nd	0	20	nd	nd	nd	nd	1	nd	nd	0
	None	506	2	2	343	898	nd	921	727	nd	nd	nd	nd	173	nd	nd	99
	Total datasets	525	2	2	343	913	nd	921	755	nd	nd	nd	nd	177	nd	nd	99

nd = no data available

11.4 Temporal assessment of organics in sediment

Normalisation for organic contaminants was simpler than for metals, in that organic carbon was the preferred normalisation method. However, as for metals, data from sieved samples could be examined without further normalisation. The number of upward and downward linear trends for time series > 4 years are presented in table 11.4. Trend data were only available from Regions II and III. There were very few significant trends in PAH concentrations in unfractionated sediment from Region II. However, a small number of trends for chlorobiphenyls were detected, almost equally divided between upward and downward trends.

There were 10 downward and 5 upward trends detected in fractionated (63µm) non-normalised data from Region II. Normalisation to carbon increased the number of trends to 20 downward and 8 upward. Data on 63µm sieved sediment from Region III detected 3 significant trends, but these were lost after normalisation to carbon, emphasising the need for good quality analyses of normalising variables.

It was not possible in the time available to make a detailed assessment of the possible underlying reasons for the observed temporal trends in either metals or organic contaminants in sediment. It is recognised that interpretation of the temporal trend data in relation to local conditions, contaminant discharges, etc. is an important further step that should be built in to future assessments.

11.5 Conclusions on statistical methods

11.5.1 Magnitude of analytical variance in biota analyses

The median % contribution of the laboratory analytical variance to the total residual variance is 10% for metals in bivalves and < 5% for metals in finfish and organics in bivalves and finfish (see Appendix 4C). This supports the suggestion that the analytical variance is normally a small component of the overall residual variance in the time series for metals, PAHs and organochlorine compounds in bivalves and fish liver. It also supports the strategy adopted in this assessment exercise to weight data points according to their accompanying QA information.

11.5.2 Statistical power of the monitoring programmes

The between year residual variance of fitted time trends determines the statistical power of the monitoring programmes to detect changes with time. As the residual variance differs between stations, so will the power of the monitoring programmes. Two approaches have been used to describe the statistical power of the monitoring to detect trends:

a. the minimum rate of change that could be detected by annual monitoring over a period of 10 years was considered. The results of these assessments are included in the sections of the report considering each compartment/contaminant combination. An advantage of this approach is that this expression of the capability of the programme is not dependent on the length of the data series. However, it does depend on the assumption that the variance observed in the available time series is a reasonable reflection of the variance that would be observed over longer periods, i.e. the residual variance about fitted time trends is not strongly dependent on the length of the time series. As in the first approach, the results would enable Contracting Parties to identify those time series with high and low power to detect changes;

b. the time series were assessed for their ability to meet an arbitrary objective, for example a change of 20% per year at a power of 80%. About 55% or less of the time series for biota could detect such a change. However many of the time series were relatively short and, as time progresses, the proportion of maintained series able to detect this degree of change will increase. It is suggested that Contracting Parties may wish to identify time series longer than 5 years with low power with a view to attempting to improve their power, or redirect resources to other activities. The process could be carried out with greater confidence if quantitative objectives for the overall programme could be specified and agreed upon.

These approaches have been applied in appendices 4D and 4E respectively.

11.5.3 Methods for weighting data according to quality assurance information

New approaches to analytical QA assessment prepared for this assessment proved to be flexible and adaptable to assessment of the quality/uncertainty of data for both single determinands and grouped determinands (such as ΣCB_7, or groups of PAH compounds). Data inclusion/exclusion policies used in previous assessments were replaced by a uniform approach applicable to data from all years. This was particularly important in relation to early data in long data series, submitted to ICES when there was no requirement for accompanying QA information. All these data could be included in the assessment.

The approach taken to data quality assessment in the previous CEMP temporal trend assessment was to establish analytical quality criteria for the acceptability of data. Data that failed to meet the criteria for acceptability were to be excluded from the assessment.

Over subsequent years, a more detailed analysis of the sources of variance in time series of field data (Nicholson *et al*, 2001) has revealed that, generally, the analytical variance is a small component of the total variance, and that field variance (e.g. between year variance) is more important. It was therefore agreed that the process of accepting/excluding data should be modified, and that data should be weighted according to the apparent quality as indicated by the supporting QA information. No data would be excluded, but data of good quality would be weighted more strongly (weight 1,0) than data with poor or absent QA information (weight 0,2).

This approach has proven to be flexible and adaptable to assess the quality/uncertainty of data for both single determinands and grouped determinands (such as ΣCB_7, or groups of PAH compounds). Data inclusion/exclusion policies used in previous assessments were replaced by a uniform approach applicable to data from all years. This was particularly important in relation to early data in long data series, submitted to ICES when there was no requirement for accompanying QA information. All these data could be included in the assessment.

11.5.4 Normalisation and analysis of sediment data

The procedures used for normalisation and analysis of sediment data were partly developed specially for this assessment. They use the best current advice available from OSPAR Guidelines and ICES documents. The suite of procedures linking the outcome of Laboratory Performance Studies (LPS) with estimation of the likely errors in the normalised data, through to analytical and statistical weighting in the trend analysis have not been used together and represent a very significant step forward.

Comparisons have been made of the power of the temporal trend analyses of non-normalised, normalised, and normalised data from sieved sediments. Normalisation has been shown to improve the statistical power of the trend analysis, and even more so when applied to sieved samples.

11.6 Conclusions on assessment criteria

11.6.1 Development, use and future application of BC/BAC/BRCs

As described in Section 6 this assessment made a trial application of values for BCs and BACs proposed following the OSPAR/ICES Workshop in 2004. For metals in mussel and fish no new values for BCs and BACs were proposed, therefore values for metals were taken from the maximum of the ranges of BRCs in OSPAR agreement 1997-14 (now superseded by OSPAR agreement 2005-06) (for fish only a value for Hg was available). As a result of this trial application an updated OSPAR agreement on Background concentrations for contaminants in seawater, biota and sediment (*OSPAR agreement 2005-06*) has been adopted, which formalises the BCs and BRCs used to represent background concentrations in this assessment.

The assessment did reveal a number of problems with the provisional BACs used for making precautionary tests of whether concentrations are near background. The BACs proposed following the workshop hosted by the Netherlands in 2004 were constructed using the residual variability found in UK monitoring data. This was the only monitoring data conveniently available at the time. In developing these provisional criteria it was recommended that the residual variation in the UK data should be compared with that found in other CEMP time series. In particular, large differences in residual variability would suggest the BACs should be revised. During the preparation of this assessment a number of criticisms of the provisional BACs were noted. As a response, revised estimates of BACs based on the complete CEMP dataset available on the ICES database were calculated. These are presented in Appendix 6 and compared with the BACs based on the UK variability. The conclusions are that:

- the 2 sets of BACs are broadly similar for metals in sediment and for CBs in sediment and in blue mussel;

- the BACs for PAHs in sediment based on the CEMP data are always less than those based on the UK data;
- the 2 sets of BACs are broadly similar for PAHs in blue mussel, although some 'larger' discrepancies appear for both the lightest and heaviest compounds.

There is one important caveat. The residual variability in the UK data was established by taking the yearly contaminant index to be the median log concentration and giving equal statistical weight to each contaminant index. The residual variability in the CEMP data was established by taking the yearly contaminant index to be the median log concentration for biota and the weighted mean log-concentration for sediment, and giving variable statistical weight to each contaminant index. Thus differences in residual variability might arise because of the different statistical treatments.

OSPAR agreement 2005-06 takes up the concept of the use of BACs as statistical tools defined in relation to the BCs, which enable testing of whether mean observed concentrations can be considered to be near background concentrations and sets out that they should be calculated according to the method set out in Section 6.1 of the 2004 report of the ICES Advisory Committee on the Marine Environment. The agreement, however, incorporates the BACs set out in Appendix 6 only as example values and states that they will be refined as further data CEMP monitoring data is collected

In the assessment, UCLs were compared with BAC/BRCs by calculating UCL/BAC (or BRC) ratios. The ratios were displayed graphically (Appendix 12). A classification of the ratios in terms of environmental risk was rejected, because of lack of knowledge concerning the environmental significance of the deviations from the BAC/BRCs. The maps (cf. Appendix 9) show the positions of datasets where the UCL/BAC (or BRC) ratio > 1. The numbers of upper confidence limits of fitted final values of time series above/below the assessment criteria for sediment and biota are set out in table 11.5.

Table 11.5 Numbers of upper confidence limits of fitted final values of time series above/below the assessment criteria for sediment and biota

Substance	**BIOTA**			**SEDIMENT**		
	BAC	BRC	EAC	BAC	BRC	EAC
Cd		103/14	192/3	168/33		202/0
Cu		110/3		125/83		210/0
Hg		180/19	204/0	184/4		147/41
Pb		102/16	30/162	206/4		211/0
Zn		51/66		194/14		209/0
Ant	42/11			93/0		
BAA	49/7			106/3		
BghiP	29/25			41/60		
BAP	3/14			103/8		
CHR	53/6			74/5		
FLU	58/2			113/5		
IDCP	32/18			69/44		
Naph	43/0		0/43			
PA	53/9			109/7		
PYR	61/0			114/4		
CB 153	162/10		128/79	112/12		
CB7	133/8		85/82	98/0		
γHCH	51/94					
Dieldrin			1/6			

For biota, the concentrations of most metals (Cd, Cu, Hg and Pb) were above the BRC or BAC values, as would be expected. By contrast, more than 50% of the Zn concentrations were below the BRC value. This may suggest that the BRC is too high, or alternatively that the regulation of Zn concentrations by biota means that biota analysis is not a good indicator of environmental contamination by Zn.
In general, most PAH concentrations in biota are also above the BAC. However, in some cases (e.g. anthracene, benzo[ghi]perylene, benzo[a]pyrene, and indeno[1,2,3-cd]pyrene) a larger proportion of the

concentrations are below the BAC, in some cases by a factor of up to 3. This may suggest that the BACs for these compounds in biota should be reviewed.

Comparisons were made between final fitted values of sediment time series and proposed BACs. The fitted values for Hg, Pb and Zn were almost all above the BAC. However, 15% of the Cd concentrations and 40% of the Cu concentrations were below the BAC. The BACs for metals in sediment were developed by ICES Working group on marine sediments (WGMS) 2004, and the values proposed were based upon BCs which were towards the upper part of the range of concentrations assessed by that working group as representing background conditions. Concentrations below the proposed BACs are therefore to be expected in areas which are subject to low levels contamination.

BCs for PAH compounds in sediments were developed by the same working group, but were based on an expression of typical background conditions (the median of medians of datasets from background areas). The slight difference in approach would be expected to lead to a smaller proportion of concentrations that were below the BAC. Only in the cases of benzo[ghi]perylene and indeno[1,2,3-cd]pyrene were there large numbers (60% and 40%) of the fitted final values below the BAC. This suggests that the proposed BC and BAC values for PAHs in sediment are generally acceptable, but that some review may be necessary of the BACs for a small number of compounds.

The following conclusions on BRC/BACs and their use in this assessment were drawn:

- for metals the BRCs for biota were felt to be generally applicable. The majority of the ratios were > 1, as was expected. However, in parts of the OSPAR Convention area the calculated ratios for Zn were below the BRC, and it is suggested the applicability of this BRC should be updated in the light of recent;
- for CBs in biota, the BACs were felt to be generally applicable. The majority of the ratios were > 1, as was expected. For PAHs in biota, the BACs were felt to be generally applicable. The majority of the ratios were > 1, as was expected. However, it was noted that the BACs for some compounds may be too high. It was noted that the BACs had been derived from a rather limited dataset, and therefore a review in relation to the whole CEMP dataset has been undertaken.

There is still a need to update the 1997 BRCs for metals in biota and, in the light of the above observations, to consolidate the set of Background Concentrations in OSPAR agreement 2005-05. Further work to do this is planned.

11.6.2 Development, use and future application of EACs

As described in Section 6 this assessment made a trial application of values for EACs proposed following the 2004 ICES/OSPAR Workshop were generally applied on a trial basis (see tables 6.1 and 6.2). The exceptions were the values for secondary poisoning for DDE, dieldrin, CB 153 and ΣCB_7 where the values were taken from OSPAR agreement 1997-14. For mussels and fish, the proposed EACs for DDE and dieldrin for secondary poisoning were considerably lower, about 1-3%, than those used in OSPAR Agreement 1997-14. It was therefore agreed to use EACs from the 1997 agreement instead. For lindane, the new EACs for mussel and fish were only about 22-29% of the previous EACs, however this was used in this assessment.

Direct application of the EACs for DDE, γ-HCH, dieldrin and ΣCB_7 in fish to the monitoring data was not possible because the EACs were expressed on a whole body of fish basis whereas monitoring data were available for fish liver. This problem was overcome by using an extrapolation factor to derive provisional EACs specifically for fish liver tissue on the basis of a literature review. The basis selected for the time trend assessment differed from the basis used for the EACs. This problem was overcome by the selection of appropriate extrapolation factors on the basis of the ICES database.

For PCBs an EAC was only available for ΣCB_7 in biota as derived from the OSPAR agreement 1997-15. The sum was not calculated when data on one or more of the CBs were missing. The datasets for the individual CBs were much more extensive. As it was not practical to assess all the PCB data, CB 153 was selected as it is most abundant. A provisional EAC was derived specifically for this CB, following the reasoning of the EAC workshop.

The dataset selected for the temporal trend assessment contained substantial information on γ-HCH concentrations in blue mussel, however, no EAC was available. An EAC from the previous assessment was used, which was derived following the approach of an earlier workshop, in order to assess this valuable information.

Generally, the comparison of the UCL with the EACs did not pose any technical problems and there were no apparent contradictions between data on different compartments from the same areas. The datasets that were generated during the assessment could be used for a more elaborate study on the performance of the EACs. The main concern identified over the interpretation of comparisons of field data with the EACs and BRC/BAC concentrations arises from the relative values of these assessment criteria. In particular, the EACs for both metals in both sediment and biota are often substantially lower than the BCs/BACs (see table 6.1). It was recognised that the methods used to derive the 2 sets of assessment criteria are different, and that no consistent relationship should be expected between them. However, it seems illogical that BCs should exceed EACs. It was not within the scope of work to make a detailed analysis of how this apparent illogicality may have arisen. However, it is suggested that the derivation of EACs might have involved estimations of critical parameters, such as bioaccumulation factors, toxicity to marine organisms, that had significant inherent uncertainty. Such uncertainties may have been amplified by the application of “safety factors” to toxicity data. It is considered that there is particular scope for review of the proposed EAC values, or reassessment of the interpretation of field sample data which exceed the EAC.

For this assessment, a simplification of the ‘traffic light’ model from previous workshops on EACs was made by focusing only on the extent to which the upper EAC concentration was exceeded. The comparison with the lower EAC concentration level can be straightforward, such as by using a factor of 10 lower than the upper EAC level, and should be made before drawing any conclusions from the assessment. It was realised that EACs do not take into account specific long term biological effects such as carcinogenicity, genotoxicity and reproductive disruption due to hormone balance disturbances, and do not include combination toxicity. With this cautionary note some remarks can be made:

- the concentrations of Cd and Hg in biota exceeded the EACs in virtually all locations. The concentrations of Cd, Pb and Zn exceeded the EAC at all locations, and the concentrations of Hg exceeded the EAC at more than 75% of the monitoring locations. It is difficult to interpret these observations, which might imply widespread cause for concern. However, it is recommended that the EAC values be reviewed in the light of this new information, and noted that in many cases the proposed EAC values were inferior to the BC/BAC values;
- the PCBs exceeded the upper EAC values for sediment and biota at a wide range of locations. Based on the recommendations of the EAC workshop, PCBs should be considered a priority and possible areas of concern should be identified. The geographical coverage of the data available for assessment, however, did not allow the identification of specific areas of concern.

In view of the above observations, further work to develop the provisional EACs used in this assessment has been planned.

11.7 Comparison of CEMP and RID Assessments

Chapter 9 presents a first attempt to consider qualitatively the trends in CEMP time series in the light of trends determined in data collected on inputs to the maritime area, in this case the RID study. An assessment of RID data for the period 1990-2002 for cadmium, mercury and lead, distinguishing between 5 sub-regions of Region II has was prepared in parallel with this assessment of CEMP data. The input of Cd, Hg and Pb from direct discharges and rivers has mainly decreased over the period 1990-2002. This is reflected in the CEMP sediment and biota time series, which predominantly show downward trends for the concentrations of these metals.

11.8 Assessment of organotin specific biological effects monitoring

Chapter 10 presents a preliminary assessment of the extent of organotin specific biological effects in three OSPAR Contracting Parties. The work is generally being carried out in accordance with the OSPAR Guidelines for TBT specific biological effects measurements. In some cases, for example UK data from Sullom Voe and data from some stations in Norway, the populations have been sampled repeatedly and regularly, using standard methodology. The data and supporting information presented and discussed here, and a cursory review of the scope of data submitted to ICES during 2004, indicated that imposex data are available, or being collected, for large parts of the OSPAR Convention area. There is therefore good evidence that a reliable broad scale spatial assessment could be carried out at MON 2005, utilising data from several countries, and that data from some locations would be suitable for temporal trend assessment.

11.9 Preparatory activities for future temporal trend assessments

The previous assessment of CEMP data recommended that the preparation of future assessments would be more effective if more time was focused on the important issues related to interpreting trends (e.g., relation to inputs, local changes, interspecies/tissue relationships). This requires:

a. prior agreement on bases;
b. prior agreement on preferred statistical information;
c. automated QA screening;
d. pre-selected time intervals;
e. a prior evaluation of the extent to which the guidelines were adhered to.

Of these 5 points only the last one was not considered in preparation for this assessment. Particular attention was paid, *inter alia*, to items 1-4 above. MIG brought to MON 2003 recommendations on the underlying principles of the assessment. With the agreement of MON, MIG then applied these principles in preparation for the temporal assessment at MON 2004.

In the light of the experience of preparing this assessment the main areas where further improvement could be made to the assessment process are:

a. there was insufficient time between the posting of biota data products on the web and the meeting date to allow assessors to look through the outputs, spot errors, and contact data centres, ICES or MIG. This should be resolved if a revised time schedule is adopted for future assessments; such as:

ICES delivery checked and finalised data extractions to MIG for processing/analysis	ICES	15 September
Primary assessment, linking to QUASIMEME and statistical assessment	ICES and MIG	7 October
Comments related to primary assessment	MON HOD	1 November
Resolve comments and do final extraction of data	ICES and MON HOD	14 November
Final assessment products for submission to the next meeting of MON in the form of a draft assessment report and annexes	MIG and ICES	Deadline for MON (21 days prior to meeting)

b. assessors were not sufficiently sensitive to apparent anomalies in their data. They should have queried all apparent anomalies as early as possible (e.g. see table above);
c. uncertainties in the data extractions made it necessary to request that the process be repeated several times during the assessment meeting. ICES and OSPAR need to develop some kind of quality assurance procedures for the data extraction phase. A more frequent assessment process would help to minimise this problem;
d. it would be very beneficial if Contracting Parties could work intersessionally with ICES to correct errors that have been identified in their data in the ICES database. MIG and ICES should also endeavour to improve the quality of data in the ICES database;
e. if necessary, it should be possible for MIG to meet with ICES before the next assessment to undertake data extraction and checking of the resultant files
f. interpretation point.

In conclusion, the experience of preparing this assessment emphasised the need for a clear timetable for the assessment process, and the need for Contracting Parties to continue to work with ICES to rectify apparent anomalies in their data held at ICES. Uncertainties in the data extractions made it necessary to request that the process be repeated several times during the meeting. ICES and OSPAR need to develop some kind of QA for the data extraction phase. A more frequent assessment process would help to minimise this problem.

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2005 Assessment of CEMP data

Appendix 1: Glossary
Appendix 2: Species list
Appendix 3: Summary of bases information for biota

2005 Assessment of CEMP data
Appendix 1: Glossary

Abbreviation	Definition
AMAP	Arctic Monitoring and Assessment Programme
ANT	anthracene
As	arsenic
ASMO	Environmental Assessment and Monitoring Committee (under OSPAR)
BAC	Background Assessment Concentration
BAC ratio	UCL/BAC
BAP	benzo[a]pyrene
(BAP+BKF)	benzo[a]pyrene + benzo[k]fluoranthene
BC	Background Concentration
BE	Belgium
BGHIP	benzo[g,h,i]perylene
(BGHIP+ICDP)	benzo[g,h,i]perylene + indeno[1,2,3-cd]pyrene
BRC	Background Reference Concentration
BAA	benz[a]anthracene
CAMP	Comprehensive Atmospheric Monitoring Programme (under OSPAR)
CB	chlorobiphenyl
ΣCB_7	sum of the ”ICES 7 CBs”, i.e. CBs 28, 52, 101, 118, 138, 153, 180
CB 153	CB 153 (a CB congener)
Cd	cadmium
CEMP	Coordinated Environmental Monitoring Programme (under OSPAR)
CHR	chrysene
C_{ORG}	organic carbon
Cr	chromium
CRM	Certified Reference Material
Cu	copper
DDE	dichlorodiphenyldichloroethylene (principle metabolite of DDT)
DDT	dichlorodiphenyltrichloroethane
DE	Germany
DIELD	dieldrin
DK	Denmark
dw	dry weight
EAC	Ecotoxicological Assessment Criteria
EAC ratio	UCL/BAC
ES	Spain
FLU	fluoranthene
(FLU+PYR+BAA+CHR)	fluoranthene + pyrene + benz[a]anthracene + chrysene
FR	France
FS20	fraction of sediment 20µm or less
FS63	fraction of sediment 63µm or less
g-HCH	gamma-HCH, γHCH, lindane
HCH	hexachlorocyclohexane
Hg	mercury
ICDP	indeno[1,2,3-cd]pyrene
ICES	International Council for the Exploration of the Sea
imposex	superimposition of penis and/or vas deferens on female gastropod molluscs
INPUT	Working Group on Inputs to the Marine Environment (under OSPAR)
intersex	pathological alterations in the oviduct of littorinid gastropods and replacement of female by male organs
IR	Ireland
IRM	Internal Reference Material (synonymous with LRM)

Abbreviation	Definition
IS	Iceland
ISI	Intersex Sequence Index
JAMP	Joint Assessment and Monitoring Programme (under OSPAR)
LO_{IGN}	loss on ignition, occasionally used for estimating organic matter (carbon) content
LPS	Laboratory Performance Study (eg QUASIMEME)
LRM	Laboratory Reference Material (synonymous with IRM)
lw	lipid weight
MIG	MON intersessional group
MLY	fitted value for the last year of a time series
MON	Working Group on Monitoring (under OSPAR)
NAP	naphthalene
Ni	nickel
NL	Netherlands
NMMP	UK National Marine Monitoring Programme
NO	Norway
normaliser	a supporting variable used to correct for the effects of changes in the bulk composition of the sample matrix on the concentration of the target contaminant
OSPAR	OSPAR Commission (Convention for the Protection of the Marine Environment of the North-east Atlantic)
OSPAR Regions	Region I: Arctic waters Region II: Greater North Sea Region III: Celtic Seas Region IV: Bay of Biscay and Iberian Coast Region V: Wider Atlantic
(PA+ANT)	phenanthrene + anthracene
PAH	polycyclic aromatic hydrocarbons
Pb	lead
PCB	polychlorinated biphenyl
ΣPCB_7	sum of the ”ICES 7 CBs”, i.e. CBs 28,52,101,118,138,153,180
PCI	Penis Classification Index
PHE	phenanthrene
ppDDE	see DDE
PYR	pyrene
QA	Quality Assurance
QSR 2000	OSPAR Quality Status Report 2000
QUASIMEME	Quality Assurance of Information for Marine Environment Monitoring in Europe
REPNO	replicate number (ICES database code)
RID	Comprehensive Study of Riverine Inputs and Direct Discharges (under OSPAR)
SE	Sweden
Se	selenium
SEQNO	sequence number (ICES database code)
SIME	Working Group on Concentrations, Trends and Effects of Substances in the Marine Environment (under OSPAR)
SUBNO	subsample number (ICES database code)
TBT	tributyltin
TOC	Total organic carbon
TS	Time Series
UCL	Upper Confidence Limit of the fitted value for the last year of a time series
UK	United Kingdom
US2000	unfractionated sediment. Sediment sieved at 2000µ and excluding material >2000µ
VDSI	Vas Deferens Sequence Index
WGMS	ICES Working Group on Marine Sediments in Relation to Pollution

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Appendix 2: Species list

Common name	Scientific name	Rubin code
Fish		
Atlantic cod	*Gadus morhua*	GADU MOR
dab	*Limanda limanda*	LIMA LIM
flounder	*Platichthys flesus*	PLAT FLE
herring	*Clupea harengus*	CLUP HAR
megrim	*Lepidorhombus whiffiagonis*	LEPI WHI
plaice	*Pleuronectes platessa*	PLEU PLA
whiting	*Merluccius productus*	MERL PRO
Invertebrates		
blue mussel	*Mytilus edulis*	MYTI EDU
common shrimp	*Crangon crangon*	CRAN CRA
common whelk	*Buccinum undatum*	
dogwhelk	*Nucella Lapillus*	
Mediterranean mussel	*Mytilus galloprovincialis*	MYTI GAL
Pacific oyster	*Crassostrea gigas*	CROS GIG
common periwinkle	*Littorina littorea*	
netted dogwhelk	*Nassarius reticulata*	
netted dogwhelk	*Hinia reticulata*	
red whelk	*Neptunea antiqua*	
sand gaper	*Mya arenaria*	MYA ARE

Abbreviation	Definition
wt	weight
ww	wet weight
Zn	zinc
Z-SCORE	standard method of expressing performance in Laboratory Performance Studies. Describes the deviation of a data point from the target (or assigned) value. Expressed as a ratio between that deviation and a pre-defined target standard deviation

2005 Assessment of CEMP data
Appendix 3: Summary of bases information for biota

Summary of bases information for biota

The following tables give, by contaminant and tissue type, the total number of yearly medians available (all), the number of yearly medians available on a wet weight basis (ww), the number of yearly medians available on a dry weight basis (dw), and for organics, the number of yearly medians available on a lipid weight basis (lw). The bases used for the assessment is highlighted in bold.

Metals

	Fish muscle			Fish liver			Bivalve tissue			Shrimp tails		
	all	**ww**	dw	all	**ww**	dw	all	ww	**dw**	all	**ww**	**dw**
Ag	0	0	0	0	0	0	37	37	**23**	0	0	0
As	76	**76**	38	74	**74**	61	245	245	**222**	0	0	0
Cd	0	0	0	695	**693**	514	1389	1354	**1355**	7	**7**	0
Cr	0	0	0	100	**100**	87	192	190	**170**	0	0	0
Cu	93	**93**	80	381	**379**	380	1322	1288	**1294**	7	**7**	0
Hg	737	**734**	598	22	**22**	20	1372	1337	**1338**	7	**7**	0
Ni	0	0	0	44	**43**	44	201	199	**181**	0	0	0
Pb	0	0	0	611	**609**	432	1361	1327	**1333**	7	**7**	0
Se	0	0	0	0	0	0	91	91	**91**	0	0	0
Zn	93	**93**	80	379	**377**	378	1370	1336	**1342**	7	**7**	0
Total	999	**996**	796	2306	**2297**	1916	7580	7404	**7349**	35	**35**	0
%loss		**0,3**	20,3		**0,4**	16,9		2,3	**3**		**0**	100

PAHs and tributyltin

	Bivalve tissue			
	all	ww	**dw**	lw
Anthracene	554	534	**541**	75
Benzo[a]anthracene	571	551	**556**	84
Benzo[a]pyrene	558	538	**544**	76
Benzo[ghi]perylene	561	541	**546**	69
Chrysene	415	413	**415**	27
Chrysene+triphenylene	103	103	**87**	54
Fluoranthene	579	559	**565**	75
Indeno[123-cd]pyrene	548	528	**534**	68
Naphthalene	503	483	**501**	45
Phenanthrene	590	570	**574**	84
Pyrene	589	569	**573**	84
Tributyltin	119	116	**117**	97
Total	5690	5505	**5553**	838
%loss		3,3	**2,4**	85,3

CB153 and related compounds

	Fish muscle				Fish liver				Bivalve tissue				Shrimp tails			
	all	**ww**	dw	lw	all	ww	dw	**lw**	all	ww	**dw**	lw	all	**ww**	dw	lw
CB153	277	**277**	162	277	554	552	383	**542**	1128	1109	**1098**	642	7	**7**	0	7
DDE (p,p’)	269	**268**	150	269	323	320	285	**321**	723	706	**709**	456	7	**7**	0	7
Dieldrin	24	**24**	0	24	23	23	0	**23**	45	45	**28**	11	7	**7**	0	7
Hexachlorobenzene	277	**277**	162	277	440	438	391	**438**	616	616	**585**	570	7	**7**	0	7
γ-HCH	275	**275**	160	275	337	335	287	**335**	996	976	**981**	490	7	**7**	0	7
Total	1122	**1121**	634	1122	1677	1668	1346	**1659**	3508	3452	**3401**	2169	35	**35**	0	35
%loss		**0,1**	43,5	0		0,5	19,7	**1,1**		1,6	**3,1**	38,2		**0**	100	0

2005 Assessment of CEMP data
Appendix 4: Details of statistical methods and analyses

Table of contents

1 Background

The statistical methods used to assess temporal trends have been developed over several meetings of the Working Group on Monitoring (MON). They have responded to the need to be:

- robust i.e. to be both routinely applicable to many datasets and to be as insensitive as possible to statistical assumptions and adverse numerical features such as individual extreme concentrations, partial bulking of samples and less-than values;
- intuitive i.e. for the results of the analysis to be understandable without a detailed understanding of statistical theory;
- revealing i.e. to provide easy access to several layers of information about the major features of the data – both those of direct interest such as evidence of simple trends and the more negative features, such as missing years, years with all results below the limit of detection, extreme values and so on.

Only biota time series have previously been assessed by OSPAR. The method used in the last assessment is briefly described below. Innovations for this assessment are then described, first for biota, and then for sediment time series.

The main characteristics of the data collected under the monitoring guidelines for contaminants in biota for temporal trend analyses are:

- biota are collected annually at the same time within each year;
- that this time should be outside the spawning period;
- the same size range of the target species is sampled each year;
- the prescribed sampling scheme is followed and the sample size is the same each year.

The aims of the guidelines are to provide some control over both between-year biological variation (e.g. mean length, condition, stock composition) and within-year biological variation (e.g. individual fish length)

Essentially, each dataset is reduced to a time series of annual contaminant indices, which for biota are the annual median log-concentrations. For each time series with 7 or more years, trends are summarised by a loess smoother, a non-parametric curve fitted to the annual contaminant indices. This summary is supported by a formal statistical test of the significance of the fitted smoother and by tests of the linear and non-linear components of the trend. Few statistical assumptions are required for the fitted smoother to be valid. Mainly, the annual contaminant indices should be independent with a constant level of variability. The validity of the statistical tests also requires the residuals from the fitted model to be normally distributed. The theory and methodology are described in detail in Fryer & Nicholson (1999).

A simpler analysis is adopted for time series with less than 7 years. For time series of 3 or 4 years, the average of the median log-concentrations is computed. For time series of 5 or 6 years, a linear regression is fitted to the median log-concentrations and the significance of the linear trend assessed.

Current levels are compared to BACs / EACs by computing the ratio of the upper 95% confidence limit on the fitted smoother in the final year of the analysis to the BAC / EAC. In the case of the BAC, this provides a precautionary test of whether concentrations are ‘close to background’ (Nicholson & Fryer, 2003; OSPAR, 2004).

The assessment presents the opportunity to review the power of the monitoring programmes to detect temporal trends in concentrations. The main body of the report considers the ten-year detectable trend; the % yearly change in concentration that would be detected by a ten-year monitoring programme with 90% power at the 5% significance level (Nicholson *et al.* 1997) (see Appendix 4D). An alternative approach, as used in assessments of data from the Baltic Sea area, is presented in Appendix 4E.

2 Innovations for biota time series

The following innovations were introduced in the current assessment.

2.1 Treatment of missing years

As in the previous assessment, a loess smoother with a fixed 7-year window is used to summarise trends. However, for practical reasons, the method was simplified in the previous assessment by treating all non-missing years as if they were contiguous, allowing a fixed smoothing matrix to be used for each length of time series. In this assessment, the coefficients of the smoothing matrix are re-calculated to deal correctly with any pattern of missing data.

2.2 Treatment of data of varying analytical quality

In the previous assessment, data screening for analytical quality resulted in two classes of data: 'acceptable' and 'unacceptable'. Only data with 'acceptable' QA were used and were assessed for trends using smoothers with each observation given equal statistical weight. However, many data were rejected as 'unacceptable' and this led to the shortening or loss of many time series. Nicholson et al (2001) argued that the QA acceptance criteria were too stringent and that some data, previously rejected as unacceptable, could be used in future assessments if they were appropriately down-weighted in the statistical analysis. Appendix 4A provides an overview of the availability of, and an evaluation of QA information.

In this assessment, data are given analytical weights according to the available QA. An iterative procedure (Fryer, 2004) is then used to convert these analytical weights into statistical weights that account for the relative magnitudes of the environmental and analytical variances. A weighted loess smoother (Nicholson & Fryer, 2001; Uhlig, 2001) is then fitted to the median log-concentrations, leading to the same tests of significance as before.

Three types of quantitative QA information are potentially available for each data point:

- QUASIMEME z-scores, as supplied to ICES by analytical laboratories, through the collations of laboratory performance study results distributed to participating laboratories on CD by QUASIMEME in summer 2004.
- QUASIMEME z-scores already previously held in the ICES QA database – these are taken to be acceptable if between -2 and +2
- CRM values – these are taken to be acceptable if the CRM lab concentration is within 25% of the CRM true concentration

Inspection of the QUASIMEME data already held in the ICES database strongly suggested that they were not very reliable, because a) they were incomplete and b) it was not clear how the multiple z-scores obtained each year for each determinand-matrix combination were reported to ICES. Procedures were therefore developed to summarise the QUASIMEME CD data to give a single annual expression of performance for each determinand-matrix combination. Specifically, the individual z-scores in each year for each determinand-matrix were squared, summed and compared to the critical value of a χ^2 distribution. The data were considered to indicate acceptable performance (pass) if:

$$\sum_{i=1}^{n} Z_i^2 < \chi_n^2(0.95)$$

where n is the number of z-scores and $\chi_n^2(0.95)$ is the upper 95 percentile of a χ^2 distribution on n degrees of freedom. In practice, the critical value was computed as $3.84 \times n^{0.66}$.

Analytical weights were then assigned to the annual contaminant indices according to the Table below:

QUASIMEME 2004 CD	QUASIMEME data already held by ICES	CRM performance	Analytical weight
Pass	Pass	Pass	1,0
Pass	Pass	Fail or absent	1,0
Pass	Fail or absent	Pass	1,0
Pass	Fail or absent	Fail or absent	1,0
Fail or absent	Pass	Pass	1,0
Fail or absent	Pass	Fail or absent	0,7
Fail or absent	Fail or absent	Pass	0,7
Fail or absent	Fail or absent	Fail or absent	0,2

2.3 Persistent bias

A problem with many trend analysis procedures is that the conclusions can be affected by the presence of persistent bias in the data. Both detection of, and correction for, persistent bias are technically difficult. To partially address this problem, MIG considered that step changes in concentrations reported in field data coinciding with step changes in QA performance might indicate some forms of persistent bias. Visual examination of some time series suggested shifts in field concentrations had occurred when QA practices had changed. More formally, a process was developed to compare concentrations in field samples in periods before and after step changes in QA performance, as indicated by step changes in the analytical weights applied to data points. The summary tables provided to assessors flagged those time series in which such changes may have occurred. Time series with less than three years of data with good QA (an analytical weight of unity) were also flagged with a view to them being excluded from the assessment.

Appendix 4C presents an examination of the magnitude of analytical variance in biota analyses.

3 Sediment time series

The assessment of sediment time series differed from that of biota time series in the following ways.

3.1 Normalisation of contaminant concentrations

Temporal trend assessment of contaminant concentrations in sediment firstly requires that the concentrations are normalised to take account changes in the bulk physical composition of the sediment, primarily to accommodate changes in particle size distribution or organic carbon content, which can work to obscure true changes in the quality of the sediment. The procedures for normalisation are fully described in Technical Annex 5 to the JAMP Guidelines for Monitoring Contaminants in Sediments (OSPAR 2002), and were applied to the data in the current assessment as detailed in Appendix 4B.

Other aspects of normalisation, including the estimation of the error of the resultant normalised concentrations, are presented in Annexes 8 and 9 to the 2002 report of the ICES Working Group on Marine Sediments in Relation to Pollution. Normalisation of concentrations requires the estimation of pivot values (i.e. the concentrations of contaminants and normalisers in pure sand sediment) and the combination of analyses of contaminants and co-factors. The procedures described in this report for the estimation of the errors in the normalised concentrations were applied to the data for each time series of sediment analyses.

The errors of measurements of contaminants and cofactors were modelled as comprising two components; a fixed component (sCm) and a variable component (V_{Cm}) as in Appendix 4B – Table 4B1. The values of sCm were applied to all data unless information was available on the detection limit of the analyses. In this case, sCm was adjusted to one third of the stated detection limit.

The value for the variable component was adjusted according to the available information on analytical performance. This consisted of z-scores from QUASIMEME CDs distributed in 2004, QUASIMEME information already in the ICES database, and z-scores calculated from analyses of CRMs. The root of the mean square z-score of each annual group of z-scores was calculated for each laboratory, for each year, and was used as an indicator of data quality. This process was moderated by truncating the range of squares at values of 1 and 9, i.e. low values less than 1 were set to 1 and high values greater than 9 were set to 9. By this process, the influence of errors arising from factors such as misreporting of units, etc were minimised.

The variable errors from Table 4B1 were then multiplied by the root of the mean square z-score to give a modified variable error applicable to each annual set of data. Combination of the fixed and modified variable errors gave an expression of the overall error in each data point.

3.2 Removal of not very useful data points

Some normalised concentrations were negative and these were excluded from any further analysis. Normalised concentrations with an overall error of 100% or more were also excluded.

3.3 Construction of annual contaminant index

The annual contaminant index was taken to be the weighted mean log-concentration, where the weights were a suitable combination of the analytical variation computed above and (where possible) an estimate of the within-year field variation.

Let c_{yi} be the normalised concentration of sample i in year y and let σ_{yi} be the analytical standard deviation associated with this concentration (the overall error calculated above).

The analytical standard deviation of the normalised log-concentration $\log(c_{yi})$ is then approximately σ_{yi}/c_{yi}.

Let τ be the within-year field standard deviation (assumed known for now).

The joint analytical and within-year field variance of $\log(c_{yi})$ is then $v_{yi} = \tau^2 + \sigma_{yi}^2 / c_{yi}^2$.

The annual contaminant index z_y is then taken to be the weighted average of the $\log(c_{yi})$:

$$z_y = \frac{\sum_i w_{yi} \log(c_{yi})}{\sum_i w_{yi}}$$

where $w_{yi} = 1 / v_{yi}$.

The joint analytical and within-year field variance of the annual contaminant index z_y is $1/\sum_i w_{yi}$

When there were multiple samples in at least one year of the time series, the within-year field standard deviation τ was estimated by restricted maximum likelihood with the analytical standard deviations assumed known and equal to σ_{yi}. When there was only one sample each year, τ was taken to be zero, and the variance of the annual contaminant index is only a measure of the analytical variability.

3.4 Assessment of temporal trends

The annual contaminant indices are given 'within-year' weights $\sum_i w_{yi}$. An iterative procedure (analogous to that used for biota) is then used to convert the 'within-year' weights into statistical weights that account for the relative magnitudes of the within-year and between-year variability. A weighted loess smoother is then fitted to the annual contaminant indices to assess for temporal trends

4. References

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Availability and evaluation of QA information

1. Types of QA information

For the use of data in an assessment it is important that the data are of acceptable quality. For the assessors several types of quantifiable QA information was available:

1. Results of reference materials reported to the ICES database.
2. Z-scores obtained in the QUASIMEME laboratory performance studies and reported to the ICES database
3. Information on the whole suite of Z-scores collected by QUASIMEME on CDs and supplied to ICES via the participating laboratories

In some cases multiple sampling was supplied offering the opportunity a component of sampling variability.

The QA information was incorporated in the assessment as described in "Statistical methods". For biota the QA information was transferred in weight factors that were 0,2, 0,7 or 1 depending on the fitness (cf. Appendix 4 section 2.2). The sediment data were normalised before use in the assessment and normalisers also have a contribution to the uncertainty of the result. Therefore, QA- information on sediment data were transferred into an error-factor (eF) that was used in the estimation of the standard deviation of the normalised result. This estimation also included the uncertainty of the pivot values (i.e. the concentrations of both normalisers and contaminants in sand) used in the normalisation process).

Results on CRM values are not useful if not information on true or assigned values are available. CRMs have been in use for a long time and therefore the CRM information for sediment in the database was evaluated, also with a view on whether it should be continued to collect these information in the ICES database (see below).

The statistical methods are described elsewhere, and some specific considerations and manipulations of the QA data are dealt with in section 3. It should be noted that this evaluation was done before eF were applied and other criteria for "satisfactory" were relevant. However, the overall conclusions for both approaches were the same.

Tables 4A1-4A3 present an overview of how much data were accompanied by QA information, what QA was available and how much was satisfactory.

Table 4A1 Summary of QA information for biota. For each year, the table gives the number of yearly medians (*n*), the proportion of yearly medians with supporting QA information (there), and the proportion of yearly medians with acceptable supporting QA information (pass). There are three types of QA information: QUASIMEME CD data, QUASIMEME data in the ICES database, and CRM data in the ICES database.

	metals							CB153 and related compounds							PAHs and tributyltin						
	n	Quas CD		Quas ICES		CRM		*n*	Quas CD		Quas ICES		CRM		*n*	Quas CD		Quas ICES		CRM	
		there	pass	there	pass	there	pass		there	pass	there	pass	there	pass		there	pass	there	pass	there	pass
1978	2	0	0	0	0	0	0														
1979	23	0	0	0	0	35	30														
1980	21	0	0	0	0	29	19	2	0	0	0	0	0	0							
1981	39	0	0	0	0	46	8	2	0	0	0	0	0	0							
1982	43	0	0	0	0	44	9	6	0	0	0	0	0	0							
1983	95	0	0	0	0	23	6	15	0	0	0	0	0	0							
1984	124	0	0	0	0	18	5	16	0	0	0	0	0	0							
1985	158	0	0	0	0	5	0	20	0	0	0	0	0	0							
1986	141	0	0	0	0	30	23	49	0	0	0	0	0	0							
1987	248	0	0	0	0	51	45	61	0	0	0	0	23	0							
1988	268	0	0	0	0	58	49	76	0	0	0	0	28	0							
1989	206	0	0	0	0	78	58	93	0	0	0	0	29	0							
1990	485	0	0	0	0	81	68	228	0	0	0	0	12	0							
1991	339	0	0	0	0	88	71	220	0	0	0	0	18	18							
1992	363	0	0	0	0	85	67	275	0	0	0	0	19	16	10	0	0	0	0	70	0
1993	412	0	0	10	9	88	81	307	0	0	10	10	8	8							
1994	670	0	0	10	9	91	87	399	0	0	24	18	28	14	529	0	0	0	0	0	0
1995	679	0	0	17	16	94	87	426	0	0	23	15	26	26	559	0	0	0	0	1	0
1996	710	30	30	48	35	94	92	456	55	42	21	15	33	21	569	0	0	0	0	1	0
1997	772	33	32	38	27	94	90	556	58	55	38	26	9	5	544	0	0	0	0	0	0
1998	767	43	38	68	66	92	75	394	81	81	51	39	22	6	610	4	1	4	1	1	1
1999	956	83	81	55	54	82	66	582	64	63	37	24	8	5	782	5	4	9	7	2	1
2000	992	83	83	34	33	71	66	631	67	63	36	35	10	10	846	3	3	7	7	64	1
2001	1013	83	53	48	47	80	73	621	66	65	40	39	19	16	753	15	8	83	73	15	13
2002	620	78	78	34	34	77	49	391	98	97	43	43	24	23	135	22	21	64	48	34	23
2003	467	94	94	51	46	76	49	354	99	85	41	40	22	22	157	68	66	6	6	75	65

TABLE 4A2 Summary of QA information for sediment. For each year- parameter-station-method combination the availability of QA information was collected. The results of the individual parameters are grouped according to co-factors (Al, Li and Corg), heavy metals (8), CBs (7) and PAH (10). In addition columns indicating the mumber of times QA was available (there) in respectively the QUASIMEME CD, Z-score reported to ICES and CRM values measured. For each individual was tested if Z-value was less than 2. LRM and measured CRM values that did not have corresponding true or assigned values were counted as absent info (not included in column "there"

	Co-factors							Heavy metals						
	n	Quas CD		Quas ICES		CRM		n	Quas CD		Quas ICES		CRM	
		there	Z<2	there	Z<2	there	Z<2		there	Z<2	there	Z<2	there	Z<2
1985	44							189						
1986	32							168						
1987	156							663						
1988	29							184						
1989	43							176						
1990	247					19	19	1220					689	549
1991	174							889					613	417
1992	175					36	36	743					525	348
1993	190					33	33	550					342	193
1994	125			10	10	4	4	632			247	214	545	444
1995	246			75	6	69	69	794			712	579	769	454
1996	302	142	142	61	55	55	55	945	706	571	672	419	751	425
1997	222	143	143	88	88	44	44	817	641	641	354	176	725	514
1998	220	162	162	105	100	5	5	689	457	457	457	367	630	630
1999	320	220	186	147	79	54	54	1182	922	852	556	441	1039	1039
2000	438	115	97	226	152	63	63	1758	1040	1002	670	501	1676	1592
2001	338	324	319	224	224	69	69	1129	1114	1075	671	671	972	967
2002	492	462	417	287	287	101	101	1419	1419	1419	866	573	1255	1091
2003	243	186	145	28	28	112	112	884	884	629	211	181	796	700

TABLE 4A3 Availability of QA information of sediment data. (see Table 4A2 for explanation).

	Chlorinated biphenyls							Polyaromatic hydrocarbons						
	n	Quas CD		Quas ICES		CRM		n	Quas CD		Quas ICES		CRM	
		there	Z<2	there	Z<2	there	Z<2		there	Z<2	there	Z<2	there	Z<2
1985	28							20						
1986	83													
1987	211							54						
1988	225							50						
1989	7							9						
1990	547					24	24	222					16	16
1991	217													
1992	349													
1993	283			99	99			144						
1994	406			187	187			60					54	48
1995	175			133	97	91	91							
1996	418	218	170	133	133	133	133	300	256	256				
1997	443	395	127	164	100	98	98	440	352	308	88	33		
1998	378	189	189	287	179	98	98	348	268	241	216	81		
1999	638	535	414	287	232	348	348	601	491	437	201	139	280	280
2000	828	576	238	313	233	301	286	1072	728	591	254	126	302	302
2001	664	631	513	329	299	376	376	898	830	686	151	119	230	230
2002	890	890	658	476	138	546	512	1147	1050	820	431	414	427	427
2003	873	728	461	474	315	475	285	1017	835	664	342	207	267	192

2. Evaluation of the data on reference materials in sediments

Reporting of data on reference materials (RM) for sediments was introduced around 1990. Information on RM analyses is reported annually in conjunction with the method information. It should give information on the performance of the applied method with regard to accuracy, variability and bias. Data on a large variety of materials have been reported. For example, for four representative parameters 13 RMs were used for aluminium, 21 for cadmium, 26 for CB153 and 21 for fluoranthene, however except for cadmium, less than half of the RMs had certified or assigned (QUASIMEME) values, i.e., 38%, 81%, 35% and 43%, respectively (Table 4A4). For some QUASIMEME samples (Cmco in Table 4A4 that start with Q and ends with MS) the assigned values were not entered yet when this evaluation was made.

Laboratories are not consistent in using the same RM throughout the years (Table 4A4). The longest series was reported for RVZB (BE) with 8 subsequent years for a QUASIMEME RM. This assessment did not take into account that laboratories may have changed names, nor that laboratories were allowed to report only one RM per year per method. Furthermore, some laboratories tend to show that their values are on a constant level while others seem to focus on showing a limited bias for different RMs. These tendencies are not consistent.

MON 2003 proposed/agreed on a screening procedure that would down-weight data of which the parallel analysed RMs show unsatisfactory results. Satisfactory result should be within 25% of the certified or assigned RM value.

However, RMs do not always have confirmed values for the parameters to be measured. From the ca.2600 reported method-year combinations, about 1500 have QC data on RMs, and 812 can be compared with confirmed values. Of these, 73% met the criterion for being satisfactory (within 25% of the target value). Of the 27% that did not meet the criterion, more than half (i.e. 16% of all data) were reported with obviously wrong units. Correcting the units for these data increased the proportion of satisfactory data to 87%. It should be noted that when the units in these data had been corrected, still only 67% of the data were satisfactory. This may indicate that careless reporting could be linked to lower analytical quality too. This situation is illustrated in Figure 4A1 for the representative parameters: aluminium, cadmium, CB153 and Fluoranthene. A high score like this is expected, because it is generally assumed that laboratories would not report unsatisfactory results to ICES.

In general, analyses of RM met the criteria set by MON. Since this criterion is 2 times a target deviation (i.e. a z-score between -2 and +2) for QUASIMEME reference materials and within 25% for the other RMs, statistically 95% of data should meet this criterion. The 87% that met this criterion for RM analyses is similar.

It is the opinion of this assessment that laboratories should not report measurements of RM if the RMs do not apply, and not submit monitoring data if accompanying measurements of RM are unsatisfactory. If this were the case then it would be sufficient just to confirm that a laboratory was using an RMs as a QA measure. It would then be that RMs would be mainly a quality assurance tool for internal laboratory use.

Occasionally, laboratories reporting analyses of QUASIMEME test materials as both QUASIMEME performance data and as analyses of reference materials. The accompanying z-scores are of course closely correlated and one of them should be ignored. Such an exclusion process was not performed by the assessors. It did not occur very often and, given the fact that most weight was given to the Z-scores from the QUASIMEME CDs, it would not have a serious effect on the weighting levels.

It is also the opinion of this assessment that ICES provide proper advice about submission of RM results. For example, whether it is preferred to report the same all the time or vary, or if the results for more than one RM can be reported, and if so, how.

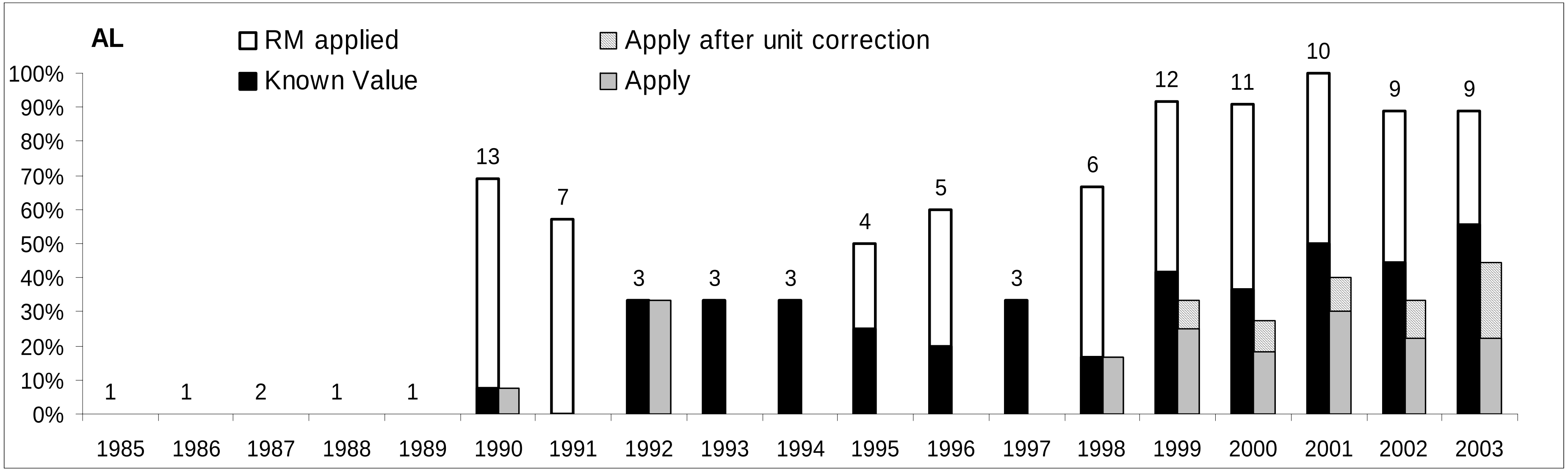
Table 4A4 Overview of reference materials (Cmco) used by laboratories (Alabo) for representative parameters of sediment 1989-2003; number of years* (n) and number of years with confirmed values (nC), which if present equals n.

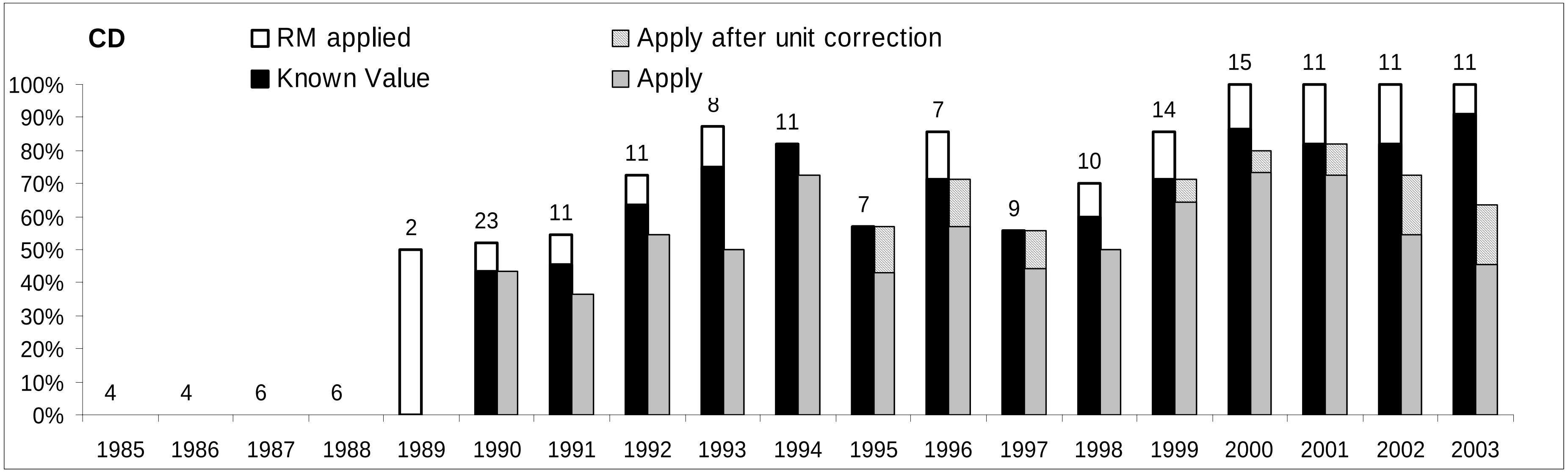
		AL		CD	
Crmco	Alabo	n	nC	n	nC
ABSS	BSHG	6	6	7	7
	IFOG	2	2	1	1
ABSS1	BSHG			2	
BCSS-1	BLUK	5		5	5
	FRCI	1		6	6
	HFLD	2		2	2
	IEOV			1	1
	ISOB	1		6	6
	NIVA	2		6	6
CRM142	LNUG	1		1	1
	LWKG	1		4	4
CRM277	DANI	5	5	5	5
CRM320	IMWT	1	1	1	1
	NLEG			3	3
	NLWG			2	2
	STUK	4	4	4	4
	WLUK	5	5	5	5
DORM-1	ISOB			1	1
GBW07401	ALNG	2		2	2
HS-1	ISUK	4		4	
IRM	DGWN			2	
	RIKZ	3		4	
MESS-1	BLUK			4	4
	FIER			4	4
	MRII	1		1	1
MESS-2	BSHG	6		6	6
	ICNF	1		1	1
	IFOG	4		4	4
	NERI	2		1	1
	NIVA			2	2
MESS-3	ICNF	1	1	1	1
	ISOB			3	3
	ISUK	1	1	1	1
	STUK	1	1	1	1
PACS-1	BLUK	6			
PACS-2	ALUK	5	5	5	5
QTM039MS	LNUG	2		2	2
QTM048MS	RIKZ			1	1
QTM052MS	NLEG			1	1
	RIKZ			1	1
QTM059MS	RIKZ			1	1
SRM1645	NLWG			1	1
SRM2704	ISHG			2	2
	KAWG			3	3
(blank)	ALUK	2		2	
	BFGG			3	
	BIOC	1		2	
	BLUK			6	
	BSHG	8		6	
	DFLH			1	
	DGWN			2	
	FRCI	5			
	FRUK			2	
	HFLD			1	
	IFOG			1	
	IHEB			3	
	IHLP			2	
	IMWP			4	
	ISHG			4	
	ISOB	1		3	
	KAWG	3			
	LSCC	1		1	
	LWKG	2			
	NIVA	2		10	
	RCMA			4	
	RIKZ	5		1	
	RIZA			1	
	RSSB			1	
	SERO			1	

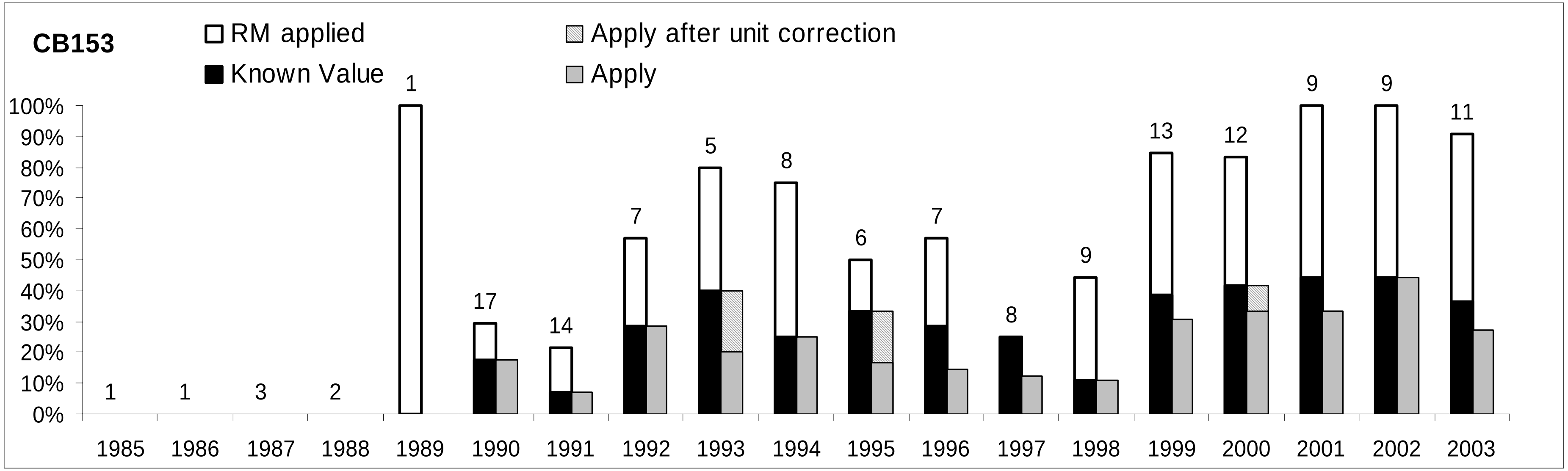
		CB153		FLU	
Crmco	Alabo	n	nC	n	nC
BCSS-1	SEPW	2			
BSHREF03	BSHG	1		1	
BSHREF1	BSHG	2		2	
CRM349	FRCI	2	2		
CRM536	DANI	4		4	
EC-7	LMRF			1	1
FHHUB1	WEJG	4			
HS-1	BLUK	2	2		
	IEOV	1	1		
	IFLI	1	1		
	ISUK	1	1		
	NIVA	3	3		
HS-2	LMRF	1	1		
HS-3	ALUK			1	1
HS-4	IMRN			2	2
	UNIN			4	4
HS-6	BLUK			4	
IAEA-357	SEPE	3			
IRICOD4	RVZB	2			
IRM	ALUK	2			
	DGWN	2		2	
	RIKZ	4		4	
IRMP2	ALNG	1		1	
IRMSEDEL	BFGG	2			
LRM	ALUK	5		5	
P2/95	ALNG	2		1	
Q23MS	SEPE			1	
QOR007MS	RVZB	1			
QOR011MS	RVZB	1			
QOR017MS	RVZB	8	8		
QOR027MS	RVZB	1	1		
	SEPW	1	1		
QOR058MS	RIKZ	1	1		
QOR062MS	LNUG	1	1		
	RIKZ	1	1		
QOR069MS	RIKZ	1			
QOR074MS	NLEG	1			
QPH022MS	RIKZ			1	1
QPH023MS	SEPE			1	1
QPH026MS	MUMM			3	3
	RIKZ			1	1
QPH033MS	RIKZ			1	1
QPH035MS	SEPE			1	
QPH038MS	NLEG			1	
SETOC701	YWUK	1		1	
SRM1941	BFGG			1	1
	NIVA	4	4	5	5
SRM1944	ISUK	2	2		
	WLUK	5	5	5	5
	YWUK	4	4	4	4
(blank)	BFGG	1		1	
	BLUK	4			
	BSHG	8		5	
	DGWN	2		2	
	ECCB			1	
	ICNF			1	
	IHEB	10		2	
	IHLP	1			
	IMRN	2		4	
	IMWP	4			
	ISHG	2			
	LABF	1			
	LMRF	1		1	
	LNUG	2			
	LWKG	4			
	NERI	1		2	
	NILU	2			
	NIVA	2		1	
	NLEG	2		2	
	RCMA	3		5	
	RIZA	1		1	
	SERI	1		1	
	UNIN	4		6	
	WEJG	5		1	

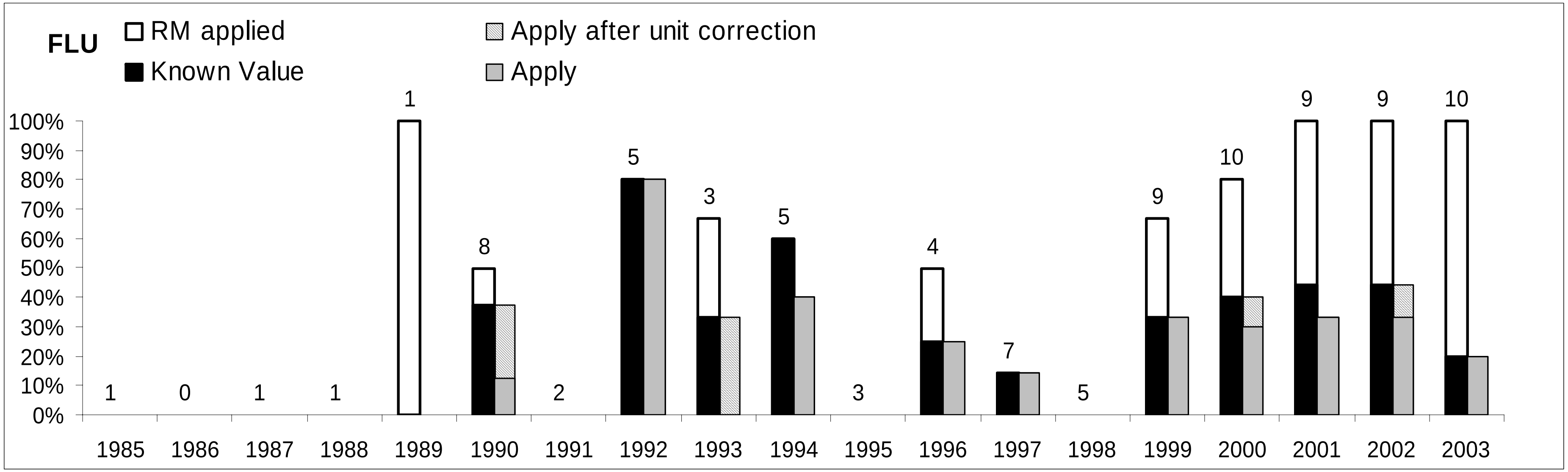
* The number actually represents the number of Cmco-Alabo combinations in the database which generally corresponds to the number of years; the few exceptions were where 2 or 3 combinations were submitted for one year.

Figure 4A1 Percentage of data for aluminium (Al), cadmium (Cd), CB153, and fluoranthene (FLU) 1989-2003: where RMs have been used (open bar), where certified or assigned (QUASIMEME) values for RM are known (solid bar), where measured values were within the ±25% range of the certified or assigned value (gray bar) and where the complied with the certified or assigned values after correction of wrong reporting units.






CB153
RM applied
Known Value
Apply after unit correction
Apply
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003


FLU
RM applied
Known Value
Apply after unit correction
Apply
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003

3. Handling of QA information.

The QA information from QUASIMEME was transformed with regard to detection limits and also where data were clearly reported with gross errors arising from the use of the wrong units, or errors of powers of 10.

3.1 Detection limits for biota and sediments

Values reported as below detection limit were usually reported as less then some concentration higher than the QUASIMEME assigned value. QUASIMEME calculate the z-scores for values below detection limit in 1996 and 1997 but this practice was discontinued because the statistics applied were inadequate and in principle values below the detection limit are not necessarily wrong. However, if the detection limit is far below the assigned value a different situation arises. The usual definition of the detection limit is 3 times the standard deviation of a measurement at or close to the detection limit. Therefore, a Z-score, which would always be negative when the detection limit is below assigned value, can be calculated using the laboratory's information:

$$Z = \frac{D - A}{0.33 \bullet D}$$

where:

Z Z-score
D detection limit
A assigned value

This Z-score was added to the list and used in determining weight factors (see main text of Appendix 4).

3.2 Unit corrections for biota and sediments

It is assumed that reporting in the wrong decimals/units to QUASIMEME does not automatically mean that also data were reported with that error to ICES. Likewise, it is assumed that reporting in the wrong decimals/units to ICES does not automatically mean that also data were reported with that error to QUASIMEME. Such errors would probably not go undetected in a trend assessment.

In this assessment all data were corrected if a decimal/unit error was evident, and a new Z-score was calculated. The procedure was first to calculate the error (e) the Z-score was based on:

$$e = \frac{M - A}{Z}$$

where:
e error
M measured value

The log of the ratio of measured and assigned value is around 0 if no decimal errors are made. For a factor 0,1 it is –1, for 10 it is 1 and for 100 it is 2 etc. Correction was only made if the log did not deviate from unity by more than a factor of 0,2 (40% downward deviation and 60% upward). Any larger deviation would not usually end in a Z-score lower than 2. This correction factor is calculated as:

$$F = round\left\{\log\left(M/A\right),0\right\}$$

where:
F correction factor

The measured value is then transferred in to a unit corrected value when the absolute value of T < 0,2:

$$T = \log\left(M/A\right) - round\left\{\log\left(M/A\right),0\right\}$$

When this applied the unit corrected value is:

$U = M*10^F$

where:

U Unit correction value

This unit corrected value was used to calculate a new Z-score

$$Z = \frac{(U \cdot M) - (A)}{e}$$

3.3 Sum-parameters for biota and sediments

For sum-parameters the individual e values were calculated first and then the sum of the measured and assigned values were calculated and the measured value was unit corrected. The Z-score of the sum-parameter was calculated as:

$$Z = \frac{\sum M - \sum A}{\sum e}$$

It should be noted that The method is not sensitive to missing values. For values below detection limit no Z-values were reported and consequently no e values could be calculated. These data were omitted. Furthermore, the procedure was applied for measured values after correction of reporting errors on units

3.4 Combining the information

Basically 3 Z-scores are possible from the procedure described above, but not more then 2 at time:

- Original;
- From reporting a detection limit that is lower than QUASIMEME's assigned value;
- After unit correction.

In case the Z-scores were different, the Z-score with the lowest absolute value was used for determining the weight factor (see statistical methods).

3.5 Sediments.

For sediments a different approach was used. In addition to the analytical weights, the normalisation process contributes to the uncertainty. The standard error of the normalisation process has been calculated by using the natural variability in pivot values and the analytical variability. For the analytical variability, as expression of current good analytical practice was used. The reduced analytical quality revealed by high Z-scores was then included by multiplying the analytical standard deviations of the determinand and cofactor by an error factor, as determined above.

Knowing that the Z-scores reflect to a certain extent the variability and bias from an analytical laboratory these were used to determine the error factor (eF):

$$eF = \sqrt{\frac{\sum Z^2}{n}}\ .$$

For this calculation Z-scores of 3 or more were designated as 3, which is the value used for historical data or when for another reason no quality information was available.

The sum included all the Z-scores from QUASIMEME, the limited number of Z-scores reported to ICES and the Z-score calculated from the reported CRM value. The latter was calculated by:

$$Z = \frac{M - C}{0.125}$$

where:

C Certified reference value

For sediment CRM data the reported values were unit corrected in the same way as done for QUASIMEME CD information. Such a correction was not applied for biota.

Normalisation of contaminant concentrations in sediments

1. Normalisation and required parameters

In addition to pollution levels contaminant concentrations in sediments also depend on the composition of individual sediment samples. In trend assessments trends should be detected irrespective of changes in, for example, particle size distribution, or organic carbon content. The procedures for normalisation are described in Technical Annex 5 to the JAMP Guidelines for Monitoring Contaminants in Sediments (reference number 2002-16), and were applied to the data in the current assessment.

Contaminants in sediments were normalised as followed:

$$C_{SS} = \left(C_M - C_X\right)\frac{N_{SS} - N_X}{N_M - N_X} + C_X \quad (1)$$

where:

C_{SS} Normalised concentration
C_M Measured concentration of contaminant
C_X Pivot value for the contaminant
N_X The pivot value for the cofactor
N_M The measured concentration (C_M) of the cofactor
N_{SS} Reference composition of the sediment as represented by cofactor content

The constants C_X and N_X have been discussed in Annexes 8 and 9 to the 2002 report of the ICES Working Group on Marine Sediments in Relation to Pollution (WGMS). The report describes how to estimate pivot values for contaminants as well as co-factors. Each of these pivot values has a natural variability and uncertainty. The report proposed a procedure for normalising the measured values taking into consideration the pivot values. Also a proposal was made for a reference composition (N_{SS}).

The uncertainty and the variability resulting from the analytical process are combined to estimate the total error in the normalised result as:

$$S_{C_{SS}} = \sqrt{\left[\frac{s_{C_M}^2 + eF_M^2.v_{C_M}^2.C_M^2 + S_{C_X}^2}{\left(C_M - C_X\right)^2} + \frac{S_{N_X}^2}{\left(N_{SS} - N_X\right)^2} + \frac{s_{N_{Mcof}}^2 + eF_{Mcof}^2.v_{N_{Mcof}}^2.N_{Mcof}^2 + S_{N_X}^2}{\left(N_{MCof} - N_X\right)^2}\right]\left(C_{SS} - C_X\right)^2 + S_{C_X}^2} \quad (2)$$

where:

s_{Css} Standard error in normalised concentration
s_{Cm} Absolute standard error in measured concentration of contaminant; fixed error component
eF_M Error factor resulting from QA information for contaminant (variable from 1-3)
v_{Cm} Coefficient of variation in measured concentration of contaminant; relative error component
S_{Cx} Standard error of C_X; Uncertainty in pivot value of contaminant.
s_{Nmcof} Absolute standard error in measured concentration of cofactor; fixed error component
eF_{Mcof} Error factor resulting from QA information for cofactor (variable from 1-3)
v_{Nmcof} Coefficient of variation in measured concentration of cofactor; relative error component
S_{Nx} Standard error of N_X; Uncertainty in pivot value of cofactor.

The eF is basically a Z-value and is deduced from the QA information on the analyses of contaminants and co-factors submitted to the ICES database. More information can be found in main text of Appendix 4 (statistical treatment) and Appendix 4A(availability of QA information).

For normalisation Annexes 8 and 9 of the ICES WGMS 2002 report, assessment of sediment data requires that pivot values are established for the different contaminants and that the errors associated with normalisation should be examined. Pivot values, cofactors and measures of uncertainty are available for all of the contaminants involved in this assessment (Table 4B1). In addition, a kind of state of the art standard analytical error is listed; the fixed (s) and variable (v) component (Table 4B1). The pivot values vary slightly with the analytical method used. The pivot values were derived from data where a strong partial digestion method was used. Total digestion methods may free more metals, especially aluminium, from the sediment.

In support of the data in Table 4B1 the data in ICES database used in this assessment were further investigated with respect to digestion methodologies (section 2), relations between the normalisers (section 3), and the plausibility of the pivot values of the trace metals (chapter 4). Based on this work for a number of trace metals slightly higher pivot values were estimated for a total digestion compared to the values proposed in the WGMS 2002 report.

Table 4B1 Sediment assessment – summary information for pivot values, where the pivot values (Nx) used for different determinands measured by different extraction/ digestion methods. The table also lists the values of the constant error (s_{Cm}) and variable error (V_{Cm}) components of the variance of each determinand/method combination, and the concentrations (Nss) of cofactors to which the contaminant concentrations are normalised (From Annexes 8 and 9 of the ICES WGMS2002 report). Note that $\mathbf{s_{Nm}} = s_{Nmcof}$

Par	ParDescription	Unit	Digestion*	C_X or N_X	S_{Cx} or S_{Nx}	s_{Cm} or s_{Nm}	V_{Cm}	N_{SS}
CB101	2,2',4,5,5'-pentachlorobiphenyl	µg/kg	nn	0	0,05	0,05	0,1	
CB118	2,3',4,4',5-pentachlorobiphenyl	µg/kg	nn	0	0,05	0,05	0,1	
CB138	2,2',3,4,4',5'-hexachlorobiphenyl	µg/kg	nn	0	0,05	0,05	0,1	
CB153	2,2',4,4',5,5'-hexachlorobiphenyl	µg/kg	nn	0	0,05	0,05	0,1	
CB180	2,2',3,4,4',5,5'-heptachlorobiphenyl	µg/kg	nn	0	0,05	0,05	0,1	
CB28	2,4,4'-trichlorobiphenyl	µg/kg	nn	0	0,05	0,05	0,1	
CB52	2,2',5,5'-tetrachlorobiphenyl	µg/kg	nn	0	0,05	0,05	0,1	
SCB7	sum of CBs,-Sum of (CB28, CB52, CB101,	µg/kg	nn	0	0,05	0,2	0,1	
DIELD	dieldrin	µg/kg	nn	0	0,05	0,05	0,1	
DDEPP	DDE (p,p')	µg/kg	nn	0	0,05	0,05	0,1	
HCHG	gamma-HCH (gamma-hexachlorocyclohexane)	µg/kg	nn	0	0,05	0,05	0,1	
CORG	organic carbon	%	nn	0	0,02	0,02	0,05	2,5
AL	aluminium	g/kg	Ps	4	4	0,5	0,03	50
LI	lithium	mg/kg	Ps	4	5	2	0,05	52
AS	arsenic	mg/kg	Ps	3	1,5	0,5	0,06	
CD	cadmium	mg/kg	Ps	0,03	0,06	0,02	0,08	
CR	chromium	mg/kg	Ps	13	6	3	0,05	
CU	copper	mg/kg	Ps	1	1	0,5	0,06	
HG	mercury	mg/kg	Ps	0	0,04	0,02	0,05	
NI	nickel	mg/kg	Ps	2,5	1,1	3	0,08	
PB	lead	mg/kg	Ps	2	2,2	3	0,08	
ZN	zinc	mg/kg	Ps	8	9	3	0,03	
HCB	hexachlorobenzene	µg/kg	nn	0	0,05	0,05	0,1	
TBTIN	tributyltin (TBT)	µg/kg	nn	0	0,05	0,05	0,1	
ANT	anthracene	µg/kg	nn	0	5	3	0,1	
BAA	benzo[a]anthracene	µg/kg	nn	0	5	3	0,1	
BAP	benzo[a]pyrene	µg/kg	nn	0	5	3	0,1	
BGHIP	benzo[ghi]perylene	µg/kg	nn	0	5	3	0,1	
CHR	chrysene	µg/kg	nn	0	5	3	0,1	

Par	ParDescription	Unit	Digestion*	C_X or N_X	S_{Cx} or S_{Nx}	s_{Cm} or s_{Nm}	V_{Cm}	N_{SS}
FLU	fluoranthene	µg/kg	nn	0	5	3	0,1	
ICDP	indeno[1,2,3-cd]pyrene	µg/kg	nn	0	5	3	0,1	
NAP	naphthalene	µg/kg	nn	0	3	3	0,1	
PA	phenanthrene	µg/kg	nn	0	5	3	0,1	
PYR	pyrene	µg/kg	nn	0	3	3	0,1	
TRI	triphenylene	µg/kg	nn	0	3	3	0,1	
MF63	Fraction <63 µm	%	nn	0	0,5	0,5	0,03	115
MF20	Fraction <20 µm	%	nn	0	0,5	0,5	0,03	85
MF16min	Fraction <16 µm after mineralisation	%	nn	0	0,5	0,5	0,03	55
AL	aluminium	g/kg	Tot	14	6	0,5	0,03	58
AS	arsenic	mg/kg	Tot	5	3	0,5	0,06	
CD	cadmium	mg/kg	Tot	0,03	0,06	0,02	0,08	
CR	chromium	mg/kg	Tot	13	6	3	0,05	
CU	copper	mg/kg	Tot	3	1	0,5	0,06	
HG	mercury	mg/kg	Tot	0	0,04	0,02	0,05	
LI	lithium	mg/kg	Tot	7	5	2	0,05	52
NI	nickel	mg/kg	Tot	4	2	3	0,08	
PB	lead	mg/kg	Tot	9	3	3	0,08	
ZN	zinc	mg/kg	Tot	13	5	3	0,03	
AL	aluminium	g/kg	Pw	3	2	0,5	0,03	40
AS	arsenic	mg/kg	Pw	1,5	1,5	0,5	0,06	
CD	cadmium	mg/kg	Pw	0,03	0,06	0,02	0,08	
CR	chromium	mg/kg	Pw	10	6	3	0,05	
CU	copper	mg/kg	Pw	1	1	0,5	0,06	
HG	mercury	mg/kg	Pw	0	0,04	0,02	0,05	
LI	lithium	mg/kg	Pw	3	2	2	0,05	40
NI	nickel	mg/kg	Pw	2,5	1,1	3	0,08	
PB	lead	mg/kg	Pw	2	2,2	3	0,08	
ZN	zinc	mg/kg	Pw	8	9	3	0,03	
AL	aluminium	g/kg	nn	4	4	0,5	0,03	50
AS	arsenic	mg/kg	nn	3	1,5	0,5	0,06	
CD	cadmium	mg/kg	nn	0,03	0,06	0,02	0,08	
CR	chromium	mg/kg	nn	13	6	3	0,05	

Par	ParDescription	Unit	Digestion*	C_X or N_X	S_{Cx} or S_{Nx}	s_{Cm} or s_{Nm}	V_{Cm}	N_{SS}
CU	copper	mg/kg	nn	1	1	0,5	0,06	
HG	mercury	mg/kg	nn	0	0,04	0,02	0,05	
LI	lithium	mg/kg	nn	4	5	2	0,05	52
NI	nickel	mg/kg	nn	2,5	1,1	3	0,08	
PB	lead	mg/kg	nn	2	2,2	3	0,08	
ZN	zinc	mg/kg	nn	8	9	3	0,03	
HG	mercury	mg/kg	Pe	0	0,04	0,02	0,05	
NONE	no cofactor for normalization	g/g	nn	0	0	0	0	1
SPAH3r	Sum of 3r PAH, 2 compounds	µg/kg	nn	0	6	6	0,1	
SPAH4r3	Sum of 4r PAH, 3 compounds	µg/kg	nn	0	9	9	0,1	
SPAH4r4	Sum of 4r PAH, 4 compounds	µg/kg	nn	0	12	12	0,1	
SPAH6r	Sum of 6 PAH, 2 compounds	µg/kg	nn	0	6	6	0,1	

* Digestion codes: nn (not required); Pw (Partial weak), Ps (Partial strong) Pe (Partial mercury only), Tot (Total)

2. Digestion method overview for metal analyses

The digestion method influences the measured concentrations of some metals. Particularly for aluminum, it is known that the component in the sandy particulate matter is only included if a total digestion is applied. When normalization is applied, this information should be included as different pivot values may apply. It was not possible to make an individual assessment for each reported method. Therefore the digestion methods were subjectively grouped according to 5“intensity” categories:

nr No method information received
Pe Extraction methods that generally do not intend to extract all metals, HCl and weaker
Pw Aqua regia methods
Ps Strong digestion using HNO_3 under pressure conditions and high temperature
Tot Methods that include metals from the sand.

For fractionated samples about half were digested by partial methods (Germany and the Netherlands) and about half by total digestion methods (Table 4B2). For un-fractionated samples mainly total digestion was used. Only the un-fractionated samples were used to estimate the pivot values for aluminium and lithium (cf section 3) and investigate the plausibility of the pivot values for trace metals (cf section 4).

Table 4B2 Overview of digestion methods for individual metals per country: for fractionated (FS) and unfractionated (US) sediment.

		Matrx FS					Matrx US				
		Digestion					Digestion				
Country	PARAM	nr	Pe	Pw	Ps	Tot	nr	Pe	Pw	Ps	Tot
Belgium	AL	226				49					51
	LI										
	CD	1			200	59				7	61
	HG		233		59					68	
	PB				232	59				7	61
Denmark	AL					15					148
	LI									104	
	CD				17					126	
	HG				15					135	
	PB					15				6	144
France	AL	60					58				212
	LI										212
	CD	9					5				212
	HG	8					5				212
	PB	9				52	5				265
Germany	AL			24		1354			24		120
	LI			24	804	36			24	1	97
	CD			280	1391	158			230	12	172
	HG			280	1391	158			230	13	92
	PB			280	1770	159			230	12	133
Iceland	AL					14					
	LI										
	CD					14					
	HG			13							
	PB					14					
Ireland	AL										217
	LI										217
	CD										215
	HG									32	180
	PB										217
Netherlands	AL				262						57
	LI				136						
	CD				324					6	57
	HG				354					6	57
	PB				372					6	57

		Matrx FS					Matrx US				
		Digestion					Digestion				
Country	PARAM	nr	Pe	Pw	Ps	Tot	nr	Pe	Pw	Ps	Tot
Norway	AL					6				28	252
	LI										327
	CD					6				49	521
	HG				6					304	271
	PB					6				52	521
Portugal	AL										
	LI										
	CD				1					38	12
	HG		1					38			12
	PB				1					38	12
Spain	AL	38					37				
	LI					37					37
	CD					36					34
	HG										
	PB					36					35
Sweden	AL										
	LI										
	CD						9				
	HG						9				
	PB						9				
UK	AL			150		1451					603
	LI					1333					166
	CD		34	201	5	1435				52	444
	HG		34	189	5	1393					567
	PB		34	195	5	1468					
Totals		351	336	1636	7350	9363	137	38	738	1102	7280

3. Derivation of pivot values of aluminium and lithium from ICES data

As discussed in ICES WGMS 2002 report, normalisation of metals concentrations in sediments requires the definition of pivot values for both the contaminants and the cofactor concentrations. These values are closely analogous to the concentrations of contaminants and the cofactors in sand (i.e. sediment without any fine grained material). The pivot values will vary with determinand, and will also vary with extraction/digestion method (cf ICES WGMS 2002).

In the absence of reliable direct regionally specific measurements, MON 2003 decided to use the pivot values as suggested in Annex 8 of the 2002 ICES WGMS report. Those data are from research by The Netherlands and mainly based on digestion methods that do not dissolve the silica matrix of sand particles. As can be seen from the digestion method overview, strong digestion is often applied for fractionated samples, but for the matrix unfractionated sediment total digestion is most frequently applied (see above).

The work in The Netherlands also included some work on total digestion methods, and this indicated that pivot values are slightly higher after total digestion through contributions of aluminium, lithium and other metals from the sand particles.

The method of digestion is not the only variable influencing the level of the pivot value; the origin of the sediment may also be of importance. For example, sand from Spain may have a different contribution to the pivot values than sand from Norway. In some areas, for example, areas where sandy sediments contained large amounts of feldspar minerals, the aluminum concentration was very much enhanced, and could be equal to the concentration in the fine fraction.

Because of this, an attempt was made to estimate the pivot values for different areas using sediment analysis data held in the ICES database. To estimate the pivot values of the secondary cofactors, aluminium and lithium for the different methods and for different areas, the concentrations of these metals were plotted against the 20µm and 63µm grainsize fractions. The concentrations found in samples without any fine material (ie pure sand sediment) are considered to represent the pivot value. This value also has a natural variation that is important for the error calculation when normalising.

When grain-size information is not available, the organic carbon content can in some cases help to estimate the pivot value. Since clay material always contains some organic carbon, a sample without organic carbon also does not contain any fine material and the concentrations of aluminium and lithium in it can represent the pivot value. However, as sediment can also contain organic carbon that is not associated with clay, the presence of organic material does not mean that clay is present. Therefore, the graphs below where aluminium and lithium are plotted versus organic carbon are mainly for information.

The results below are evaluated for each country in the Figures 4B1-4B10. Comments were given in the legend of each figure. The scatter about the correlations between metals and grain size is often quite large and it is not clear if this is due to the metal analysis or the grain size measurements. Because of this large scatter, it was not always possible to estimate the natural variation (s_{Nx}.). The variation in the estimated pivot values N_X is, however, not equally large. The variation within countries is generally as large as the variation between countries. The results of the evaluation are summarized in Table 4B3. The pivot values derived from the figures are summarised in Table 4B3. The variation about the fitted line should represent the natural variability and is determined as about 1/3 of the observed range. In general, only results for total digestion are available. In view of the large variation, no attempt was made to apply statistical analysis to these data. By contrast, the relatively small number of data (from Germany) which were derived using the partial digestion with Aqua Regia procedure show the best correlation with the grainsize. Although it was initially considered as a low intensity digestion, the gradient of the correlation with the grainsize suggests that it is comparable with the stronger partial digestion using HNO_3.

Based on these observations, MON agreed that:

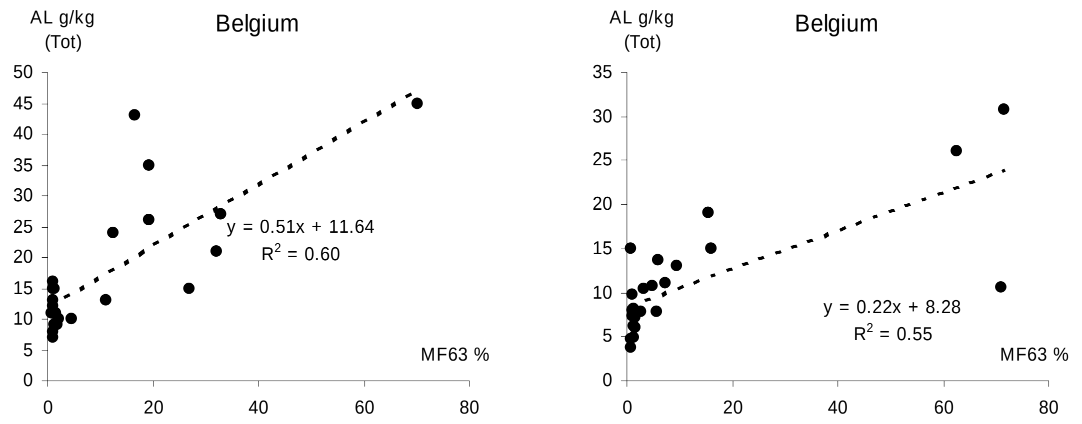
- The pivot values and their variation (as standard deviation) should be used in the assessment (cf Table 4B3).
- If no information is available on the analytical method used, the pivot values from strong partial digestion (Ps) should be used.
- For Hg and Cd, all digestion methods are considered to be complete. That means that weak digestion (Pe or Pw) results for these elements do not need method dependent mercury and cadmium pivot values

Table 4B3 Pivot values for aluminium (Al) and lithium (Li) for different digestion methods: total digestion (Tot), strong digestion using HNO_3 under pressure conditions and high temperature (Ps) and Aqua regia method (Pw). Based on data from the ICES database from which Figures 4B1-4B10 are derived. Pivot values agreed by MON 2004 are noted.

	Al g/kg						Li mg/kg					
	Tot		Ps		Pw		Tot		Ps		Pw	
Belgium	10	±4										
Denmark	25	±10							5	±?		
France	14	±?					5	±?				
Germany	12	±8			3	±2	4	±2			3	±2
Ireland	12	±5					11	±5				
Netherlands	12	±6										
Norway	19	±4					4	±3				
Spain	10	±?					10	±?				
UK high	20	±?					7	±?				
UK low	6	±?					5	±?				
WGMS 2002	nd	+?	4	±4			8	±5	4	±5		
MON 2004	14	±6	4	±4	3	±2	7	±5	4	±5	3	±2

Figures 4B1-4B10 Plots of the secondary cofactors Al and Li versus grainsize and CORG for 63µm (MF63) and 20µm (MF20) sediment grainsize fractions. For Belgium (Figure 4B1), Denmark (Figure 4B2), France (Figure 4B3), Germany (Figures 4B4 and 4B5), Ireland (Figure 4B6), The Netherlands (Figure 4B7), Norway (Figure 4B8), Spain (Figure 4B9), United Kingdom (Figure 4B10). Note comments included in figure text. See also main text and Table 4B3 for summary of pivot values.

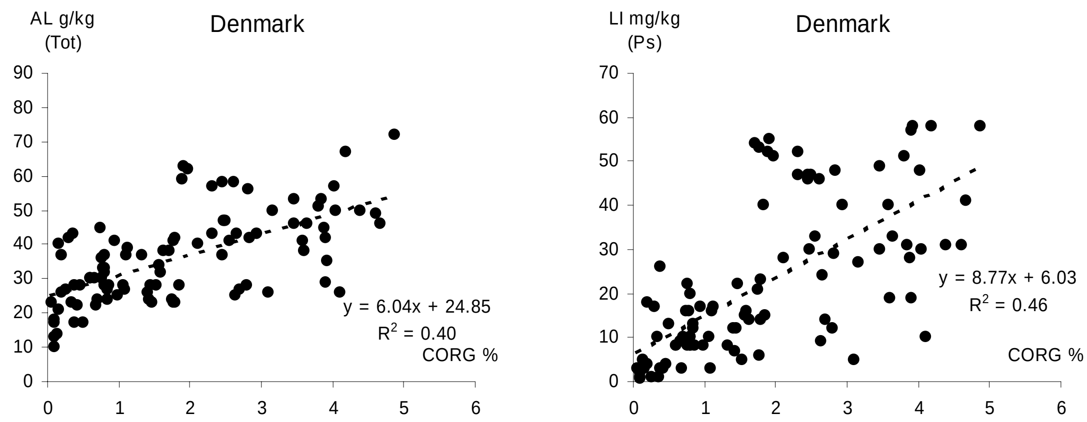
Figure 4B1 Belgium



Data MUMM from 1990 Data MUMM from 1991

Pivot value for Aluminum, total method is 10±4g/kg, ranging from 4-16,

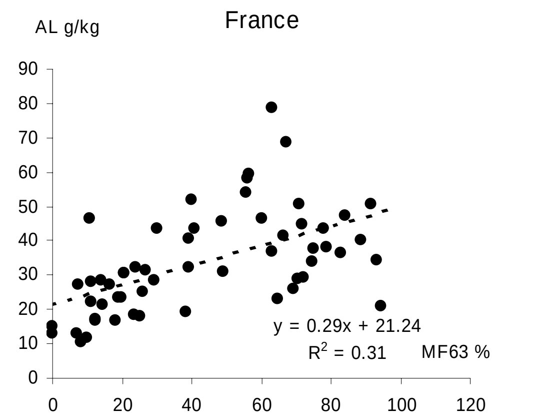
Figure 4B2 Denmark



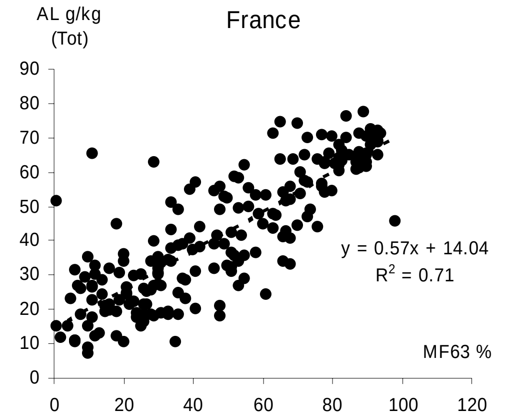
1999-2004 (one point left out) 1999-2004 (one point left out)

CORG was not suitable for determining pivot values because there are a number of samples very close to zero and which consequently will not contain significant amounts or fine material to which organic carbon would be associated. From this viewpoint a pivot value for Al (Tot) would be 25±10 g/kg, ranging from 10-40. For Li (Tot) the graph does not give any clear answer. Investigating individual years reveals that a value of around 5 mg/kg may be is a good guess.

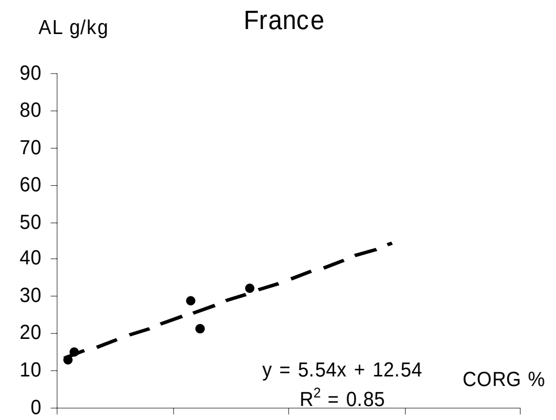
Figure 4B3 France



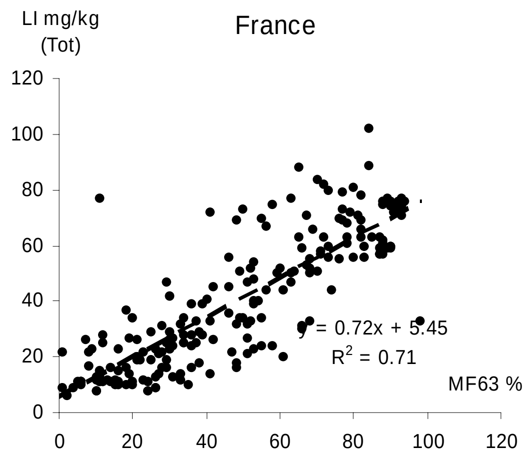
Data 1987 to 1991 (method for Al undefined)



Data 1999 and 2001



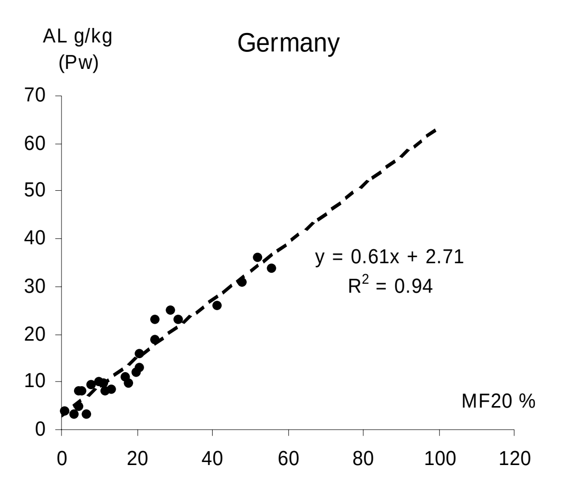
Data 1987 and 1988 (method for Al undefined)



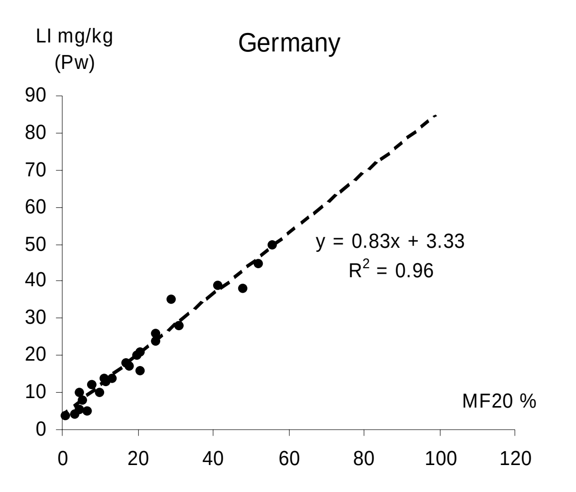
Data 1999 and 2001

For aluminium by total digestion a pivot value of 14 g/kg seems the best choice, but it is difficult to determine a range. Not shown is the Al-Li ratio which indicated that the main variability probably came from the determination of the grainsize fraction. For lithium (Tot) the pivot point is about 5 mg/kg but again it is difficult to indicate a range.

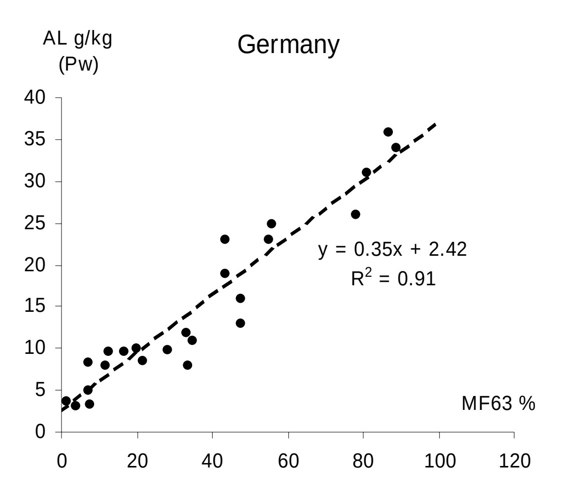
Figure 4B4 Germany (Pw)

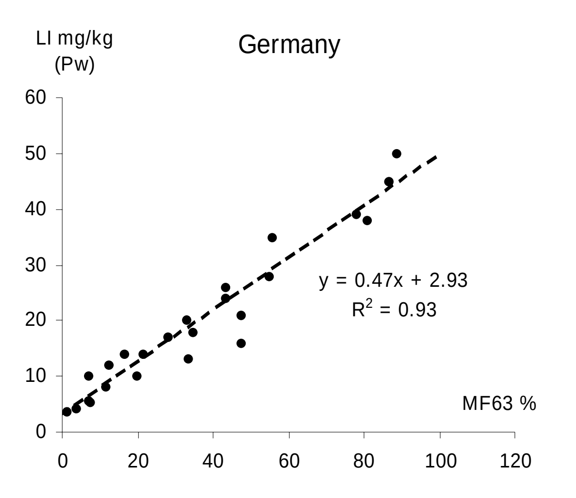


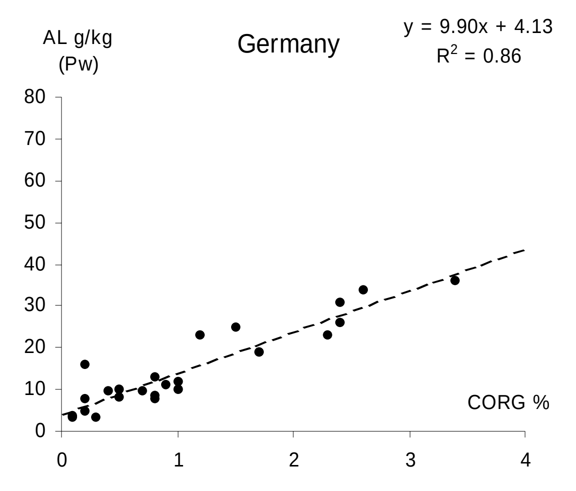
Data 1996-1998



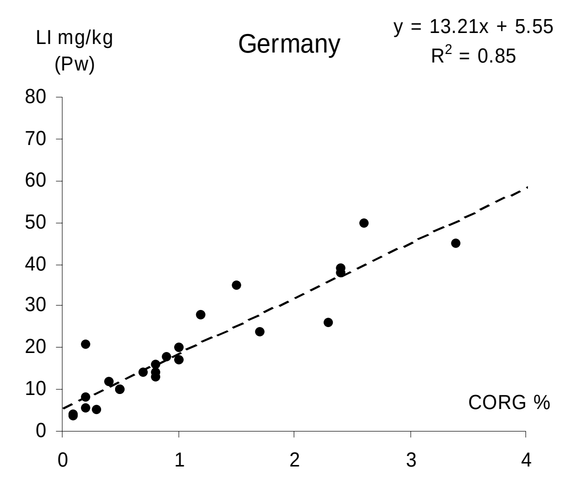
Data 1996-1998







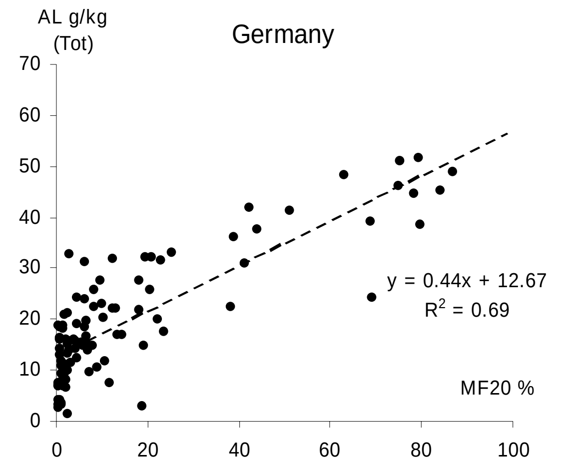
Data 1996-1998



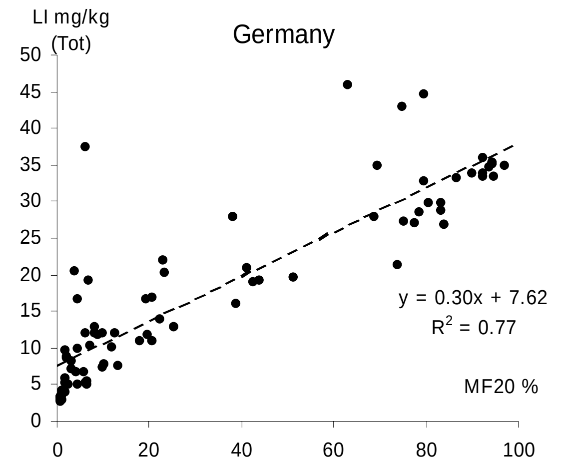
Data 1996-1998

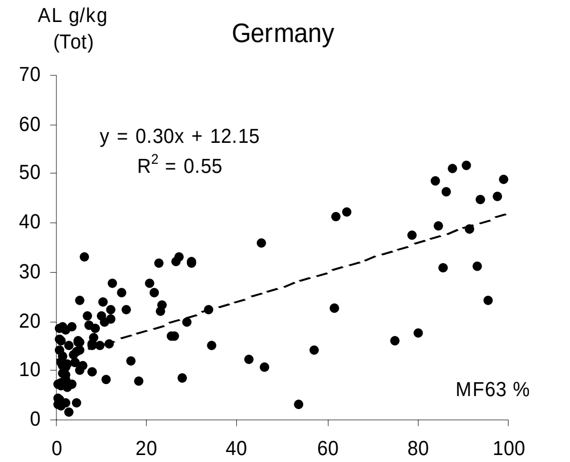
Pivot values for partial (weak:Pw) method for both aluminium and lithium is about 3±2 g/kg. The intercepts with CORG are a little higher but are not statistically significantly different. Exclusion of the left outlier point would probably bring them to the same level.

Figure 4B5 Germany (Tot)

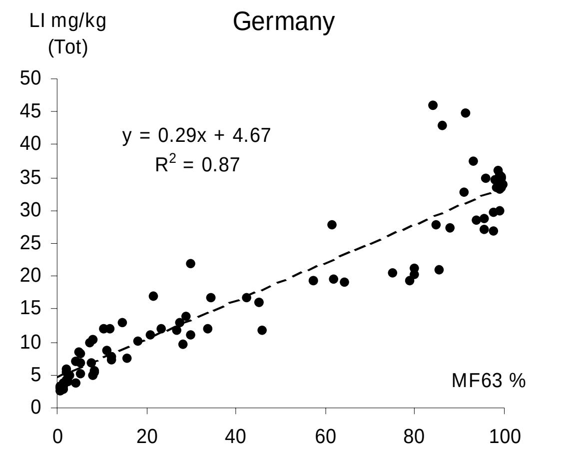


1990,1992,1993, 1994, 1996, 1999, 2000

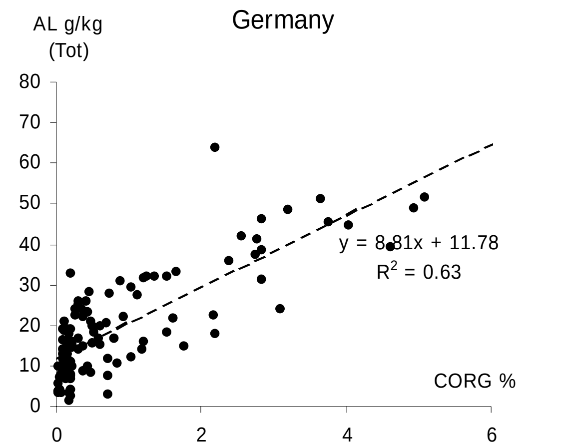




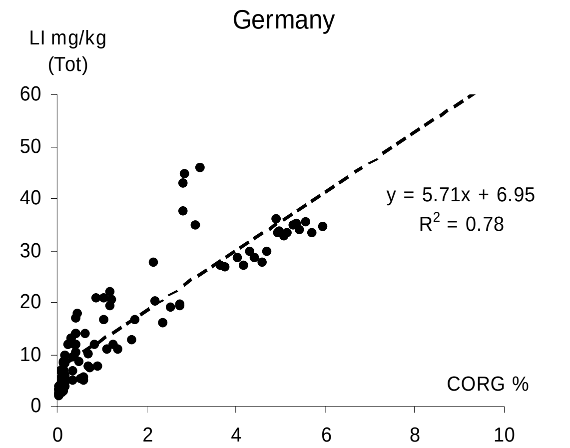
1990, 1992, 1993, 1994, 1995, 1996,1999 and 2000



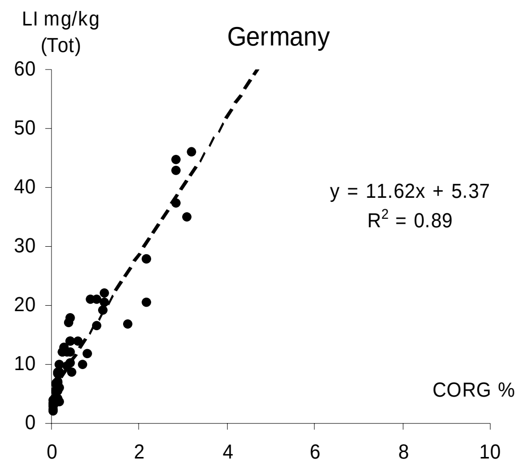
1990, 1993, 1999 and 2000



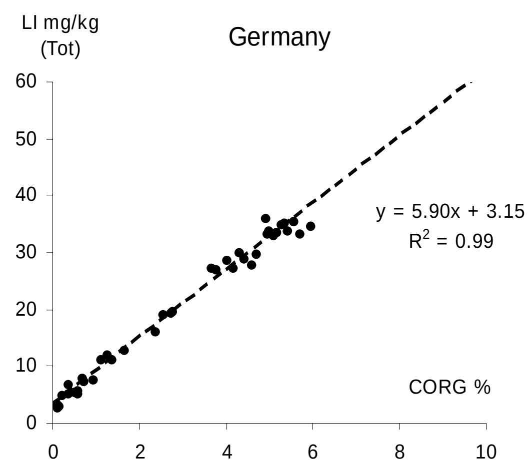
1990, 1992, 1993, 1995, 1996,1999 and 2000



1990, 1993, 1999 and 2000
(one outlier excluded)



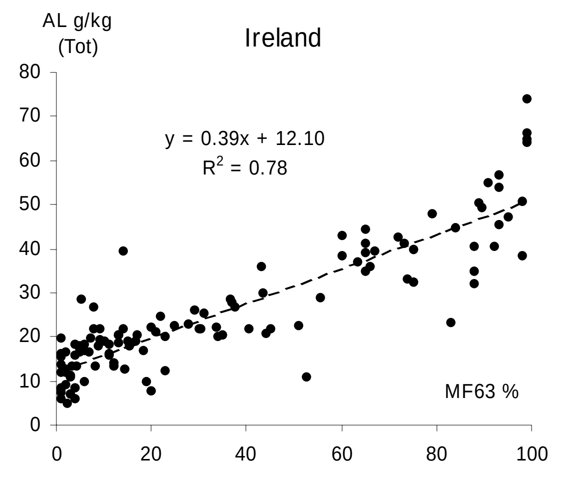
1990,1999 and 2000



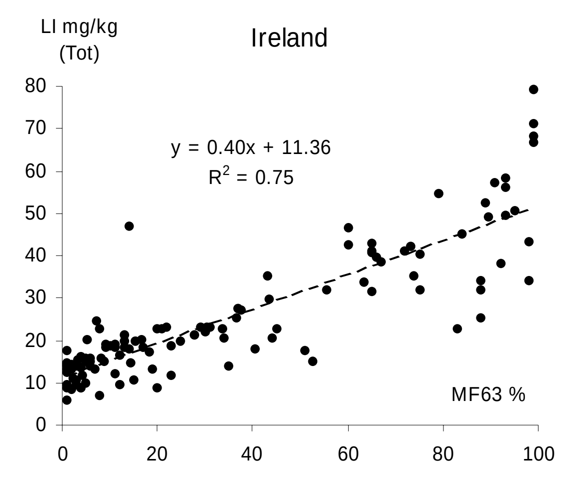
Only the 1993 data
(one outlier excluded)

Figures above indicate pivot values for aluminium by total digestion of about 12±8 g/kg. The large scatter undermines this estimate. The level is in good agreement when plotted against CORG. Also, for lithium there is a lot of scatter but a pivot value can be recognized. The plots with CORG show that there are relationships with two different slopes. For 1993 data, the slope is half of that for other years. It is not clear if this is due to differences in the method of CORG determination or possibly to wrong classification of the strength of the digestion methods. The same duality can also be found in the plot of lithium (Tot) versus the 63µm sediment fraction (MF63). Taking this dual character into account and considering the two lines then the pivot value can be estimated from the figures to be about 4±2 mg/kg..

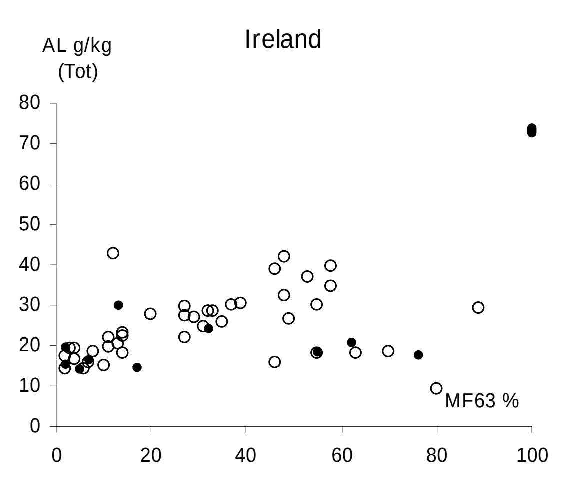
Figure 4B6 Ireland



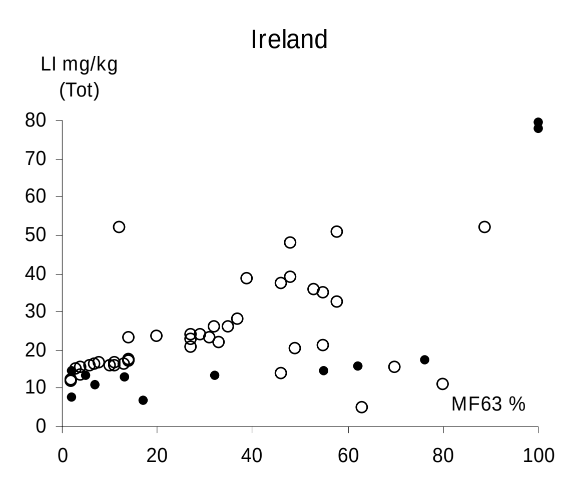
1990, 1993 and 1995



1990, 1993 and 1995



1990, 1993 and 1995

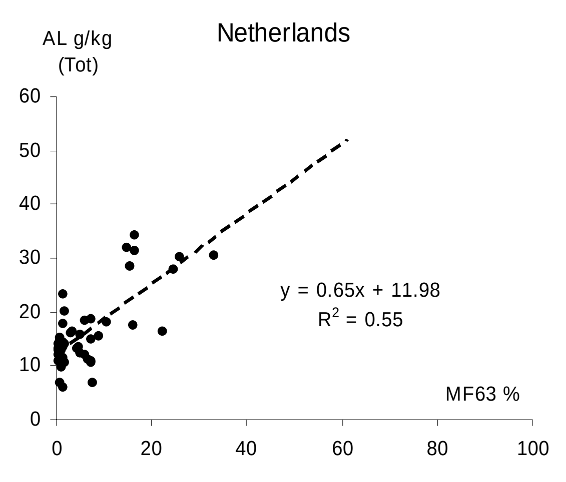


1990, 1993 and 1995

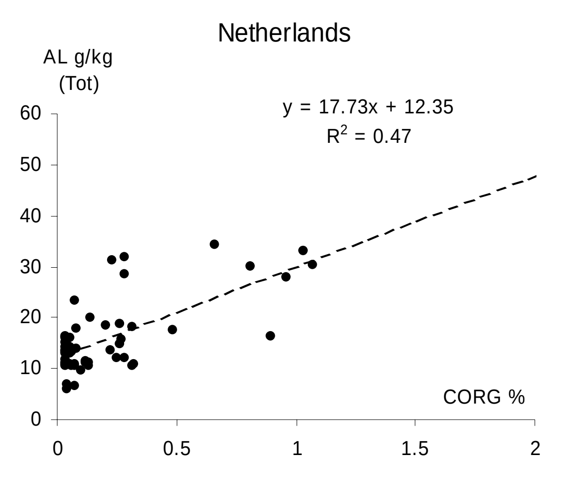
1992 (closed) 1994 (open)

Data for Ireland show pivot values for aluminium (Tot) of 12±5 g/kg and for lithium (Tot) of 11±5 mg/kg The results of 1992 (closed circles) were plotted separately as no clear relation with griansize was present for the individual years. The results for coarse samples are in agreement with the pivot values indicated by the other years. (one sample with 140 mg/kg lithium was excluded).

Figure 4B7 The Netherlands



1990 data



1990 data

Pivot value for aluminium, total method is 12±6 g/kg, ranging from 4 to 23. Data for unfractioned sediment (US) using Tot digestion methods were produced only in 1990 by a different laboratory than for any other data. The 63µm sediment fraction (MF63) is determined after removal of organic and mineral (carbonates and manganese or iron oxides) matter. Futhermore, all other results (except 1985) are measured in the 63µm or 20µm fraction using strong digestion methods (Ps). The main conclusion from this graphs is that the results are in agreement with Belgian and German results for total digestion method when considering the level as well as scatter.

Figure 4B8 Norway

<table>
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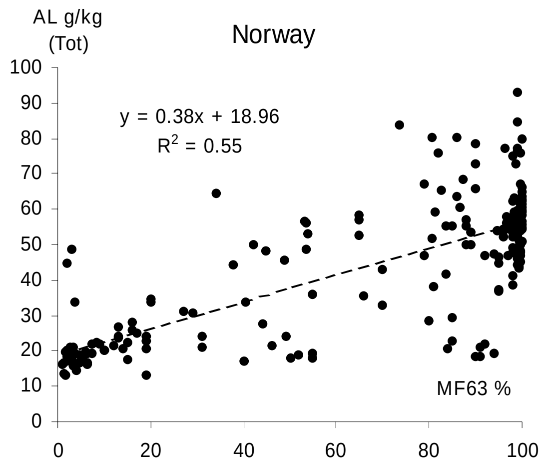
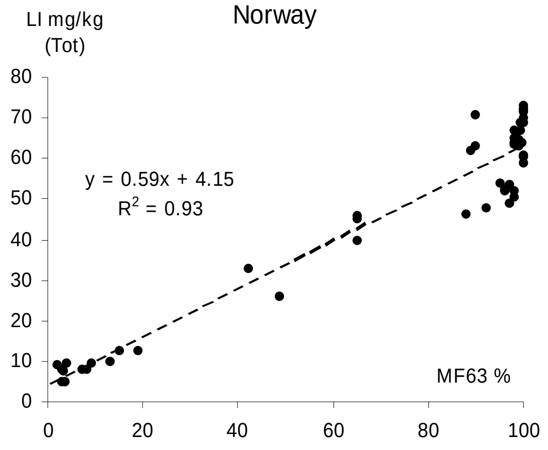
<td>

Data 1990</td>
<td>

Data 1990 (One datapoint excluded)</td>
</tr>
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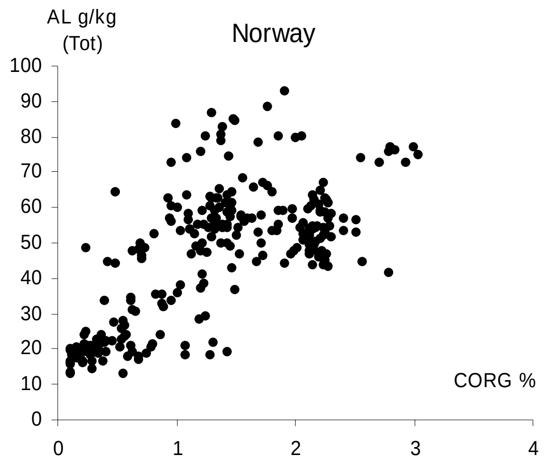
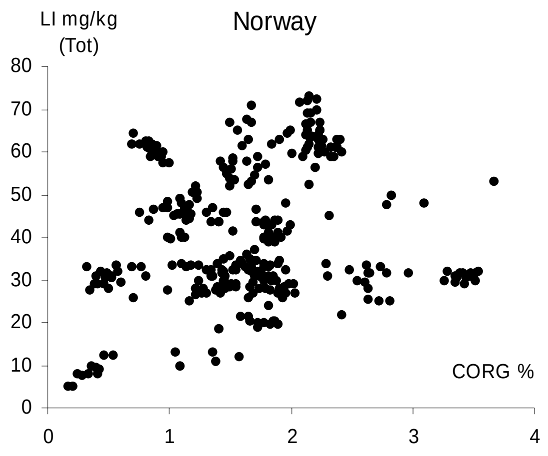
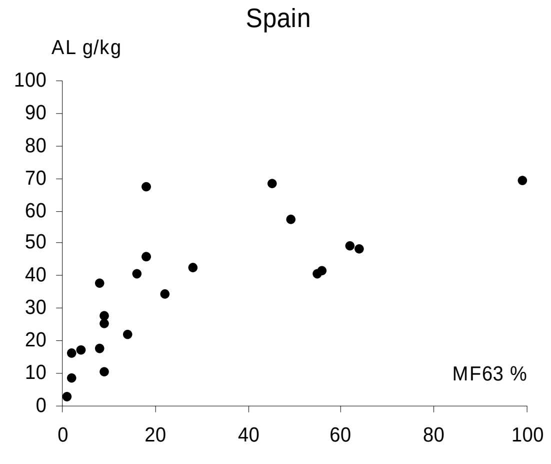
<td>

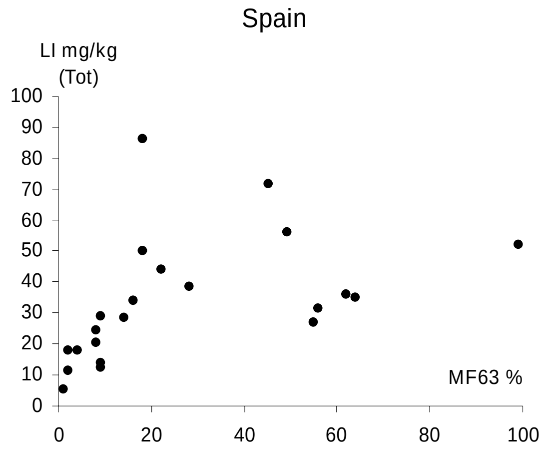
Data 1990</td>
<td>

Data 1990 (One datapoint excluded)</td>
</tr>
<tr>
<td>Only 1990 data</td>
<td>1990, 1992, 1994, 1996 and 1997</td>
</tr>
<tr>
<td colspan="2">A pivot value of 19±4 g/kg is found for aluminium (Tot) and 4±3 mg/kg for lithium (Tot). CORG was not well correlated with these metals indicating that CORG can behave very independently from grainsize.</td>
</tr>
</table>

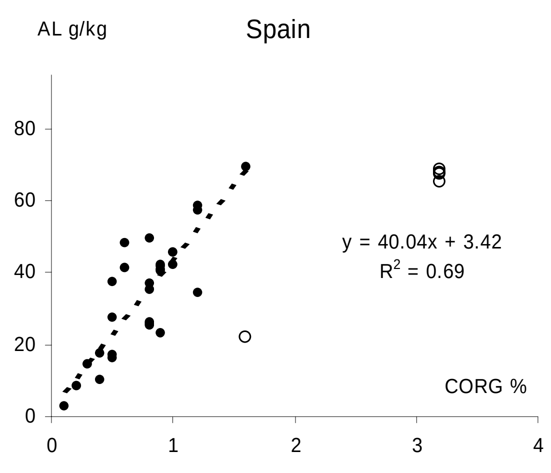
Figure 4B9 Spain



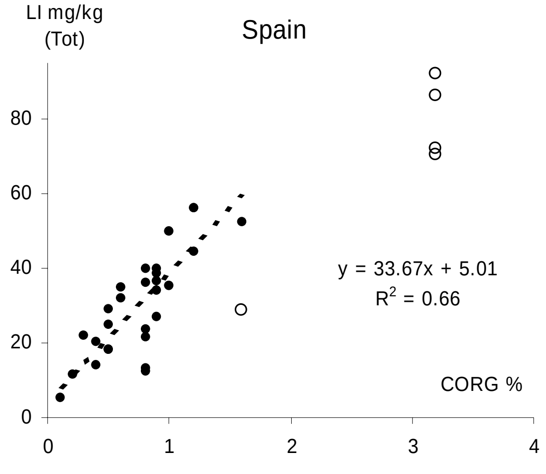
1990



1990



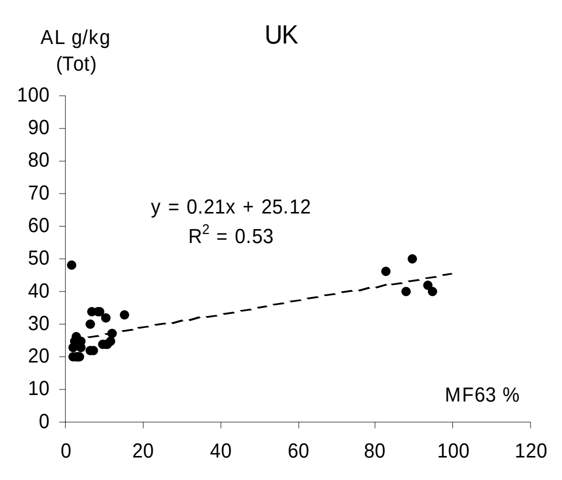
1990 (open symbols excluded in regression)



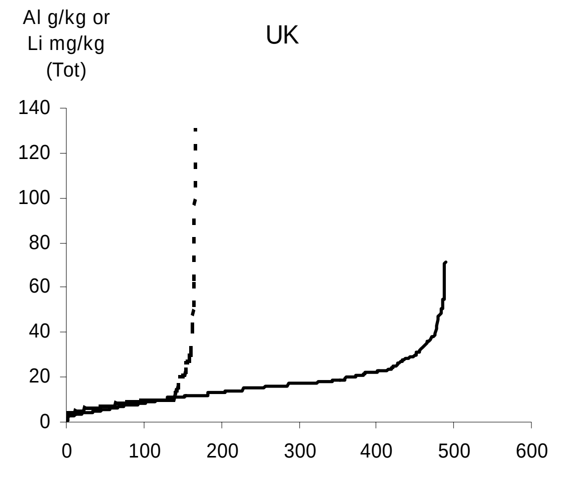
1990 (open symbols excluded in regression)

The relation of aluminium and lithium with the grainsize is very poor and a regression analysis was not done. A rough estimate of the pivot values would give 10 g/kg and 10 mg/kg for aluminium and lithium, respectively. For aluminium no digestion method was reported, but is was likely that total digestion by HF was used like for the other metals. The plots of aluminium and lithium tend to suggest that pivot values are lower but it is quite possible that CORG is present (eg as grain coatings) even if fine grained material is absent, and therefore might still be a significant co-factor. More information would be necessary to adjust them downwards.

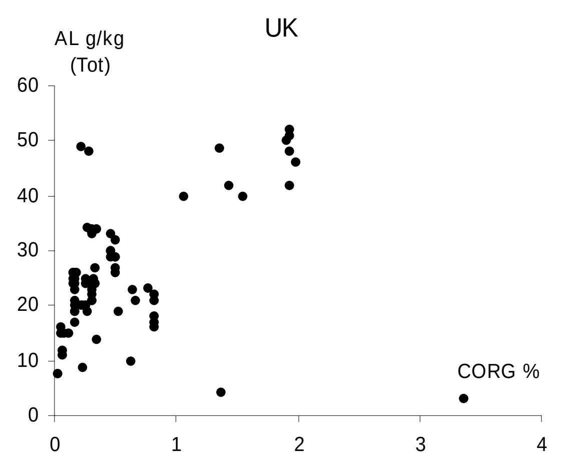
Figure 4B10 United Kingdom



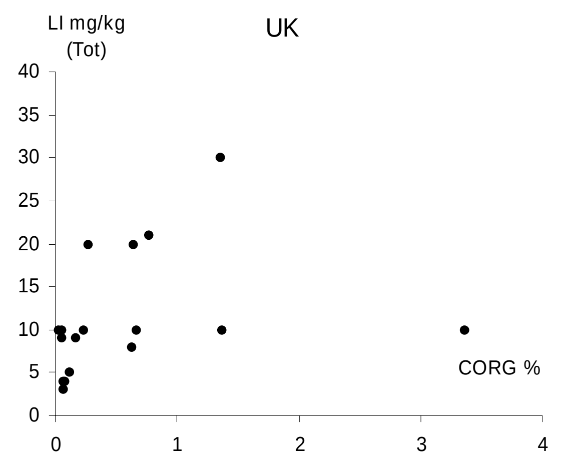
1990 and 1991



Results for Al and Li sorted on value.



1990 and 1991



Results for Al and Li sorted on value.

The UK data in the upper left plot suggest a pivot value of about 25 g/kg for aluminium (Tot). For the relationship between lithium (Tot) and grainsize there are no data available. The plots with CORG might suggest pivot values of about 12 g/kg for aluminium (Tot) and 4-10 mg/kg for lithium (Tot). A property of a pivot value suggest that generally no significant lower values will be found in samples. Sorting all values in unfractionaed sediment samples, as is shown in the upper left plot, show that there are a considerable fraction (85%) of samples lower than 25 g/kg aluminium meaning that the outcome might not be realistic. Taking the average of the 25%, most sandy samples results in pivot values of 6 g/kg for aluminium (Tot) and 5 mg/kg for lithium (Tot).

4. Pivot values for heavy metals by total digestion

MON had agreed to use the pivot values as listed in annex 8 of the WGMS 2002 report. However, these were determined for a strong partial method and it may be possible that higher values would be found for total digestion methods. Therefore, the data in the ICES database on heavy metal concentrations after total digestion were also investigated in order to make estimations of pivot values.

Metals are present in the environment at different pollution levels and it is in principle not possible to determine pivot values from random data. A closer correlation between a cofactor and heavy metal is more likely when samples have been exposed to the same pollution level over a long period, i.e. the metals are in equilibrium with the solid phases or with the overlying water phase. Therefore, the approach as used for aluminium and lithium does not apply for contaminants. The data in the ICES database represent different times as well as stations, and have been collected to investigate different pollution levels. The pivot value is defined as the concentration in the pure sand fraction of sediment (i.e., grainsize >63µm and <2000µm). For equally polluted samples, the primary cofactor (i.e. grain size) intercept of the regression line gives the pivot value For secondary cofactors, aluminium and lithium, the pivot values as the respective intercepts should be used (i.e., the concentration of aluminium or lithium in sand).

For the ICES data, the only possibility to obtain a value for the pivot values of heavy metals is to investigate the concentrations of the metals in samples that do not contain any fine material or organic matter, i.e. pure sand. Pure sand has a negligible binding capacity and concentrations will not be seriously elevated even in polluted situations. Samples were considered to be sand if the concentration of aluminium or lithium was equal or lower than their respective pivot value.

For those samples that proved to be close to pure sand (ie concentration of aluminium or lithium was equal or lower than their respective pivot value), the heavy metal concentrations were collated and the medians and variation were determined (Table 4B4) and used as pivot values. In addition the uncertainty (Lower S) of the pivot values for each country were calculated. From these data, a consensus value was selected (Table 4B5), weighted heavily by the median pivot value of all data (cf. Table 4B4).

Table 4B4 Pivot values for As, Cd, Cr, Cu, Hg, Ni, Pb, Zn in sediment based on data from ICES for sandy samples. Variation (Lower S) is estimated as the difference between the median and 16 percentile (corresponding to one "s" of a Gaussian distribution on the lower side). The number of observations (n) is also given.

	For Al up to 14 g/kg			For Li up to 7 mg/kg		
	Median	Lower S	n	Median	Lower S	n
As (Arsenic) Pivot values from low concentration (most sandy) samples						
Belgium						
Denmark	7,6	3,0	2			
France						
Germany	4,0	2,1	22	3,3	0,7	2
Ireland						
Netherlands						
Norway	35	23	3	30,8	6,5	2
Portugal						
Spain						
UK						
All data	4,3	2,5	27	12,8	9,5	4
Median	7,6	17	3	17,0	19,4	2
Cd (Cadmium) Pivot values from low concentration (most sandy) samples						
Belgium	0,07	0,04	35			
Denmark						
France	0,09	0,01	11	0,06	0,00	1
Germany	0,04	0,02	40	0,03	0,02	29
Ireland	0,05	0,02	26	0,06	0,01	2
Netherlands	0,04	0,03	29			
Norway	0,02	0,00	3	0,02	0,00	2
Portugal						
Spain				0,03	0,00	1
UK	0,03	0,01	165	0,02	0,00	58

All data	0,04	0,02	309	0,03	0,01	93
Median	0,04	0,02	7	0,03	0,02	6
Cr (Chromium) Pivot values from low concentration (most sandy) samples						
Belgium	22	11	19			
Denmark						
France	10	1	11	7,0	0,0	1
Germany	12	4	45	9,8	5,1	30
Ireland	20	9	26	14,2	2,3	2
Netherlands						
Norway	20	10	3	9,6	0,7	2
Portugal						
Spain						
UK	9	4	162	10,0	4,0	58
All data	10	5	266	10,0	4,3	93
Median	16	6	6	9.8	2.6	5
Cu (Copper) Pivot values from low concentration (most sandy) samples						
Belgium	2,1	0,8	35			
Denmark	1,9	1,0	5			
France	2,2	0,7	11	1,9	0,0	1
Germany	3,0	1,4	46	3,1	1,3	30
Ireland	2,1	0,5	26	2,6	0,4	2
Netherlands	1,6	0,7	29			
Norway	2,9	0,3	3	3,6	0,3	2
Portugal						
Spain				2,1	0,0	1
UK	3,0	0,0	270	3,0	0,0	58
All data	3,0	1,0	425	3,0	0,4	94
Median	2,2	0,5	8	2,8	0,6	6
Hg (Mercury) Pivot values from low concentration (most sandy) samples						
Belgium						
Denmark						
France	0,01	0,00	11	0,01	0,00	1
Germany	0,04	0,02	22	0,03	0,01	2
Ireland	0,01	0,00	20	0,01	0,00	2
Netherlands	0,01	0,00	29			
Norway						
Portugal						
Spain						
UK	0,02	0,01	251	0,03	0,02	58
All data	0,02	0,01	333	0,02	0,01	63
Median	0,01	0,01	5	0,02	0,01	4
Ni (Nickel) Pivot values from low concentration (most sandy) samples						
Belgium	6,6	3,7	19			
Denmark	1,0	0,0	3			
France	3,9	0,9	11	3,6	0,0	1
Germany	3,7	1,7	23	2,5	0,9	12
Ireland						
Netherlands						
Norway	2,4	0,6	3	3,6	0,1	2
Portugal						
Spain				2,0	0,0	1
UK						
All data	4,1	2,0	59	2,7	1,0	16
Median	3,7	2,1	5	3,0	0,8	4

Pb (Lead) Pivot values from low concentration (most sandy) samples						
Belgium	7,3	3,1	35			
Denmark	4,0	0,6	5			
France	8,6	0,9	11	7,3	0,0	1
Germany	6,5	1,8	23	13,1	6,8	12
Ireland	10,2	3,9	26	12,6	1,7	2
Netherlands	7,0	1,0	29			
Norway	7,7	0,7	3	11,3	0,2	2
Portugal						
Spain				4,7	0,0	1
UK	7,9	2,3	168	8,6	2,4	58
All data	7,7	2,2	300	8,9	2,7	76
Median	7,5	1,8	8	9,9	3,3	6
Zn (Zinc) Pivot values from low concentration (most sandy) samples						
Belgium	21	10	35			
Denmark	10	0	5			
France	21	4	11	14	0	1
Germany	17	9	47	16	9	30
Ireland	22	12	26	19	6	2
Netherlands	12	6	29			
Norway	10	0	3	20	7	2
Portugal						
Spain				8	0	1
UK	11	6	270	10	5	58
All data	12	6	426	11	4	94
Median	15	5	8	15	5	6

The consensus data for arsenic, copper, nickel, lead and zinc, based on the ICES data for total digestion, are slightly higher than those reported by WGSM 2002 where partial digestion was used (Table 4B5). These data were applied in normalisation in those cases where a total digestion method was applied. For the other elements (cadmium, chromium and mercury), the pivot values reported by WGMS were used even when total digestion was applied.

Table 4B5 Consensus data for pivot values for sediment (Nx) based on ICES data where total digestion was used, and associated uncertainties (sNx) expressed as standard deviation. Also shown are the pivot values from Annex 8 of the WGMS 2002 report which were based on partial digestion. Values in bold indicate where the ICES-based results are higher than those reported by WGSM. Percent lower than suggested pivots values as derived from Figures 2B11-2B18 is shown.

	Ps from WGMS		ICES data Tot		% lower than suggested pivot values
	Nx	sNx	Nx	sNx	
As	3	1,5	**5**	**3**	28
Cd	0,03	0,06	0,04	0,02	24
Cr	13	6	12	5	21
Cu	1	1	**3**	**1**	14
Hg	0,00	0,04	0,02	0,01	31
Ni	2,5	1,1	**4**	**2**	14
Pb	2	2,2	**9**	**3**	19
Zn	8	9	**13**	**5**	18

As a plausibility check for these values, the plots in Figures 4B11 to 4B18 are made. The figures (see also summary in Table 4B5) show that 14 to 31% of the concentrations are below the estimated pivot values. On the grounds that pivot values are supposed to be the lowest possible concentrations, it is clear that the estimated values are not too low. Too low a value could lead to steeper extrapolation and consequently to normalised values that also are too high.

Figure 4B11 Ranked arsenic concentrations based on all available data in unfractionated sediments and analysed by total digestion (mg/kg, left axis). The horizontal line is the consensus pivot value for total digestion (cf. Table 4B5). The open symbols indicate the corresponding aluminium concentrations (g/kg, right axis).

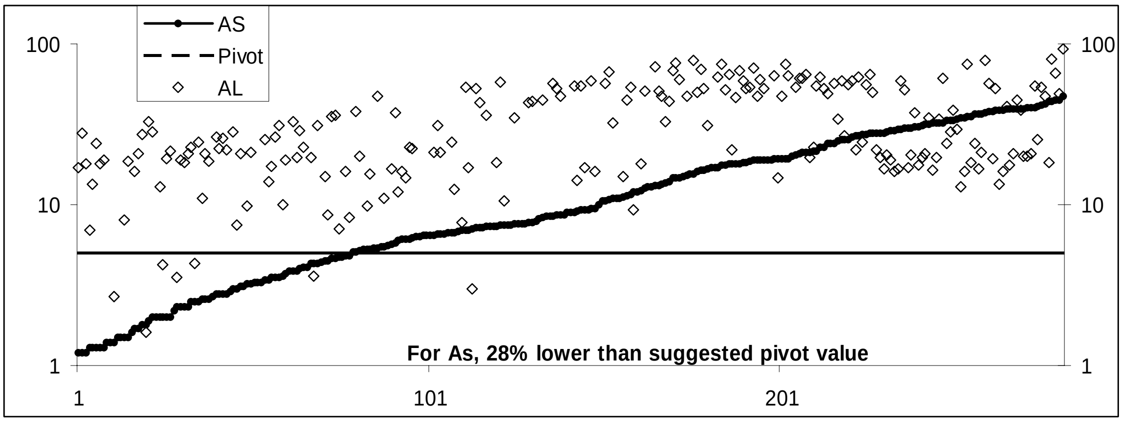


Figure 4B12 As Figure 4B11 but for cadmium

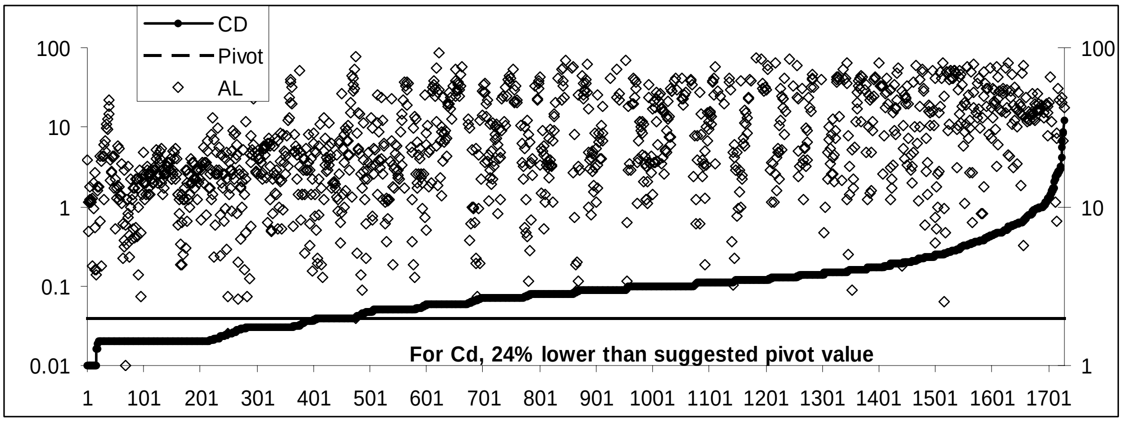


Figure 4B13 As Figure 4B11 but for chromium

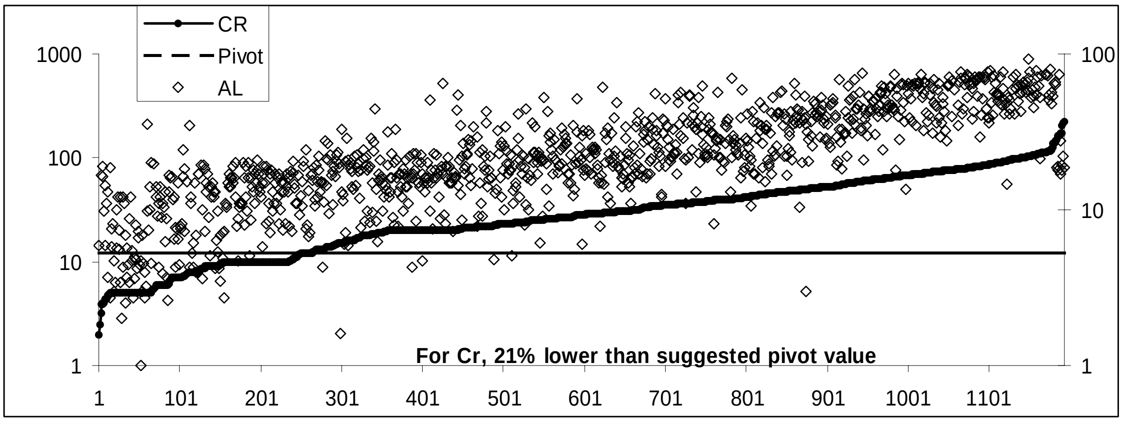


Figure 4B14 As Figure 4B11 but for copper

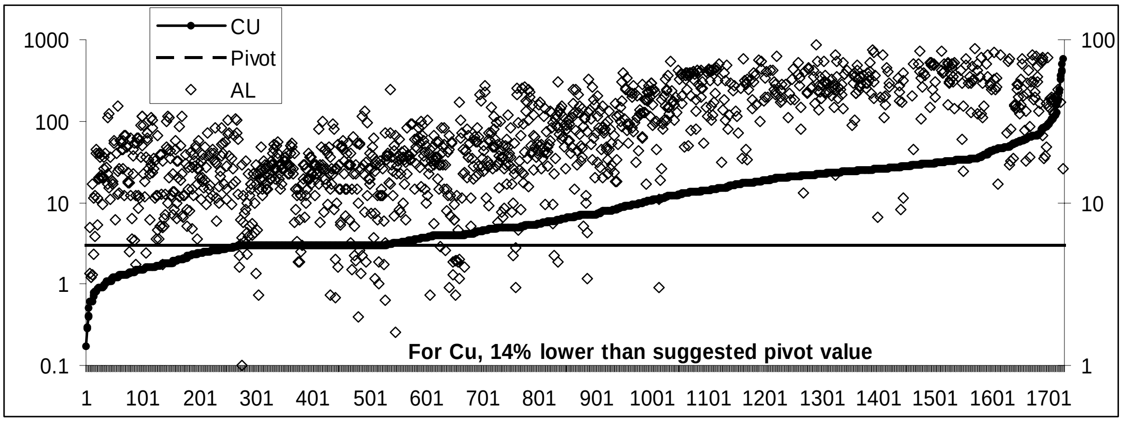


Figure 4B15 As Figure 4B11 but for mercury

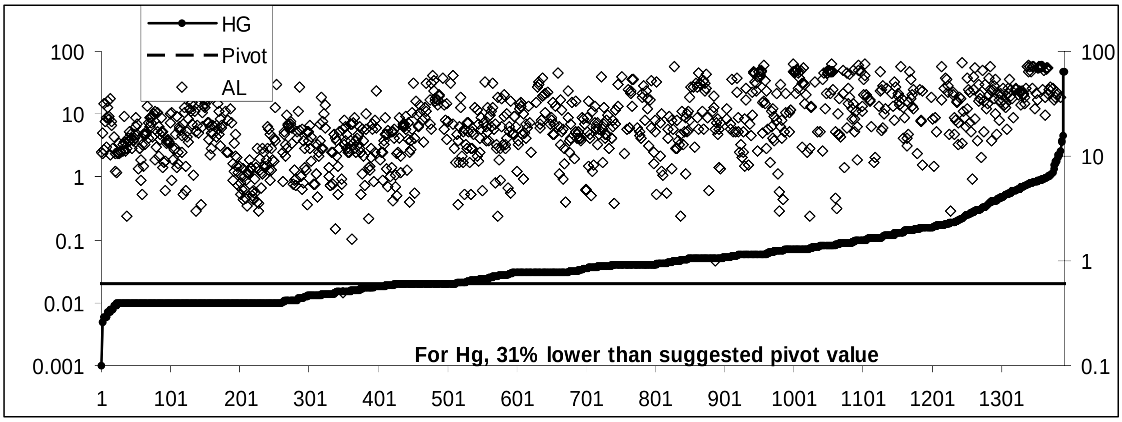


Figure 4B16 As Figure 4B11 but for nickel

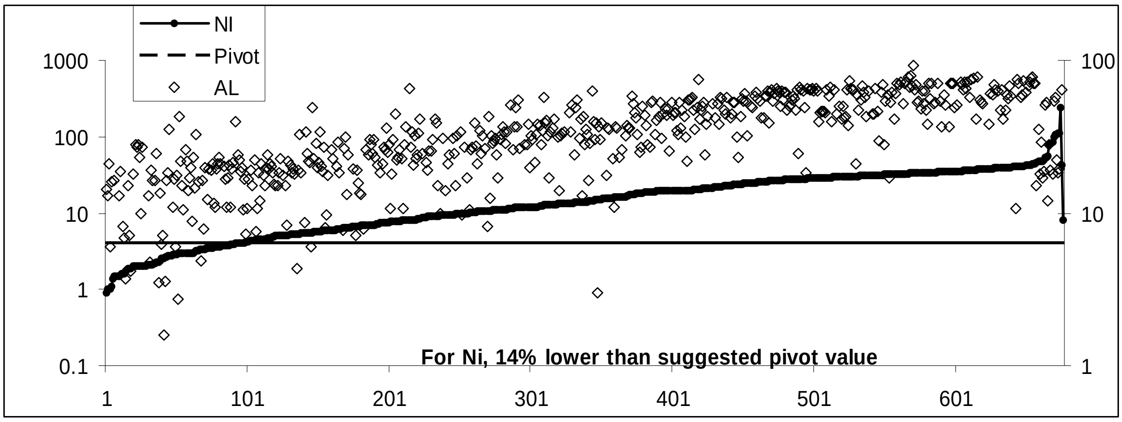


Figure 4B17 As Figure 4B11 but for lead

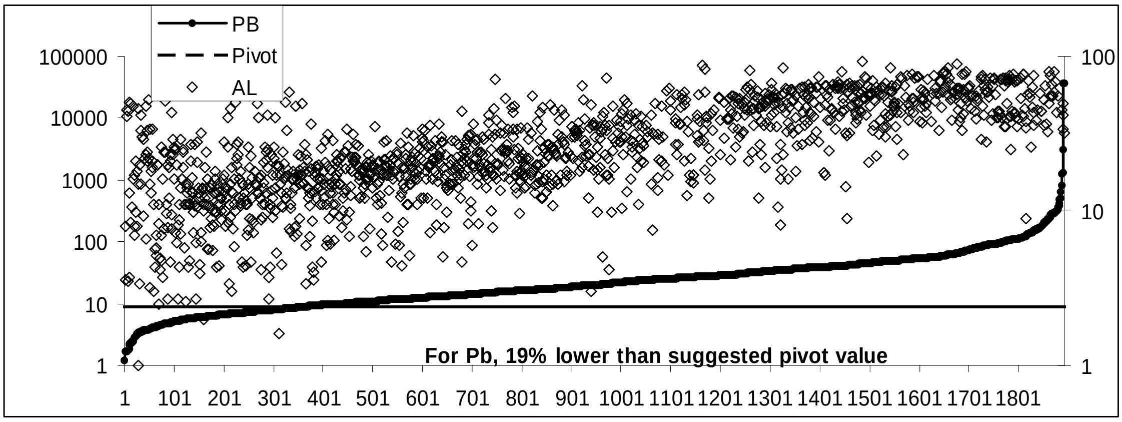
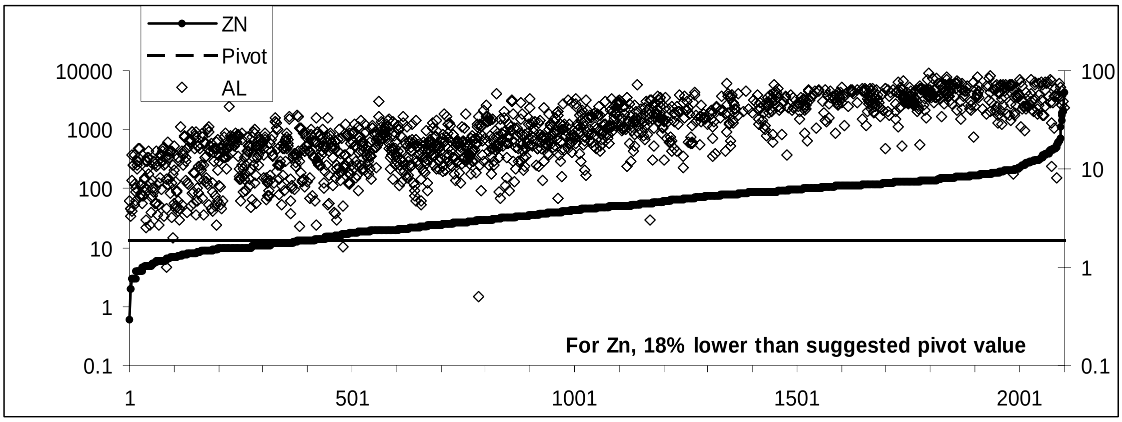


Figure 4B18 As Figure 4B11 but for zinc



Magnitude of analytical variance in biota analyses

1. Introduction

One of the factors which led to the adoption of a new approach to the assessment of analytical QA data in the current assessment was that intersessional work had suggested that the within year analytical variance was relatively small compared to other sources of variance in the data. However, this suggestion had been based on the examination of a relatively small amount of data, for a limited range of determinands. The assessors decided that it was necessary to examine more data with a view to confirming that the suggestion was more widely applicable.

This appendix uses all the data on contaminants in biota held in the ICES database and used in the current assessment (i.e. metals, PAHs and organochlorine compounds in bivalves and fish liver), and estimates the contribution of laboratory performance (analytical variation) to the residual variation in the CEMP data. Only the biota data are considered: the sediment data require more detailed study.

3. Method

Each contaminant-in-biota time series is modelled as:

$$y_t = f(t) + \varepsilon_t$$

where y_t is the median log-concentration in year t; $f(t)$ is a smooth function of time; and ε_t is an error term assumed to be normally distributed with variance ψ^2, the *residual* variance. The table summarises the estimates of ψ by contaminant, for bivalves and finfish, by giving the number of time series and the 25%, 50% and 75% quantiles of the estimates of ψ. The quantiles can be thought of as representing low, medium and high variability.

The residual variance can be decomposed into residual environmental variation (e.g. due to variation between individuals and random perturbations over time) and residual analytical variation:

$$\psi^2 = \psi^2_{\text{enviromental}} + \psi^2_{\text{analtyical}}$$

Making several assumptions and approximations (the sampling guidelines have been followed; there is negligible variation in analytical bias over time; the variation in median log-concentration is similar to that in mean log-concentration) the residual analytical variation can itself be written:

$$\psi^2_{\text{analytical}} = \frac{\sigma^2_{\text{analytical}}}{A}$$

where $\sigma^2_{\text{analytical}}$ is the analytical variation associated with each contaminant measurement and A is the number of measurements (per year). The percentage contribution of laboratory performance to the residual variation is thus:

$$\%\ \text{laboratory contribution} = 100\frac{\psi^2_{\text{analytical}}}{\psi^2} = 100\frac{\sigma^2_{\text{analytical}}}{A\psi^2}$$

The table shows estimates of the % laboratory contribution assuming that $\sigma_{\text{analytical}} = 0.125$ (i.e. a coefficient of variation of 12.5%), that $A = 3$ for bivalves and 5 for finfish, and that ψ is the 50% quantile in the table.

3. Conclusion

The median % laboratory contribution to the residual variance is 10% for metals in bivalves and less than 5% for metals in finfish and organics in bivalves and finfish. This supports the original suggestion that the analytical variance is normally a small component of the overall residual variance in the time series for metals, PAHs and organochlorine compounds in bivalves and fish liver.

	Bivalves					Finfish				
	n	ψ 25%	ψ 50%	ψ 75%	% lab cont	*n*	ψ 25%	ψ 50%	ψ 75%	% lab cont
Ag	5	0,04	0,09	0,37	60	0				
As	32	0,09	0,15	0,29	22	27	0,17	0,23	0,33	6
Cd	149	0,15	0,21	0,31	12	80	0,22	0,33	0,46	3
Cr	28	0,22	0,37	0,55	4	12	0,62	0,73	0,94	1
Cu	145	0,12	0,18	0,25	16	42	0,18	0,3	0,44	3
Hg	149	0,18	0,25	0,36	8	87	0,19	0,26	0,41	5
Ni	38	0,25	0,34	0,47	4	7	0,2	0,55	0,85	1
Pb	152	0,18	0,26	0,44	8	76	0,27	0,39	0,58	2
Se	12	0,28	0,32	0,35	5	0				
Zn	149	0,12	0,18	0,24	16	42	0,12	0,17	0,23	11
Median					**10**					**3**
Anthracene	84	0,21	0,36	0,56	4	0				
Benzo[a]anthracene	88	0,28	0,41	0,63	3	0				
Benzo[a]pyrene	84	0,19	0,3	0,57	6	0				
Benzo[ghi]perylene	86	0,26	0,38	0,6	4	0				
Chrysene	91	0,33	0,47	0,67	2	0				
Fluoranthene	91	0,21	0,34	0,53	5	0				
Indeno[123-cd]pyrene	82	0,28	0,44	0,76	3	0				
Naphthalene	74	1,05	1,38	1,56	0	0				
Phenanthrene	94	0,24	0,37	0,55	4	0				
Pyrene	93	0,2	0,28	0,5	6	0				
Tributyltin	29	0,35	0,49	0,64	2	0				
Median					**4**					
CB153	149	0,19	0,26	0,45	7	92	0,27	0,38	0,57	2
DDE (p,p’)	127	0,27	0,36	0,48	4	55	0,31	0,42	0,56	2
Dieldrin	3	0,47	0,48	0,49	2	4	0,78	1,16	1,53	0
Hexachlorobenzene	71	0,15	0,26	0,36	8	63	0,2	0,29	0,37	4
γ-HCH	123	0,39	0,52	0,81	2	55	0,21	0,3	0,39	4
Median					**4**					**2**

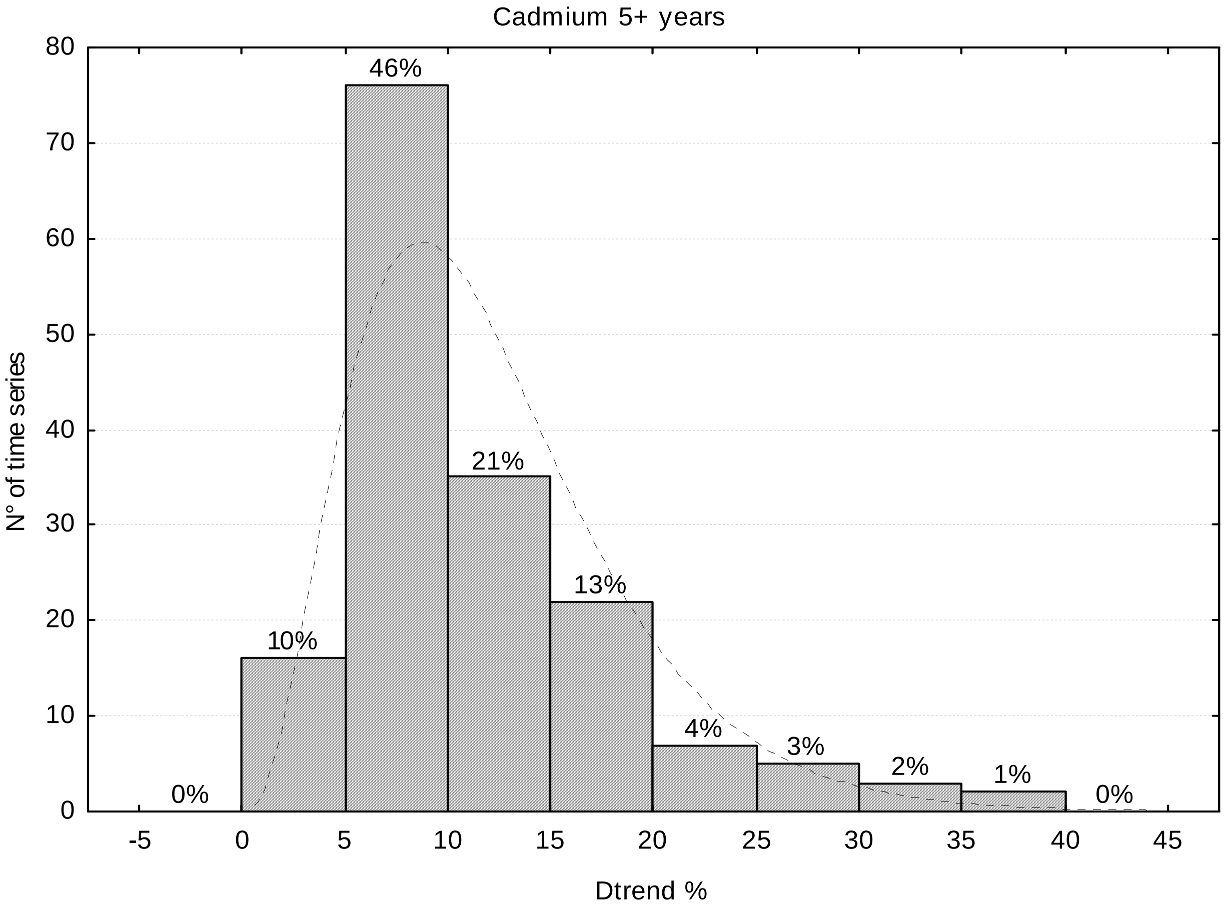
Power of temporal trend programmes to detect changes in concentrations of contaminants

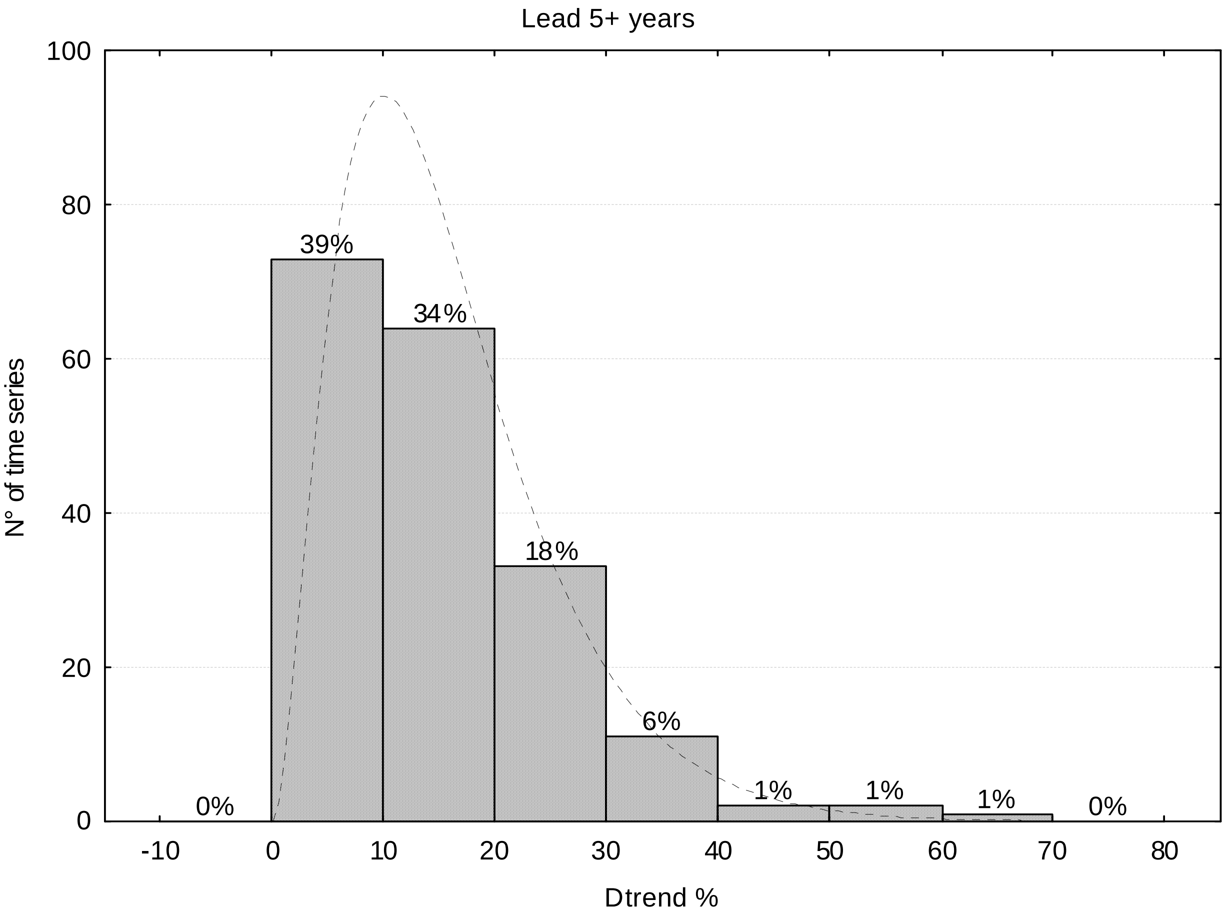
The between year residual variance about fitted time trends determines the statistical power of the monitoring programmes to detect changes with time. As the residual variance differs between stations, so will the power. Various approaches can be used to describe the statistical power of the monitoring to detect trends.

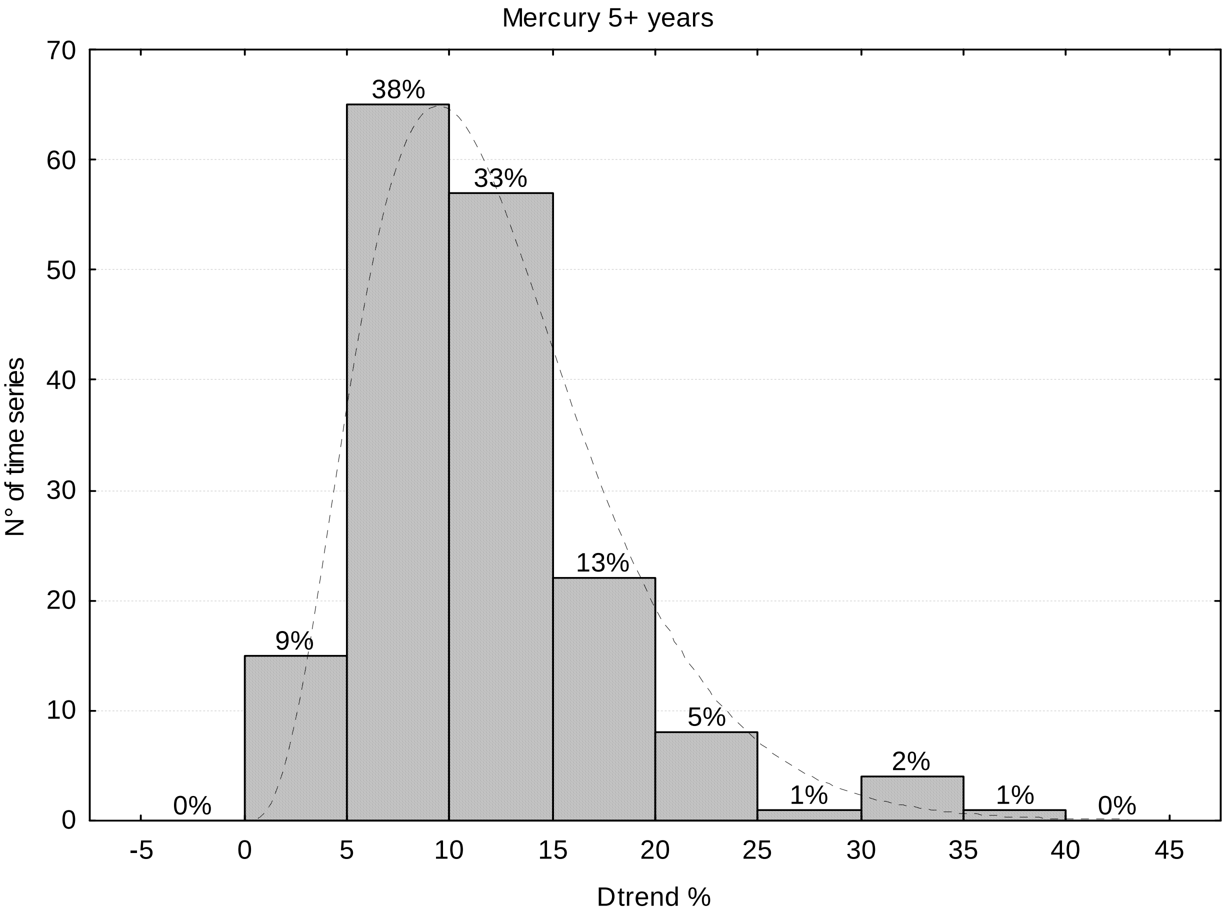
The approach used here considers the minimum rate of change that could be detected by annual monitoring over a period of 10 years. This expression of the capability of the programme is not dependent on the length of the data series. However, it is dependent on the assumption that the variance observed in the available time series is a reasonable reflection of the variance that would be observed over longer periods, i.e. the residual variance about fitted time trends is not strongly dependent on the length of the time series. In order to reduce the uncertainty arising from this assumption, this approach has been applied only to time series which contain 5 or more years of data.

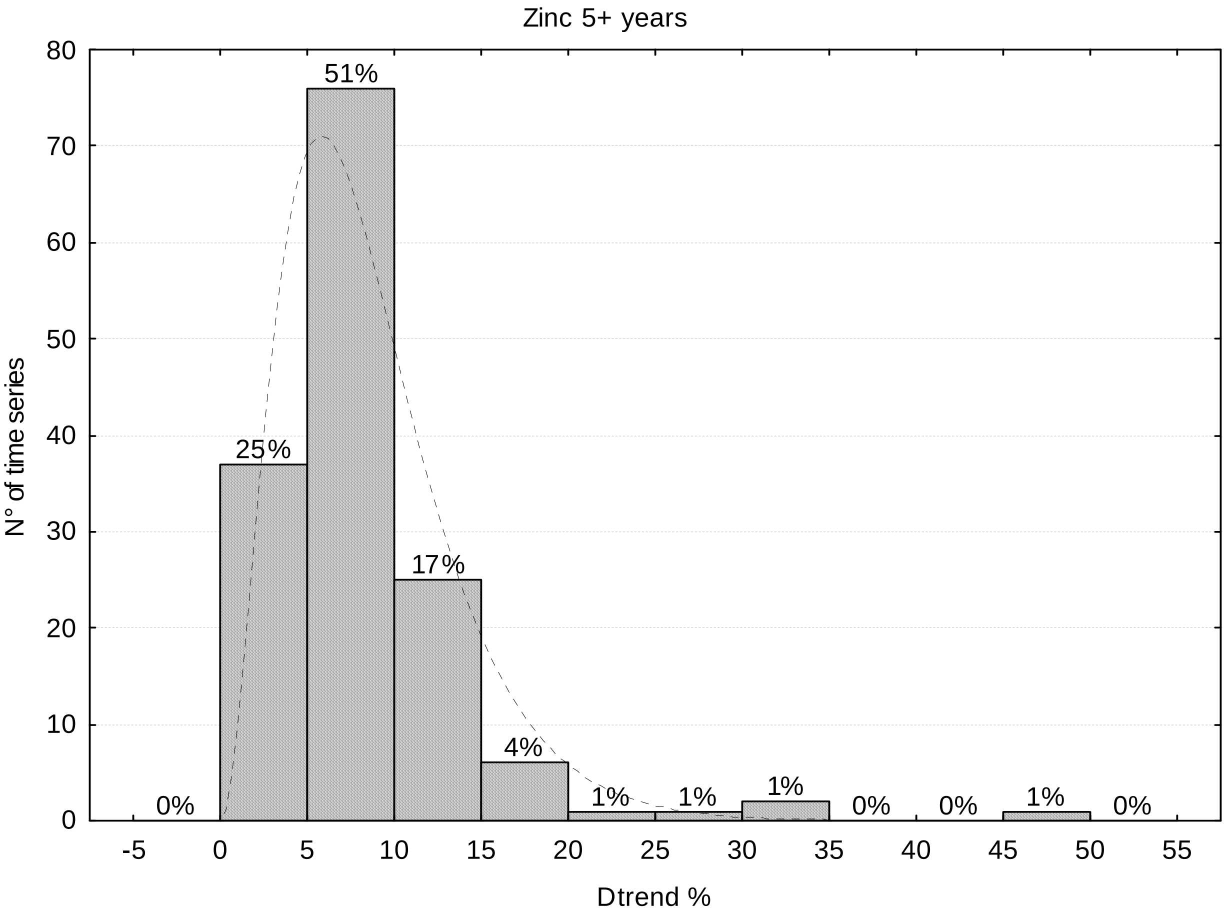
The results of these assessments for time series of contaminants in biota are illustrated in the following histograms, and are summarised in the sections of the report considering each matrix/contaminant combination. The results of this analysis could be used by Contracting Parties to identify those time series with relatively high and low power to detect changes, and therefore used in the optimisation of monitoring programmes.

1. Metals in biota

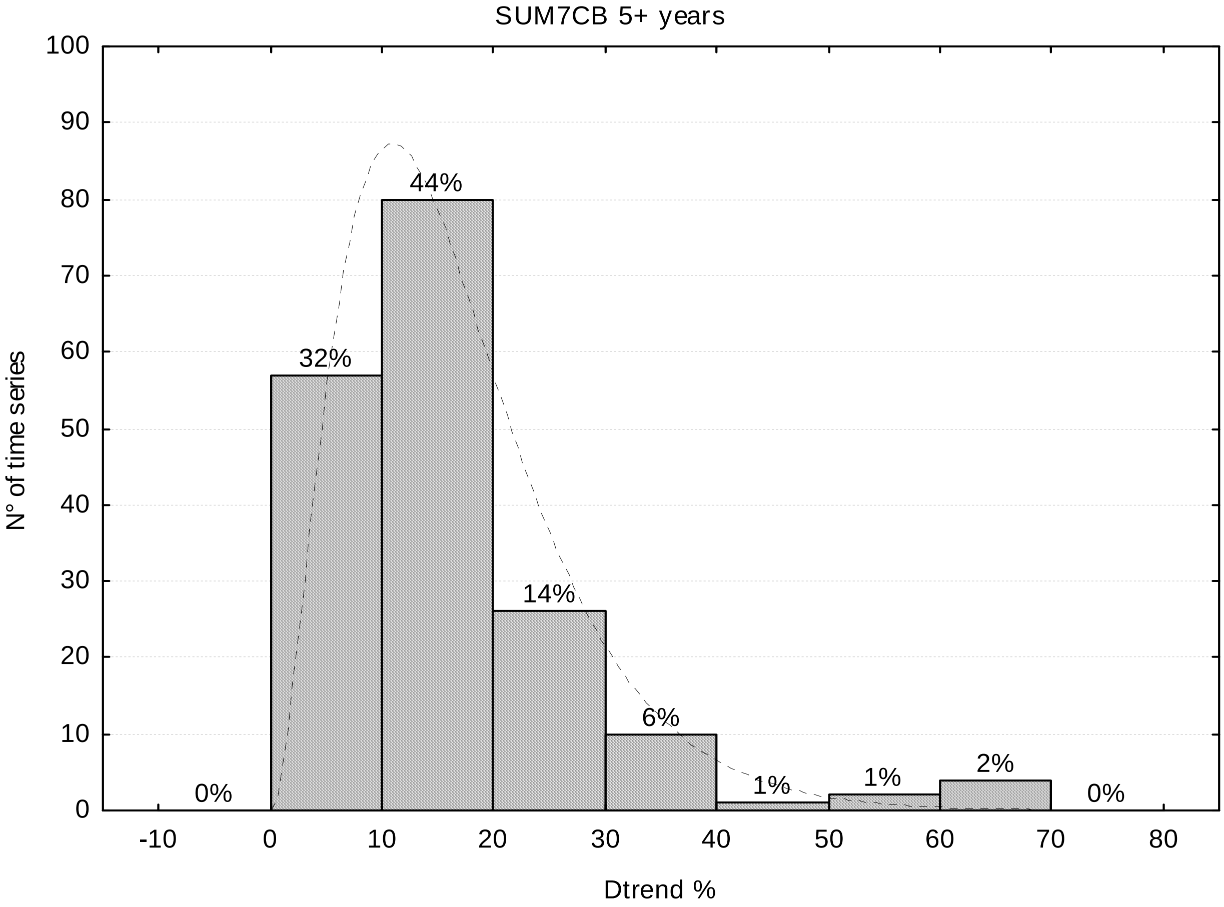


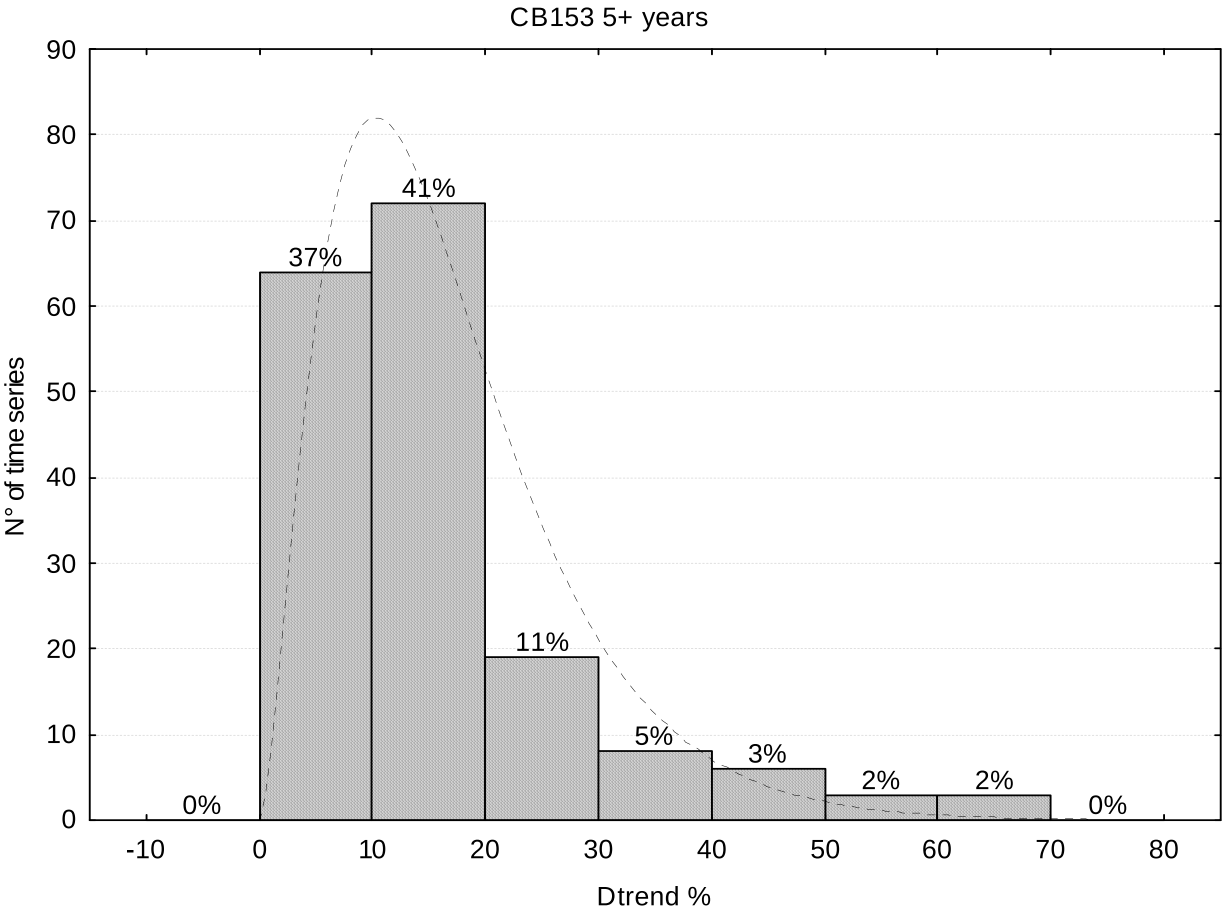



Mercury 5+ years
N° of time series
Dtrend %
38%
33%
13%
9%
5%
2%
1%
1%
0%
0%

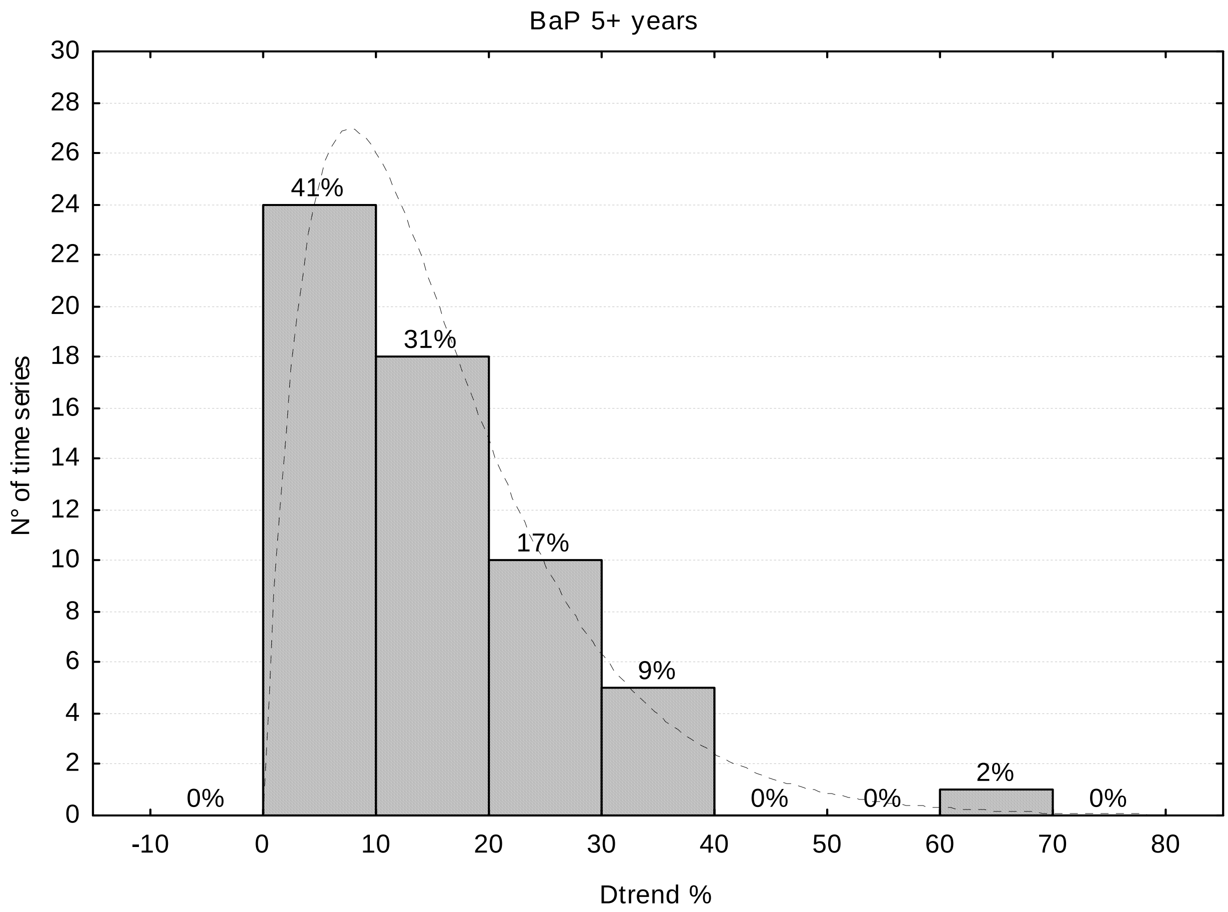

Zinc 5+ years
N° of time series
Dtrend %
51%
25%
17%
4%
1%
1%
1%
1%
0%
0%
0%
0%
0%

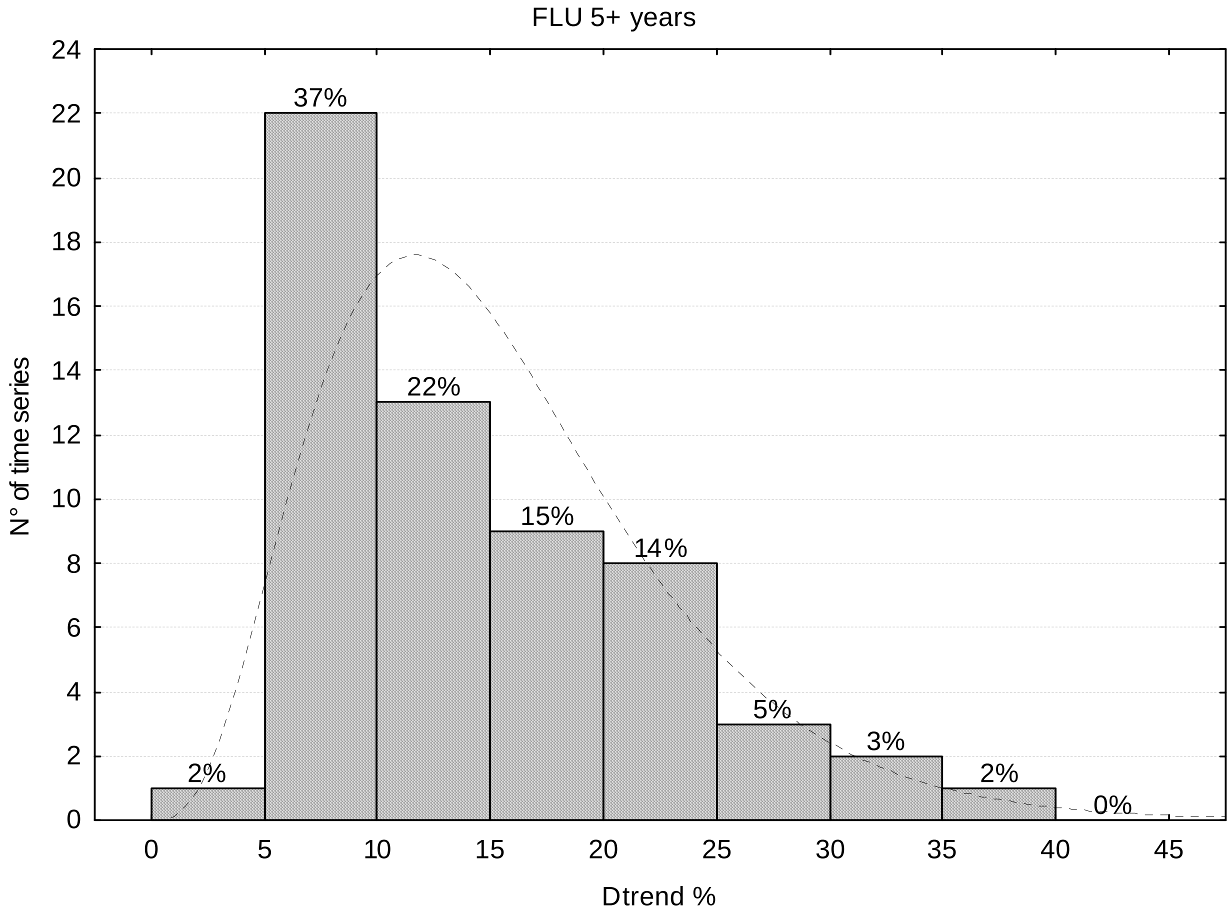
2 CBs in biota

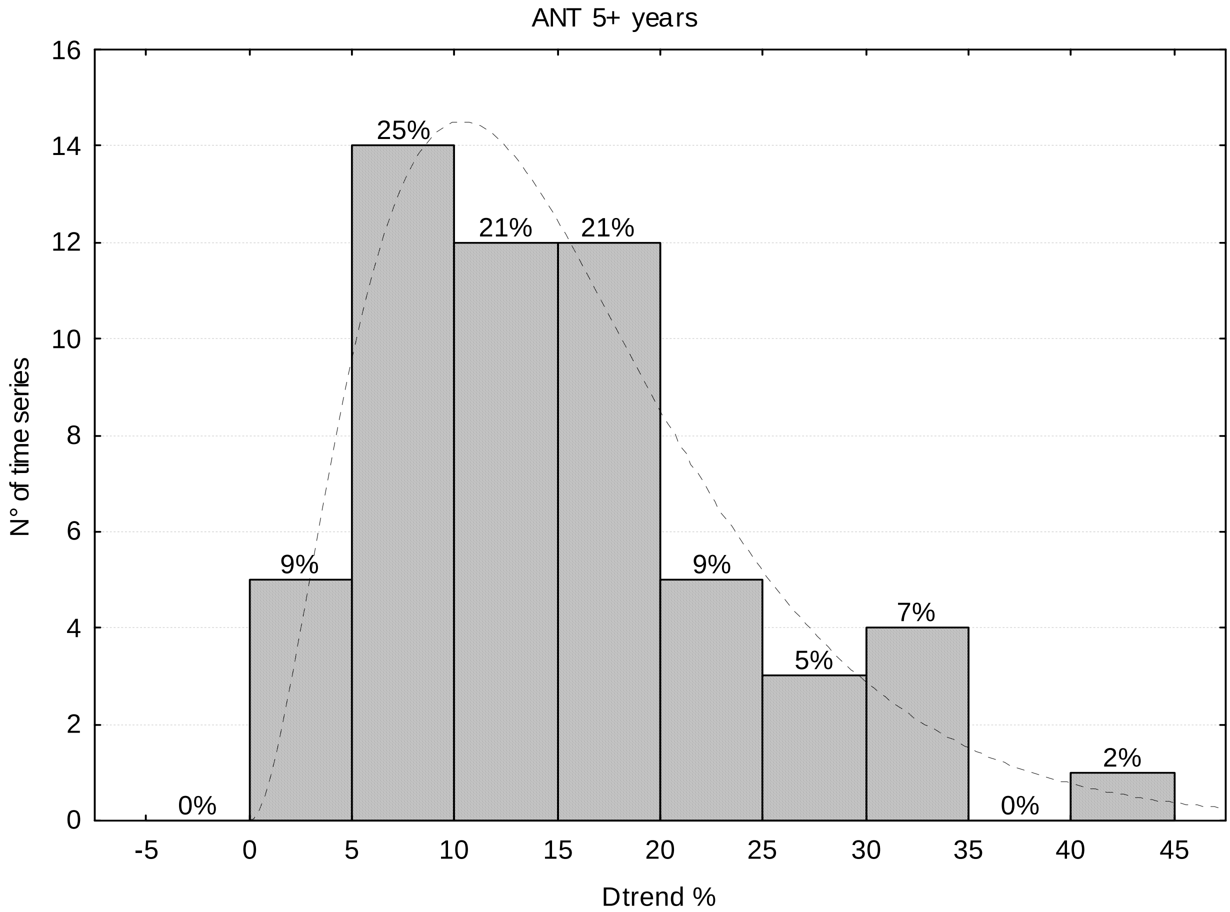


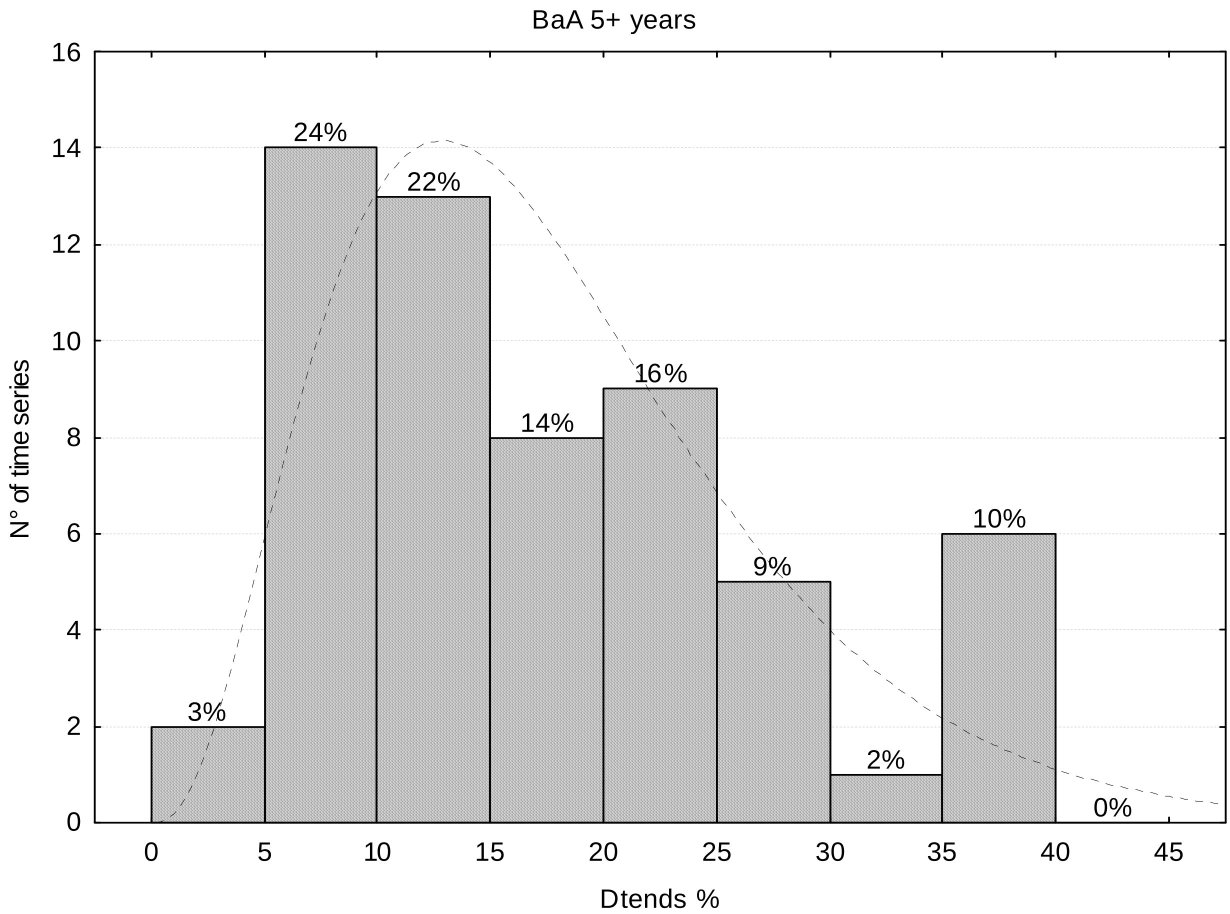


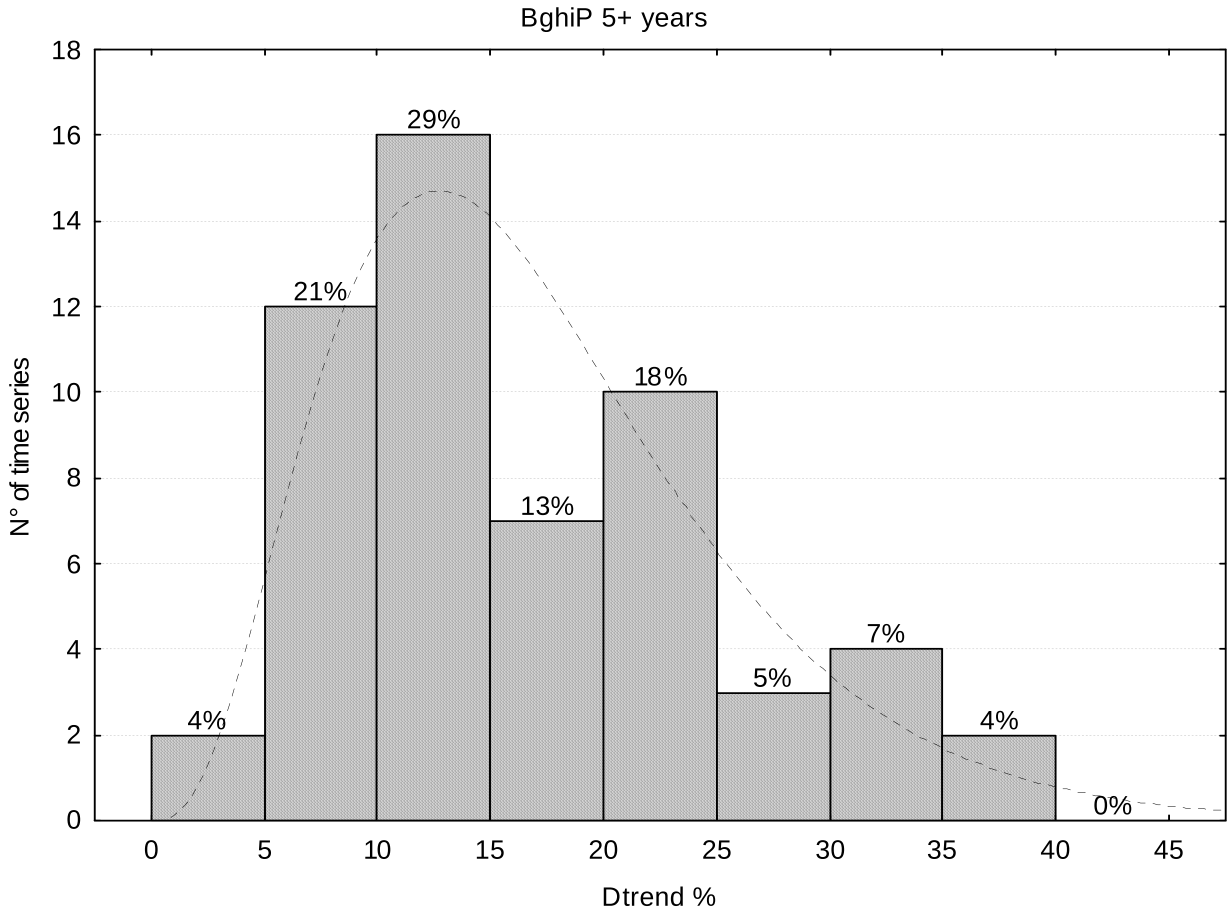
3 PAHs in biota

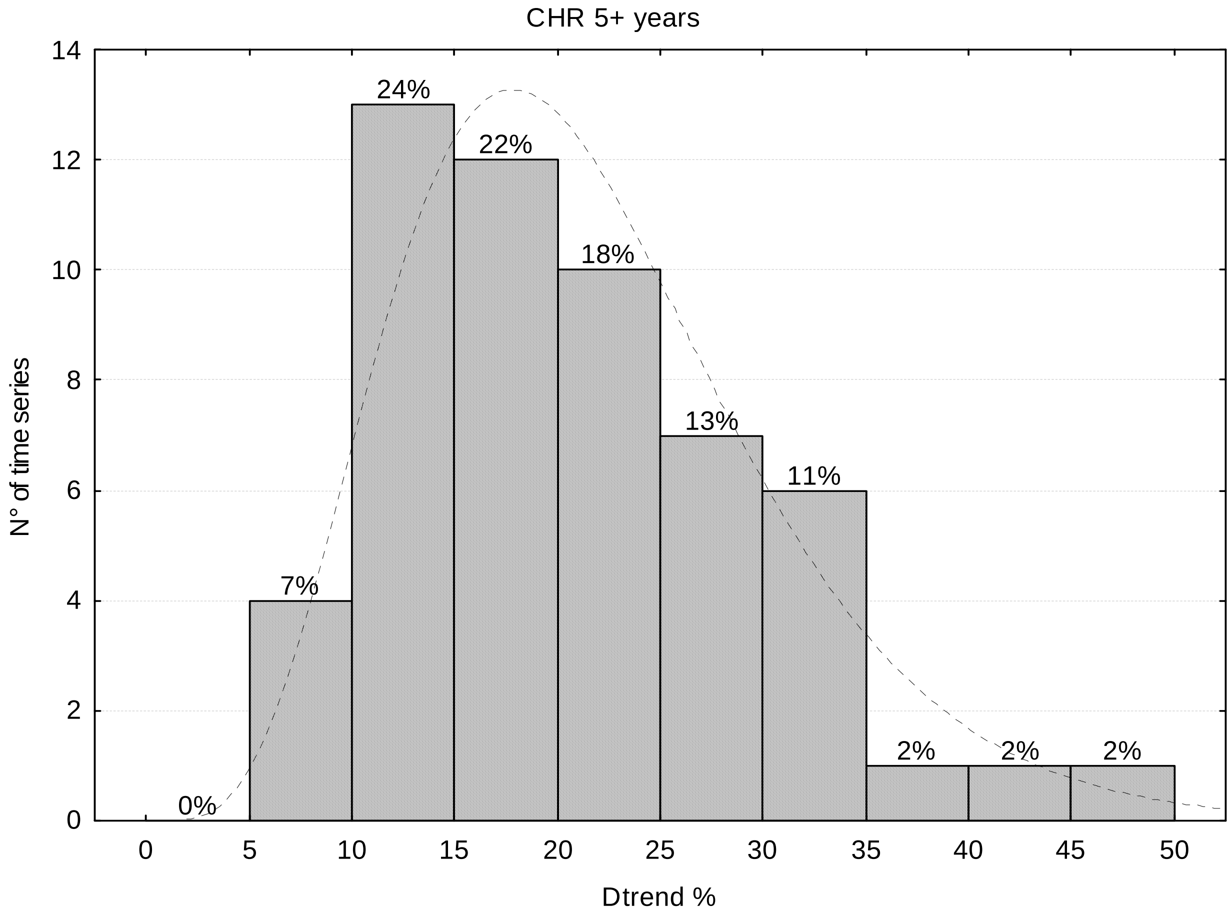


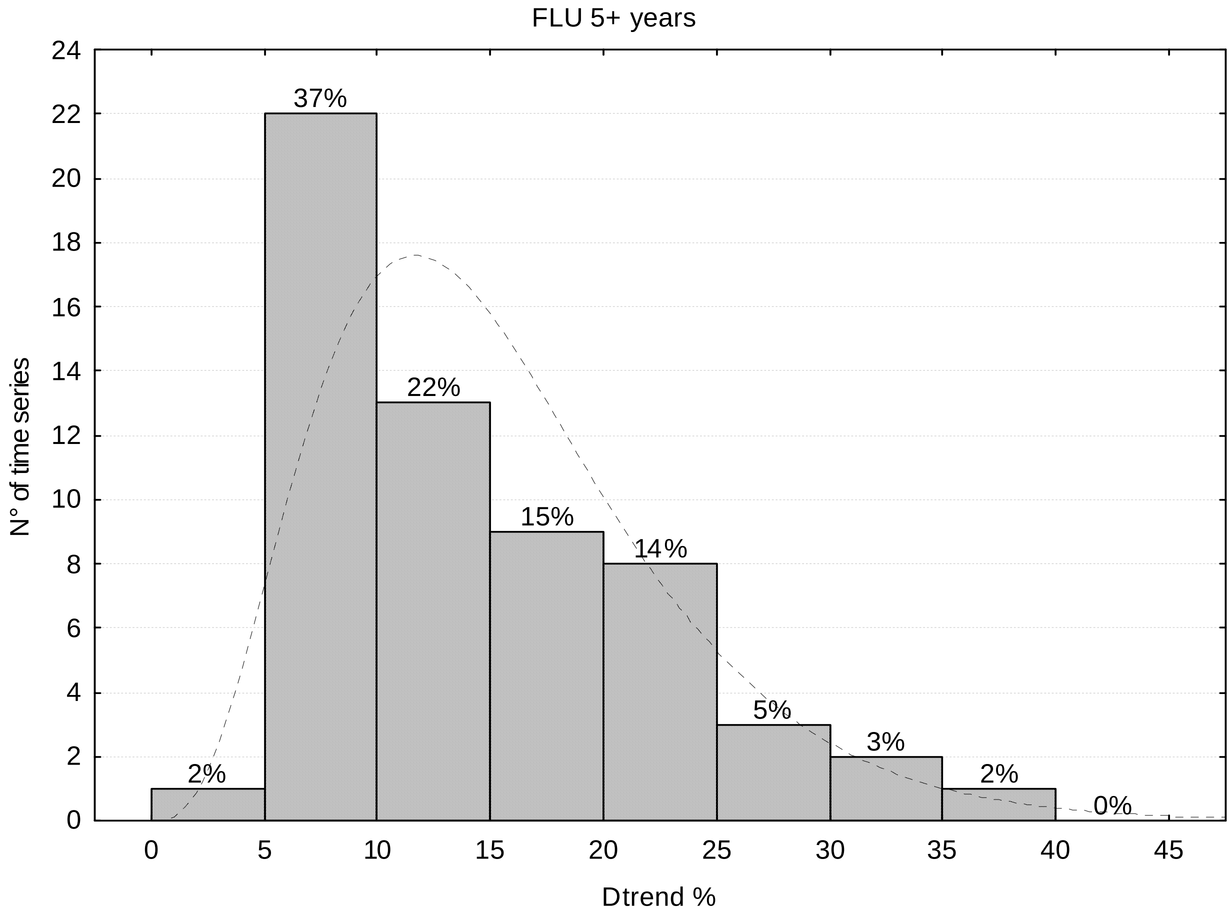


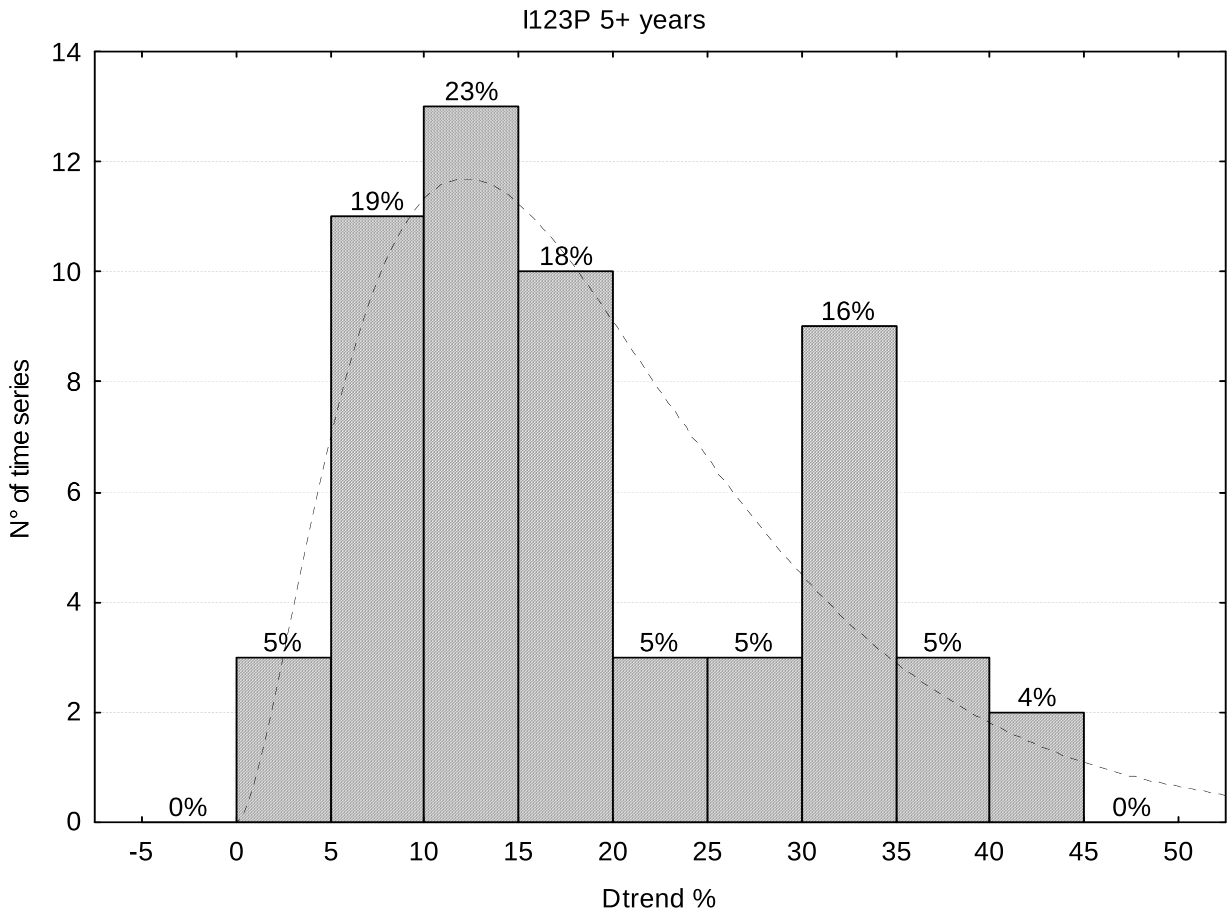

ANT 5+ years
N° of time series
Dtrend %
0%
9%
25%
21%
21%
9%
5%
7%
0%
2%
0
2
4
6
8
10
12
14
16
-5
0
5
10
15
20
25
30
35
40
45


BaA 5+ years
N° of time series
Dtends %
3%
24%
22%
14%
16%
9%
2%
10%
0%
0
2
4
6
8
10
12
14
16
0
5
10
15
20
25
30
35
40
45


BghiP 5+ years
18
16
14
12
10
8
6
4
2
0
N° of time series
29%
21%
18%
13%
7%
5%
4%
4%
0%
0
5
10
15
20
25
30
35
40
45
Dtrend %


CHR 5+ years
14
12
10
8
6
4
2
0
N° of time series
24%
22%
18%
13%
11%
7%
0%
2%
2%
2%
0
5
10
15
20
25
30
35
40
45
50
Dtrend %


FLU 5+ years
N° of time series
Dtrend %
37%
22%
15%
14%
5%
3%
2%
2%
0%
0
2
4
6
8
10
12
14
16
18
20
22
24
0
5
10
15
20
25
30
35
40
45


I123P 5+ years
N° of time series
Dtrend %
0%
5%
19%
23%
18%
5%
5%
16%
5%
4%
0%
0
2
4
6
8
10
12
14
-5
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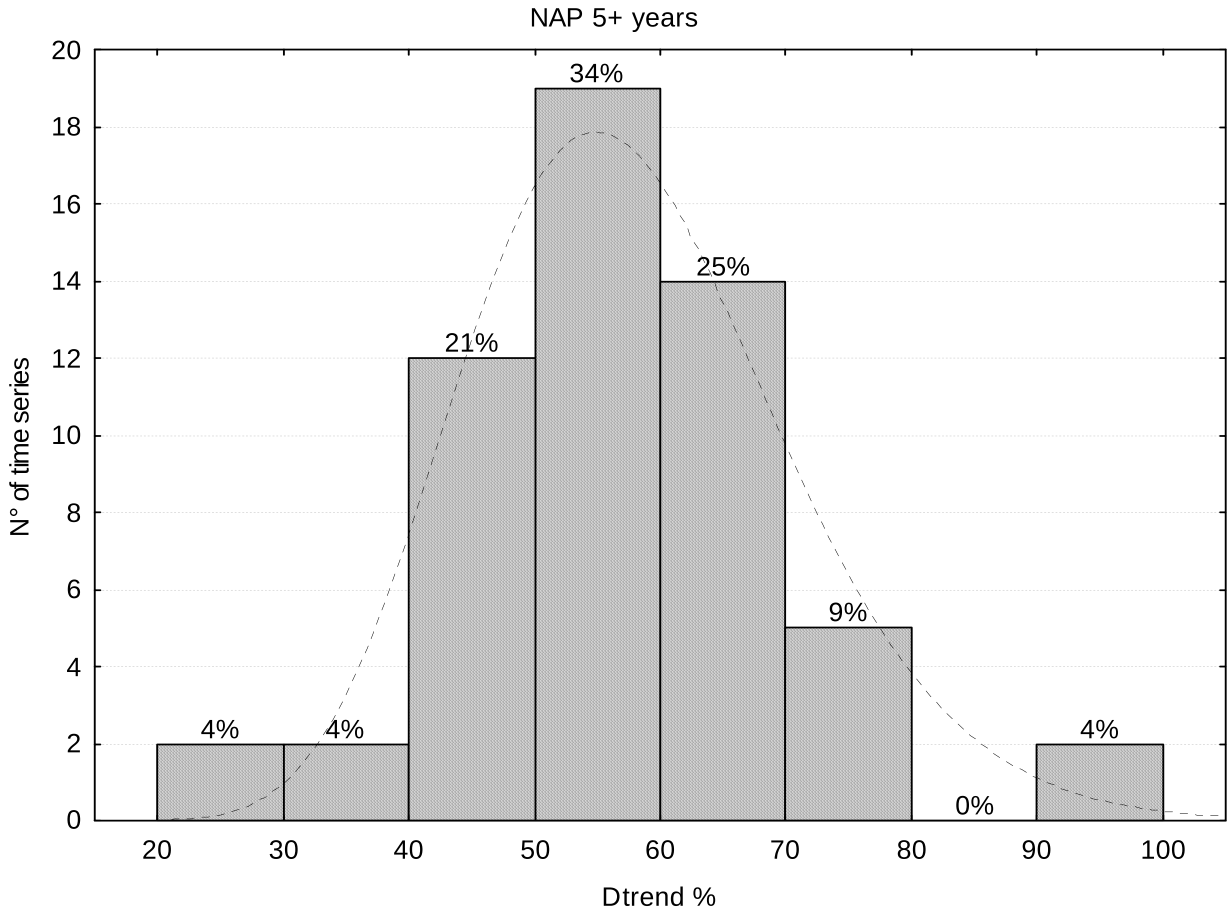
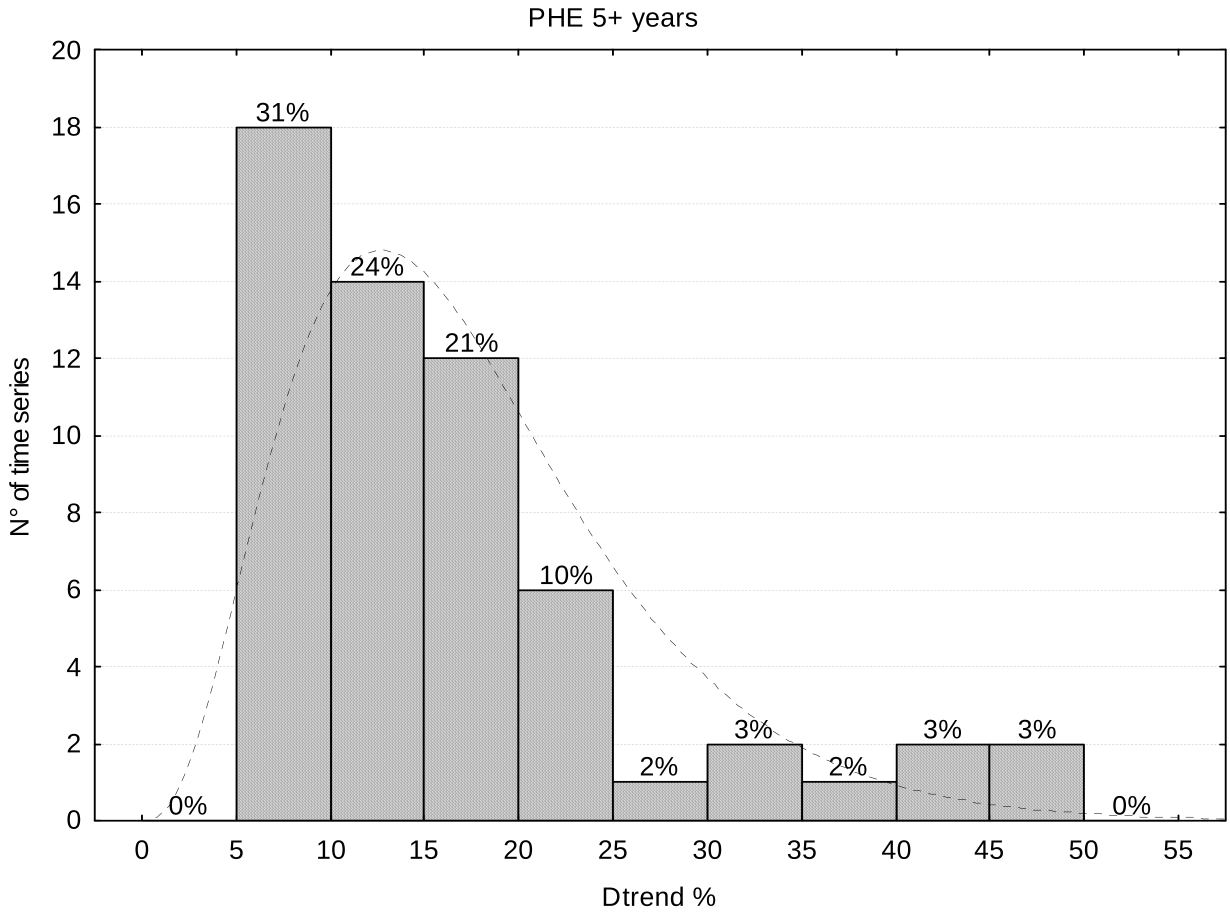
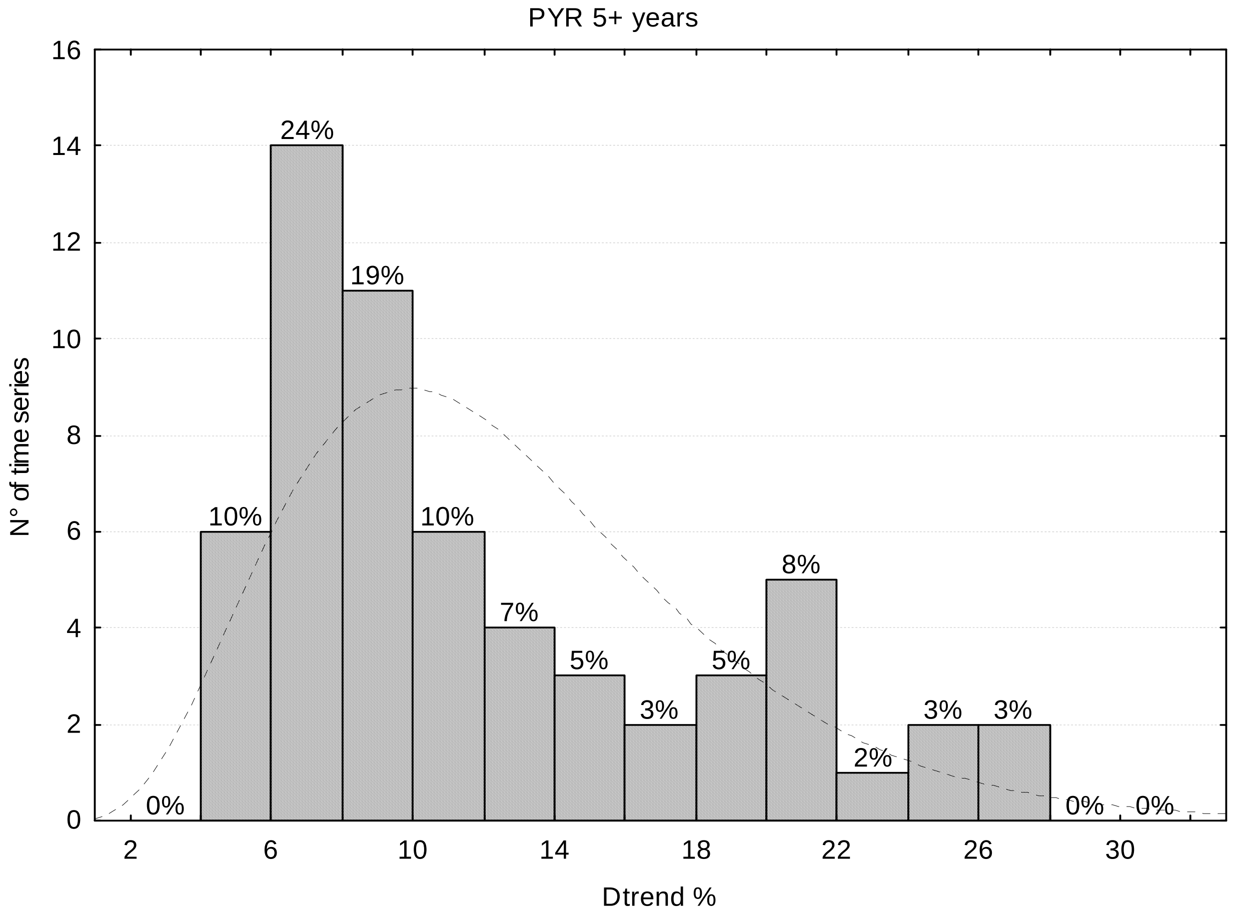
30
35
40
45
50


NAP 5+ years
N° of time series
Dtrend %
20
18
16
14
12
10
8
6
4
2
0
20
30
40
50
60
70
80
90
100
4%
4%
21%
34%
25%
9%
0%
4%


PHE 5+ years
N° of time series
Dtrend %
20
18
16
14
12
10
8
6
4
2
0
0
5
10
15
20
25
30
35
40
45
50
55
0%
31%
24%
21%
10%
2%
3%
2%
3%
3%
0%


PYR 5+ years
N° of time series
Dtrend %
0
2
4
6
8
10
12
14
16
2
6
10
14
18
22
26
30
0%
10%
24%
19%
10%
7%
5%
3%
5%
8%
2%
3%
3%
0%
0%

Proportion of time series that fulfil certain quantitative objectives

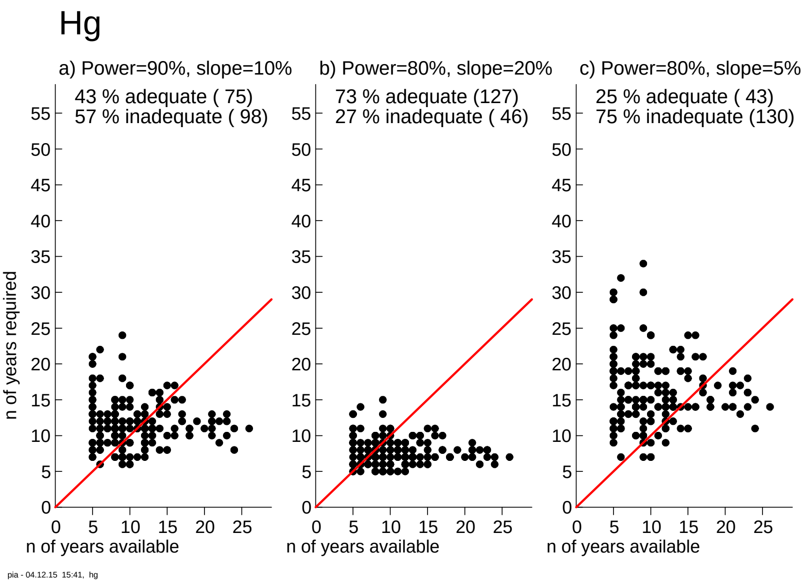
In the present assessment, time series of lengths between 3 and about 25 years are assessed together. Similarly, the random between-year variations show a large range implying that the capability to detect a specified trend varies to a great extent among the series. Clearly, a certain proportion of the assessed series are not likely to detect trends of magnitudes that may be of interest. It is helpful to know the proportion of time-series that fulfill certain quantitative objectives when evaluating the number significant trends in the assessment. If this proportion is small, the proportion (and number) of significant trends that are found will also be, small despite a possible true change in contamination in the assessed areas.

An appropriate quantitative objective for temporal trends specifies the smallest trend that should be possible to detect with a certain power within a specified period at a specified significance level. No firm quantitative objectives have yet been defined for OSPAR programmes, but some alternatives are investigated below.

In order to estimate the proportion of time-series that fulfill a certain objective, the number of years required to detect a certain trend at a certain power at a specified significance level was calculated (using the residual variance of each time series) and plotted against the number of years of data available in the present assessment. It should be stressed that the validity of the estimated minimum number of years required relies on, among other assumptions, that an appropriate estimate of the between-year variance is available. The estimate of the between-year variance depends on the trend model being applied to the data. Residual variances estimated from short time-series may be very uncertain. Single outliers may strongly bias the variance estimate. A recent evaluation of mercury time-series within the AMAP, phase II, program describes the procedure in detail (Bignert *et al*., 2004). The time-series that fall below the diagonal line in the Figures below can be considered adequate in relation to the specified quantitative objective i.e. "adequacy" is defined as a situation in which the number of years of data collection required to achieve the minimum level of power equals or is less than the number of years of data collected. The proportion and number of time-series above the line ("inadequate") and below ("adequate") are presented in the figures. A low proportion of "adequate" time-series may be due to a large proportion of short time-series, high random between-year variation, or a combination of both factors. The Figures also clearly show that the uncertainty in estimated number of years required to detect a certain trend is generally much larger for the short time-series. Three alternative objectives are presented for some trace metals and organic contaminants in biota:

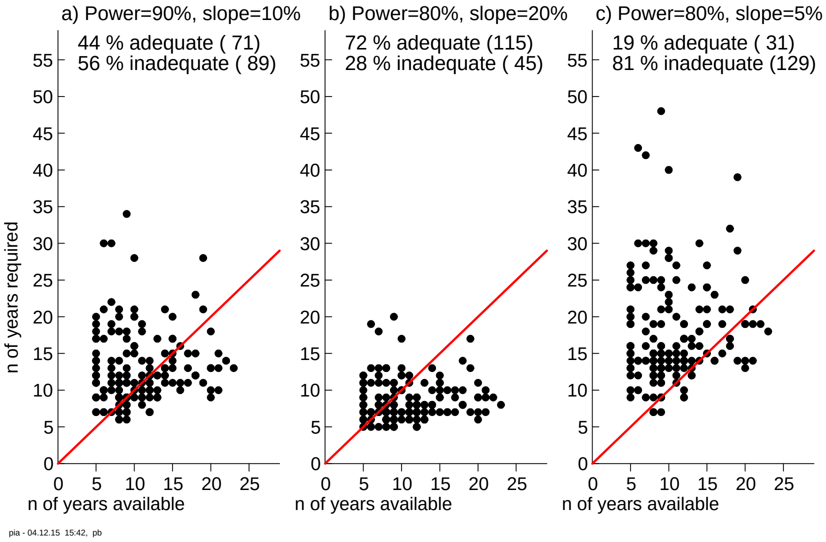
a. to detect a minimum slope of 10%, at a power of 90%*, at a significance level of 5%
b. to detect a minimum slope of 20%, at a power of 80%*, at a significance level of 5%
c. to detect a minimum slope of 5%, at a power of 80%*, at a significance level of 5%.

The analysis has been applied to all time series of three years or more length.

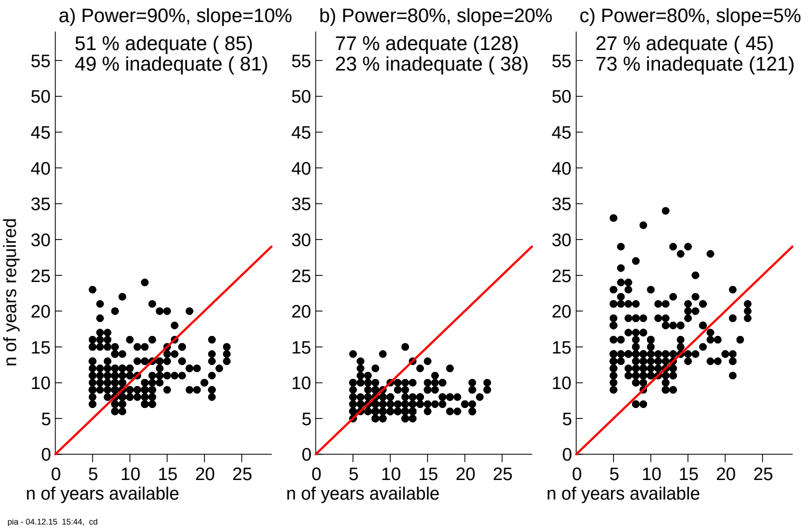


* The actual average power will be somewhat higher then the specified since the power is checked in steps adding one year at a time

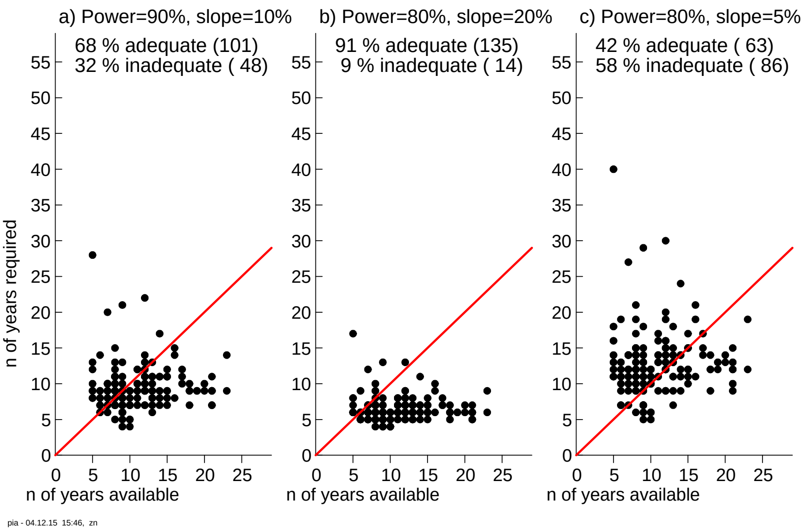
Pb


a) Power=90%, slope=10%
44 % adequate (71)
56 % inadequate (89)
b) Power=80%, slope=20%
72 % adequate (115)
28 % inadequate (45)
c) Power=80%, slope=5%
19 % adequate (31)
81 % inadequate (129)
n of years required
n of years available
pia - 04.12.15 15:42, pb

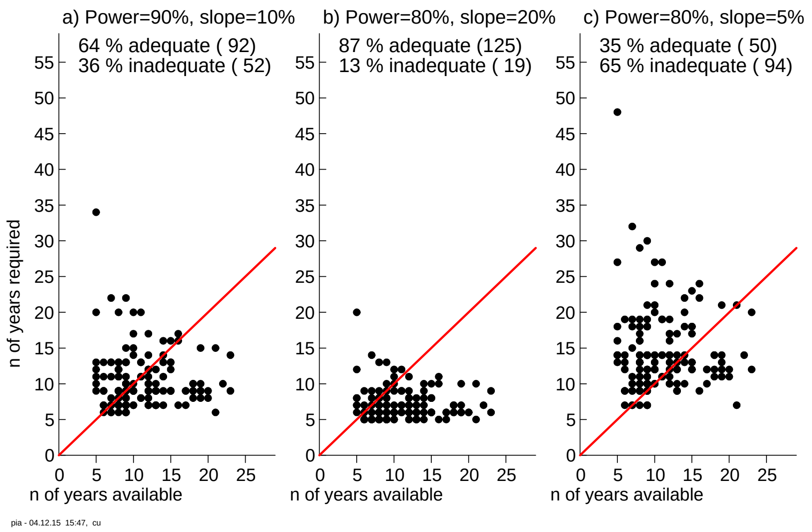
Cd


a) Power=90%, slope=10%
51 % adequate (85)
49 % inadequate (81)
b) Power=80%, slope=20%
77 % adequate (128)
23 % inadequate (38)
c) Power=80%, slope=5%
27 % adequate (45)
73 % inadequate (121)
n of years required
n of years available
pia - 04.12.15 15:44, cd

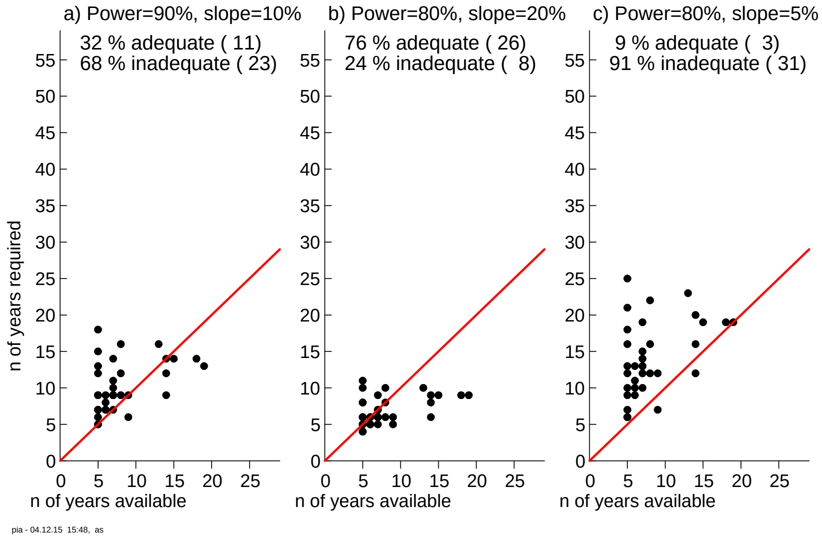
Zn


a) Power=90%, slope=10%
68 % adequate (101)
32 % inadequate (48)
b) Power=80%, slope=20%
91 % adequate (135)
9 % inadequate (14)
c) Power=80%, slope=5%
42 % adequate (63)
58 % inadequate (86)
n of years required
n of years available
pia - 04.12.15 15:46, zn

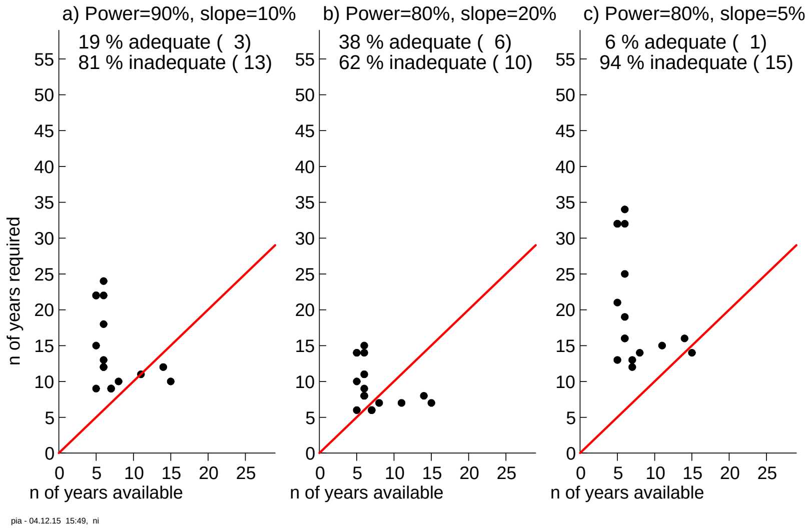
Cu


a) Power=90%, slope=10%
64 % adequate (92)
36 % inadequate (52)
b) Power=80%, slope=20%
87 % adequate (125)
13 % inadequate (19)
c) Power=80%, slope=5%
35 % adequate (50)
65 % inadequate (94)
n of years required
n of years available
pia - 04.12.15 15:47, cu

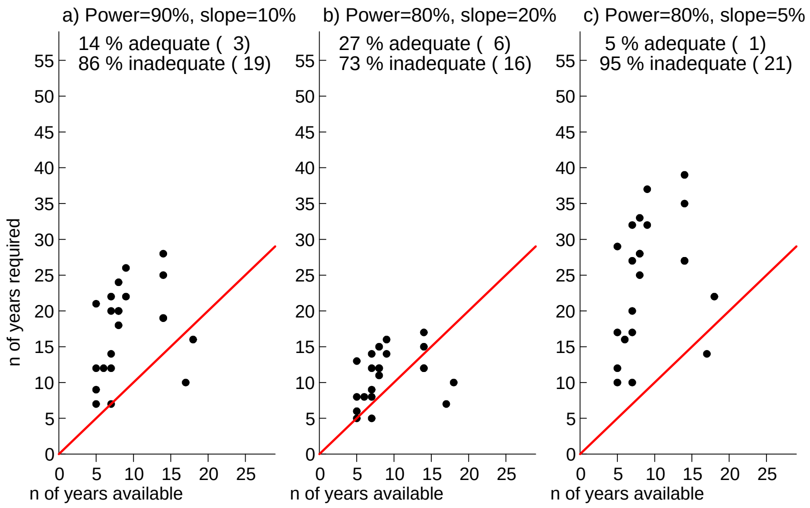
As


a) Power=90%, slope=10%
32 % adequate (11)
68 % inadequate (23)
b) Power=80%, slope=20%
76 % adequate (26)
24 % inadequate (8)
c) Power=80%, slope=5%
9 % adequate (3)
91 % inadequate (31)
n of years required
n of years available
pia - 04.12.15 15:48, as

Ni

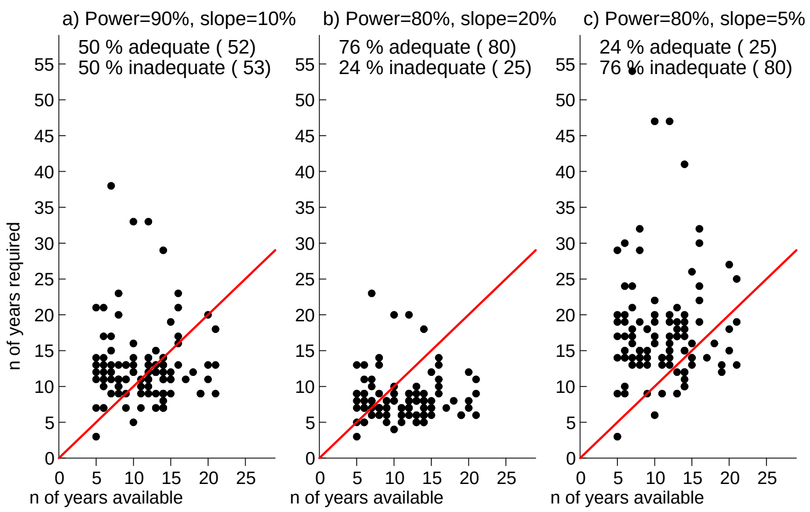

a) Power=90%, slope=10%
19 % adequate (3)
81 % inadequate (13)
b) Power=80%, slope=20%
38 % adequate (6)
62 % inadequate (10)
c) Power=80%, slope=5%
6 % adequate (1)
94 % inadequate (15)
n of years required
n of years available
pia - 04.12.15 15:49, ni

Cr



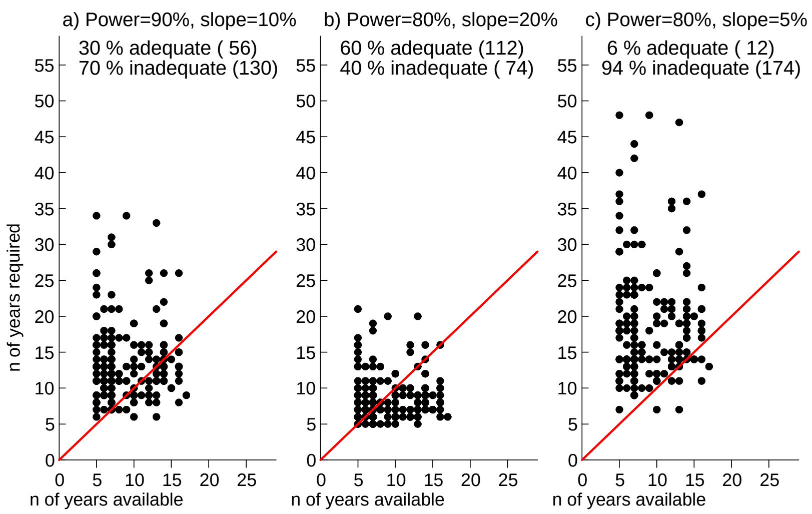
pia - 04.12.15 15:49, cr

HCB



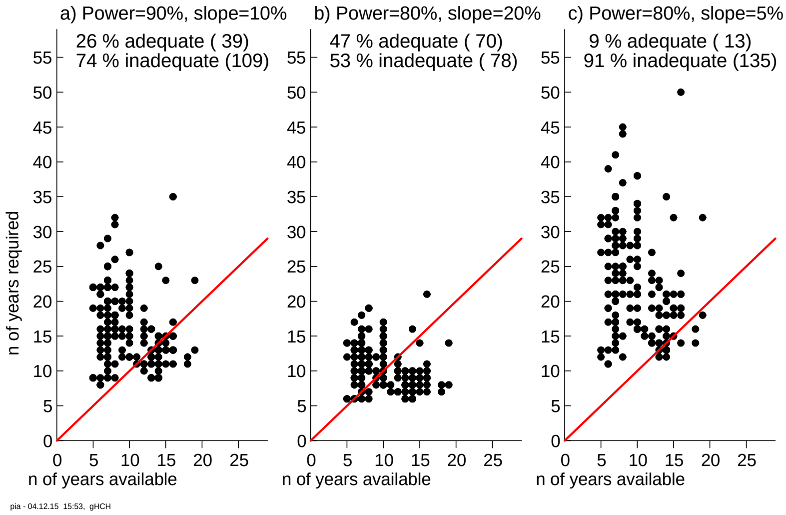
pia - 04.12.15 15:51, HCB

CB-153

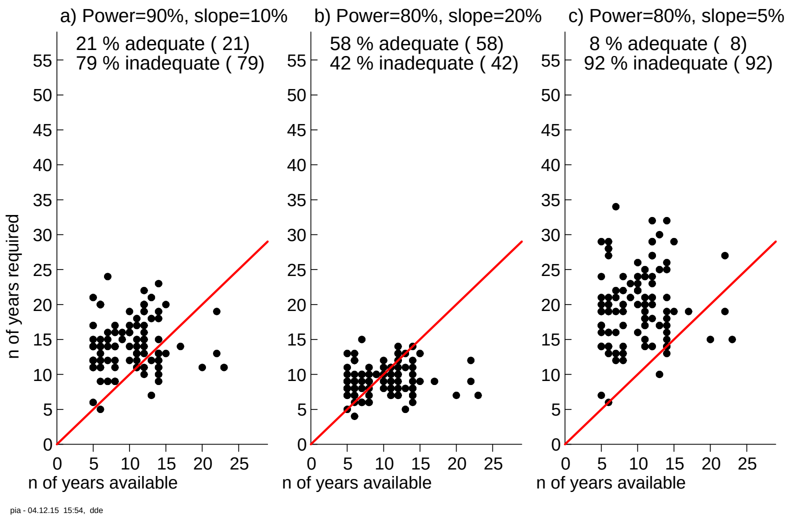


pia - 04.12.15 15:53, CB-153

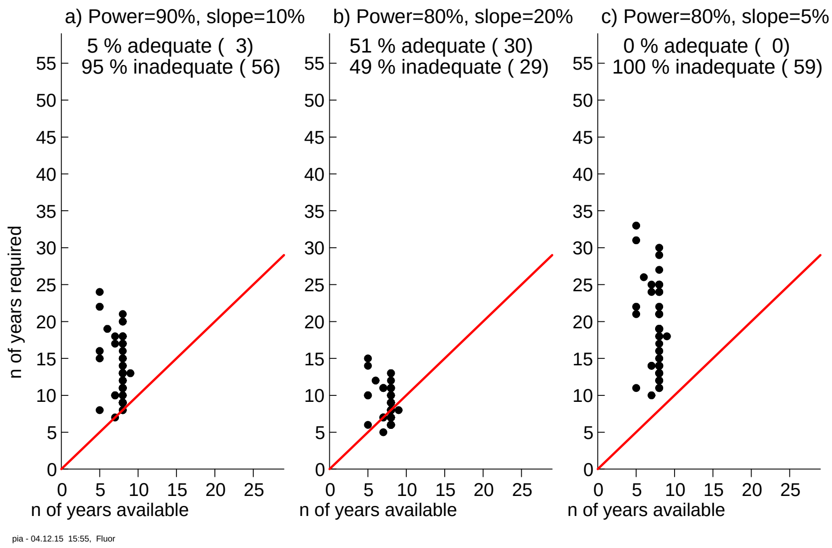
g-HCH



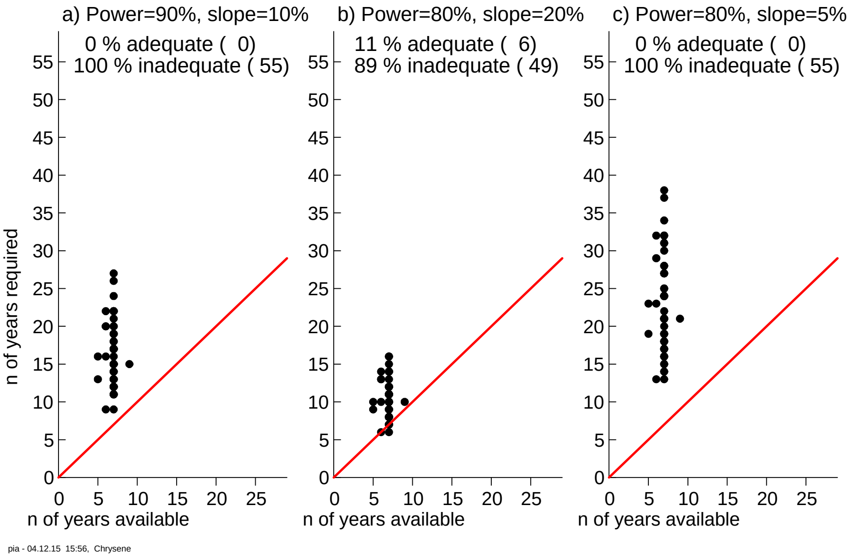
DDE



Fluoranthene



Chrysene



Conclusions

The investigated trace metals; mercury (Hg), lead (Pb) and cadmium (Cd) seem to have similar proportions of "adequate" time-series ranging between 14 and 56% depending on the chosen objective. Higher proportions (better performance) are found for zinc (Zn) ranging between 33 and 72% and copper (Cu) 27-66%. Nickel (Ni) and chromium (Cr) show poor results with only 2-16% and 3-15%, respectively, passing the objectives. Arsenic (As) shows a range between 5 and 47%. The last three elements have relatively few (45, 40 and 59 respectively) and short time-series though.

The investigated organic contaminants show larger differences among themselves. Hexachlorobenzene (HCB) show a similar range (19-60%) as the trace metals, whereas the proportion of adequate time-series of CB-153 is less (5- 46%), γ-HCH (7-39%), DDE (4-32%). The PAH's, fluoranthene (0-33%) and chrysene (0-8%) show very low numbers of "adequate" time series (however, none of the PAH-time-series are longer than 8 year).

In general, even with a modest quantitative objective; to be able to detect a slope of 20% per year at a power of 80%, only about 55% or less of the assessed time-series managed to qualify.

A simple way to increase this proportion would be to exclude time-series shorter than e.g. 5 years (instead of 3). The current assessment of OSPAR data, for example, only investigated trends in data sets of 5 or more years length. The figures show quite many time-series requiring more than 30 years of monitoring to be able to detect the specified trends. For some of these, the estimated required number of years is very uncertain due to the small number of years on which the estimate is based. In other cases, possible sampling errors, analytical problems etc affecting the data in the database may increase the apparent variance.

It is suggested that:

- Contracting Parties may wish to identify time-series longer than 5 years with low power with a view to attempting to improve their power, or redirect resources to other activities, and noted that:
- the process could be carried out with greater confidence if quantitative objectives for the overall programme could be specified and agreed upon.

References

Bignert A., Riget F, Braune B., Outridge P., Wilson S. 2004. Recent temporal trend monitoring of mercury in Arctic biota – how powerful are the existing datasets? J. Environ. Monit, 6, 351 – 355).

2005 Assessment of CEMP data

Appendix 5: Dry weights and lipid weights information for biota
Appendix 6: Alternative background assessment concentrations
Appendix 7: Numbers of yearly means

2005 Assessment of CEMP data
Appendix 5: Summary % dry weights and % lipid weights for monitored species / tissues and suggested conversion factors

Summary % dry weights and % lipid weights for monitored species / tissues and suggested conversion factors

	Number of yearly medians	1st quartile	Median	3rd quartile	100 / median	Suggested conversion factor
% dry weight						
Blue mussel	1096	15,0	18,3	22,6	5,5	5
% lipid weight in liver						
Cod	552	34,0	45,0	50,9	2,2	2
Whiting	3	41,0	44,0	44,3	2,3	2
Common dab	242	7,7	15,9	23,0	6,3	7[1]
Flounder	696	6,1	11,0	14,3	9,1	9
Megrim	59	17,4	20,4	27,0	4,9	5
Plaice	91	8,1	11,2	13,9	8,9	9

1 A conversion factor of 6 would seem more appropriate, but the conversion factor of 7 was used in practice. This is consistent with the conversion factor used in the previous assessment.

2005 Assessment of CEMP data
Appendix 6: Background Assessment Concentrations: alternative estimates based on the variability in the CEMP data

Background Assessment Concentrations:
alternative estimates based on the variability in the CEMP data

Background Assessment Concentrations (BACs), used for making precautionary tests of whether concentrations are *near background*, were proposed following the OSPAR/ICES workshop on the evaluation and update of BRCs and EACs and How these Assessment Tools should be Used in Assessing Contaminants in Water, Sediment and Biota (9-13 February 2004, The Hague). The BACs were constructed using the residual variability found in UK monitoring data, the only monitoring data conveniently available at the time. During the trial application of the proposed BACs as part of the 2005 CEMP assessment it was recommended that the residual variation in the UK data should be compared with that found in other CEMP time series. Large differences in residual variability would suggest the BACs should be revised.

Accordingly, here BACs based on the CEMP data are estimated and compared with the BACs based on the UK data. The methodology for estimating BACs is described in Section 6.1 of the 2004 report of the ICES Advisory Committee on the Marine Environment. The comparison is made for metals, PAHs and CBs in sediment and for PAHs and CBs in blue mussel. BACs for CBs in fish liver have nor been compared because of difficulties in converting between bases (the UK data were on a wet weight basis, whereas the CEMP data were on a lipid weight basis, and there were different conversion factors for converting between bases for different species). There are no BACs for metals in fish or shellfish because of the lack of progress in establishing the underlying Background Concentrations (BCs).

Results

The following tables give the BCs and associated BACs based on both the UK data and the CEMP data (usual font). 95% confidence intervals on the BACs are shown in grey.

Metals in sediments (mg kg^{-1} normalised to 5% aluminium)

		BC		BAC (UK)			BAC (CEMP)	
Arsenic	as	15	20	22	23	23	25	27
Cadmium	cd	0,2	0,28	0,31	0,35	0,28	0,31	0,33
Chromium	cr	60	68	76	84	76	81	87
Copper	cu	20	28	31	36	26	27	29
Mercury	hg	0,05	0,,07	0,08	0,09	0,06	0,07	0,08
Nickel	ni	45	62	70	77	59	61	63
Lead	pb	25	30	34	38	34	38	42
Zinc	zn	90	108	116	125	114	122	132

PAHs in sediment (μg kg^{-1} normalised to 2,5% organic carbon)

		BC		BAC (UK)			BAC (CEMP)	
Naphthalene	nap	5	7	11	17	5	8	11
Phenanthrene	pa	17	29	41	60	26	32	38
Anthracene	ant	3	5	8	12	4	5	6
Fluoranthene	flu	20	30	44	65	31	39	49
Pyrene	pyr	13	18	28	43	20	24	30
Benzo[a]anthracene	baa	9	14	22	33	13	16	21
Chrysene	chr	11	20	29	41	15	20	27
Benzo[a]pyrene	bap	15	40	56	78	24	30	36
Benzo[ghi]perylene	bghip	45	105	140	187	71	80	90
Indeno[123-cd]pyrene	icdp	50	99	128	166	91	103	116

CBs in sediment (μg kg^{-1} normalised to 2,5% organic carbon)

	LC		BAC (UK)			BAC (CEMP)	
CB153	0,1	0,3	0,5	1,0	0,1	0,2	0,3
ΣCB_7	0,4	0,5	1,3	3,0	1,0	1,5	2,1

PAHs in blue mussel (µg kg^{-1} **dry** weight)

		BC	BAC (UK)			BAC (MON)		
Naphthalene	nap	1		5,5		34,3	81,2	192,1
Phenanthrene	pa	4,5	5,4	24,7	112,3	8,0	12,6	19,7
Anthracene	ant	1		2,0		2,2	2,7	3,4
Fluoranthene	flu	7	6,0	12,7	26,7	8,0	11,2	15,7
Pyrene	pyr	5,5	5,5	8,9	14,6	7,8	10,1	13,1
Benzo[a]anthracene	baa	1,5	2,3	5,4	12,9	2,6	3,6	5,1
Chrysene	chr	6,5	7,8	17,0	37,2	15,4	21,8	30,9
Benzo[a]pyrene	bap	1	1,1	3,5	11,7	1,6	2,1	2,9
Benzo[ghi]perylene	bghip	2,5	2,6	13,3	69,3	5,2	7,2	10,0
Indeno[123-cd]pyrene	icdp	2	0,6	8,1	104,7	3,8	5,5	8,1

BCs have been converted from wet weight by multiplying by five. Few UK time series were available for anthracene, so there are no 95% confidence intervals on the BAC (UK). There were no UK time series available for naphthalene, so the BAC (UK) was based on the maximum % CV observed in the other PAHs.

CBs in blue mussel (µg kg^{-1} **dry** weight)

	LC	BAC (UK)			BAC (CEMP)		
CB153	0,5	0,9	1,9	3,7	0,9	1,1	1,3
ΣCB_7	2,0	2,0	3,6	6,6	4,1	4,6	5,2

BCs have been converted from wet weight by multiplying by five.

The graphs in figures 1-5 show the % coefficient of variation (%CV) in each time series plotted against the estimated mean concentration in the final year, with a smooth curve fitted to the data. The UK data are plotted in blue, the CEMP data are plotted in red. The horizontal axis is on a square root scale and there is a second vertical axis showing the scaling factor to get from the BC to the BAC. The vertical grey line indicates the BC. The fitted %CV at the BC is used to estimate the BAC. When the BC is below the minimum estimated mean concentration, the fitted %CV at the minimum estimated mean concentration is used to estimate the BAC.

Summary

- The two sets of BACs are broadly similar for metals in sediment and for CBs in sediment and in blue mussel.
- The BACs for PAHs in sediment based on the CEMP data are always less than those based on the UK data.
- The two sets of BACs are broadly similar for PAHs in blue mussel, although some 'larger' discrepancies appear for both the lightest and heaviest compounds.

There is one **important caveat**. The residual variability in the UK data was established by taking the yearly contaminant index to be the median log-concentration and giving equal statistical weight to each contaminant index. The residual variability in the CEMP data was established by taking the yearly contaminant index to be the median log-concentration for biota and the weighted mean log-concentration for sediment, and giving variable statistical weight to each contaminant index. Thus differences in residual variability might arise because of the different statistical treatments. More detailed investigations should be undertaken before any formal revisions to the BACs are made.

Figure 1 - Metals in sediment

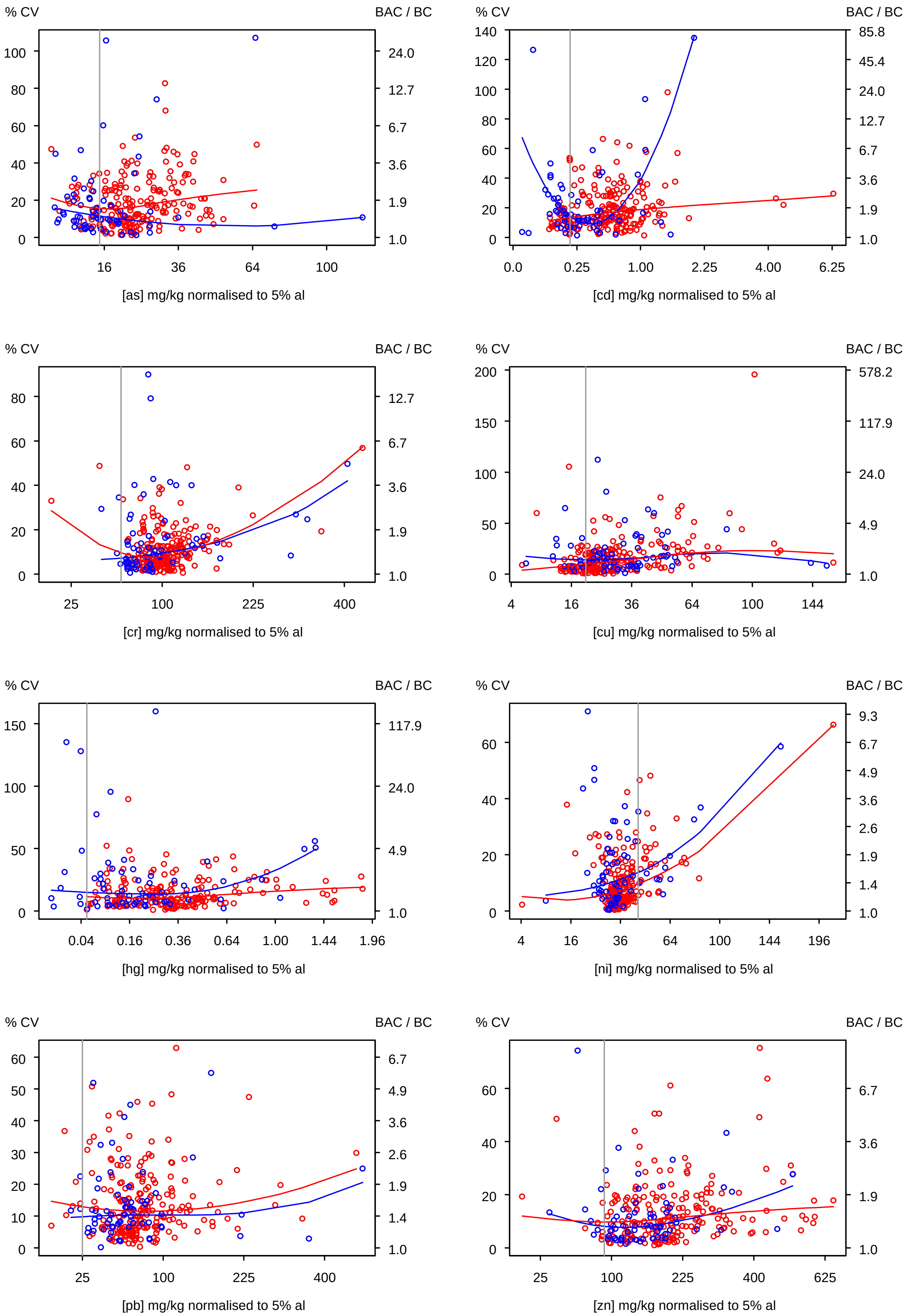


Figure 2 - PAHs in sediment

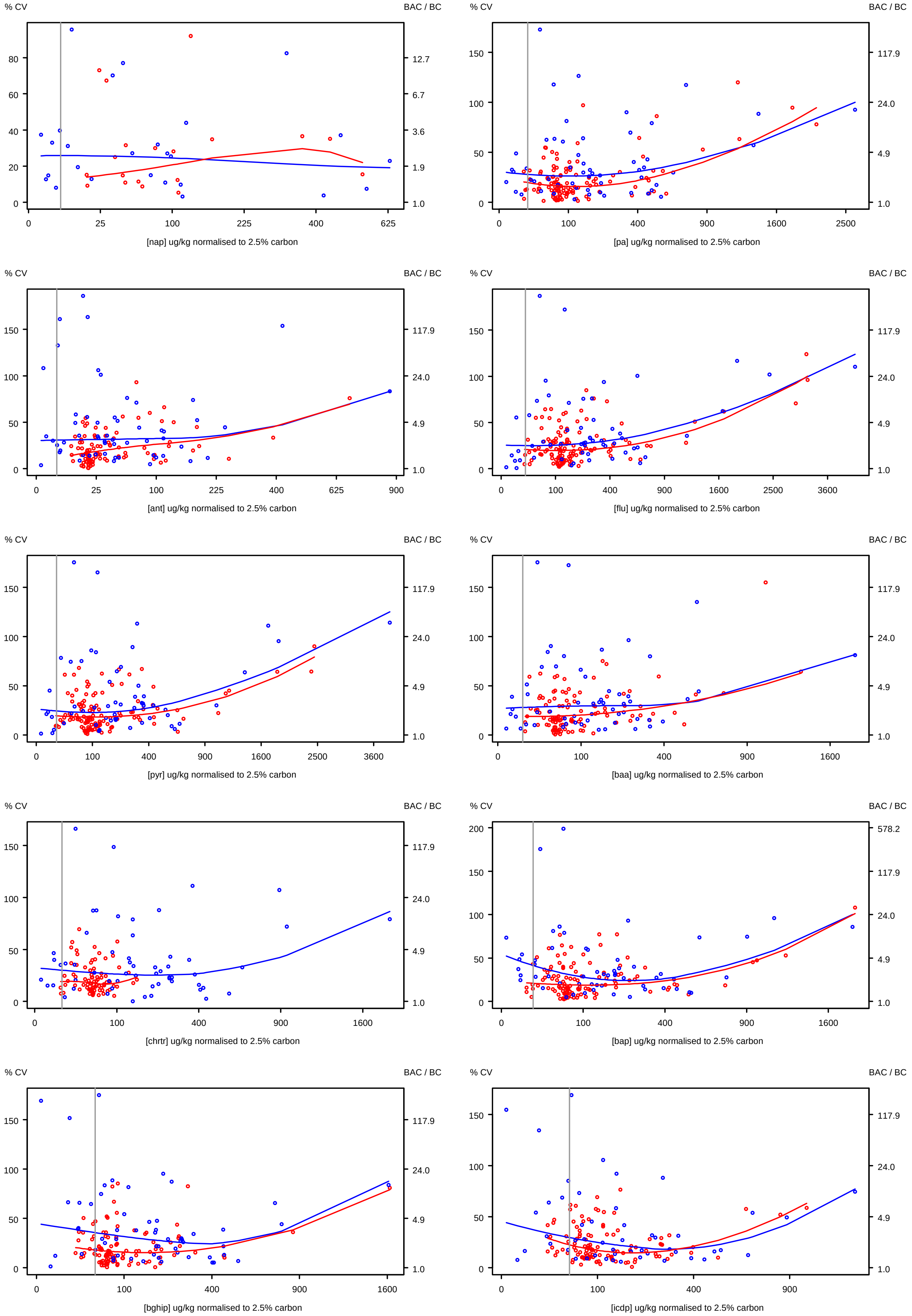


Figure 3 - CBs in sediment

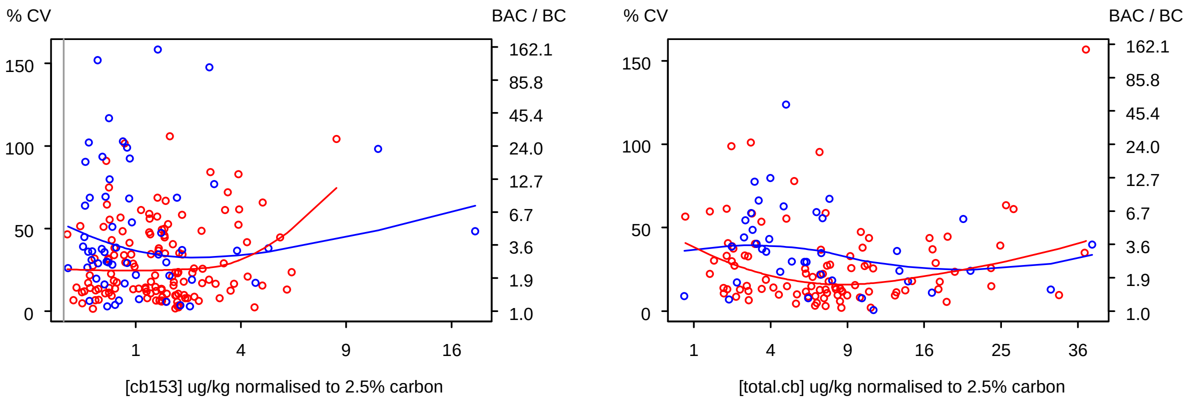


Figure 4 - PAHs in blue mussel

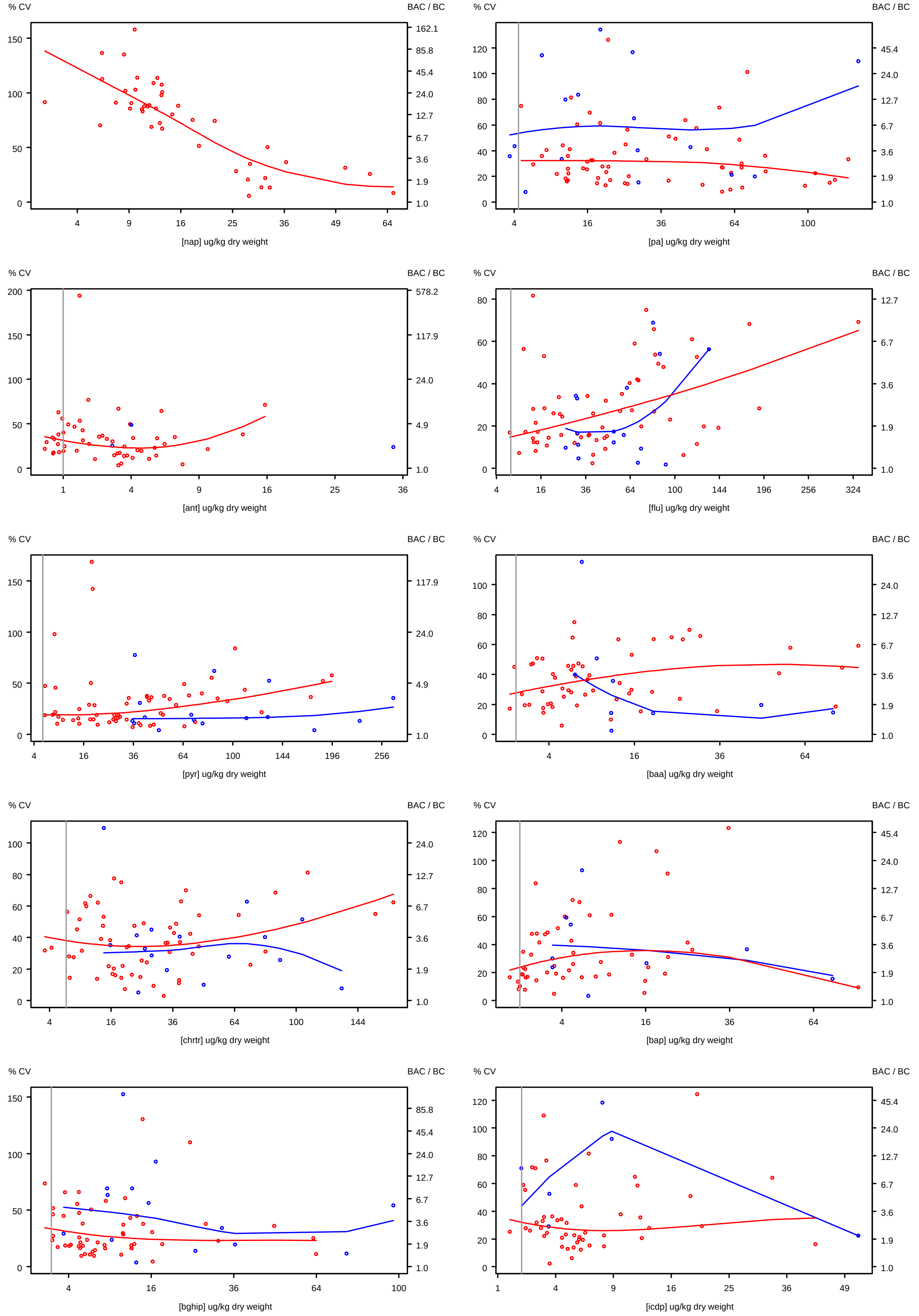
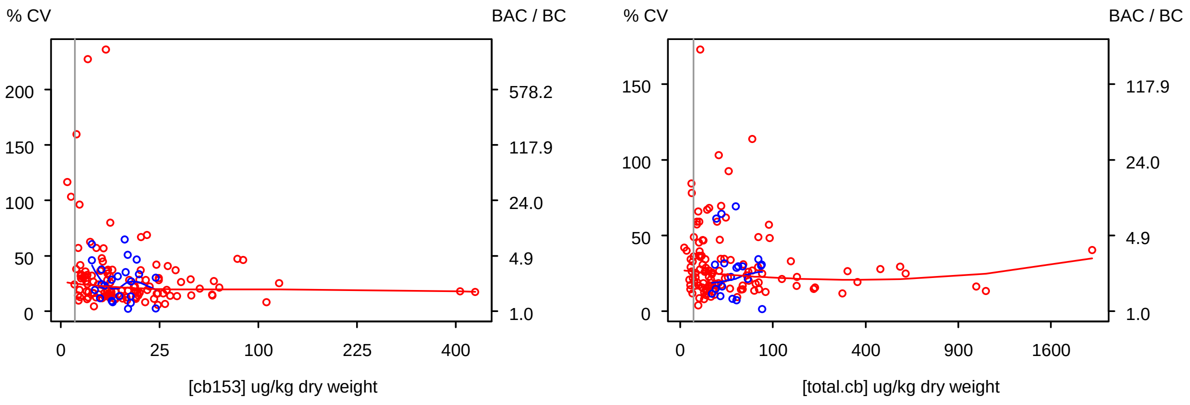


Figure 5 - CBs in blue mussel



2005 Assessment of CEMP data
Appendix 7: Number of yearly contaminant indices in final datasets by country and contaminant

For biota, the number of yearly medians on the chosen bases; for sediments, the number of yearly weighted means when no cofactor was used (i.e. the data were not normalised).

1 BIOTA	Belgium	Denmark	France	Germany	Iceland	Ireland	Netherlands	Norway	Spain	Sweden	UK
Ag	0	0	0	0	0	0	0	0	0	0	19
As	13	0	0	159	68	0	0	0	0	0	125
Cd	61	131	593	176	108	24	100	505	91	65	194
Cr	0	0	0	156	0	24	0	0	0	25	58
Cu	22	133	585	176	69	24	48	484	91	65	67
Hg	72	127	591	176	98	23	108	505	87	70	235
Ni	0	95	0	40	0	0	0	0	0	25	57
Pb	61	130	585	176	84	24	45	491	90	65	191
Se	0	0	0	0	91	0	0	0	0	0	0
Zn	22	133	585	176	108	24	48	491	91	63	71
Total	251	749	2939	1235	626	143	349	2476	450	378	1017
Anthracene	0	41	449	0	0	0	0	9	27	0	8
Benzo[a]anthracene	0	50	450	0	0	0	0	9	27	0	13
Benzo[a]pyrene	0	38	450	0	0	0	0	9	27	0	13
Benzo[ghi]perylene	0	32	450	0	0	0	0	9	27	0	23
Chrysene	0	50	388	0	0	0	0	9	27	0	23
Fluoranthene	0	41	450	0	0	0	0	9	27	0	33
Indeno[123-cd]pyrene	0	31	450	0	0	0	0	9	26	0	13
Naphthalene	0	38	450	0	0	0	0	9	0	0	0
Phenanthrene	0	50	449	0	0	0	0	9	27	0	32
Pyrene	0	50	450	0	0	0	0	9	27	0	30
Tributyltin	0	85	0	0	0	0	0	32	0	0	0
Total	0	506	4436	0	0	0	0	122	242	0	188
CB153	67	97	395	184	104	20	96	641	90	37	178
DDE (p,p’)	67	96	220	109	104	10	0	619	0	53	24
Dieldrin	63	0	0	0	0	0	0	0	0	0	10
Hexachlorobenzene	67	101	0	183	104	20	95	679	0	37	12
γ-HCH	67	92	499	173	69	17	0	644	0	37	0
total	331	386	1114	649	381	67	191	2583	90	164	224

2 **SEDIMENT**	Belgium	Denmark	Germany	Netherlands	UK
As	153	0	1113	329	1434
Cd	189	0	1385	239	1331
Cr	206	0	1344	326	1529
Cu	217	5	1407	326	1535
Hg	210	5	1353	308	1099
Ni	209	5	1338	329	1540
Pb	217	5	1696	326	1547
Zn	221	5	1422	325	1539
Total	1622	25	11058	2508	11554
Anthracene	50	0	74	247	912
Benzo[a]anthracene	47	0	160	311	1077
Benzo[a]pyrene	53	0	163	323	1019
Benzo[ghi]perylene	53	0	178	323	945
Chrysene	47	0	127	323	0
Fluoranthene	53	0	192	326	1106
Indeno[123-cd]pyrene	53	0	176	322	1063
Naphthalene	53	0	176	0	375
Phenanthrene	0	0	182	329	1089
Pyrene	53	0	185	326	1096
Tributyltin	0	5	102	0	0
Total	462	5	1715	2830	8682
CB153	197	5	335	314	1162

2005 Assessment of CEMP data
Appendix 8: Station list

The following tables give an overview of the stations where biota and sediment samples were collected

Column heading	Explanation
Region	I, II, III, IV or V
Country	
Station	station names in square brackets ([]) are not on ICES database, but were derived from participants at MON 2004 and may not be official designation
Latitude	in decimal degrees north
Longitude	in decimal degrees east, negative values indicate west longitude
I-MET	number of stations where inorganic metals (As, Cd, Cr, Cu, Hg, Pb, Se, Zn) were analysed
O-MET	number of stations where organic metals (TBT) were analysed
O-PAH	number of stations where PAHs were analysed
OC-CB	number of stations where organochlorines (PCB, γHCH, ppDDT, dieldrin) were analysed

BIOTA

Region	Country	Station	Latitude	Longitude	I-MET	O-MET	O-PAH	OC-CB	Total
I	Iceland	Dvergasteinn Alftafjördur	65,983333	-23,033333	1			1	2
		Eyri Hvalfjördur	64,333333	-21,716667	1			1	2
		Grimsey	66,566667	-18,016667	1			1	2
		Hvalstöd Hvalfjördur	64,383333	-21,433333	1			1	2
		Hvassahraun	64,016667	-22,150000	1			1	2
		Hvitanes Hvalfjördur	64,350000	-21,483333	1			1	2
		Mjófjördur (Dalatangi)	65,266667	-13,566667	1			1	2
		Mjófjördur (head)	65,183333	-14,000000	1			1	2
		Mjófjördur (Hofsá)	65,200000	-13,806154	1			1	2
		Straumur Straumsvik	64,033333	-22,033333	1			1	2
		Ulfsá Skutulsfjördur	66,050000	-23,150000	1			1	2
		Vestmannaeyjar	63,435842	-20,304122	1			1	2
	Norway	10A Skallneset	70,099111	30,257111	1	1		1	3
		10B Varangerfjorden	69,933333	29,666667	2			2	4
		10F Skogerøy	69,916667	29,850000	2			2	4
		11A Brashavn	69,883333	29,733333	1	1		1	3
		11A Sildekroneset Bøkfjorden	69,783333	30,183333	1			1	2
		41A Fensneset Grytøya	68,933333	16,633333	1			1	2
		44A Elenheimsundet	70,500000	22,233333	1	1		1	3
		98A Svovlvær	68,254560	14,661792	1	1		1	3
		98B+F Lille Molla	68,200000	14,800000	4			4	8
I Total					26	4		26	56
II	Belgium	BCP	51,333333	2,833333	6			6	12
		DVZ_KNO	51,350000	3,333333	1		1	1	3
		DVZ_NPT	51,150000	2,716667	1		1	1	3
		DVZ_OST	51,233333	2,916667	1		1	1	3
	Denmark	Arhus Bugt 170166	56,033333	10,433333	1	1	1	1	4
		Arhus Bugt 170167	56,133333	10,216667	1	1	1	1	4
		Arhus havn 170165	56,183333	10,350000	1	1	1	1	4
		Great Belt - Egholm Flak M39	55,233333	11,183333	1	1	1	1	4
		Great Belt - S39	55,666667	10,666667	1	1	1	1	4
		Great Belt - S39b	55,300000	10,933333	2			2	4
		Great Belt S39	55,250000	11,166667	2				2
		Hanstholm	57,202627	8,482235	1				1
		Horsens Fjord H1/2	55,833333	9,883333	1	1	1	1	4
		Horsens Fjord H4	55,833333	9,958685	1	1	1	1	4
		Hvide Sande 1035	56,233333	7,966667	4			2	6
		LIMFJORDEN - NIBE BREDNING MSS	57,000000	9,619333	1	1	1	1	4
		Little Belt - LBMTM2	55,000000	9,959924	1	1	1	1	4
		Nivå Bugt 31	55,915400	12,533333	3	1	1	1	6
		Odense Fjord M1	55,466667	10,450000	1	1	1	1	4
		Odense Fjord M2	55,483333	10,500000	1	1	1	1	4
		Odense Fjord M3	55,483333	10,600000	1	1	1	1	4
		Randers Fjord 230987	56,533333	10,216667	1	1	1	1	4
		Randers Fjord 230988	56,600000	10,300000	1	1	1	1	4
		Ringkjobing Fjord MS1	56,033333	8,156250	2	2	1	2	7
		Ringkjobing Fjord MS2	55,883333	8,289418	1	1	1	1	4
		Ringkjobing Fjord MS3	55,950000	8,242157	1	1	1	1	4
		Roskilde Fjord 60	55,700000	12,066667	1	1	1	1	4
		Roskilde Fjord 65	55,916667	12,016667	1	1	1	1	4
		THE SOUND - LYNETTEN	55,716667	12,616667	1	1	1	1	4
		THE SOUND SKOVSHOVED	55,808388	12,583333	3	1	1	2	7
		Wadden Sea HALEN 2161010	55,433333	8,433333	1	1	1	1	4
		Wadden Sea JDMTM1	55,166667	8,600000	1	1	1	1	4
		Wadden Sea LDMTM1	55,083333	8,566667	1	1	1	1	4
		Wadden Sea SJELBORG 2161022	55,518939	8,333333	1	1	1	1	4

BIOTA

Region	Country	Station	Latitude	Longitude	I-MET	O-MET	O-PAH	OC-CB	Total
	France	Aber Benoit	48,566667	-4,600000	1		1	1	3
		Antifer Digue	49,650000	0,150000	1		1	1	3
		Authie - Berck Bellevue	50,416667	1,550000	1		1	1	3
		Baie de la Fresnaye	48,633333	-2,283333	1		1	1	3
		Baie des Veys Gefosse	49,370728	-1,095939	1		1	1	3
		Boulogne et Canche - Ambleteus	50,800000	1,583333	1		1	1	3
		Brest - Aulne rive droite	48,266667	-4,250000	1		1	1	3
		Brest - Baie de Daoulas	48,333333	-4,346867	1		1	1	3
		Brest - Baie de Roscanvel	48,296800	-4,533333	1		1	1	3
		Brest - Elorn Rive Gauche	48,369800	-4,410400	1		1	1	3
		Calais - Dunkerque - Oye Plage	51,000000	2,000000	1		1	1	3
		Calvados Ouistreham	49,283333	-0,233333	1		1	1	3
		Calvados Port en Bessin	49,350000	-0,733333	1		1	1	3
		Cancale - Le Vivier sur Mer	48,633333	-1,783333	1		1	1	3
		Dieppe - Varengeville	49,916667	0,983333	1		1	1	3
		Douarnenez - Kernel	48,116667	-4,283333	1		1	1	3
		Fecamp - Vaucottes	49,733333	0,283333	1		1	1	3
		Grande Rade de Cherbourg	49,666667	-1,616667	1		1	1	3
		Lannion - Saint Michel en Grev	48,683333	-3,566667	1		1	1	3
		Morlaix - Penze Rive Droite	48,666667	-3,933333	1		1	1	3
		Ouest Cotentin - Breville	48,883333	-1,583333	1		1	1	3
		Ouest Cotentin - Pirou Nord	49,183333	-1,600000	1		1	1	3
		Paimpol - Beg Nod	48,816667	-3,033333	1		1	1	3
		Rance - La Gautier	48,583333	-2,000000	1		1	1	3
		Saint Brieuc - Pointe de Rosel	48,550000	-2,700000	1		1	1	3
		Saint Vaast Le Moulard	49,650000	-1,216667	1		1	1	3
		Seine Cap de la Heve	49,500000	0,050000	1		1	1	3
		Seine Villerville	49,400000	0,116667	1		1	1	3
		Somme - Pointe de Saint Quenti	50,266667	1,516667	1		1	1	3
	Germany	Baltrum	53,783333	7,383333	4			2	6
		Borkum	53,663346	6,808628	5			3	8
		ELBE INNER	53,871676	8,961851	2			2	4
		ELBE OUTER	53,937827	8,597384	3			3	6
		German Bight - outer	54,366667	7,821690	2				2
		Helgoland	54,183805	7,916195	1			1	2
		JADE INNER	53,633333	8,116667	2			1	3
		JADE OUTER	53,850000	7,916667	2			1	3
		JANSSAND	53,716667	7,683333	1			1	2
		Norderaue	54,666667	8,612951	1			1	2
		Norderney	53,683333	7,233333	1			1	2
		Suedfall	54,443445	8,771548	1			1	2
		WESER INNER	53,633333	8,366667	2			1	3
		WESER OUTER	53,751008	8,357564	2			1	3
	Netherl	BOCHTVWTND	53,413275	6,906078	2			1	3
		BORKND30	54,208904	6,597851	2			1	3
		DDOVBMDN	53,005321	5,020662	2			1	3
		DOGGBK	55,209832	3,632254	2			1	3
		IJMDWT80	52,698201	3,373501	2			1	3
		TERSLG100	54,111942	4,286352	2			1	3
		TERSLNWT40	53,683333	4,891367	2			1	3
		WESTSDWT	51,421474	3,666967	2			1	3
	Norway	15A Ullerø area	58,048485	6,884848	1	1		1	3
		15B/F Ullerø area	58,050000	6,716667	4			4	8
		21F Åkrefjord	59,750000	6,116667	6			6	12
		221A/G Stangeland	59,272222	5,311111		2			2
		226A Karmsund Bridge	59,366667	5,283333		2			2
		227X Høievarde	59,323810	5,309524		2			2
		22A Esepvær west	59,583333	5,133333	1	1		1	3
		22F Borøyfjorden	59,716667	5,350000	2			2	4
		23B+F Karihavet area	59,914405	5,118928	2			2	4

BIOTA

Region	Country	Station	Latitude	Longitude	I-MET	O-MET	O-PAH	OC-CB	Total
		30A Gressholmen	59,869111	10,714222	1	1	1	1	4
		30B+C Oslo City area	59,805482	10,561812	2			2	4
		31A Solbergstrand	59,600000	10,650000	1			1	2
		33B Sande (east side)	59,516667	10,350000	2			2	4
		35A Mølen	59,483333	10,500000	1			1	2
		36A Færder	59,016667	10,516667	1	2		1	4
		36B Færder area	59,033333	10,498710	2			2	4
		36F Færder area	59,066667	10,383333	2			2	4
		51A Byrkjenes	60,083333	6,550000	1			1	2
		52A Eitrheimsneset	60,083333	6,533333	2			2	4
		53B Inner Sørfjord	60,166667	6,566667	5			5	10
		56A Kvalnes	60,216667	6,600000	1			1	2
		57A Krossanes	60,383333	6,683333	1			1	2
		63A Ranaskjær	60,416667	6,400000	1			1	2
		65A Vikingneset	60,233333	6,150000	1			1	2
		67B Strandebarm	60,266667	6,033333	9			9	18
		69A Lille Terøy	59,966667	5,750000	1			1	2
		71A Bjørkøya (Risøyodd.)	59,016667	9,750000	1	1		1	3
		76A Risøy	58,716667	9,283333	1	1		1	3
	Sweden	Fladen	57,216667	11,829916	4			3	7
		Väderöarna	58,516667	10,900000	3			2	5
	UK	NMMP105 [Moray Firth Offshore]	58,050000	-3,000000	2			1	3
		NMMP125	56,450000	-2,850000	1		1	1	3
		NMMP165	56,500000	-1,500000	2			1	3
		NMMP200	55,983333	-2,883333	1		1	1	3
		NMMP207	56,000000	-3,500000	3		1	2	6
		NMMP220	55,600000	-1,766667	3		1	2	6
		NMMP225	54,983333	-1,516667	2			1	3
		NMMP235	55,000000	-1,416667	3		1	2	6
		NMMP244	55,283333	-1,250000	2			1	3
		NMMP275	54,916667	-1,350000	2			1	3
		NMMP286	54,833333	1,250000	2			1	3
		NMMP287	54,500000	2,666667	2			1	3
		NMMP288	55,500000	4,133333	2			1	3
		NMMP294	54,750000	-1,133333	2			1	3
		NMMP344	54,233333	0,483333	2			1	3
		NMMP346	54,062243	1,924133	2			1	3
		NMMP357	53,583333	-0,033333	3		1	2	6
		NMMP389	52,883333	0,383333	3		1	2	6
		NMMP390	51,750000	0,983333	1		1	1	3
		NMMP395	52,752405	2,509620	4			2	6
		NMMP435 [Thames Woolwich (E)]	51,483333	0,030952	2			1	3
		NMMP455	51,483333	0,466667	3		1	2	6
		NMMP475	52,000000	2,333333	2			1	3
		NMMP486	50,866667	0,800000	2			1	3
		NMMP505	50,866667	-1,383333	3			2	5
		NMMP527	51,383333	0,516667	3		1	2	6
		NMMP555	50,416667	-4,183333	3		1	2	6
		NMMP567	50,683333	-2,016667	3		1	2	6
		NMMP95 [Moray Firth]	57,583333	-3,650000	2			1	3
II Total					249	40	71	194	554
III	Ireland	Cork West Passage/ Ringaskiddy	51,816667	-8,300000	1			1	2
		Dublin Bay - North Inner Bay/	53,383333	-6,116667	1		1	1	3
		Irish Sea /fish trend	53,233333	-5,933333	1				1
		Shannon Estuary - Aughinish	52,616667	-9,033333	1		1	1	3
		Waterford Harbour - Arthurstow	52,233333	-6,950000	1		1	1	3

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Region	Country	Station	Latitude	Longitude	I-MET	O-MET	O-PAH	OC-CB	Total
	UK	NMMP25	54,750000	-4,000000	2			1	3
		NMMP35	55,033333	-5,083333	2			1	3
		NMMP45	55,816667	-4,966667	1		1	1	3
		NMMP55	55,933333	-4,883333	1		1	1	3
		NMMP649	52,700000	-4,533333	2			1	3
		NMMP65	55,933333	-4,666667	1		1	1	3
		NMMP656	52,266667	-4,300000	2			1	3
		NMMP665	52,500000	-5,000000	2			1	3
		NMMP690	53,333333	-3,266667	5		1	3	9
		NMMP70	55,583333	-4,783333	1			1	2
		NMMP706	53,466667	-3,350000	2			1	3
		NMMP715	53,500000	-3,683333	2			1	3
		NMMP755	53,400000	-3,000000	3		1	2	6
		NMMP765 [Mersey Channel]]	53,516667	-3,133333	3		1	2	6
		NMMP766 [Ribble 11 mile post]	53,716667	-3,000000	3		1	2	6
		NMMP767 [Morecambe Bay North Bay]]	54,033333	-3,100000	5		1	3	9
		NMMP768 [St.Bees Cumbria Coast]	54,500000	-3,650000	4		1	2	7
		NMMP776	53,350000	-4,133333	2			1	3
		NMMP796 [Morecambe Bay Offshore]	53,900000	-3,400000	2			1	3
		NMMP805	54,000000	-3,833333	2			1	3
		NMMP809	54,466667	-5,583333	1		1	1	3
		NMMP845	54,666667	-5,800000	2		1	1	4
		NMMP85	58,283333	-6,183333	2			1	3
		NMMP880	55,066667	-7,216667	2		1	1	4
III Total					59		15	36	110
IV	France	Adour	43,516667	-1,500000	1		1	1	3
		Arcachon - Cap Ferret	44,633333	-1,233333	1		1	1	3
		Arcachon - Comprian	44,683333	-1,083333	1		1	1	3
		Arcachon - Les Jacquets	44,716667	-1,183333	1		1	1	3
		Audierne - Penhors	47,933333	-4,400000	1		1	1	3
		Baie de l`Aiguillion	46,233333	-1,151684	1		1	1	3
		Bourgneuf - Coupelasse	47,000936	-2,016667	1		1	1	3
		Capbreton Ouest	43,650000	-1,433333	1		1	1	3
		Chatelaillon	46,050000	-1,085395	1		1	1	3
		Ciboure - La Nivelle	43,383333	-1,650000	1		1	1	3
		Concarneau - Fouesnant	47,884983	-3,983333	1		1	1	3
		Concarneau - Pointe de Mouster	47,833333	-4,033333	1		1	1	3
		Gironde - Bonne Anse	45,683333	-1,205679	1		1	1	3
		Gironde - La Fosse	45,468217	-0,983333	1		1	1	3
		Gironde - Pontaillal	45,616667	-1,050000	1		1	1	3
		Hendaye - Chingoudy	43,351675	-1,768342	1		1	1	3
		Loire - Pointe de Chemoulin	47,233333	-2,284375	1		1	1	3
		Loirient - La Potee de Beure	47,700000	-3,350000	1		1	1	3
		Marennes - Boyardville	45,955760	-1,222426	1		1	1	3
		Marennes - Dagnas	45,866667	-1,166667	1		1	1	3
		Marennes - La Moucliere	45,967749	-1,101082	1		1	1	3
		Marennes - Les Palles	45,966667	-1,134568	1		1	1	3
		Marennes - Mus de Loup	45,789336	-1,139336	1		1	1	3
		Morbihan - Arradon	47,616667	-2,785008	1		1	1	3
		Morbihan - Locmariaquer	47,555965	-2,918421	1		1	1	3
		Noirmoutier - Gresseloup	46,950000	-2,134270	1		1	1	3
		Pertuis Breton - Rive Doux	46,151684	-1,268350	1		1	1	3
		Riec Sur Belon	47,816667	-3,700000	1		1	1	3
		Vendee- Talmont	46,418342	-1,633333	1		1	1	3
		Vilaine - Er Fosse	47,500000	-2,645556	1		1	1	3
		Vilaine - Le Croisil	47,283333	-2,500000	1		1	1	3
		Vilaine - Pen Be	47,417955	-2,466667	1		1	1	3

BIOTA

Region	Country	Station	Latitude	Longitude	I-MET	O-MET	O-PAH	OC-CB	Total
	Spain	A Coruna	43,375480	-8,383333	1		1	1	3
		Arosa	42,579532	-8,870468	1		1	1	3
		Bilbao Azcorri	43,366667	-3,000000	1		1	1	3
		Bilbao Ciervana	43,350000	-3,083333	1		1	1	3
		Pontevedra	42,396647	-8,733333	1		1	1	3
		Santander Pantalan	43,429524	-3,783333	1		1	1	3
		Santander Pedrena	43,433333	-3,750000	1		1	1	3
		Vigo	42,215782	-8,748890	1		1	1	3
IV Total					40		40	40	120
Total					374	44	126	296	840

SEDIMENT

Region	Country	Station	Latitude	Longitude	I-Met	O-MET	O-PAH	OC-CB	Total
II	Belgium	150	51,416700	3,400000	1				1
		120	51,185000	2,701200	1				1
		140	51,325000	3,050000	1				1
		435	51,580700	2,790300	1				1
		545	51,726700	3,050000	1				1
		710_a	51,440800	3,138700	1		1		2
		780	51,471200	3,058000	1		1		2
		B04	51,433300	3,266700	2				2
		B08	51,435000	3,365000	1		1		2
		B10	51,422800	3,380000	1				1
		S04	51,345000	3,825000	1				1
		S09	51,370000	4,078300			1		1
		S18	51,266700	4,300000	2				2
		S22	51,218800	4,391700	2				2
	Germany	BL 4	54,250000	7,800000	4				4
		BL13	54,108300	7,401700	4				4
		BL14	53,943300	7,400000	4				4
		BL3	54,250000	8,101700	4				4
		Borkum	53,561700	6,750000	1		1		2
		BSH-27	54,251700	7,500000	2				2
		BSH-30	54,225000	8,381700	2				2
		Buesum	54,141700	8,783300	2				2
		Dollart	53,286700	7,223300	1		1		2
		E-Groden	53,731700	7,926700	2				2
		EL-S1	53,913800	8,483300	3				3
		EL-S11	53,890000	9,144300	3				3
		EL-S13	53,793000	9,407700	3				3
		EL-S3	53,867500	8,572700	6				6
		EL-S4	53,901300	8,637500	5				5
		EL-S7	53,832700	8,852700	6				6
		EL-S8	54,022700	8,807700	3				3
		EL-S9	53,937500	8,904700	5				5
		ES1	53,673300	6,500000	4				4
		ES2	53,816700	6,383300	3				3
		Hoher Weg	53,610000	8,270000	1				1
		Jadebusen	53,428300	8,173300	1				1
		KS11	54,066700	8,125000	3				3
		L1	55,050000	8,201700	4				4
		L2	55,058300	8,166700	4				4
		Langeness	54,650000	8,616700	1		1		2
		Leybucht	53,543300	7,118300	1		1		2
		List	55,032500	8,450800	2				2
		Norderney	53,698300	7,238300	1				1
		Oland	54,700000	8,725000	2		1		3
		Spiekeroog	53,763300	7,718300	2				2
		Suedfall	54,466700	8,750000	2		1		3
		Tettens	53,551700	8,491700	1		1		2
		Ti13	54,375000	7,646700	4				4
		UE 11	54,233300	7,498300	3				3
		UE15	54,500000	6,500000	3				3
		UE18	54,500000	8,000000	4				4
		UE19	54,758300	7,176700	1				1
		UE20	55,000000	6,500000	4				4
		UE26	54,750000	6,501700	2				2
		UE28	54,500000	8,201700	2				2
		UE67	55,250000	4,500000	3				3
		UE68	55,483300	4,500000	3				3
		UE69	55,500000	4,000000	4				4
		UE70	55,750000	4,000000	4				4

SEDIMENT

Region	Country	Station	Latitude	Longitude	I-Met	O-MET	O-PAH	OC-CB	Total
		UE71	55,920000	3,350000	1				1
		UE74	55,501700	5,751700	1				1
		WB1	54,833300	6,583300	4				4
		WB5	55,066700	6,333300	4				4
	Netherlands	BOCHTVWTOT	53,343300	6,940300	1		1	1	3
		DANTZGZD	53,409500	5,723300	2			1	3
		DOOVBWT	53,066700	5,066700	1		2		3
		HAMMOT	51,683300	3,800000	1				1
		HANSWBIOHMG	51,440800	3,992000			1		1
		KOFFBNPT	53,431700	5,558300	1				1
		NOORDWK2	52,260800	4,406300	2		2	1	5
		ROTTMPT3	53,569700	6,564300	2		1	1	4
		TERSLG100	52,750000	4,250000	1		1		2
		TERSLG235	55,171000	3,157200	1			2	3
		TERSLG4	53,415500	5,149500	2			1	3
		WALCRN70	51,956200	2,676700			2		2
		ZUIDOLWZOT	53,459500	6,520000	1		1		2
	UK	NMMP235 Tyne Ferry Crossing (E)	55,007800	-1,430700	3				3
		NMMP245 Off Tyne NSTF14 (I)	55,007700	-1,129300	1				1
		NMMP275 Wear Sandy Point (E)	54,917500	-1,357200	1				1
		NMMP295 Off Tees (I)	54,733300	-5,600000			1		1
		NMMP316 Tees No, 23 Buoy (E)	54,594500	-1,179200	2				2
		NMMP326 Tees Phillips Buoy (E)	54,629500	-1,250700				1	1
		NMMP356 Humber Inside Spurn Head (E)	53,590700	0,084800	1				1
		NMMP390 Blackwater (E)	51,760200	0,998800	1				1
		NMMP435 Thames Woolwich (E)	51,487800	0,064500	3		1	1	5
		NMMP527 Medway Sun Pier (E)	51,385500	0,521500	1				1
		NMMP565 Tamar Hamoaze (E)	50,381300	-4,189500	1				1
		NMMP95	57,883700	-3,658000	2			1	3
II Total					186	0	24	10	220
III	UK	NMMP635 Severn Bedwin (E)	51,560000	-2,769000	2				2
		NMMP645 Severn Peterstone (E)	51,470000	-3,022500	2		1	1	4
		NMMP646 Milford Haven Cosheston Point (E)	51,701300	-4,918200	2				2
		NMMP690 Dee Mostyn Bank (E)	53,336700	-3,279700				1	1
		NMMP806 Irish Sea NMP4 (O)	54,250000	-5,200000	1				1
		NMMP808 Irish Sea Buoy (O)	53,783300	-5,633300	1				1
		NMMP815 Dundrum Bay (O)	54,066700	-5,500000	1				1
		NMMP820 Bann Estuary BR3 (E)	55,148700	-6,684500	2				2
III Total					11	0	1	2	14
Total					197	0	25	12	234

Appendix 12, BAC / EAC ratios for all stations is not yet available.

2005 Assessment of CEMP data
Appendix 11: Biota trend plots and yearly medians

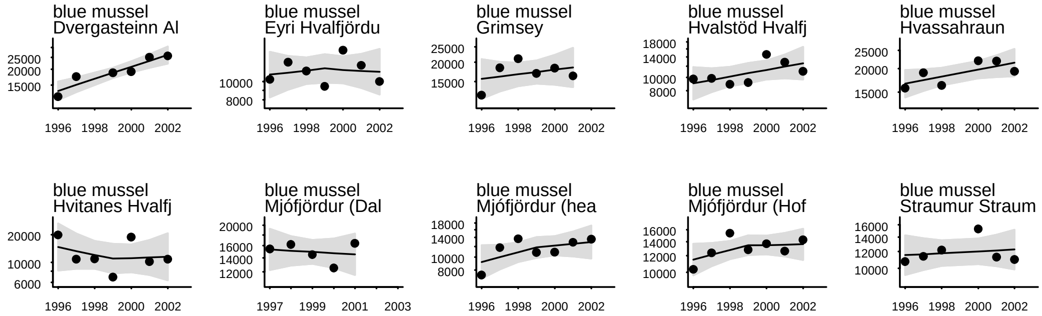
Page numbers

NB: not all figures and contaminants are discussed in main assessment report

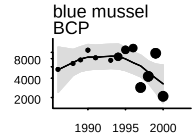
Yearly means for contaminants in biota can be found in document MON 04/02/08

Arsenic ug/kg

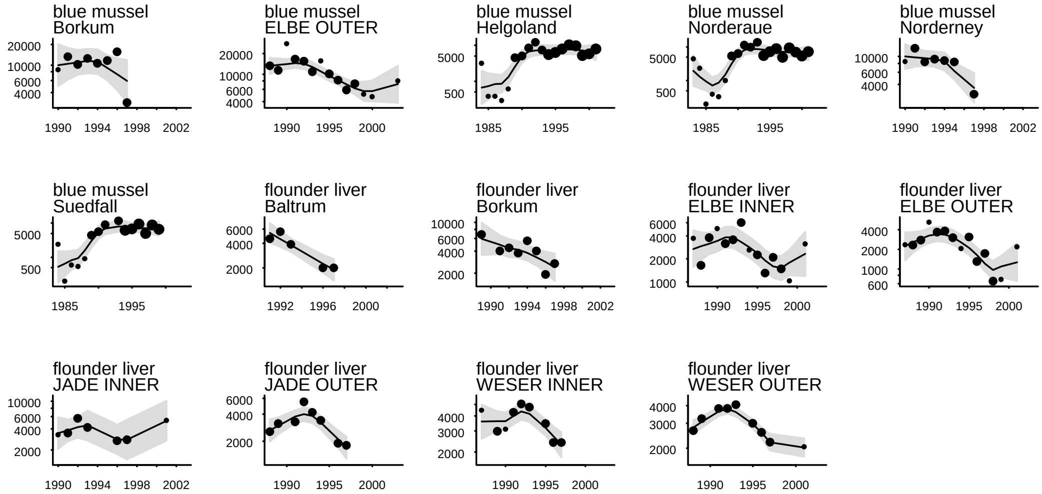
region I Iceland



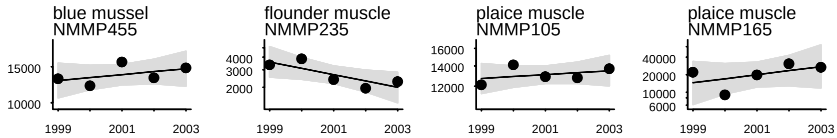
region II Belgium



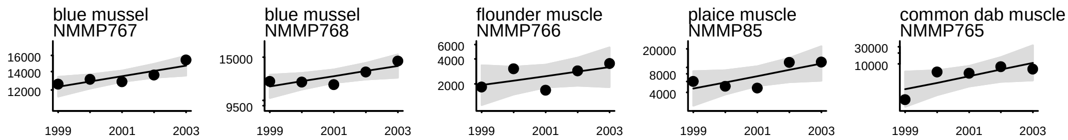
region II Germany



region II UK

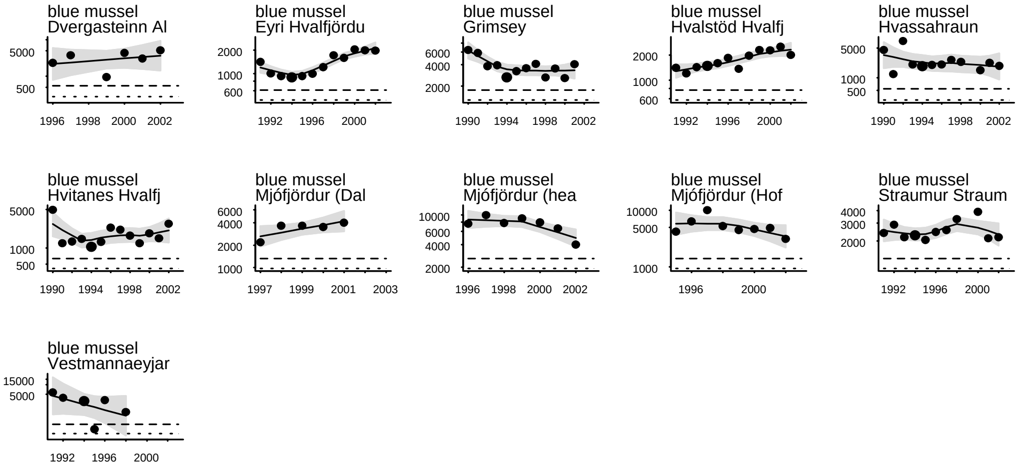


region III UK

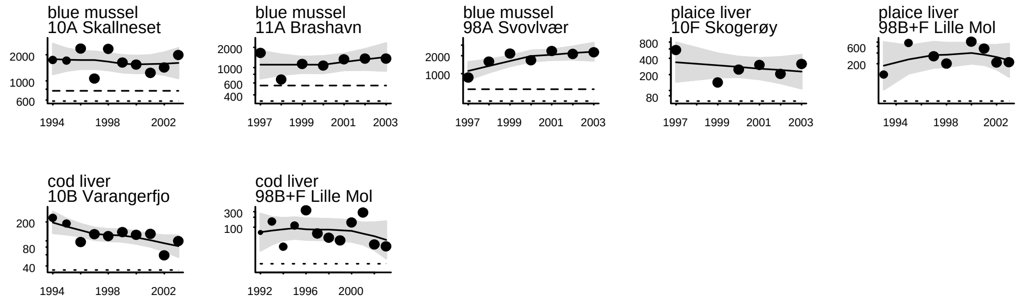


Cadmium ug/kg

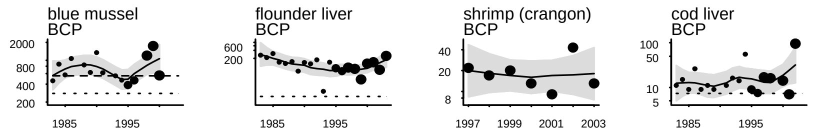
region I Iceland



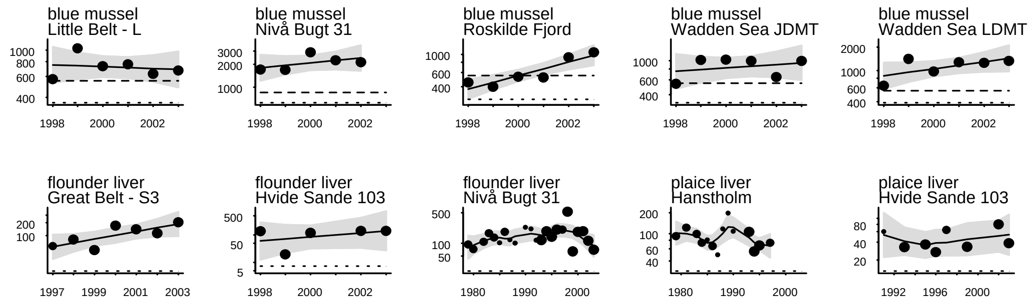
region I Norway



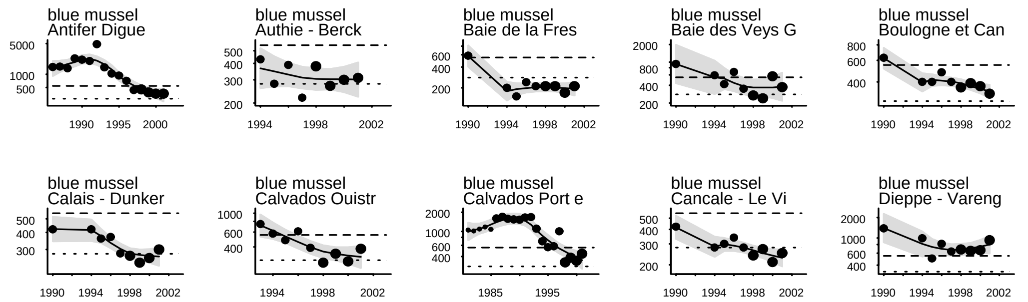
region II Belgium



region II Denmark

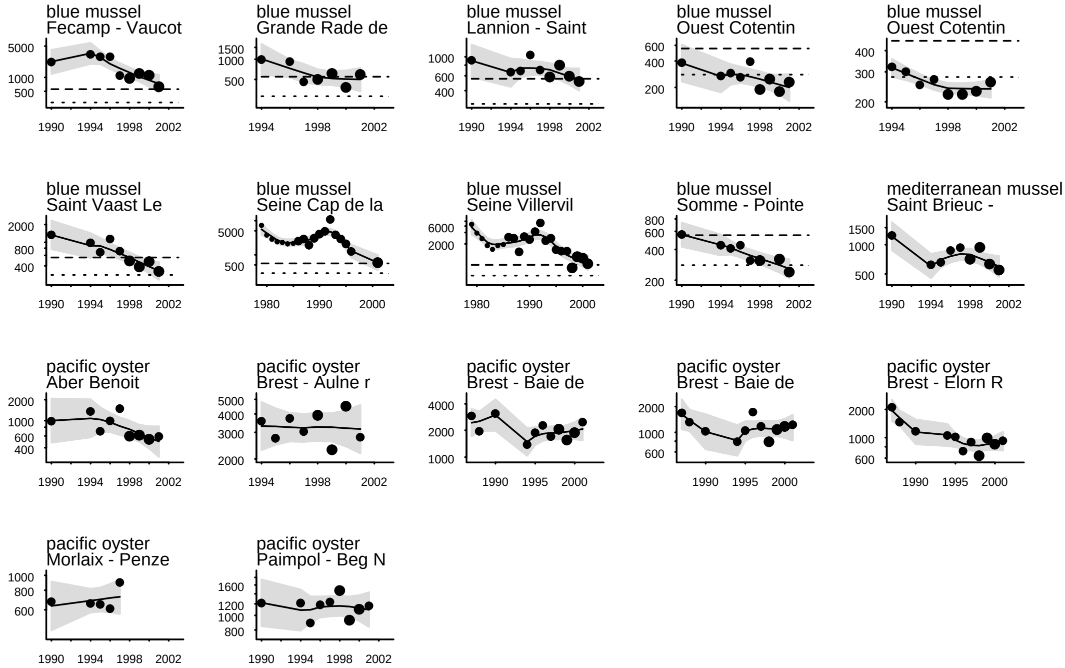


region II France

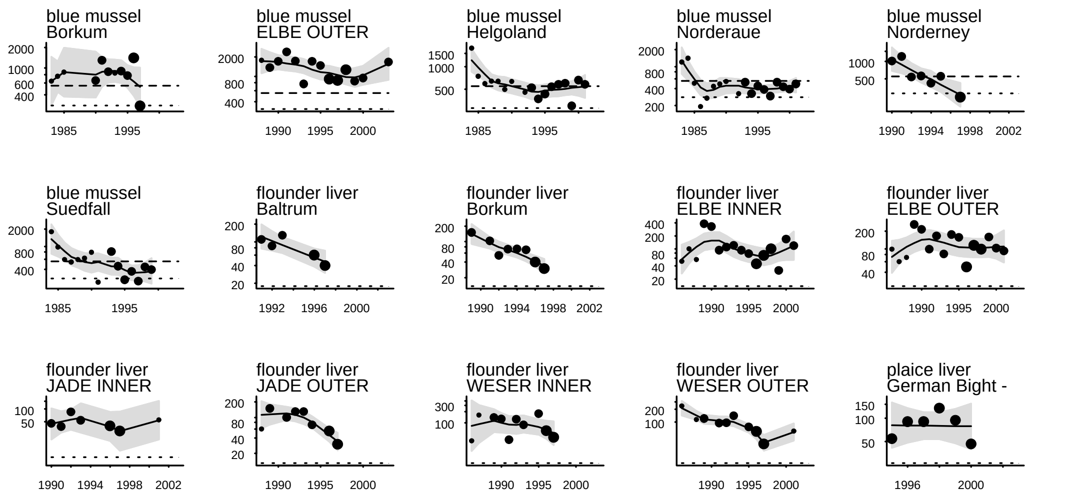


Cadmium ug/kg (continued)

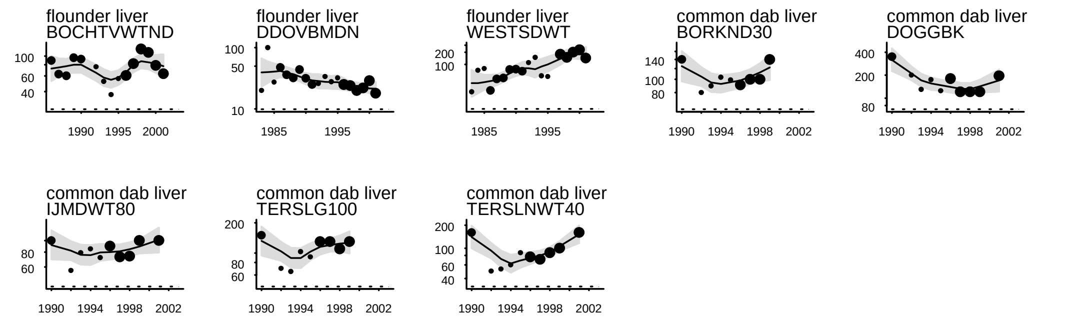
region II France



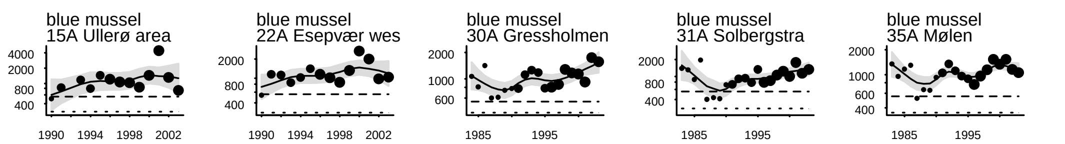
region II Germany



region II Netherlands

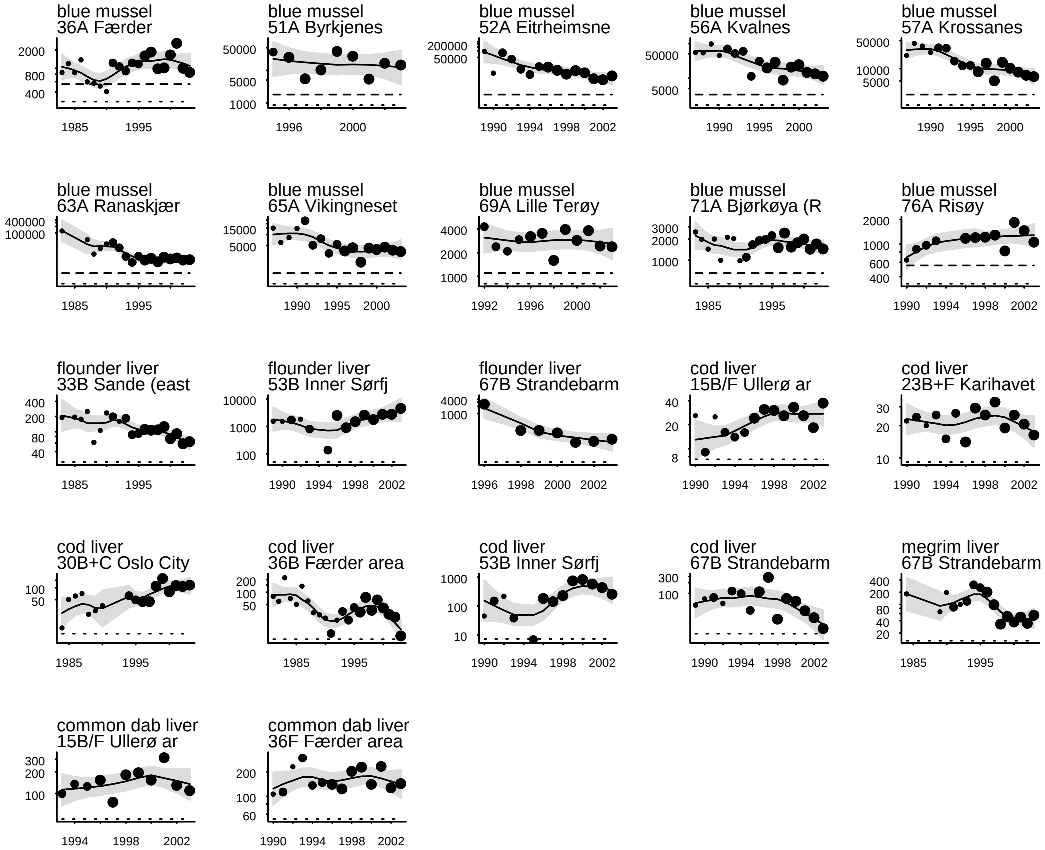


region II Norway

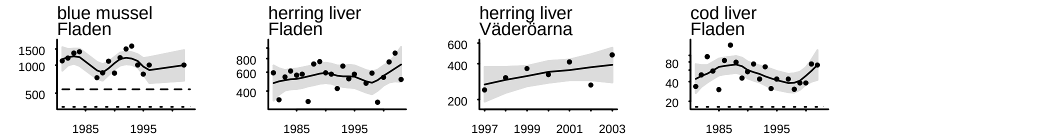


Cadmium ug/kg (continued)

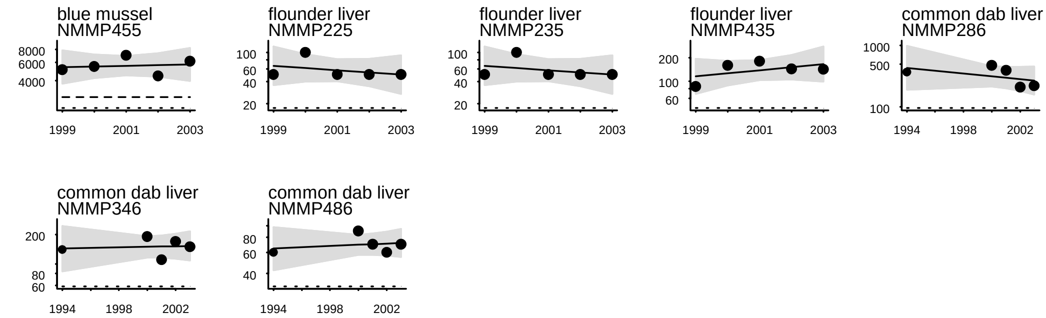
region II Norway



region II Sweden

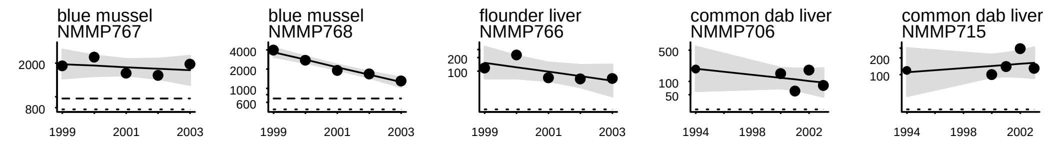


region II UK



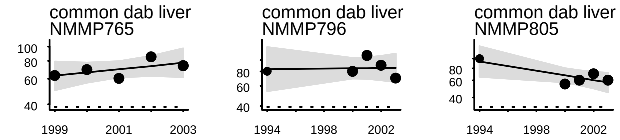
region III Ireland

region III UK

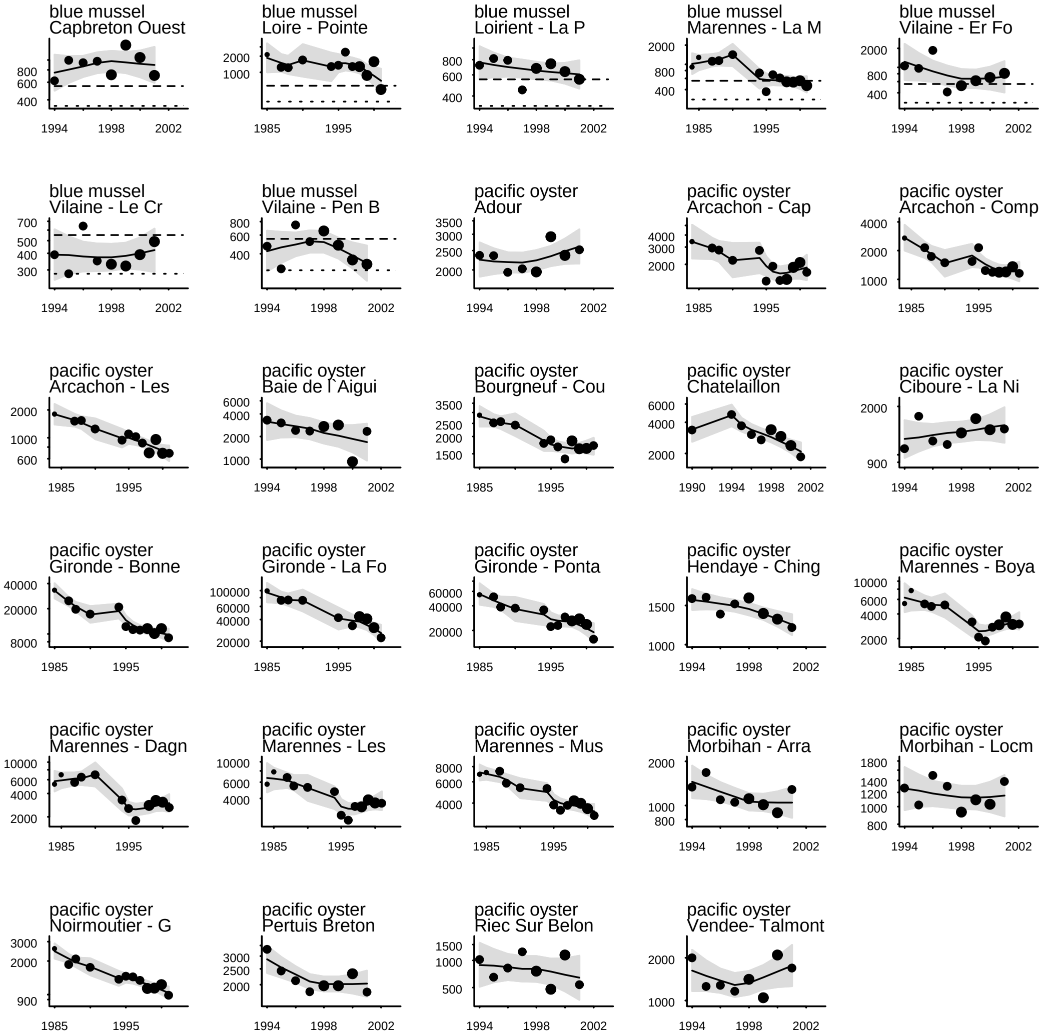


Cadmium ug/kg (continued)

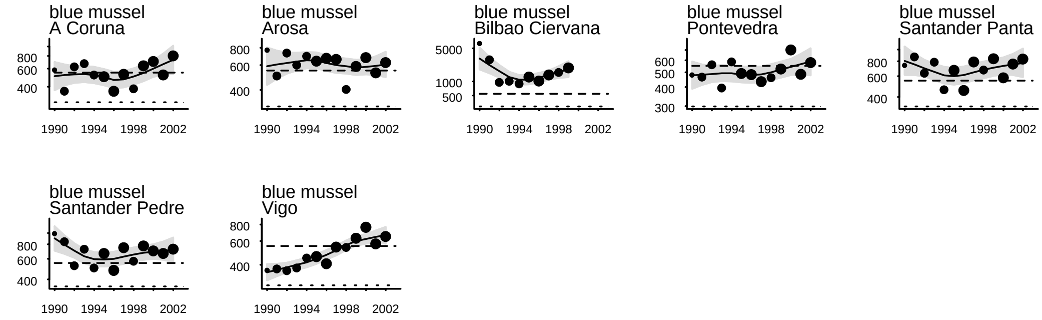
region III UK



region IV France

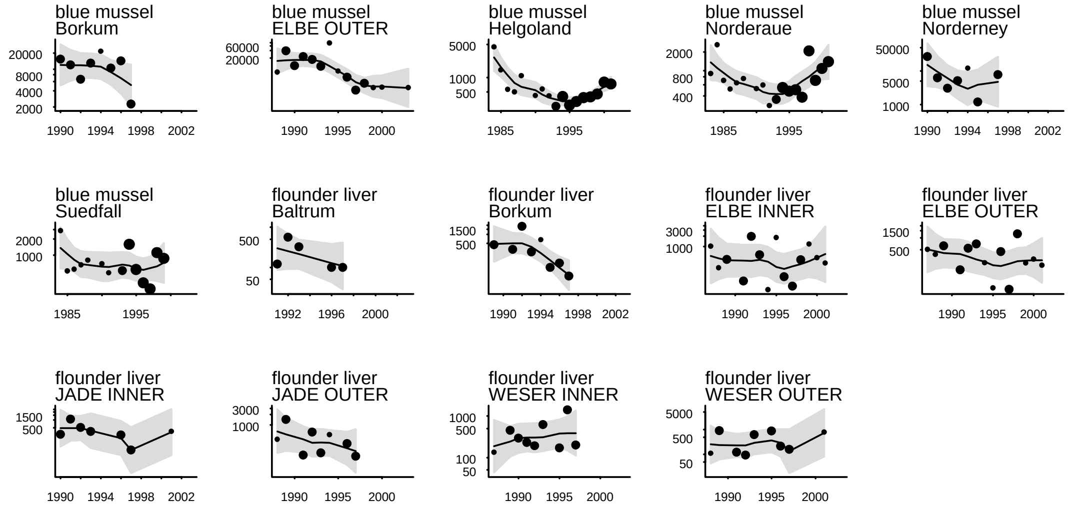


region IV Spain

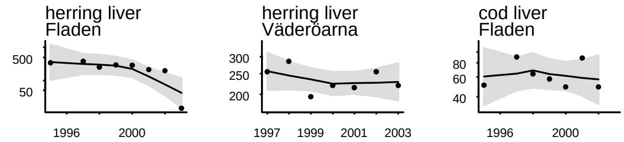


Chromium ug/kg

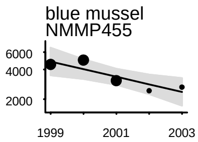
region II Germany



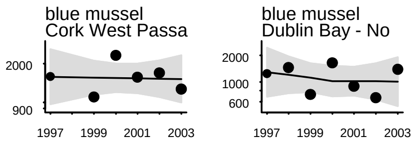
region II Sweden



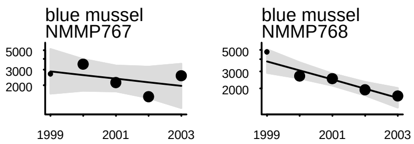
region II UK



region III Ireland

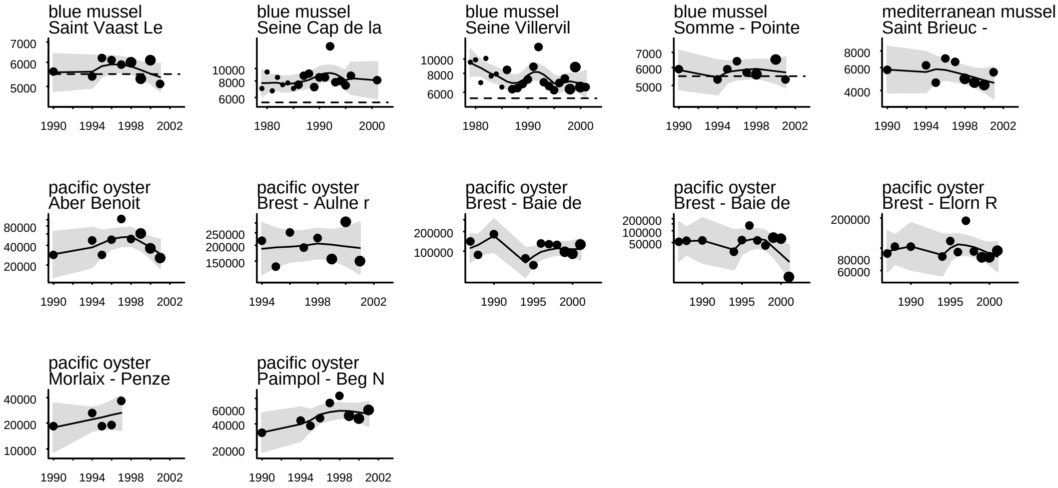


region III UK

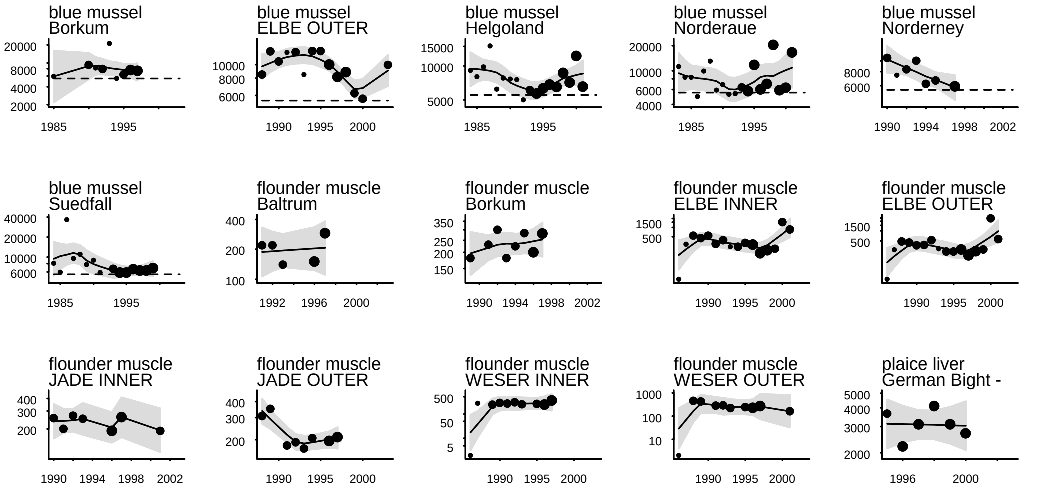


Copper ug/kg (continued)

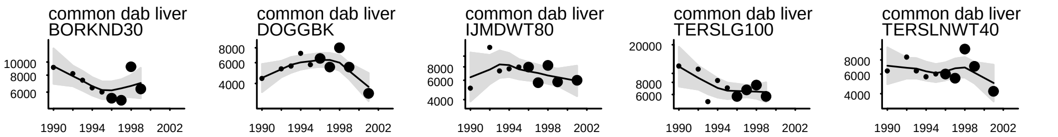
region II France



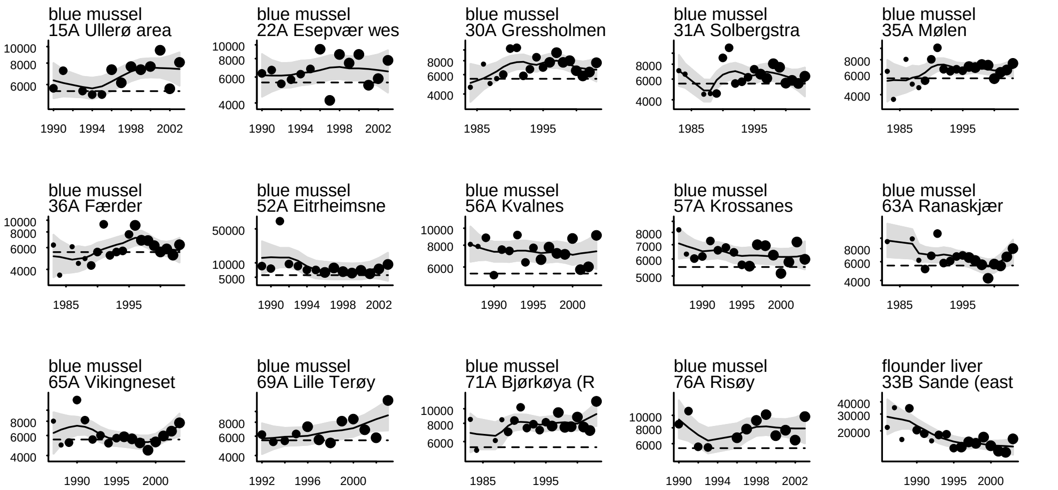
region II Germany



region II Netherlands

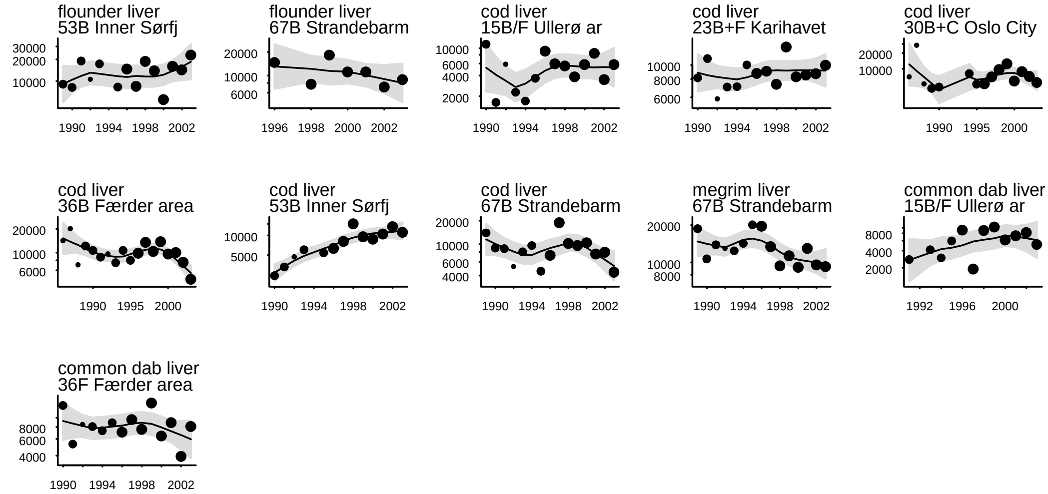


region II Norway

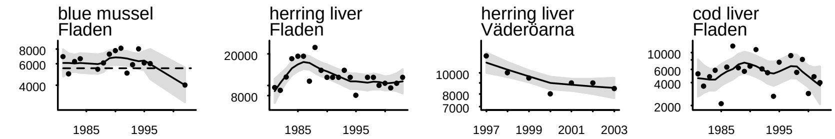


Copper ug/kg (continued)

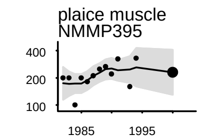
region II Norway



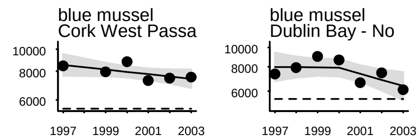
region II Sweden



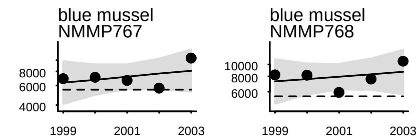
region II UK



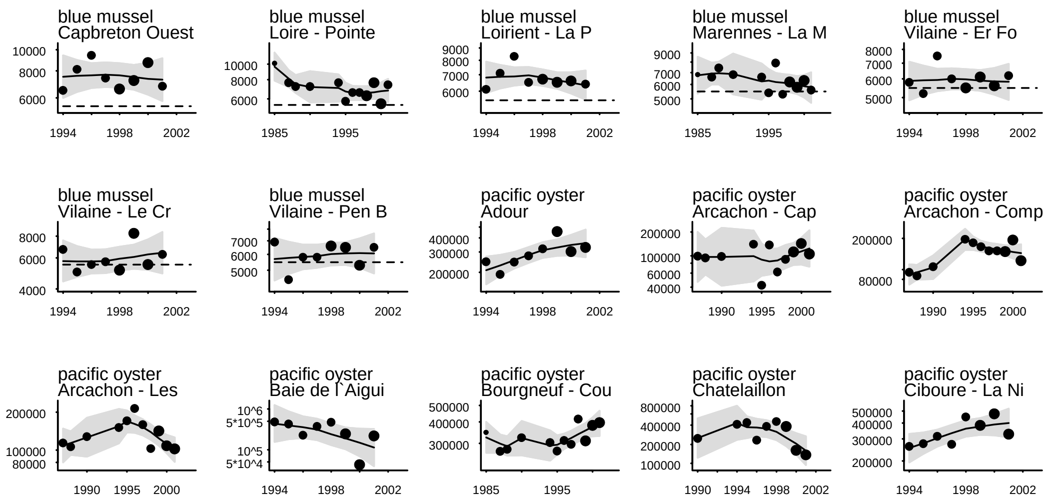
region III Ireland



region III UK

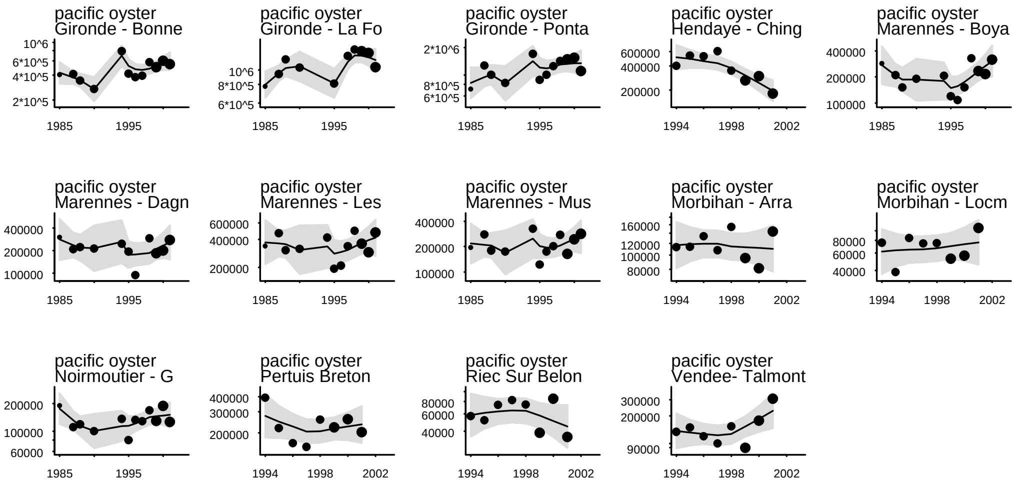


region IV France

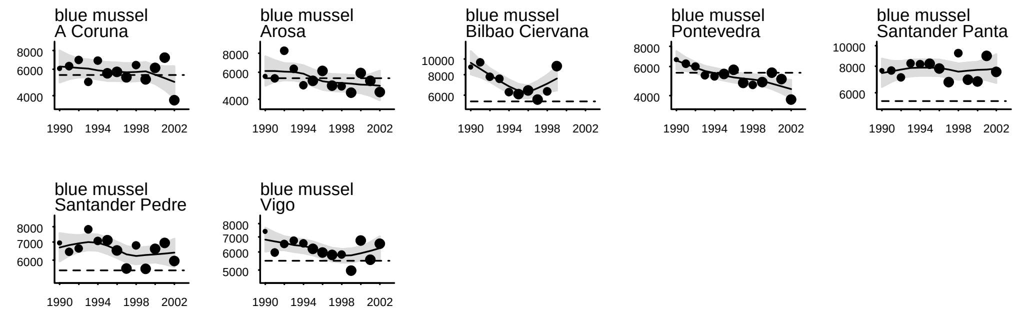


Copper ug/kg (continued)

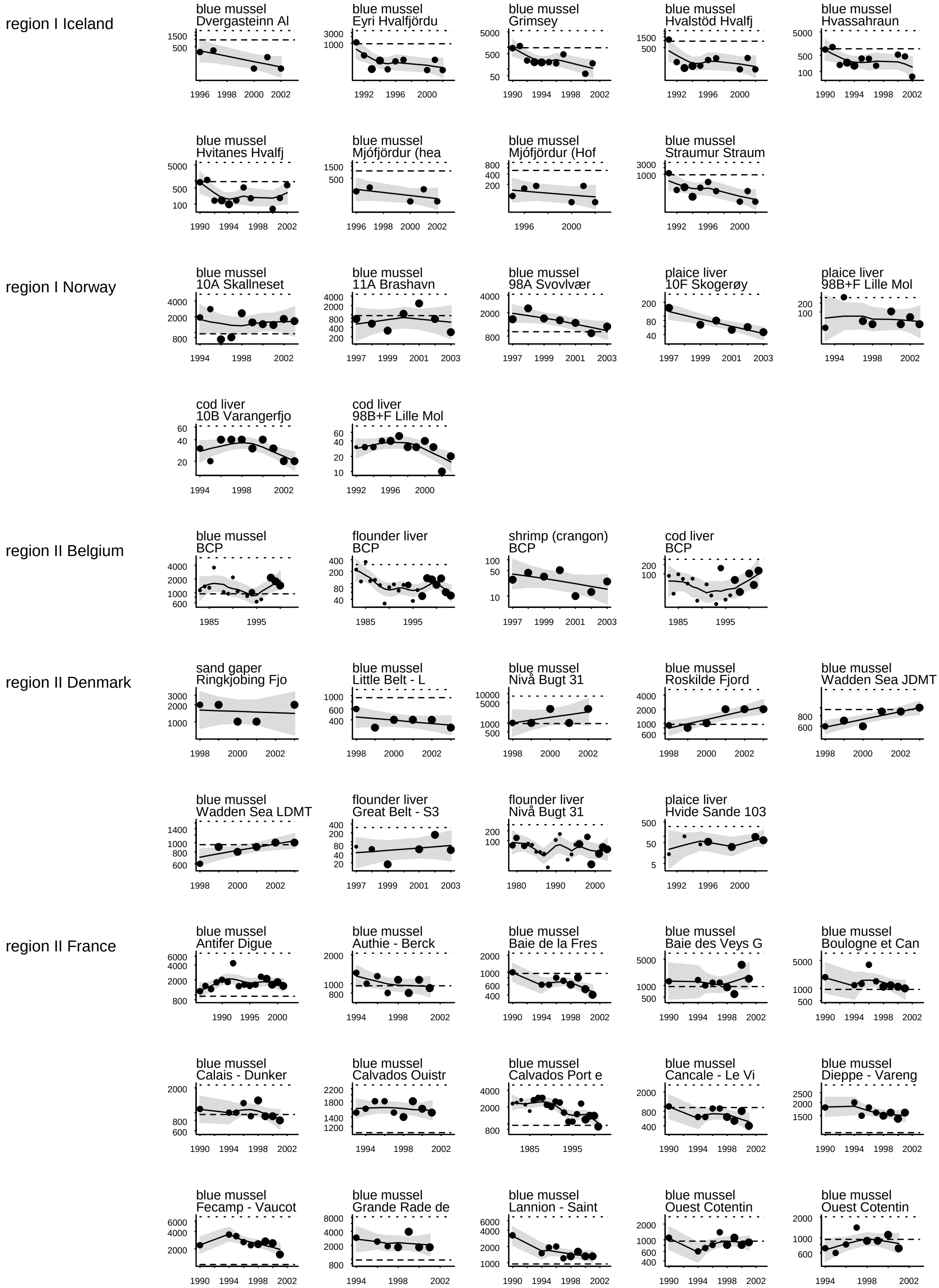
region IV France



region IV Spain

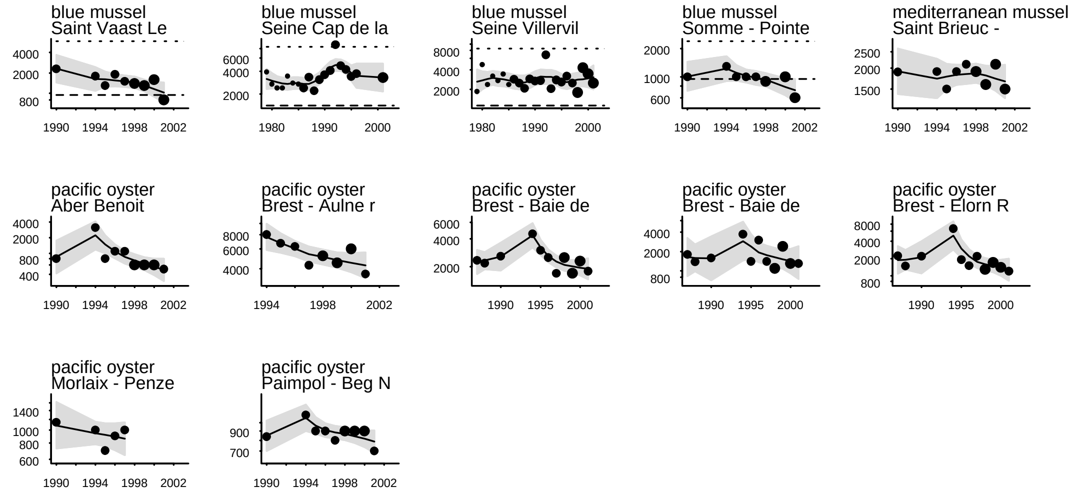


Lead ug/kg

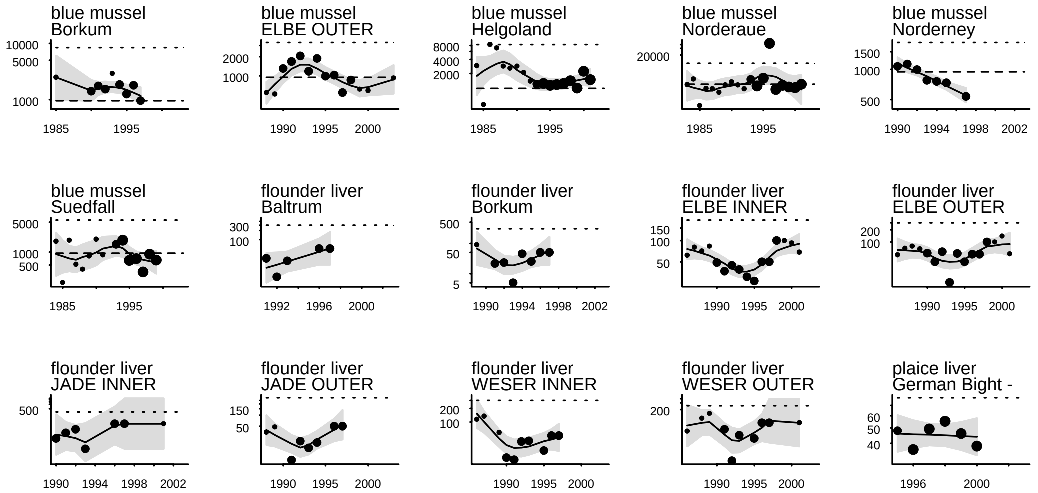

region I Iceland
blue mussel Dvergasteinn Al
blue mussel Eyri Hvalfjördu
blue mussel Grimsey
blue mussel Hvalstöd Hvalfj
blue mussel Hvassahraun
blue mussel Hvitanes Hvalfj
blue mussel Mjófjördur (hea
blue mussel Mjófjördur (Hof
blue mussel Straumur Straum
region I Norway
blue mussel 10A Skallneset
blue mussel 11A Brashavn
blue mussel 98A Svovlvær
plaice liver 10F Skogerøy
plaice liver 98B+F Lille Mol
cod liver 10B Varangerfjo
cod liver 98B+F Lille Mol
region II Belgium
blue mussel BCP
flounder liver BCP
shrimp (crangon) BCP
cod liver BCP
region II Denmark
sand gaper Ringkjobing Fjo
blue mussel Little Belt - L
blue mussel Nivå Bugt 31
blue mussel Roskilde Fjord
blue mussel Wadden Sea JDMT
blue mussel Wadden Sea LDMT
flounder liver Great Belt - S3
flounder liver Nivå Bugt 31
plaice liver Hvide Sande 103
region II France
blue mussel Antifer Digue
blue mussel Authie - Berck
blue mussel Baie de la Fres
blue mussel Baie des Veys G
blue mussel Boulogne et Can
blue mussel Calais - Dunker
blue mussel Calvados Ouistr
blue mussel Calvados Port e
blue mussel Cancale - Le Vi
blue mussel Dieppe - Vareng
blue mussel Fecamp - Vaucot
blue mussel Grande Rade de
blue mussel Lannion - Saint
blue mussel Ouest Cotentin
blue mussel Ouest Cotentin

Lead ug/kg (continued)

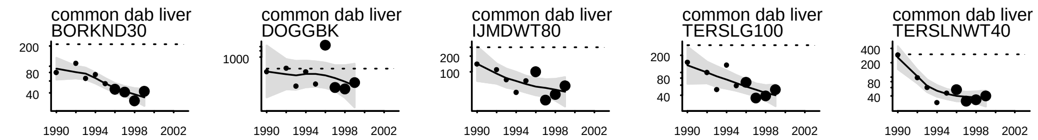
region II France



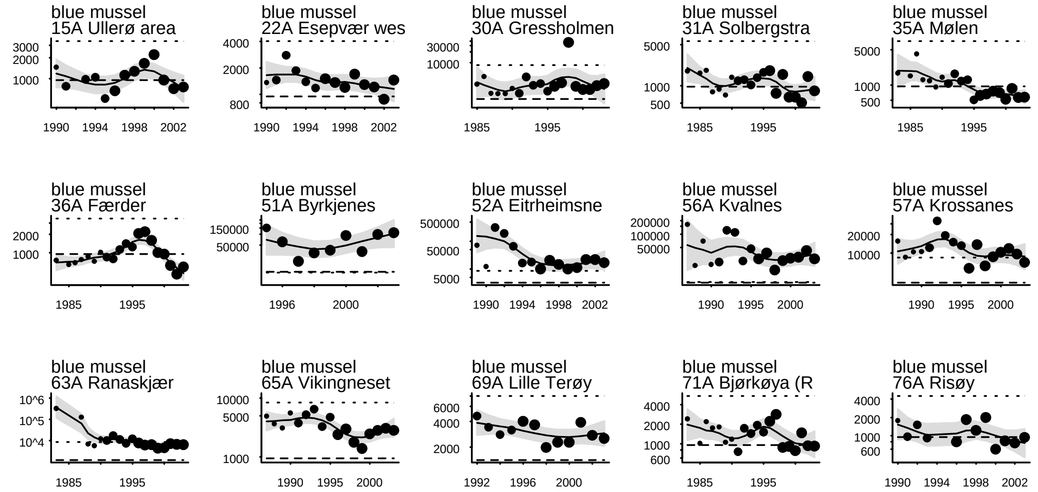
region II Germany



region II Netherlands

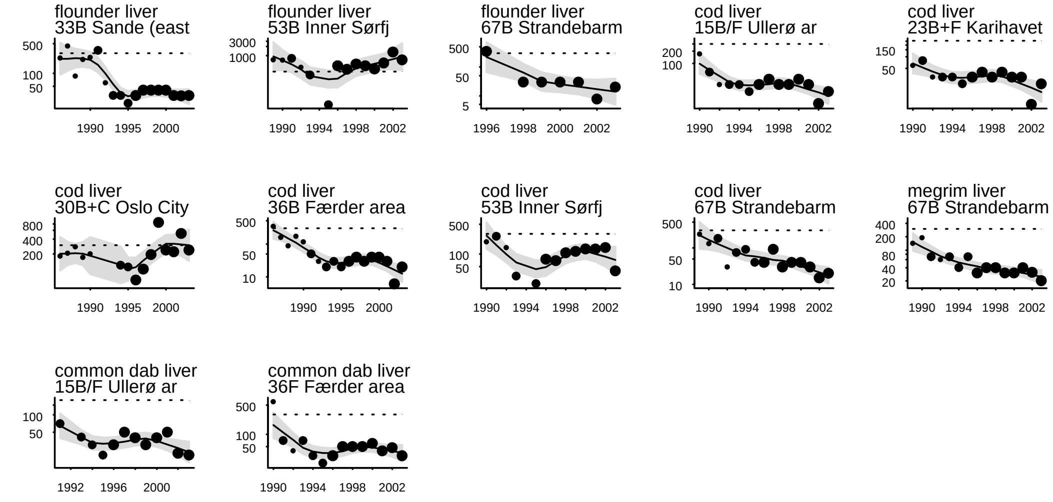


region II Norway

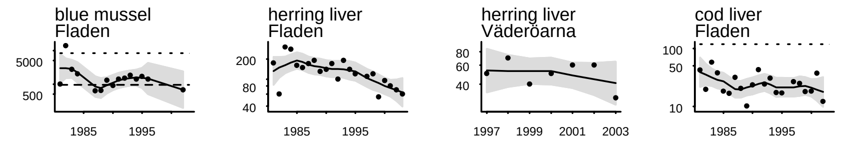


Lead ug/kg (continued)

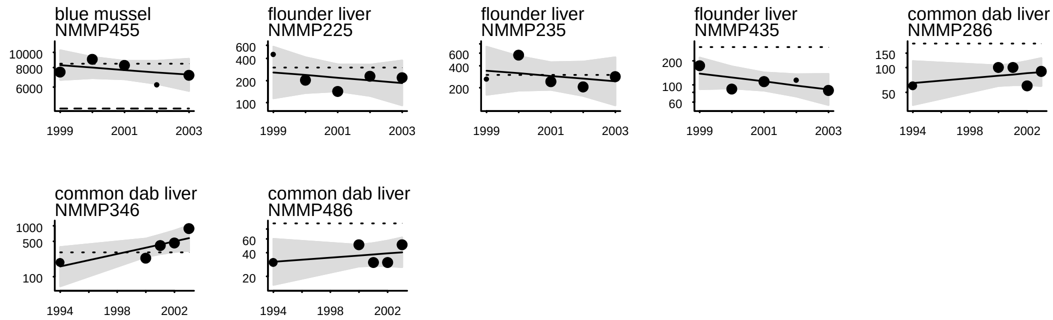
region II Norway



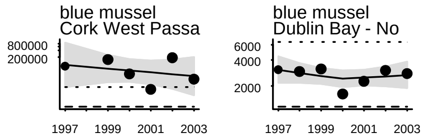
region II Sweden



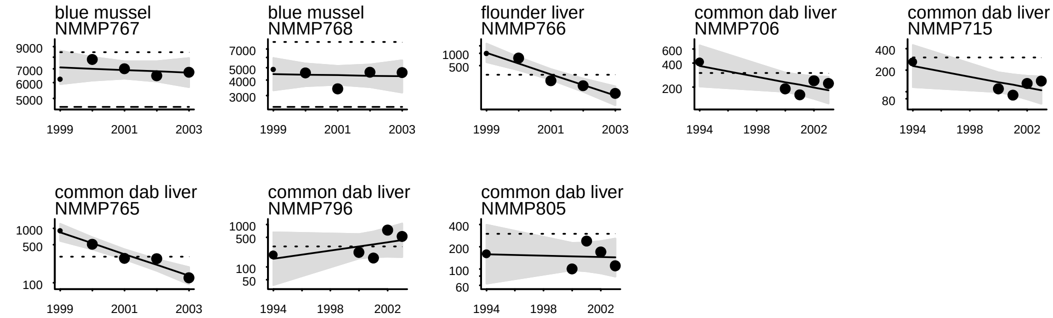
region II UK



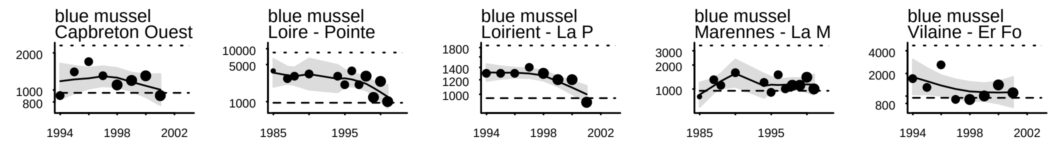
region III Ireland



region III UK

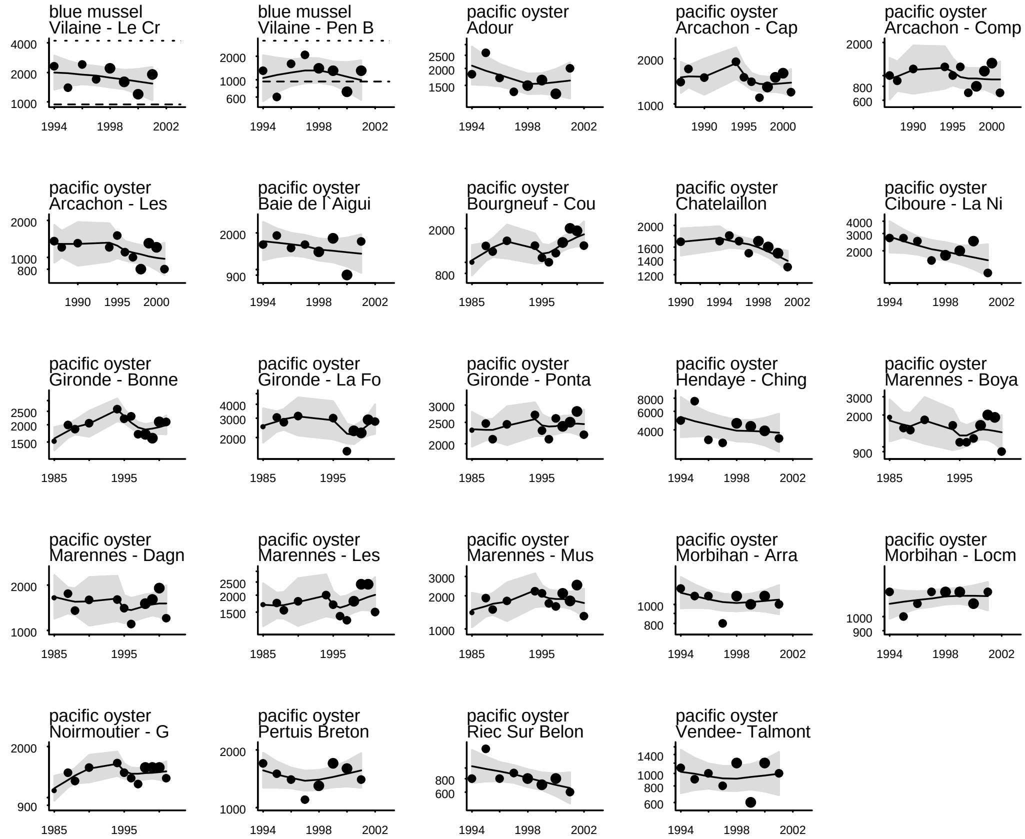


region IV France

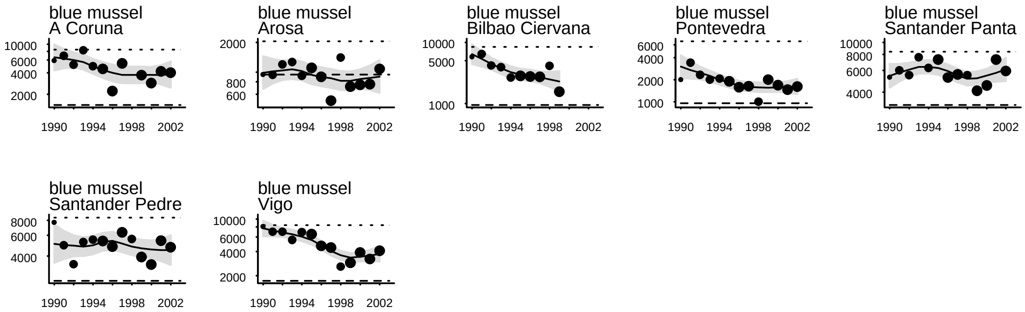


Lead ug/kg (continued)

region IV France

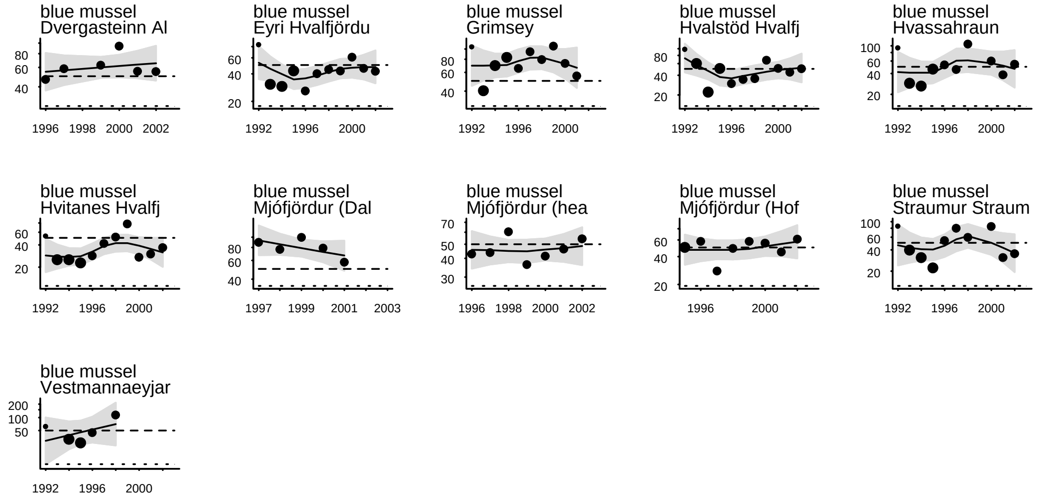


region IV Spain

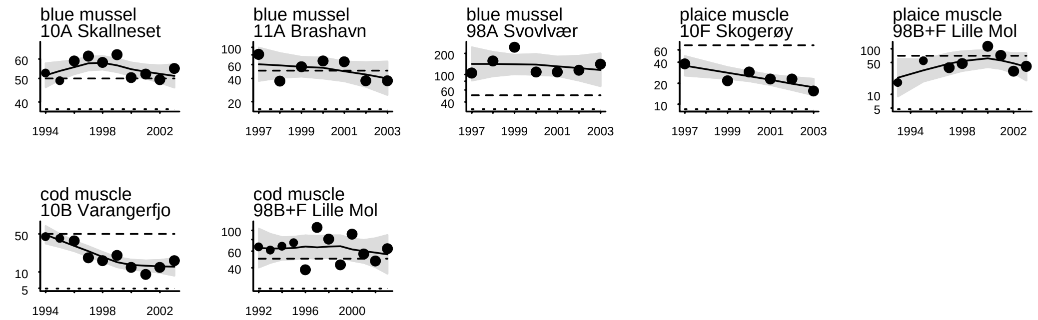


Mercury ug/kg

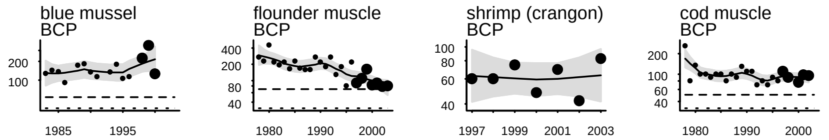
region I Iceland



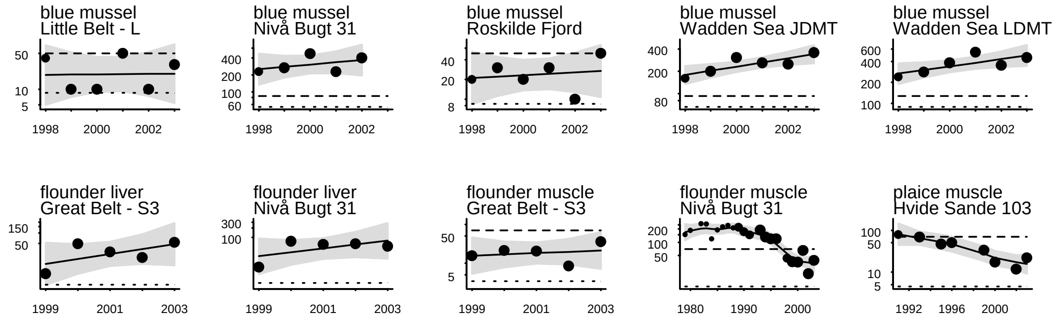
region I Norway



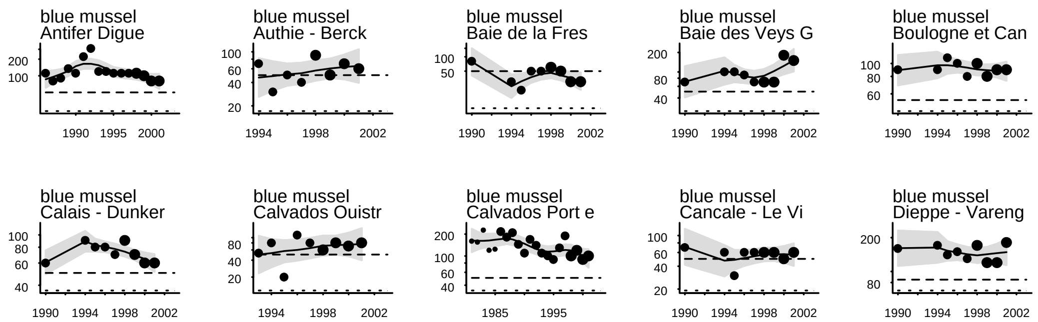
region II Belgium



region II Denmark

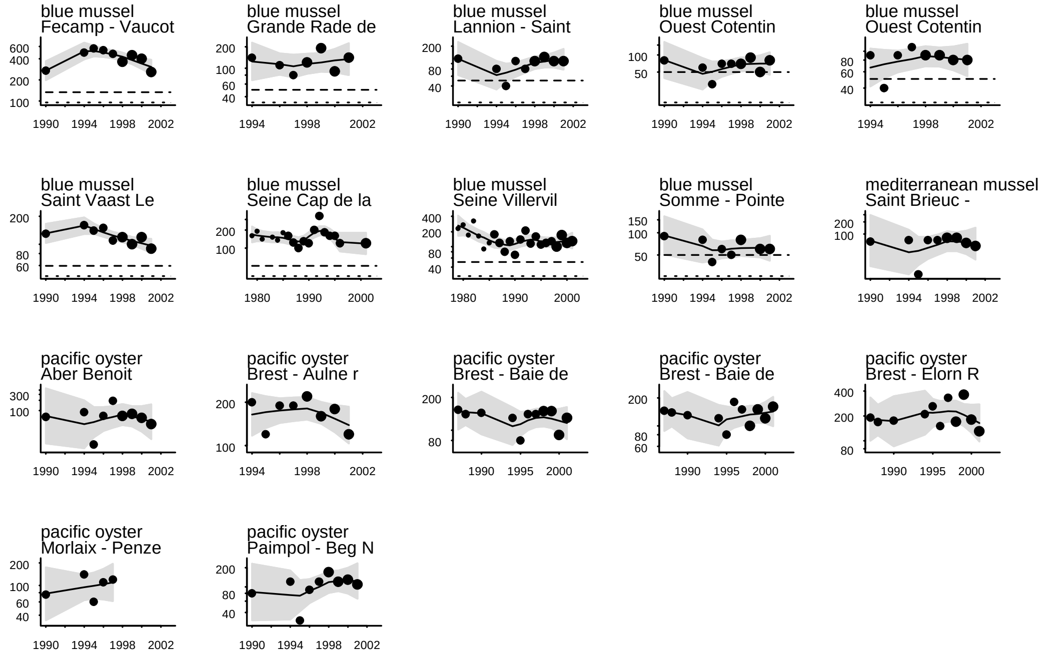


region II France

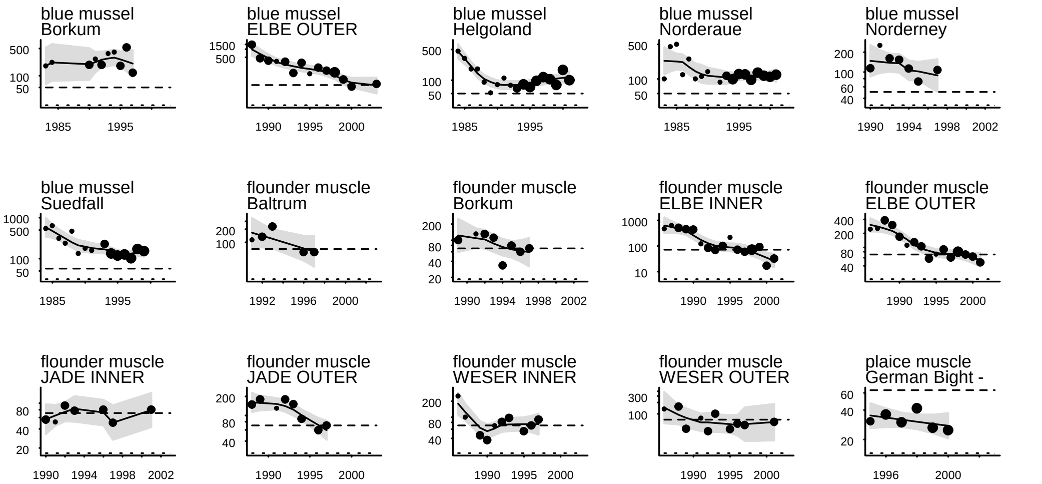


Mercury ug/kg (continued)

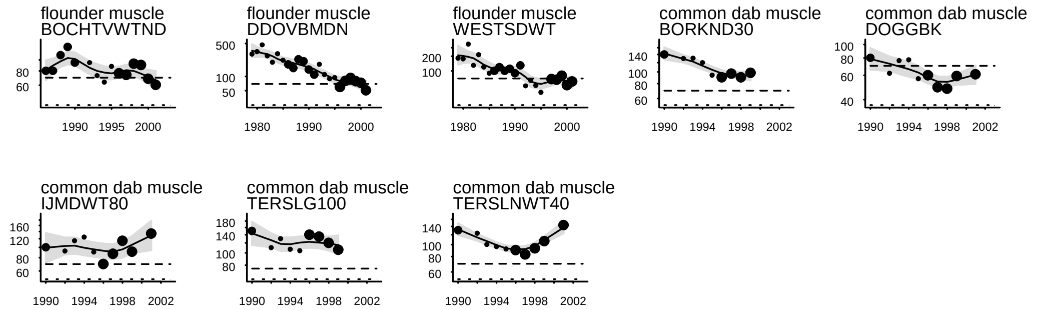
region II France



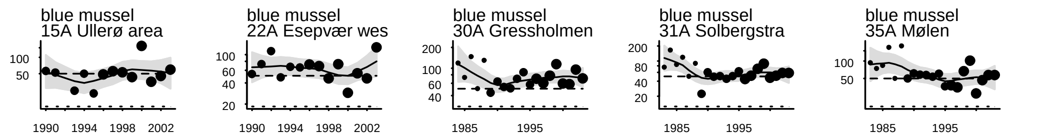
region II Germany



region II Netherlands

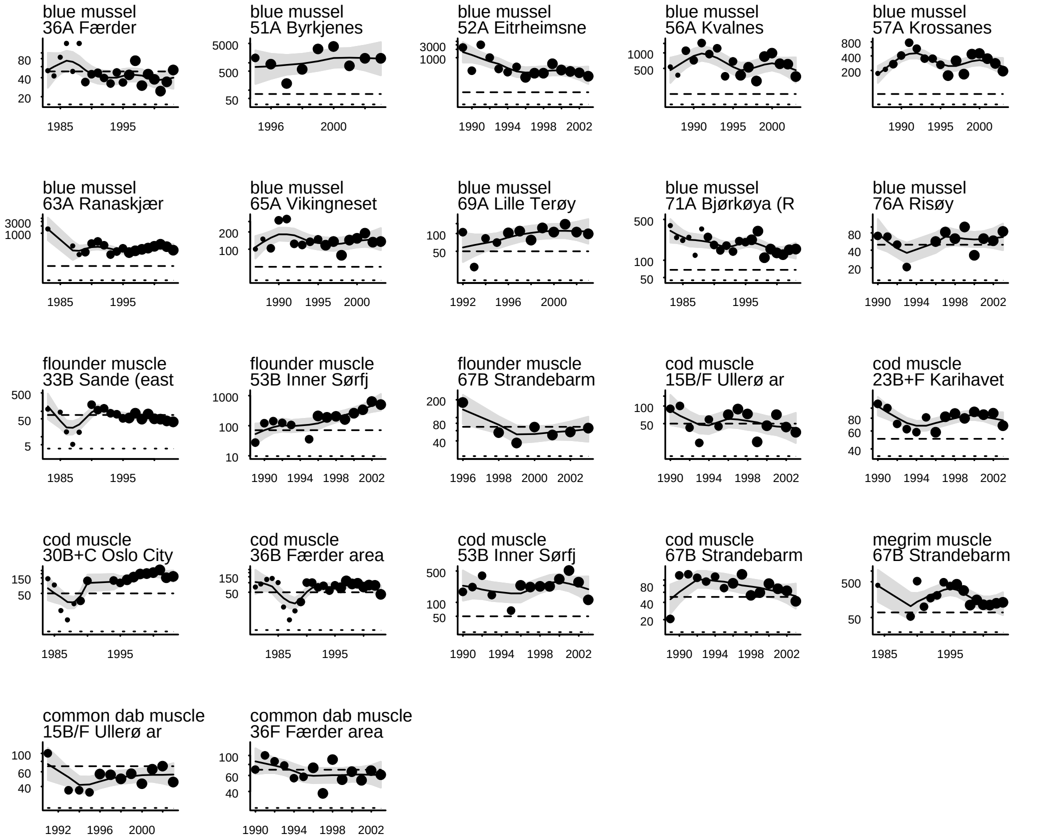


region II Norway

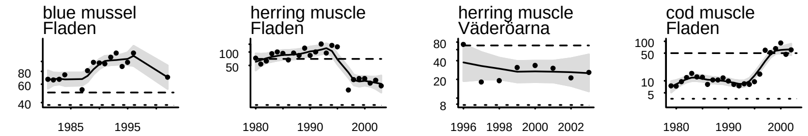


Mercury ug/kg (continued)

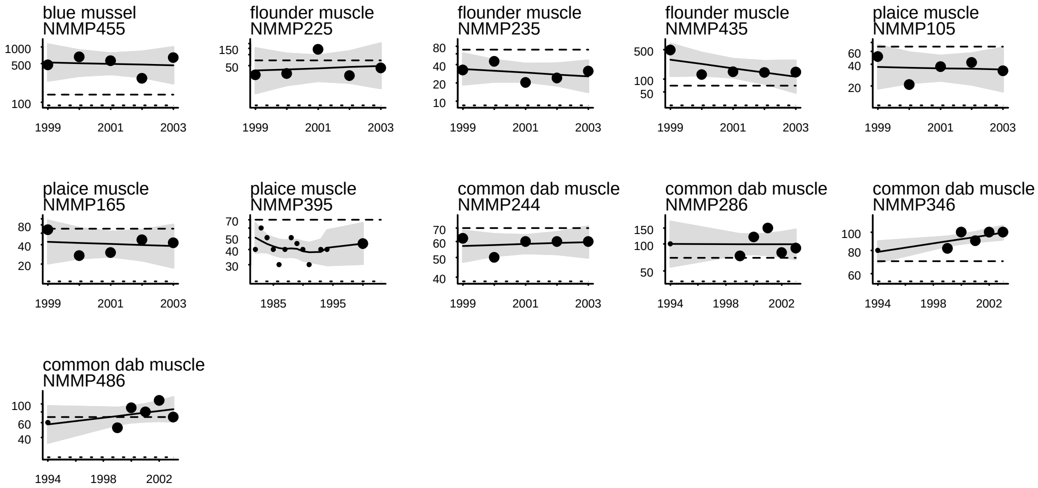
region II Norway



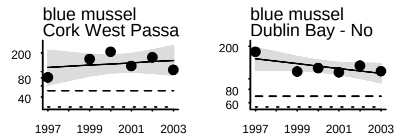
region II Sweden



region II UK

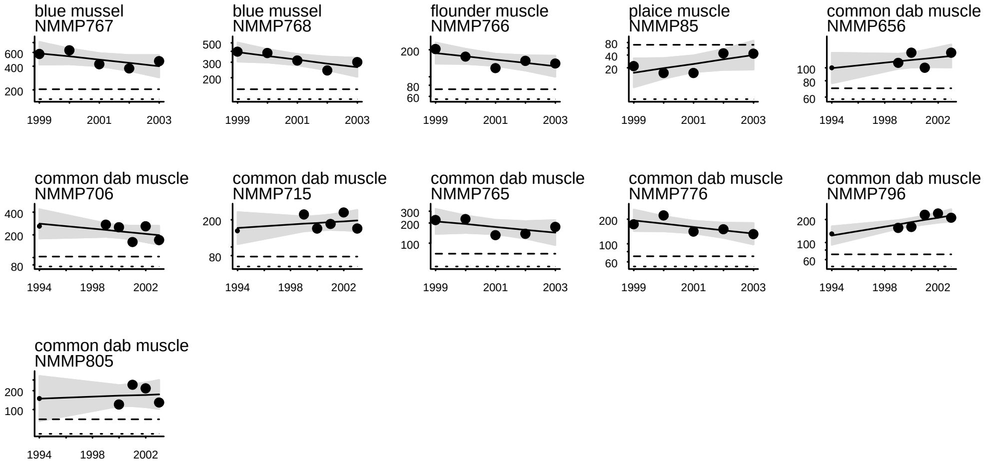


region III Ireland

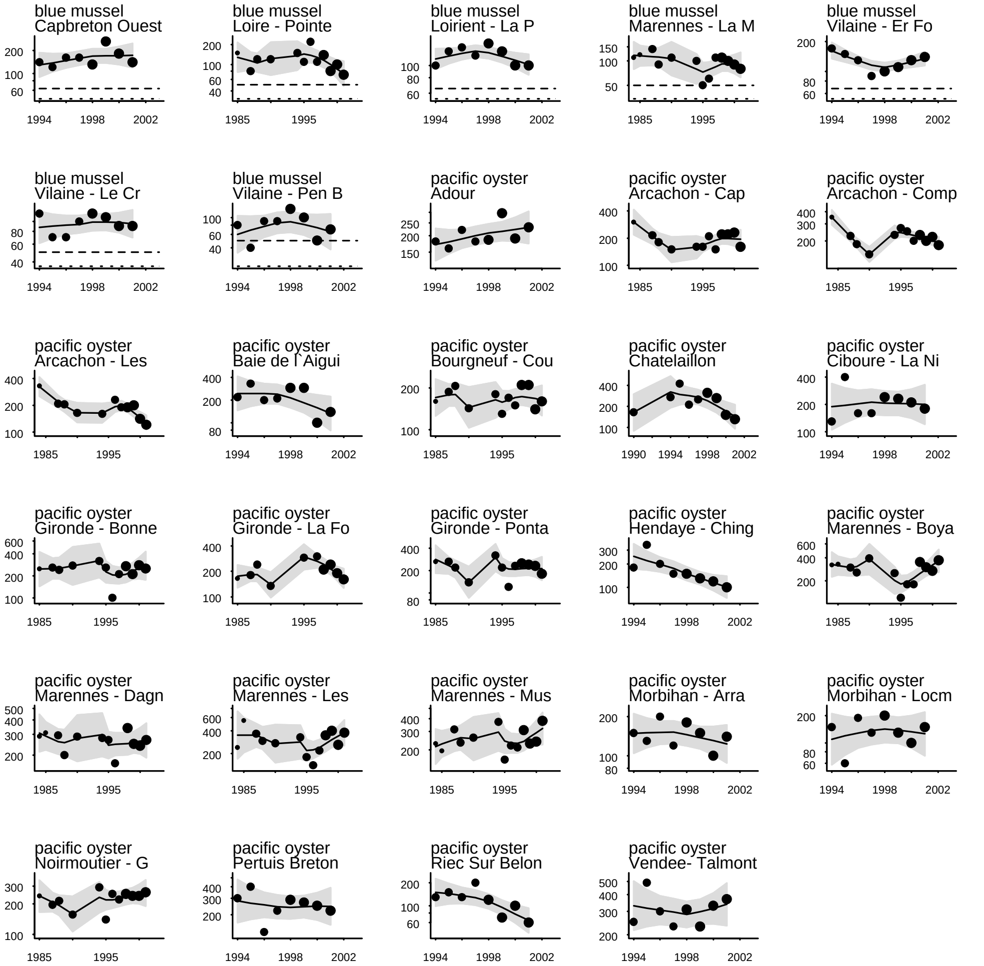


Mercury ug/kg (continued)

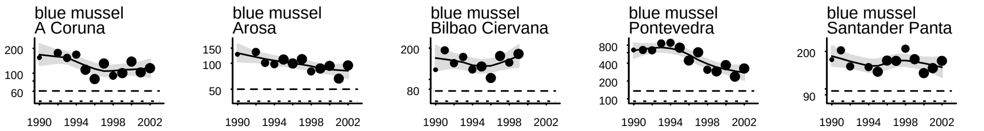
region III UK



region IV France

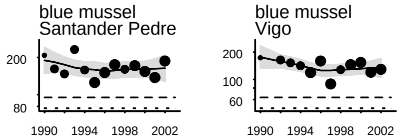


region IV Spain



Mercury ug/kg (continued)

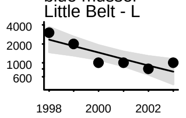
region IV Spain



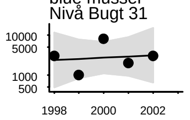
Nickel ug/kg

region II Denmark

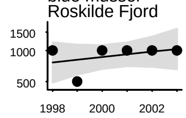
blue mussel
Little Belt - L



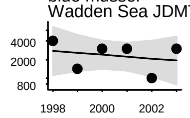
blue mussel
Nivå Bugt 31



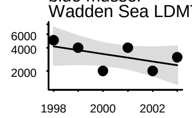
blue mussel
Roskilde Fjord



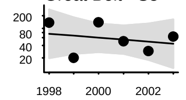
blue mussel
Wadden Sea JDMT



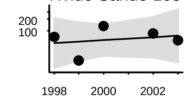
blue mussel
Wadden Sea LDMT



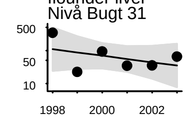
flounder liver
Great Belt - S3



flounder liver
Hvide Sande 103

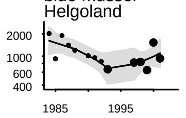


flounder liver
Nivå Bugt 31

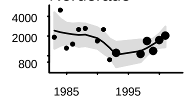


region II Germany

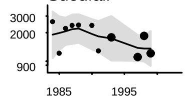
blue mussel
Helgoland



blue mussel
Norderaue

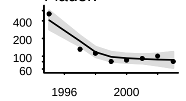


blue mussel
Suedfall

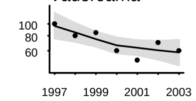


region II Sweden

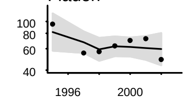
herring liver
Fladen



herring liver
Väderöarna

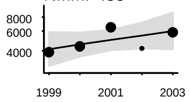


cod liver
Fladen



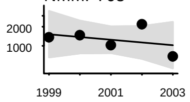
region II UK

blue mussel
NMMP455



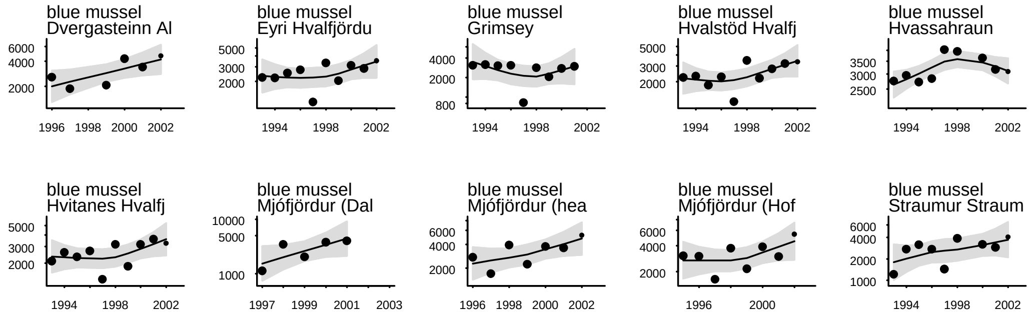
region III UK

blue mussel
NMMP768



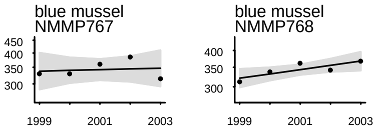
Selenium ug/kg

region I Iceland



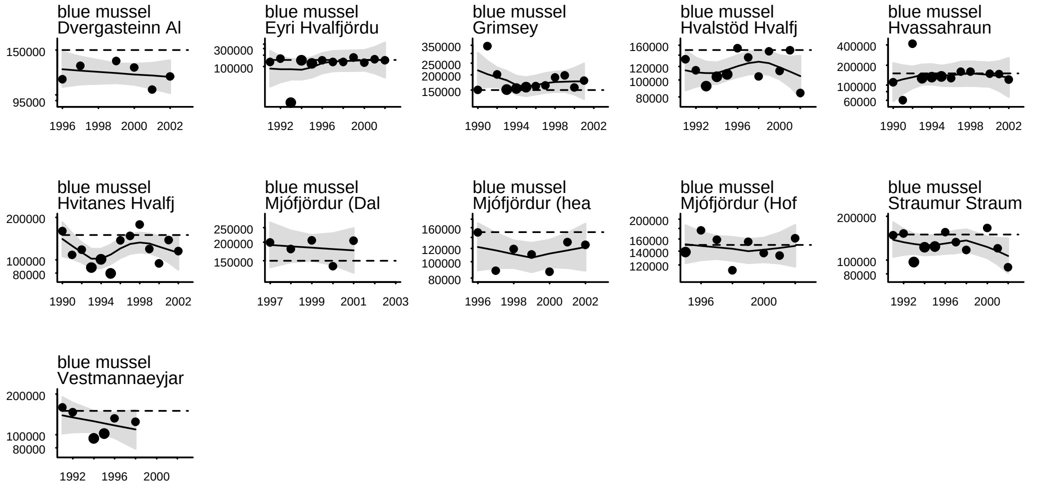
Silver ug/kg

region III UK

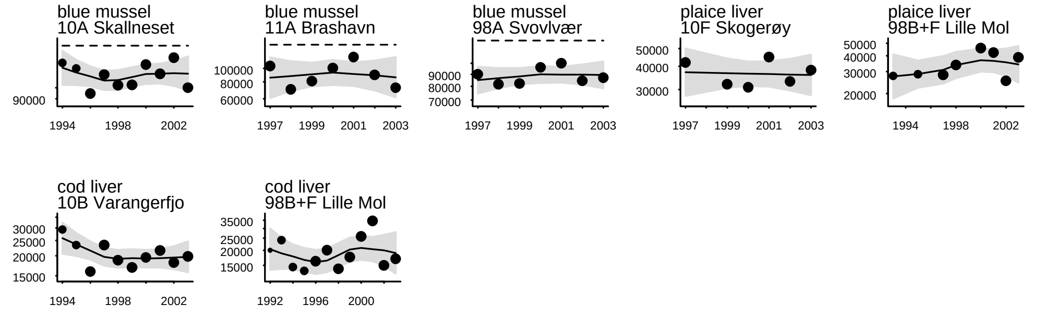


Zinc ug/kg

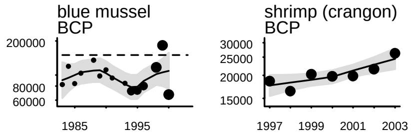
region I Iceland



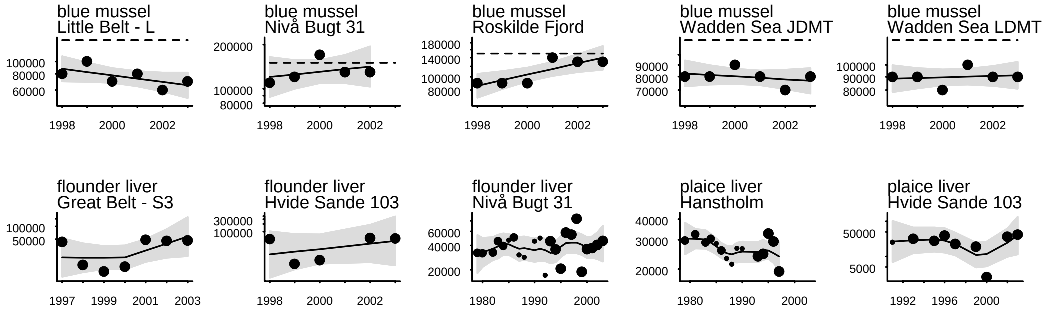
region I Norway



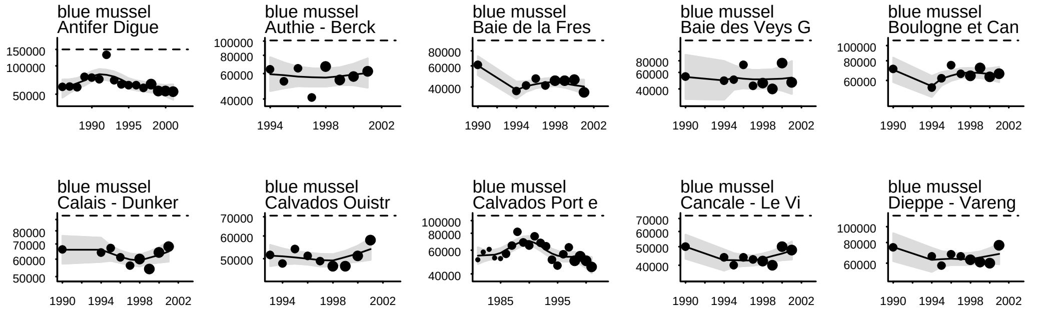
region II Belgium



region II Denmark

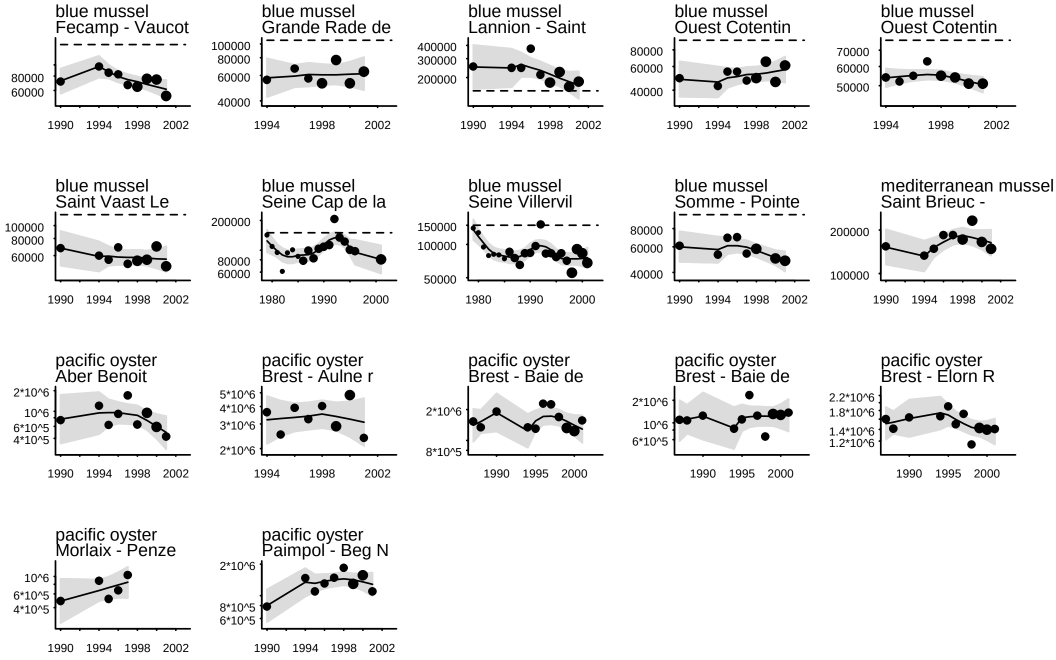


region II France

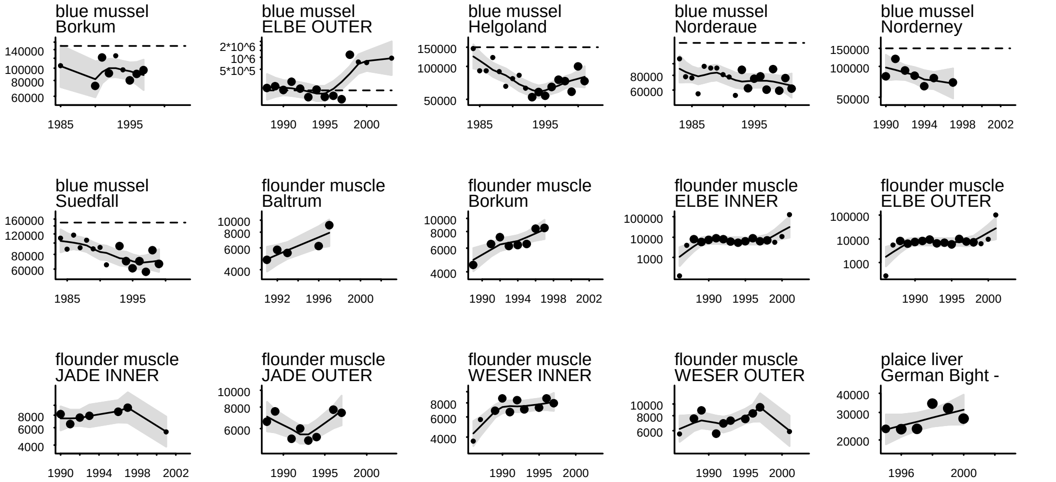


Zinc ug/kg (continued)

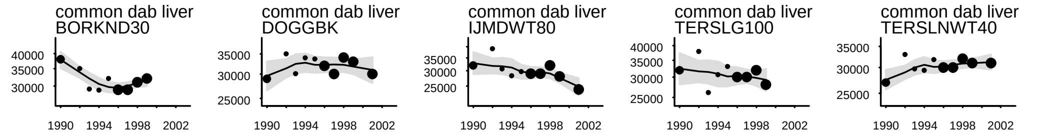
region II France



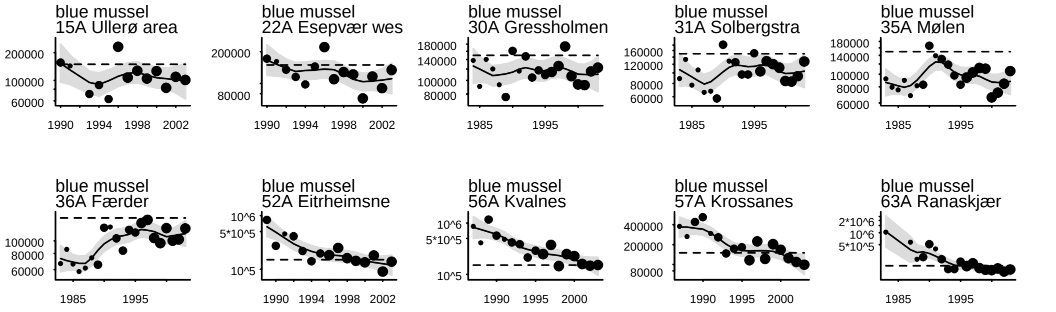
region II Germany



region II Netherlands

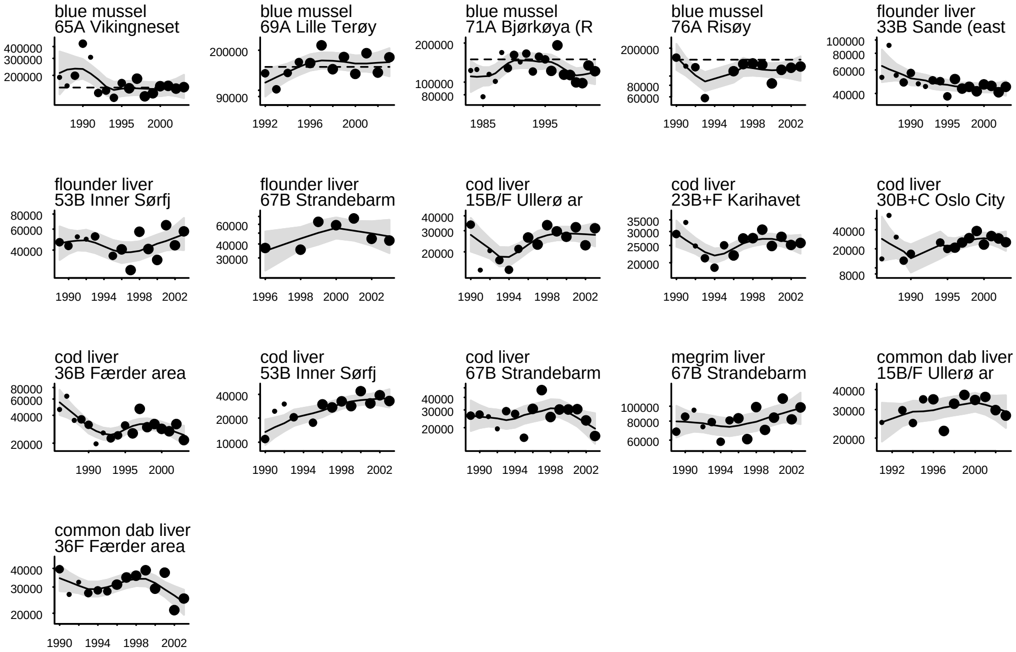


region II Norway

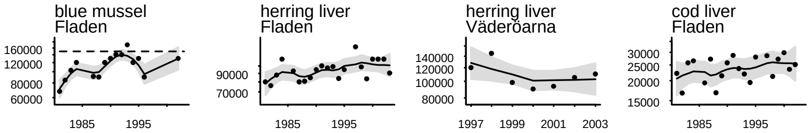


Zinc ug/kg (continued)

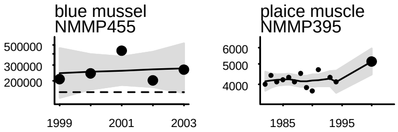
region II Norway



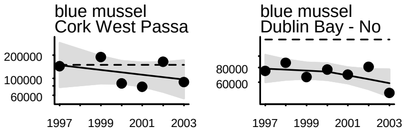
region II Sweden



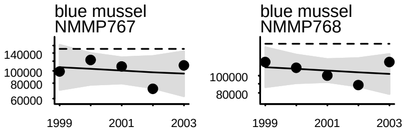
region II UK



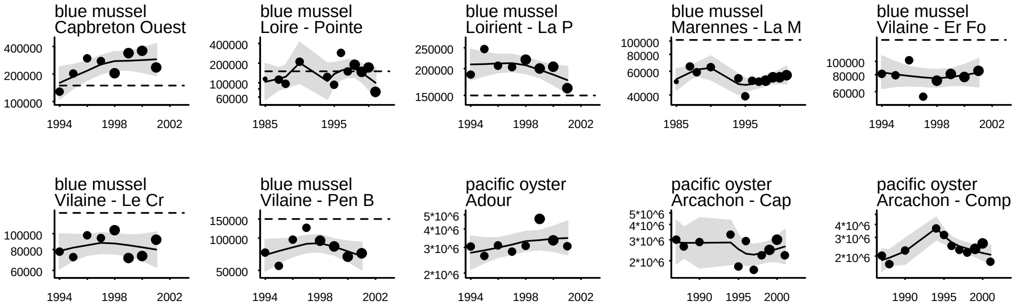
region III Ireland



region III UK

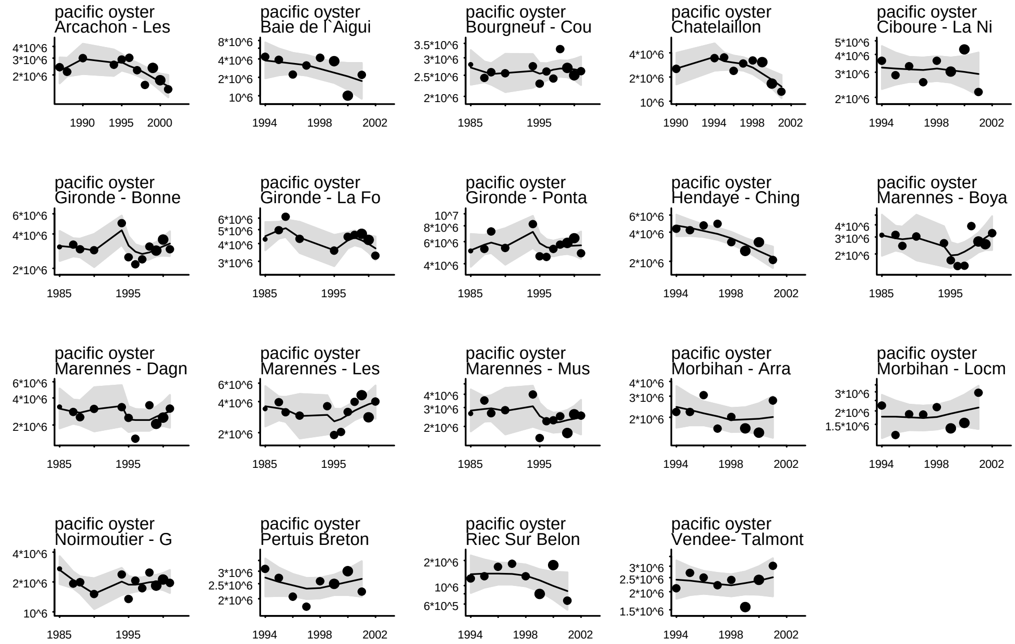


region IV France

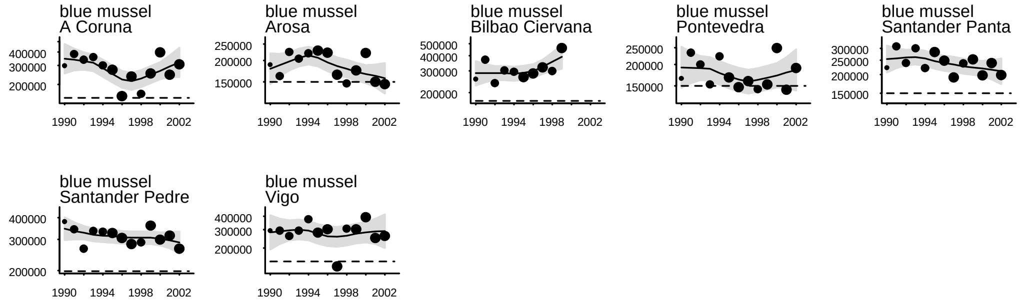


Zinc ug/kg (continued)

region IV France



region IV Spain



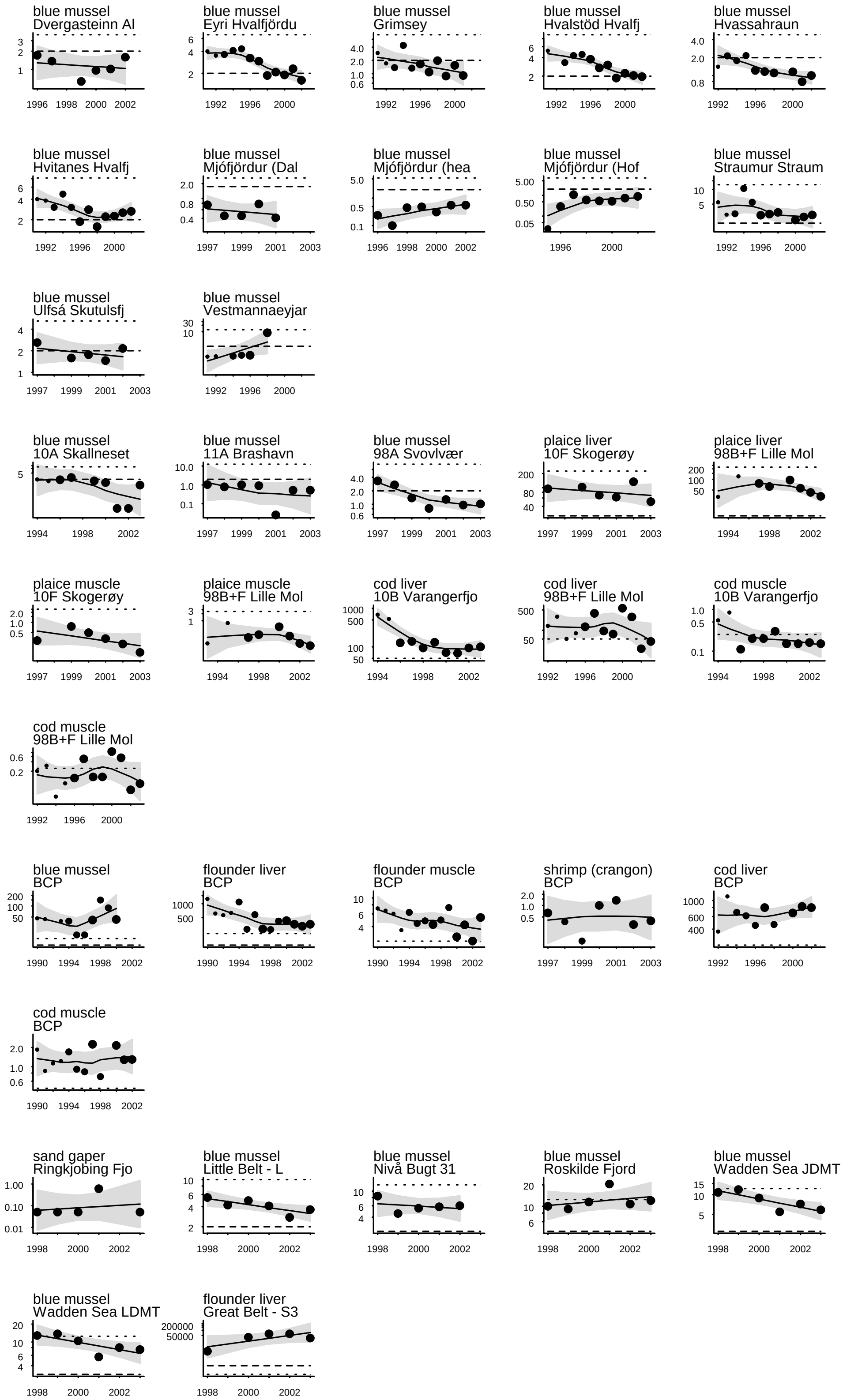
CB153 ug/kg

region I Iceland

region I Norway

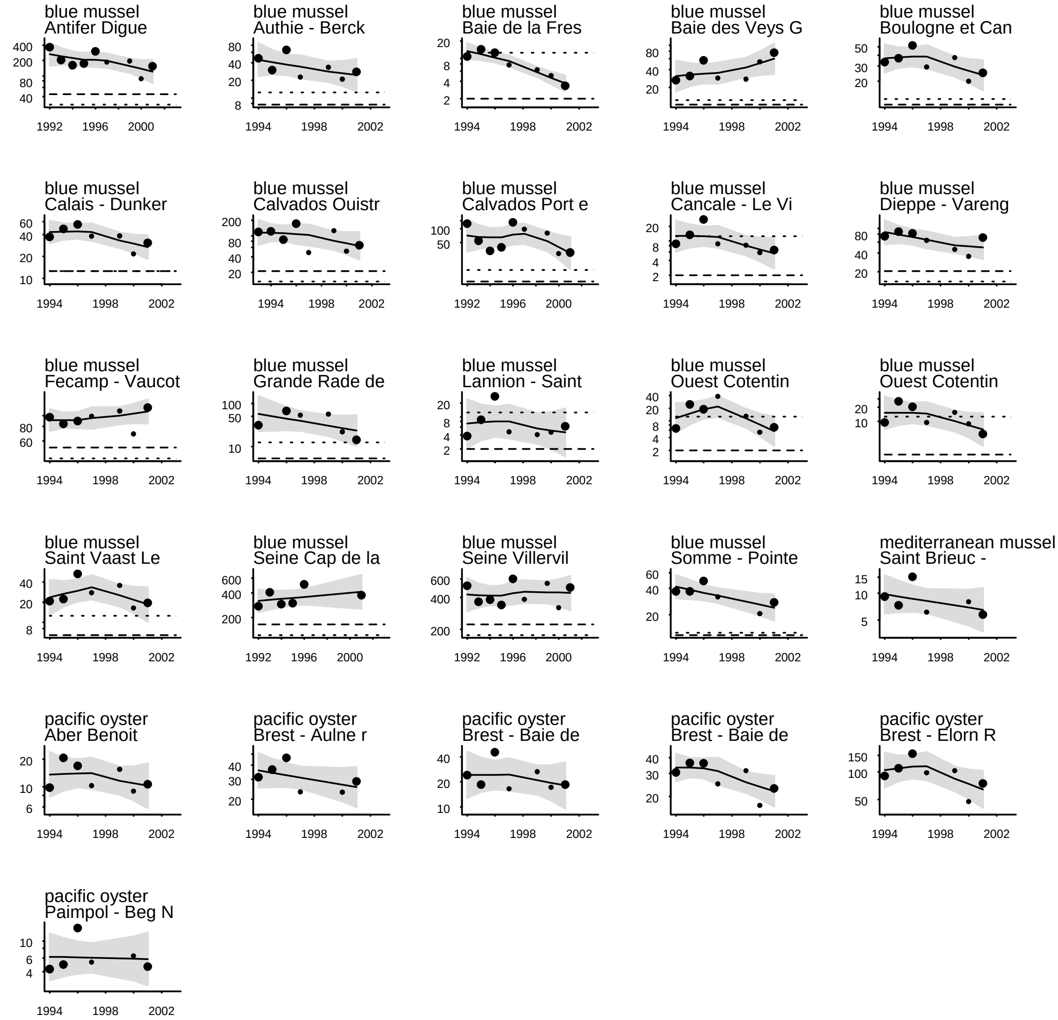
region II Belgium

region II Denmark

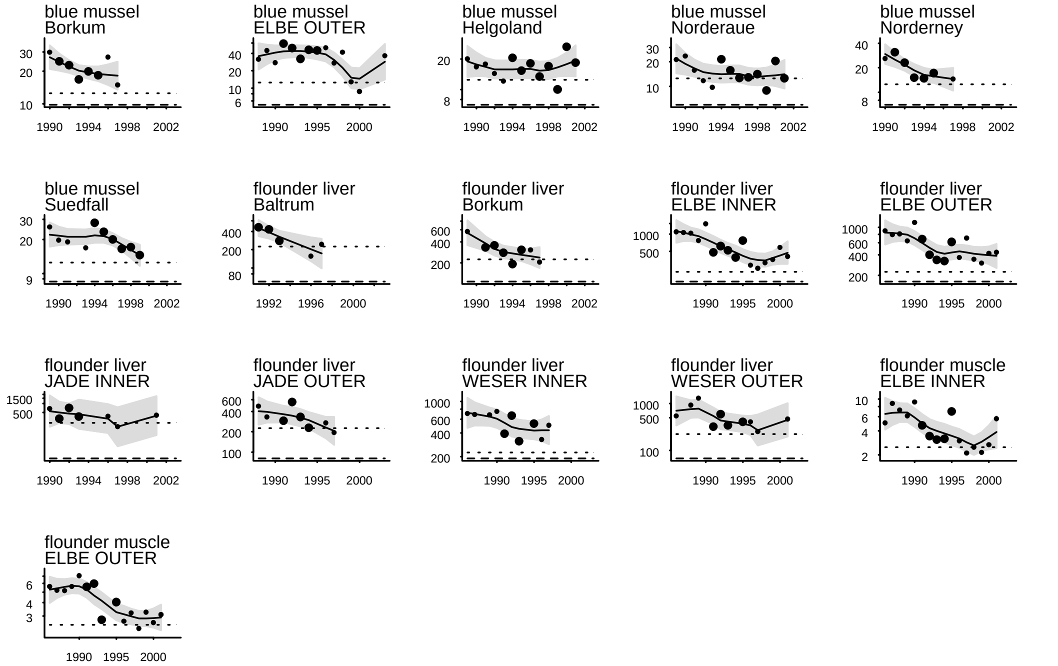


CB153 ug/kg (continued)

region II France

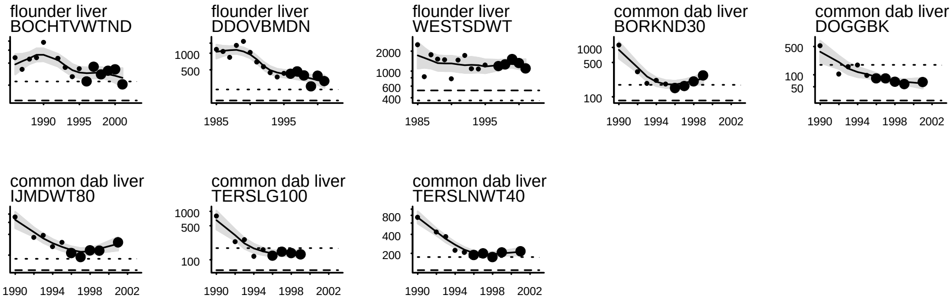


region II Germany

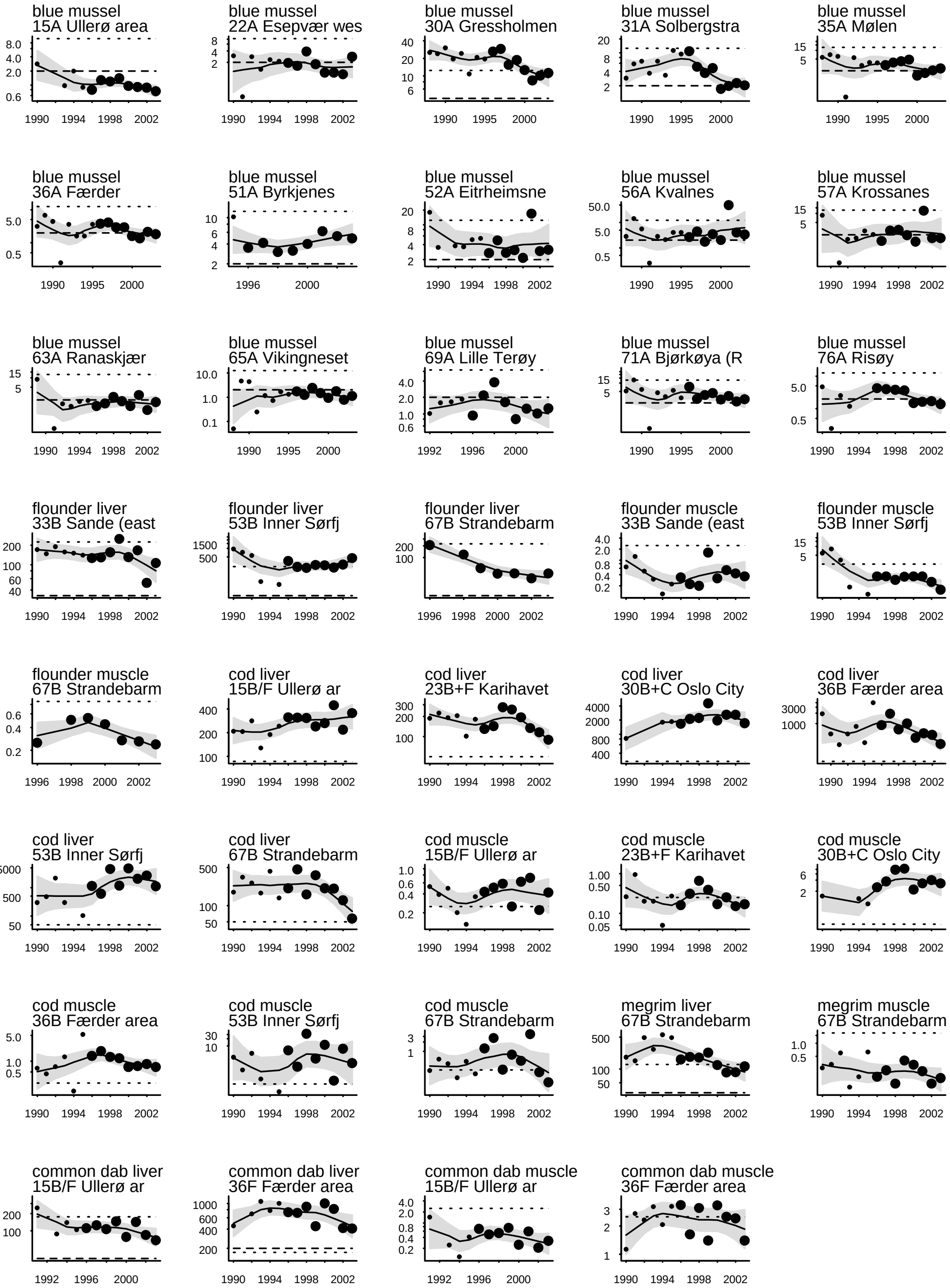


CB153 ug/kg (continued)

region II Netherlands

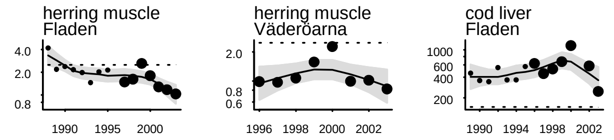


region II Norway

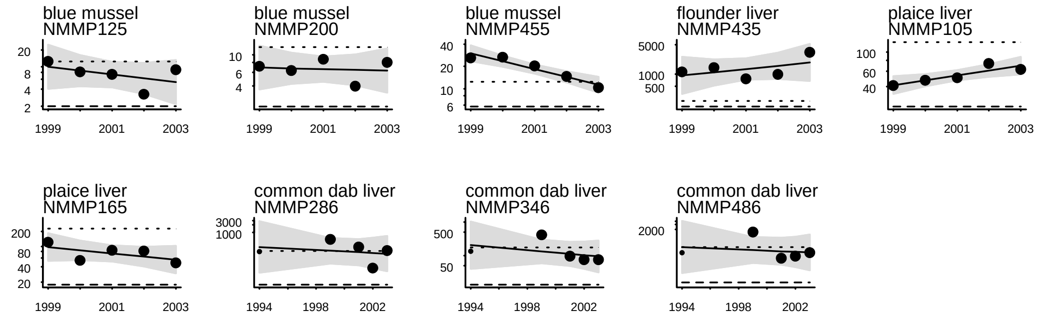


CB153 ug/kg (continued)

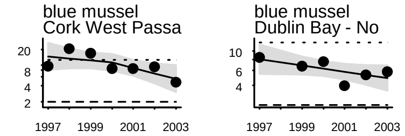
region II Sweden



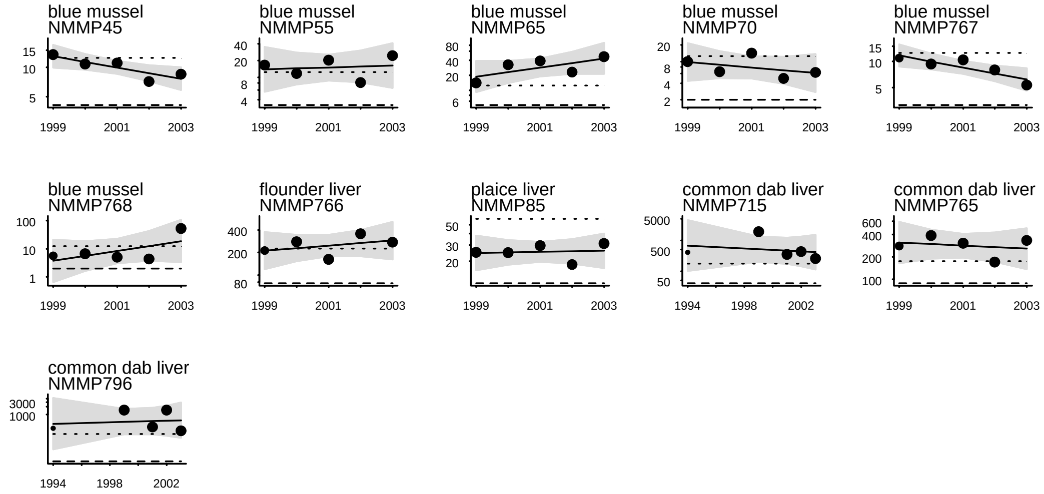
region II UK



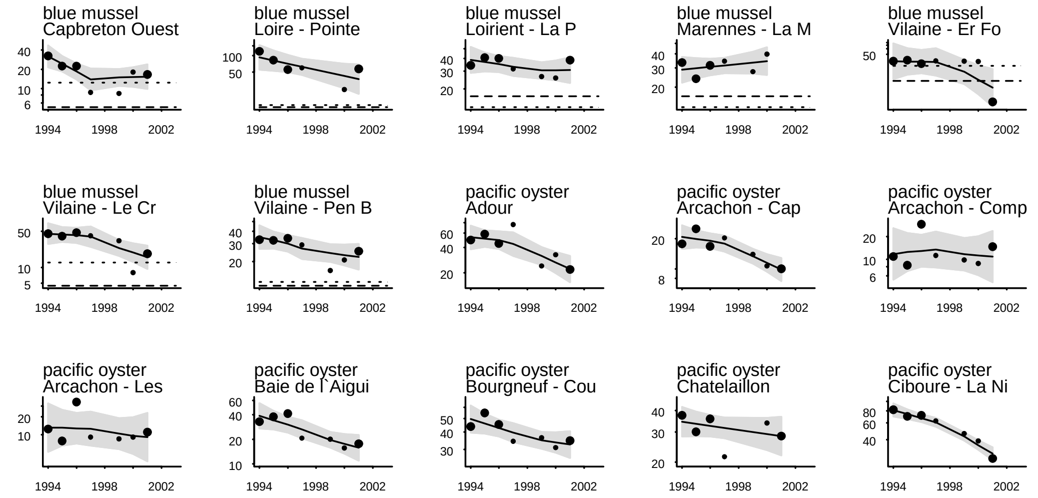
region III Ireland



region III UK

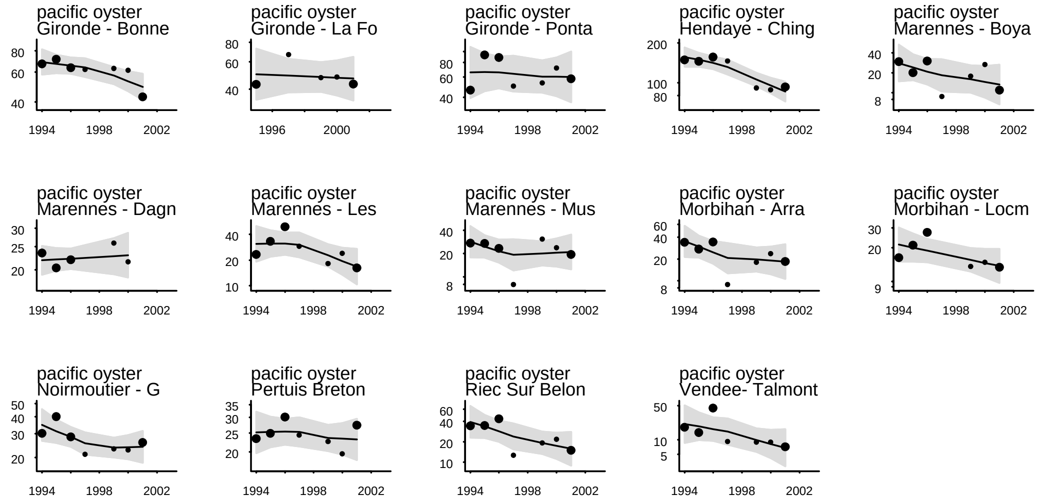


region IV France

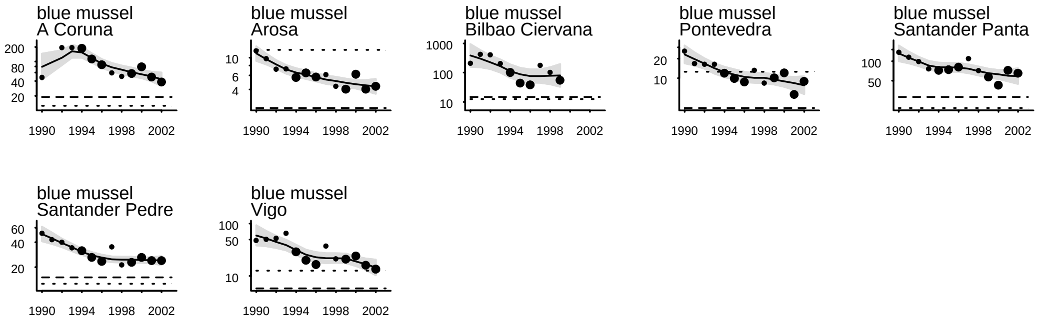


CB153 ug/kg (continued)

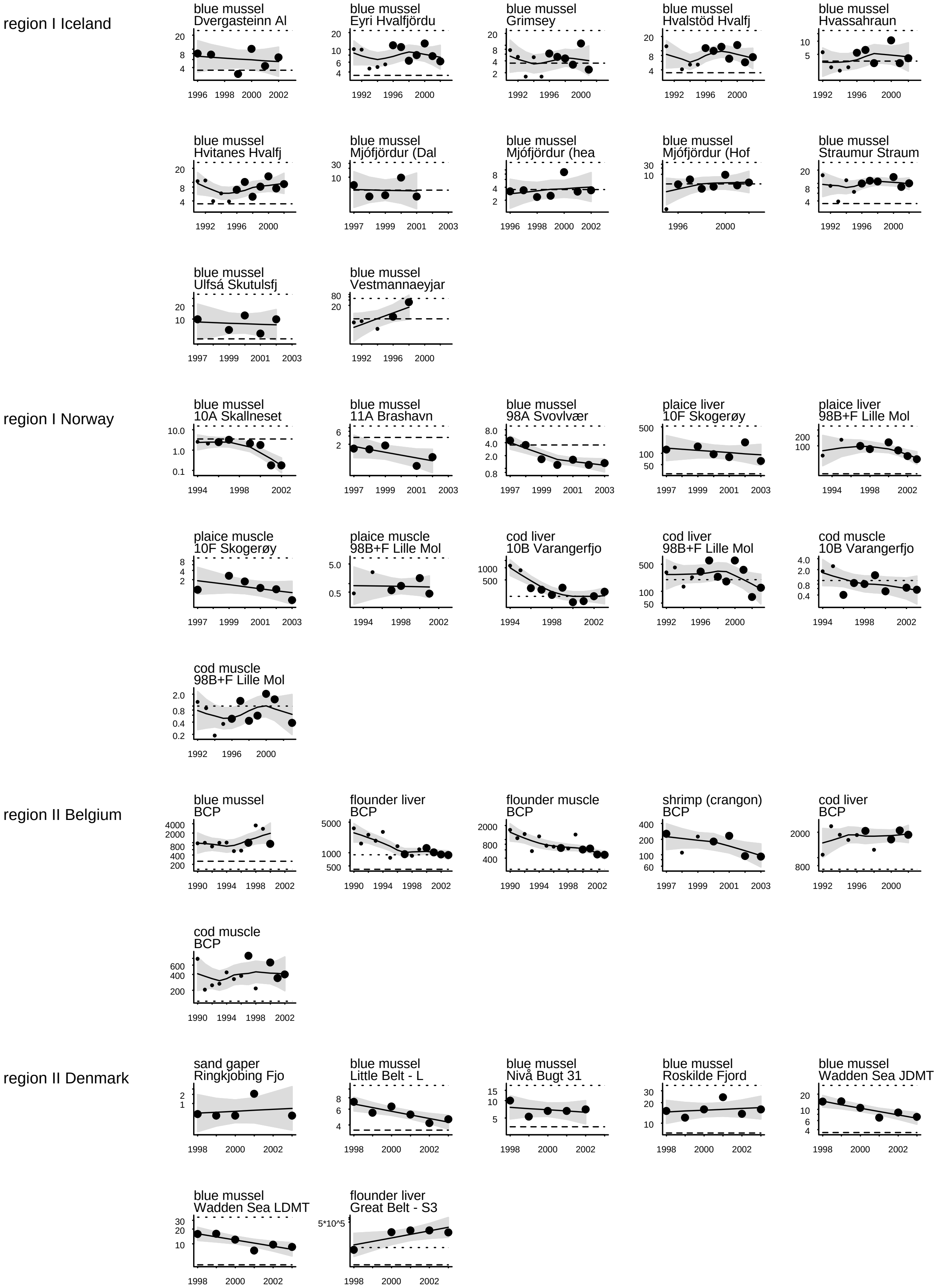
region IV France



region IV Spain

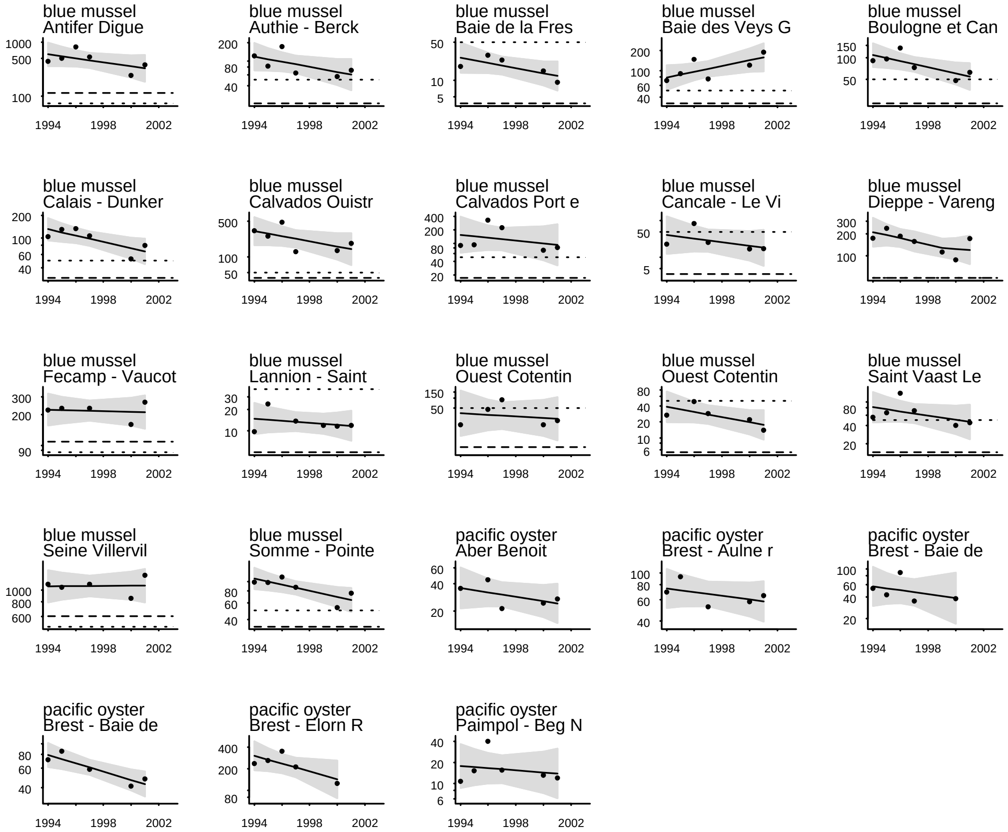


Sum of ICES 7 CBs ug/kg

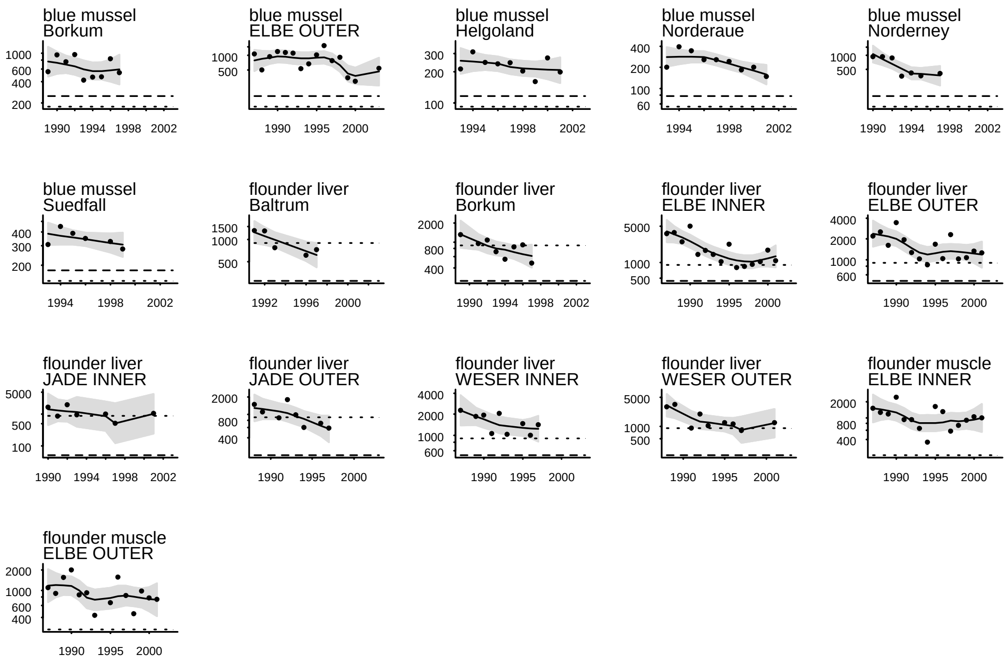


Sum of ICES 7 CBs ug/kg (continued)

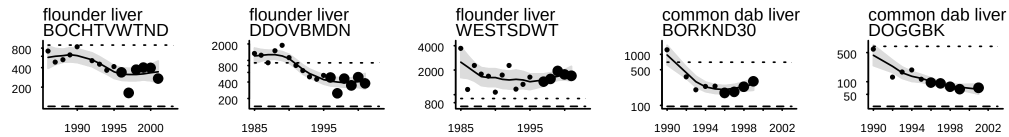
region II France



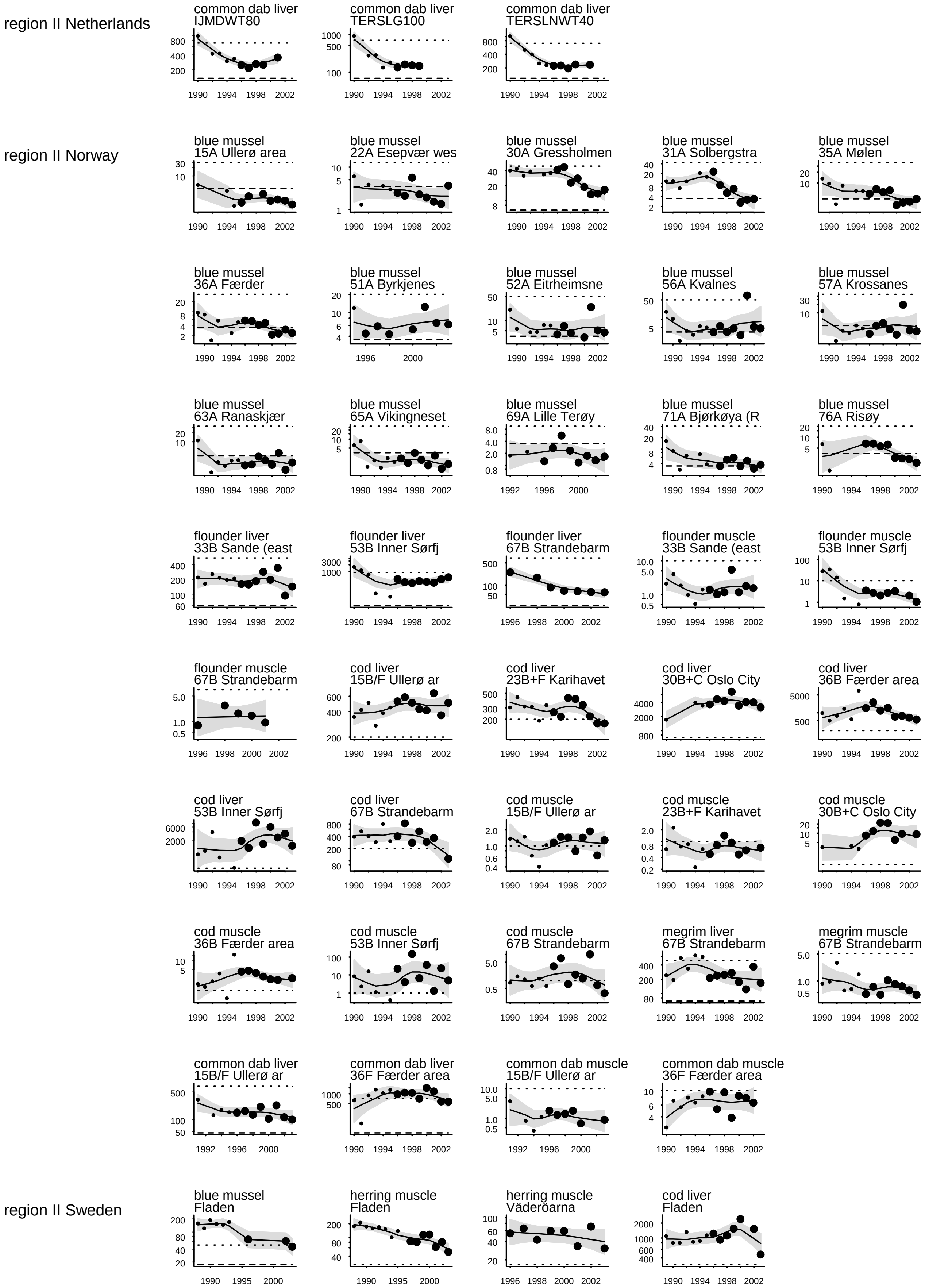
region II Germany



region II Netherlands



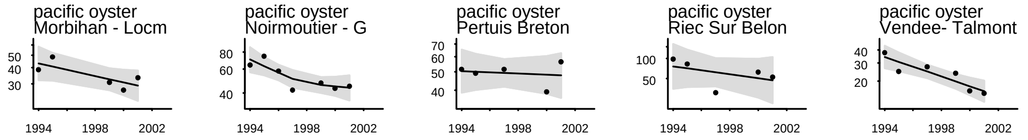
Sum of ICES 7 CBs ug/kg (continued)



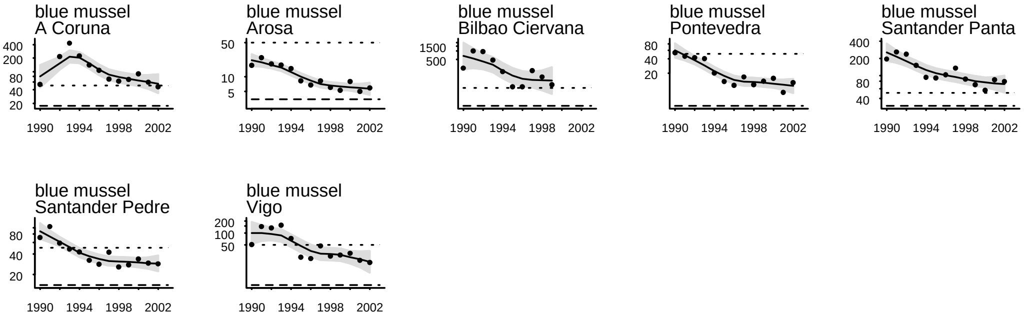
Sum of ICES 7 CBs ug/kg (continued)

Sum of ICES 7 CBs ug/kg (continued)

region IV France

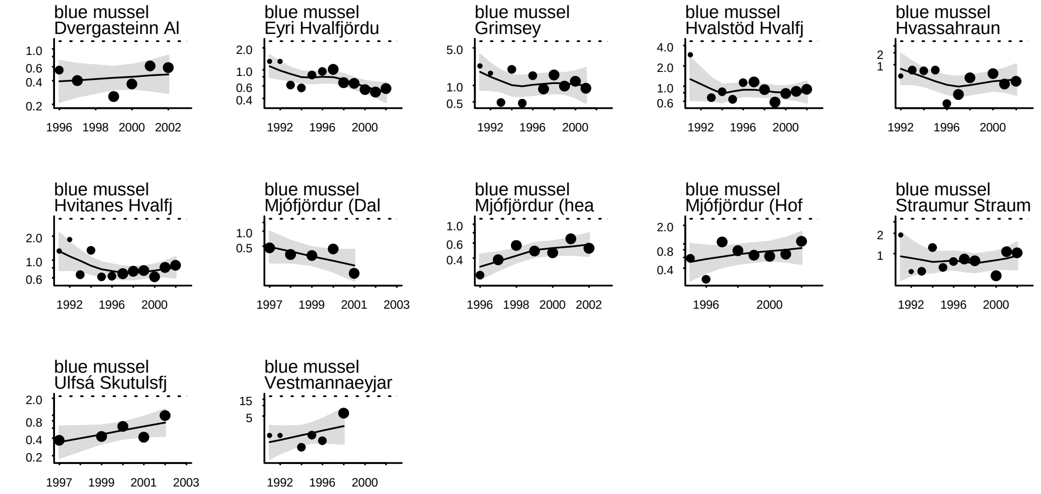


region IV Spain

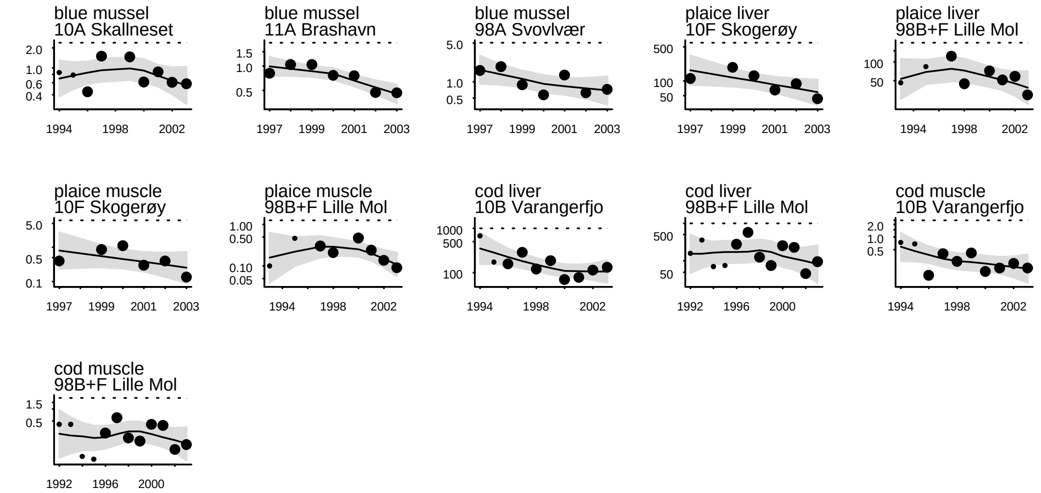


DDE (p,p') ug/kg

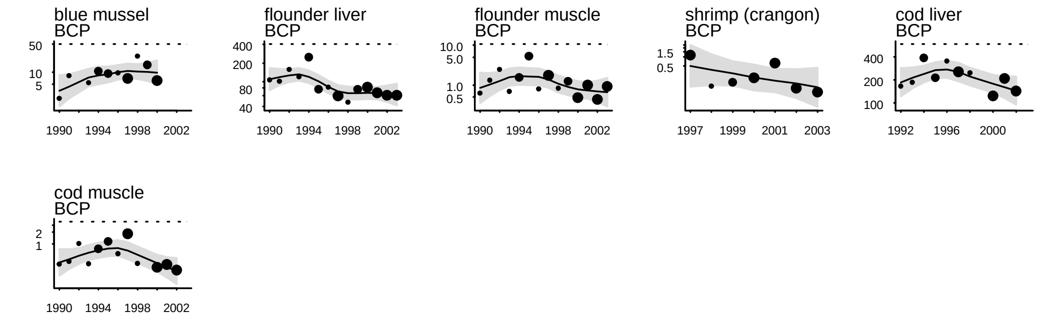
region I Iceland



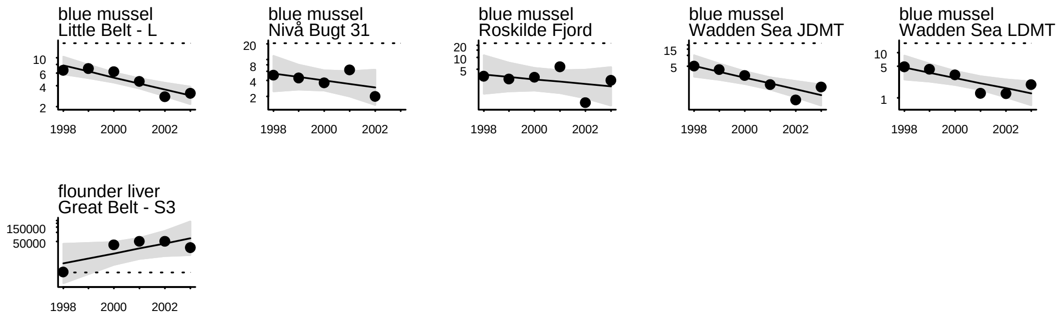
region I Norway



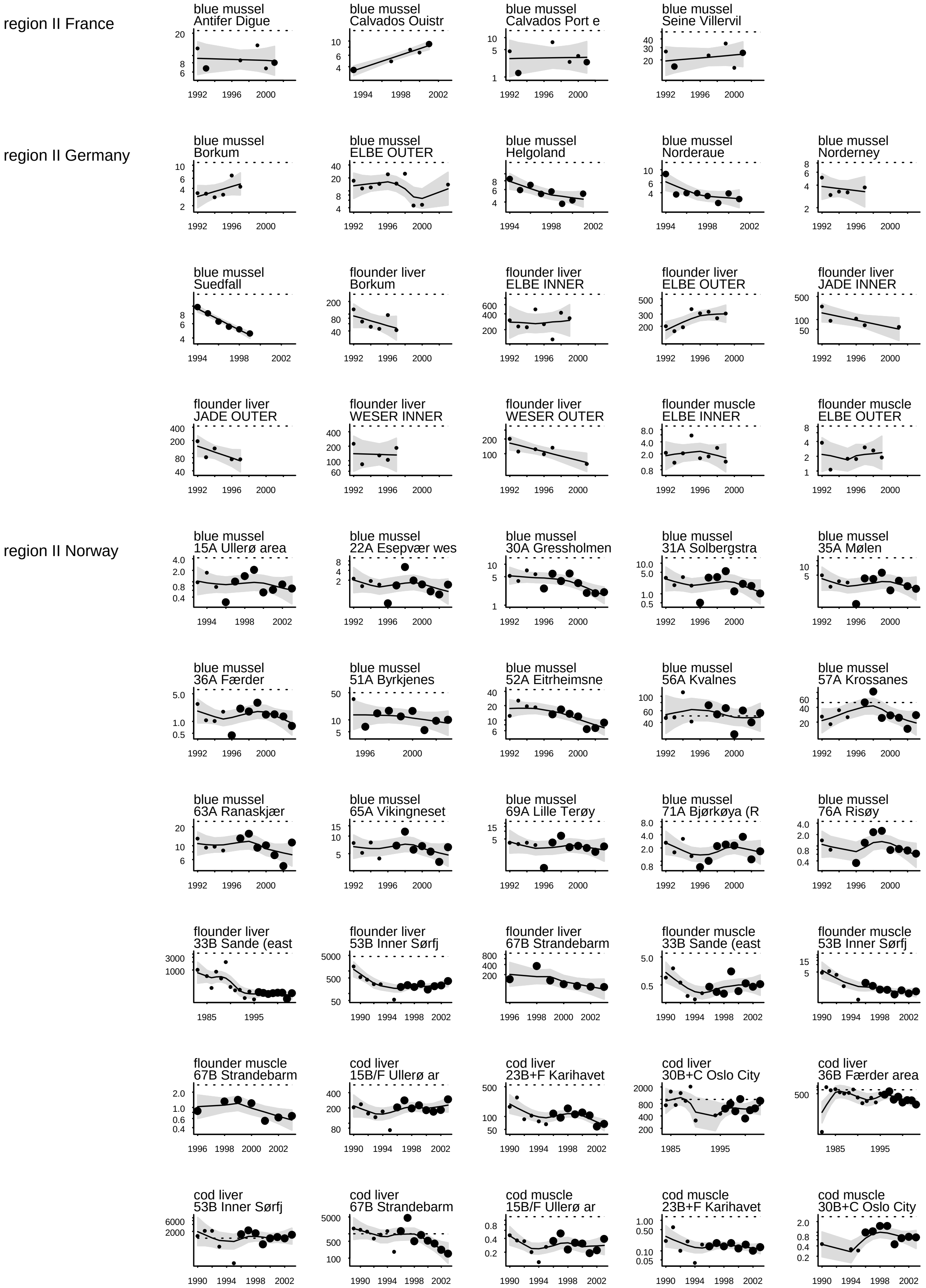
region II Belgium



region II Denmark

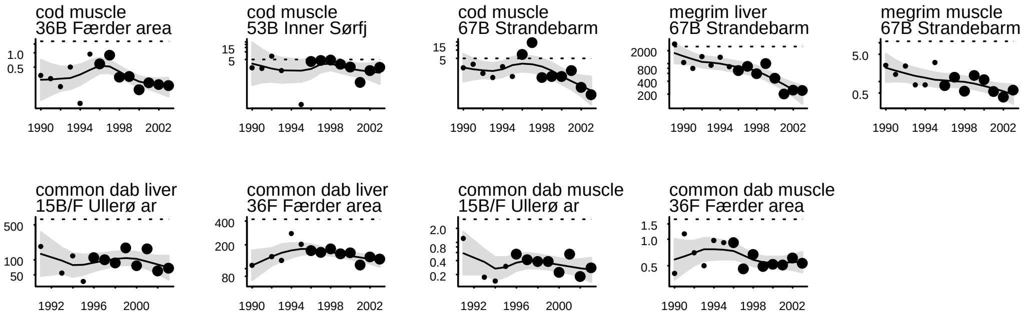


DDE (p,p') ug/kg (continued)

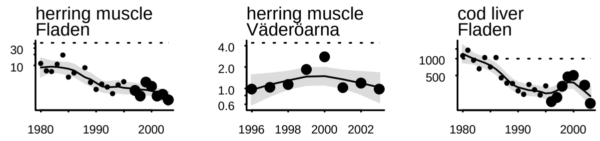


DDE (p,p') ug/kg (continued)

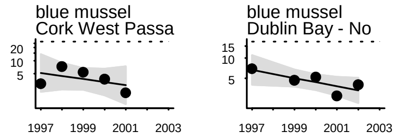
region II Norway



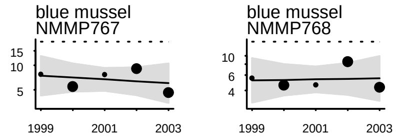
region II Sweden



region III Ireland



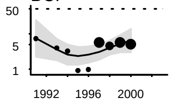
region III UK



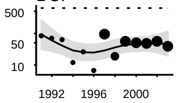
Dieldrin ug/kg

region II Belgium

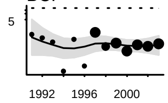
blue mussel
BCP



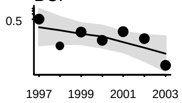
flounder liver
BCP



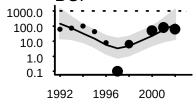
flounder muscle
BCP



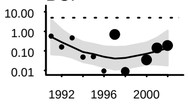
shrimp (crangon)
BCP



cod liver
BCP

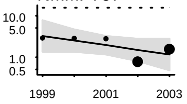


cod muscle
BCP



region III UK

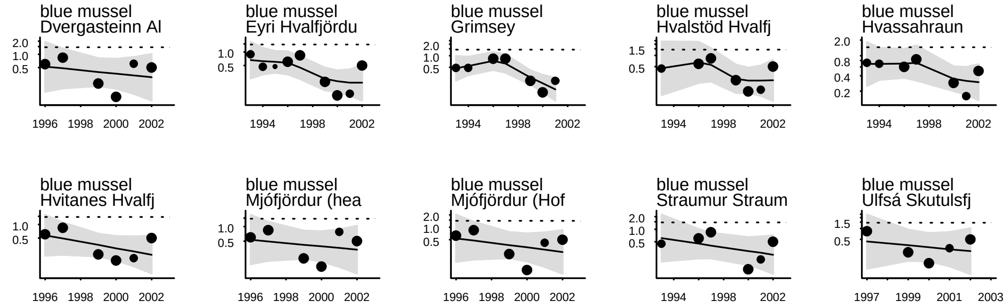
blue mussel
NMMP767



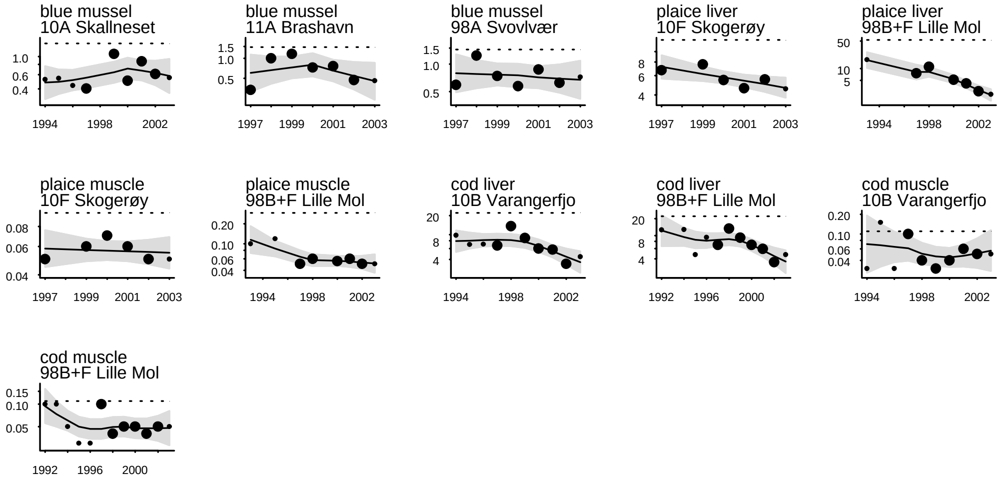
blue mussel
NMMP768

gamma HCH ug/kg

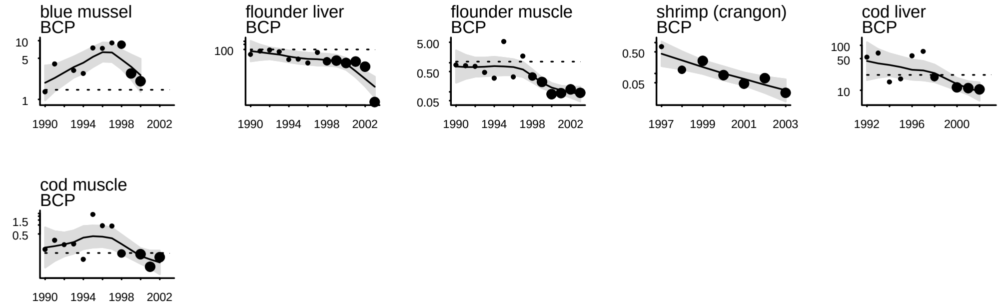
region I Iceland



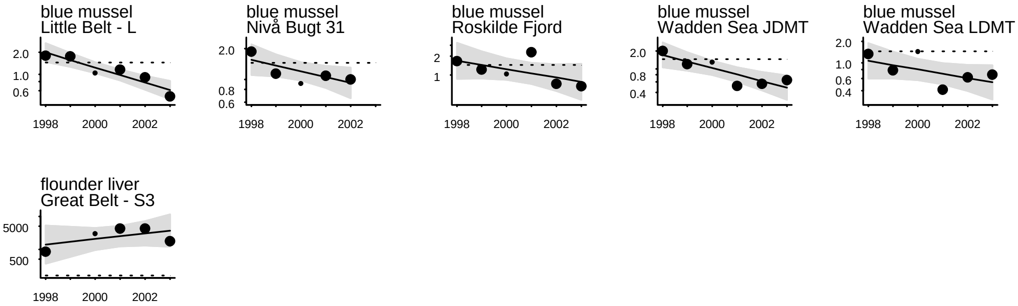
region I Norway



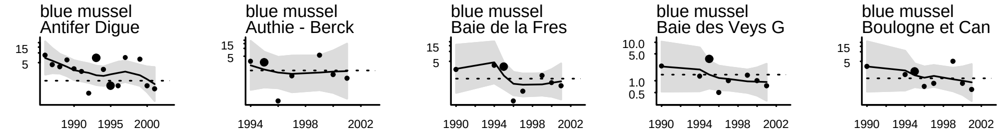
region II Belgium



region II Denmark

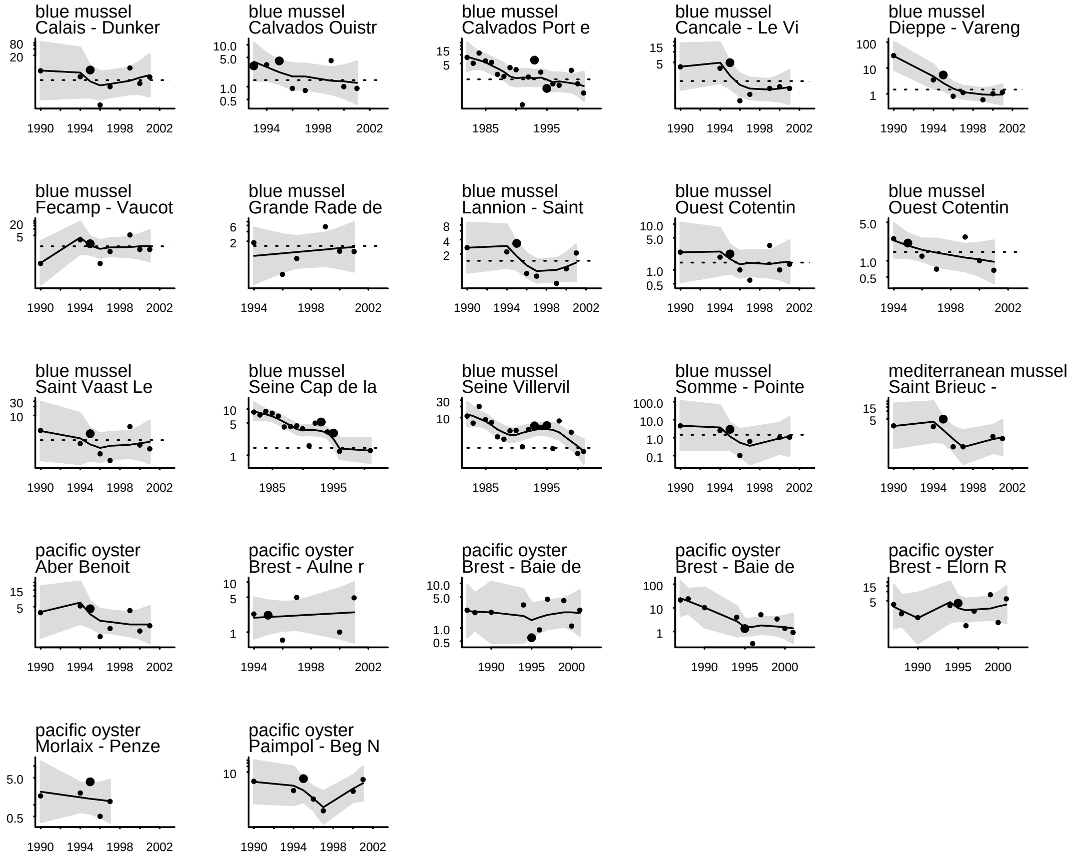


region II France

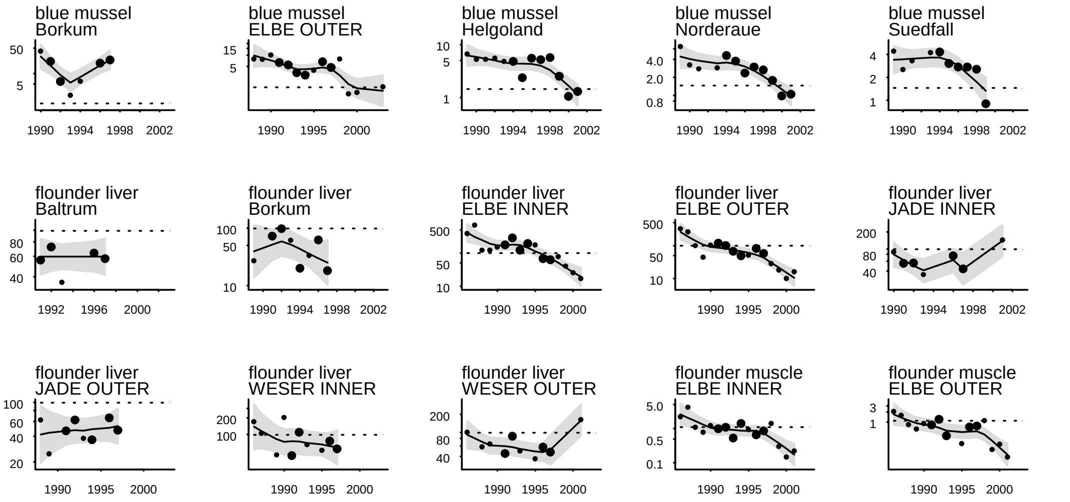


gamma HCH ug/kg (continued)

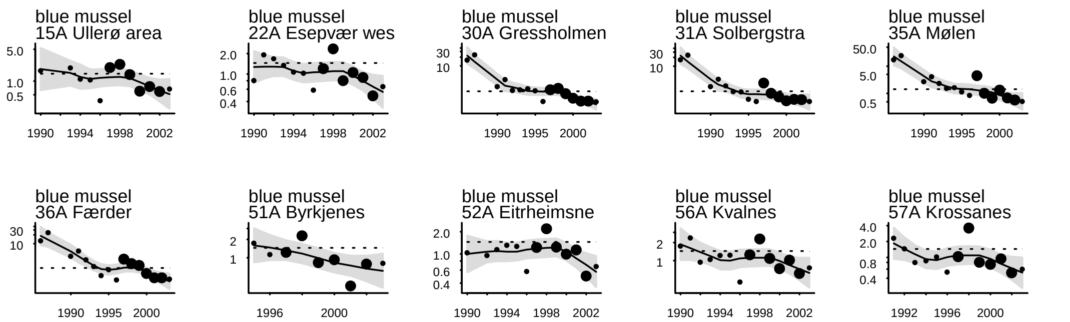
region II France



region II Germany

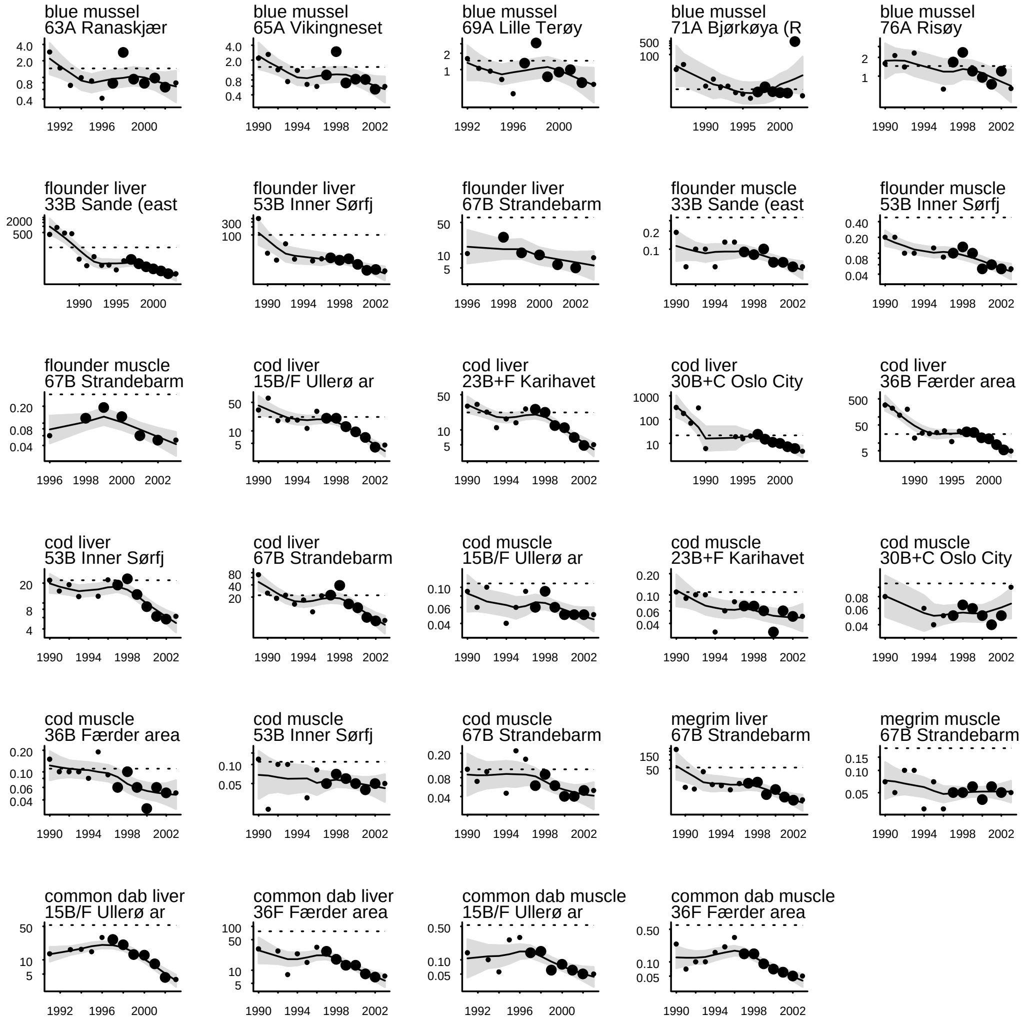


region II Norway

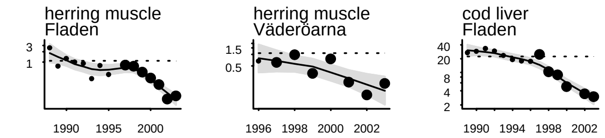


gamma HCH ug/kg (continued)

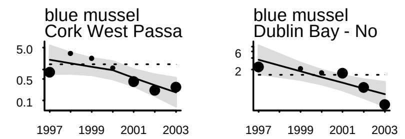
region II Norway



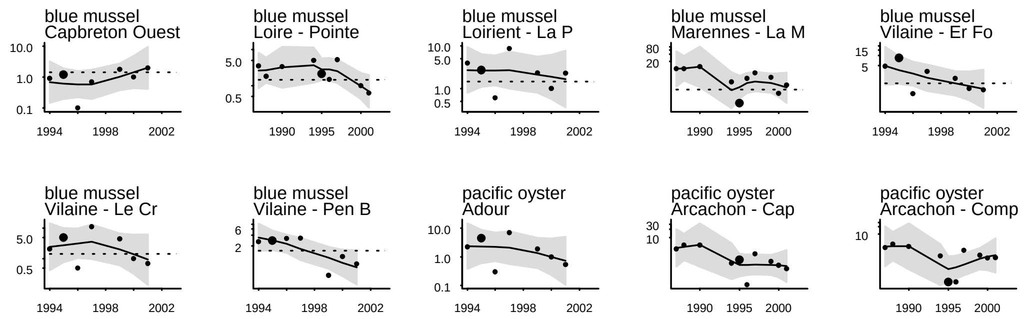
region II Sweden



region III Ireland

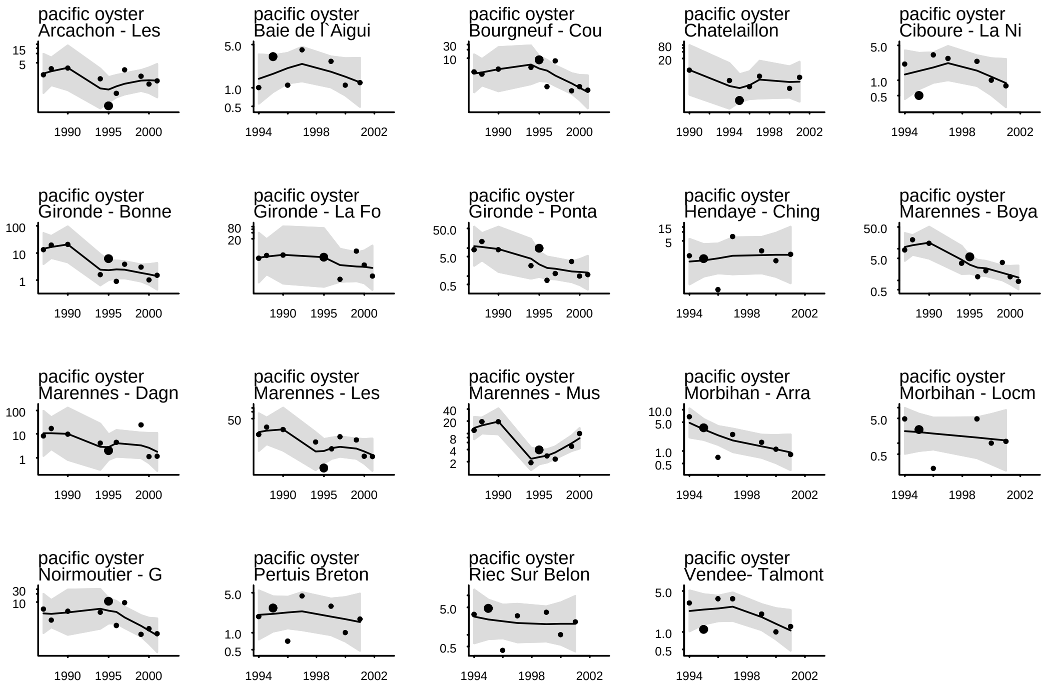


region IV France



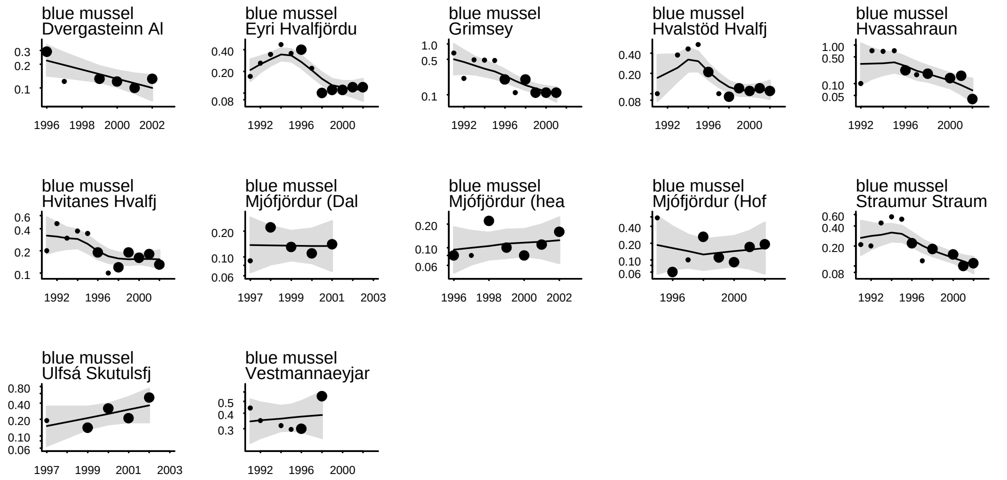
gamma HCH ug/kg (continued)

region IV France

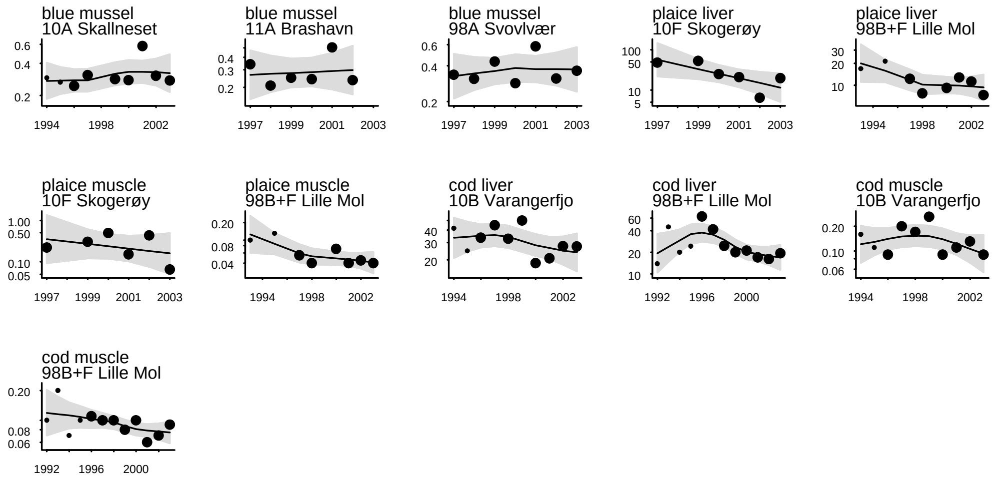


Hexachlorobenzene ug/kg

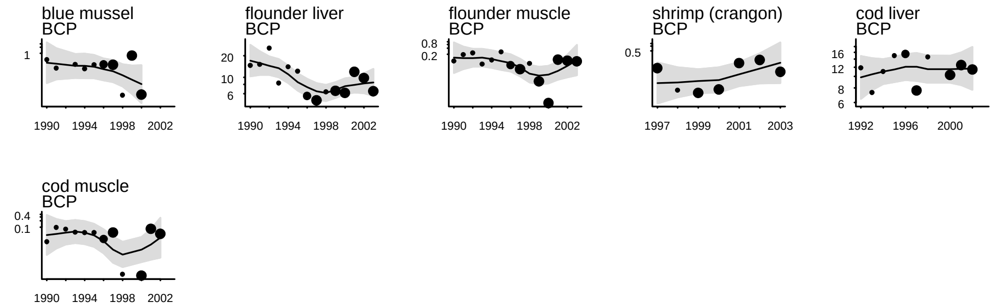
region I Iceland



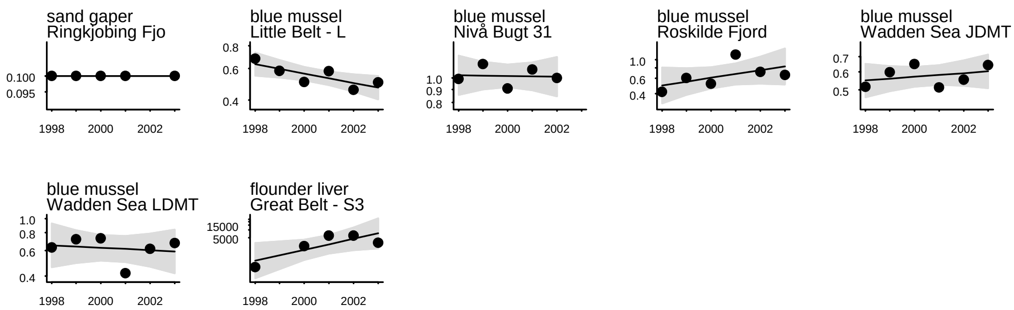
region I Norway



region II Belgium

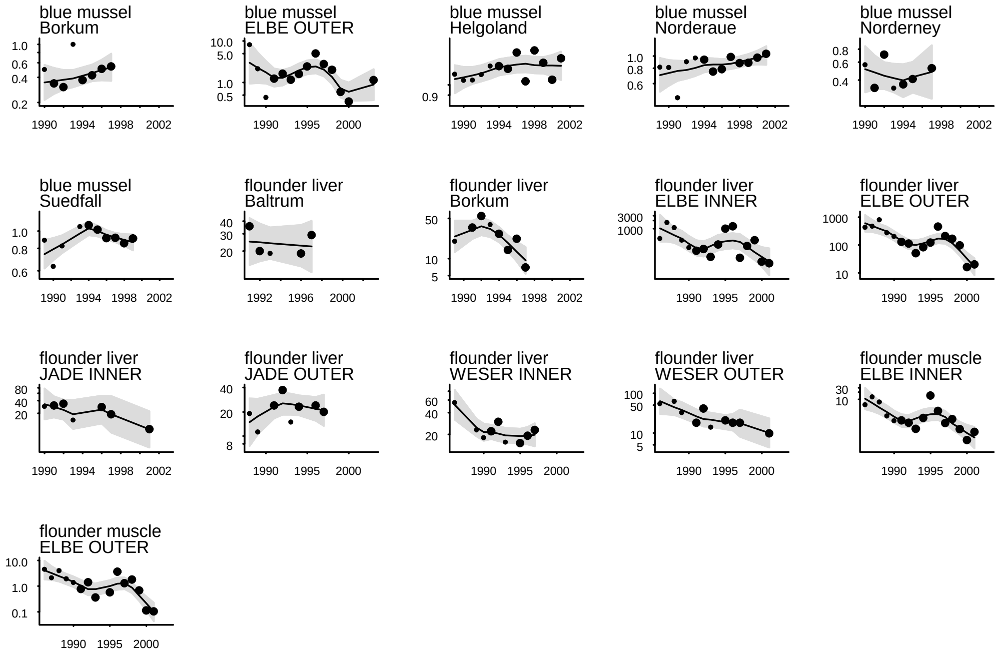


region II Denmark

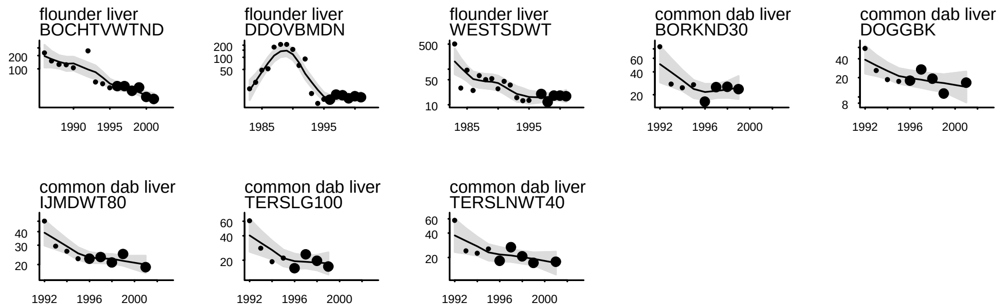


Hexachlorobenzene ug/kg (continued)

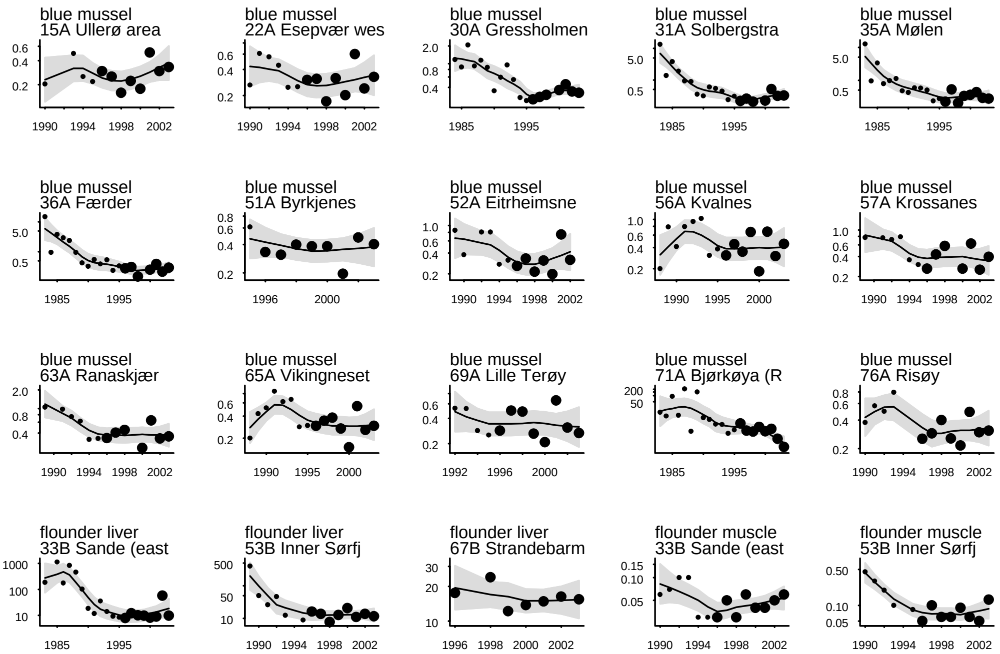
region II Germany



region II Netherlands

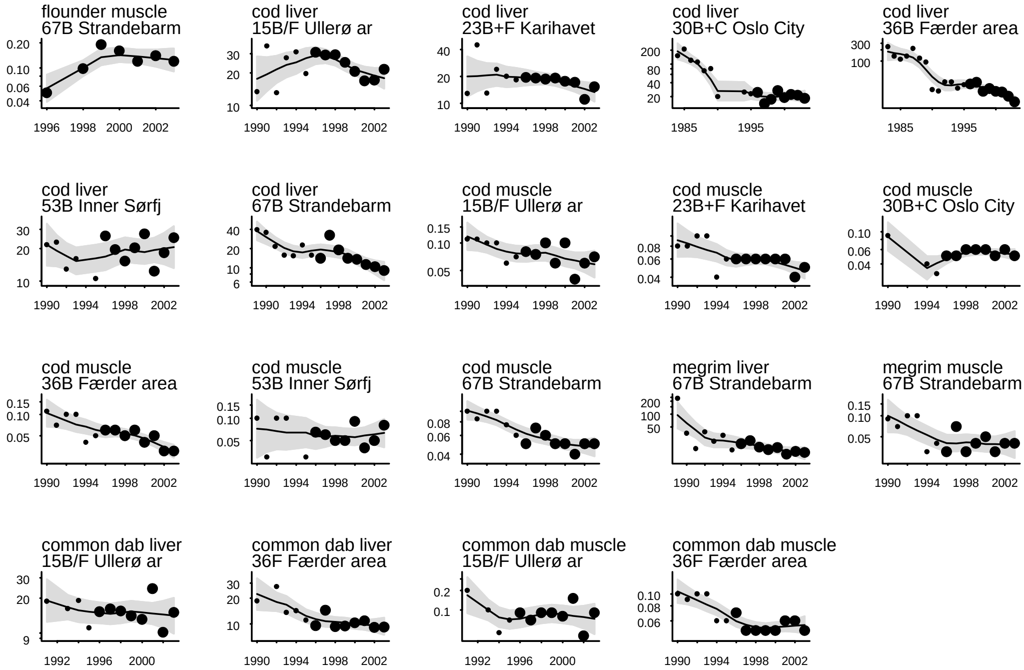


region II Norway

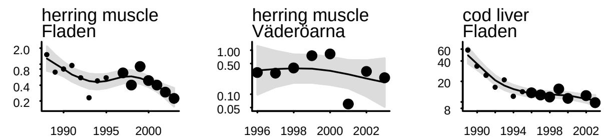


Hexachlorobenzene ug/kg (continued)

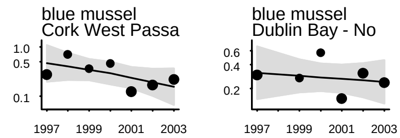
region II Norway



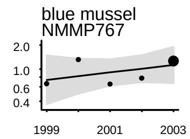
region II Sweden



region III Ireland



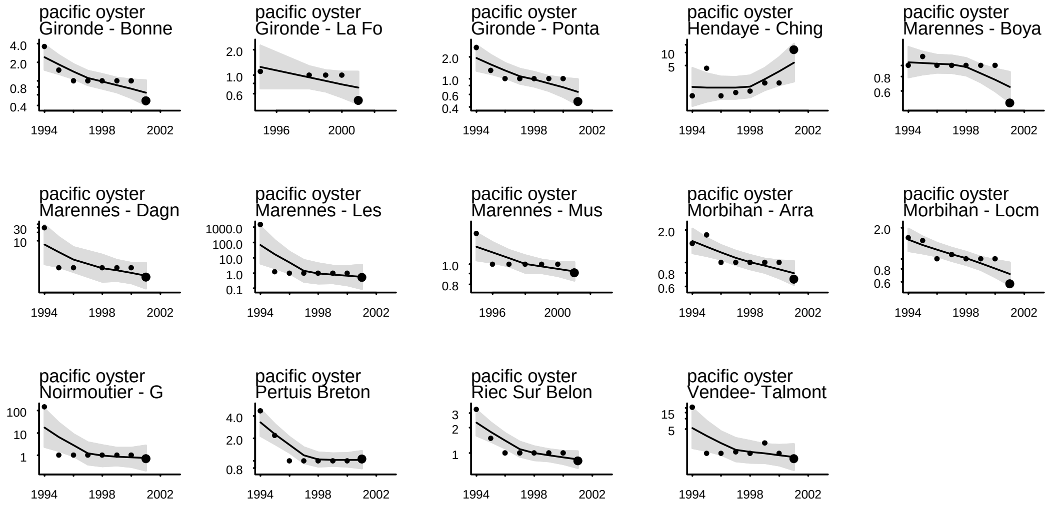
region III UK



Anthracene ug/kg

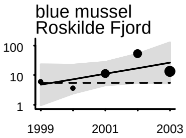
Anthracene ug/kg (continued)

region IV France

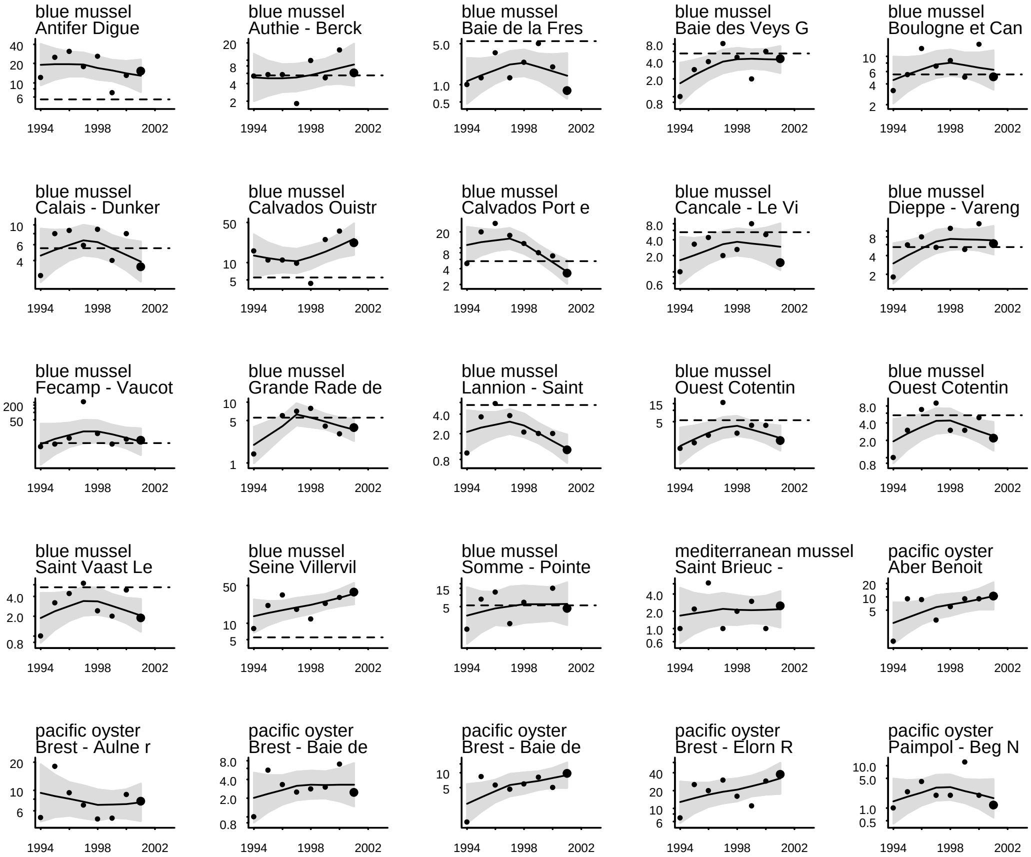


Benzo[a]anthracene ug/kg

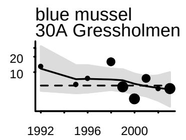
region II Denmark



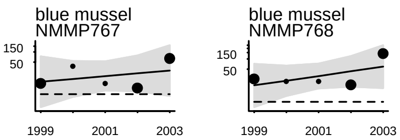
region II France



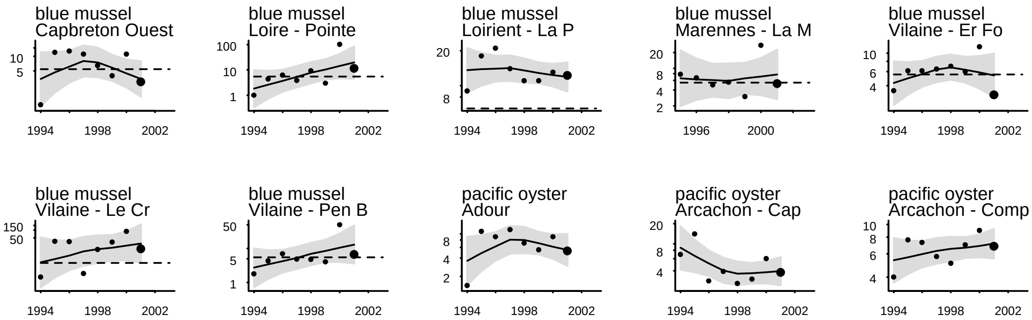
region II Norway



region III UK

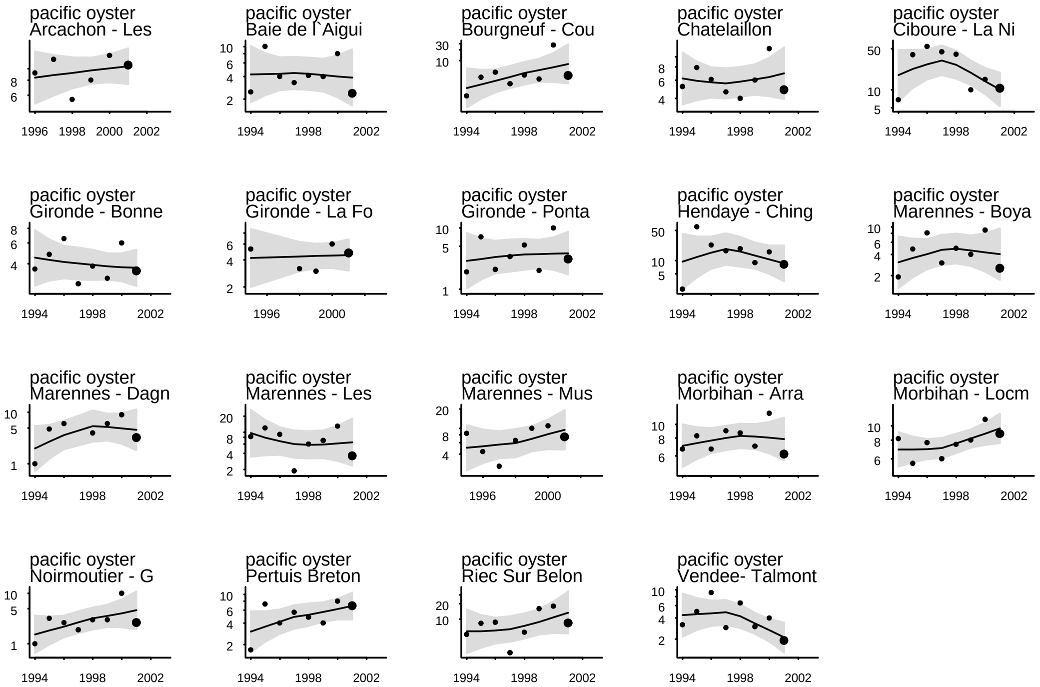


region IV France

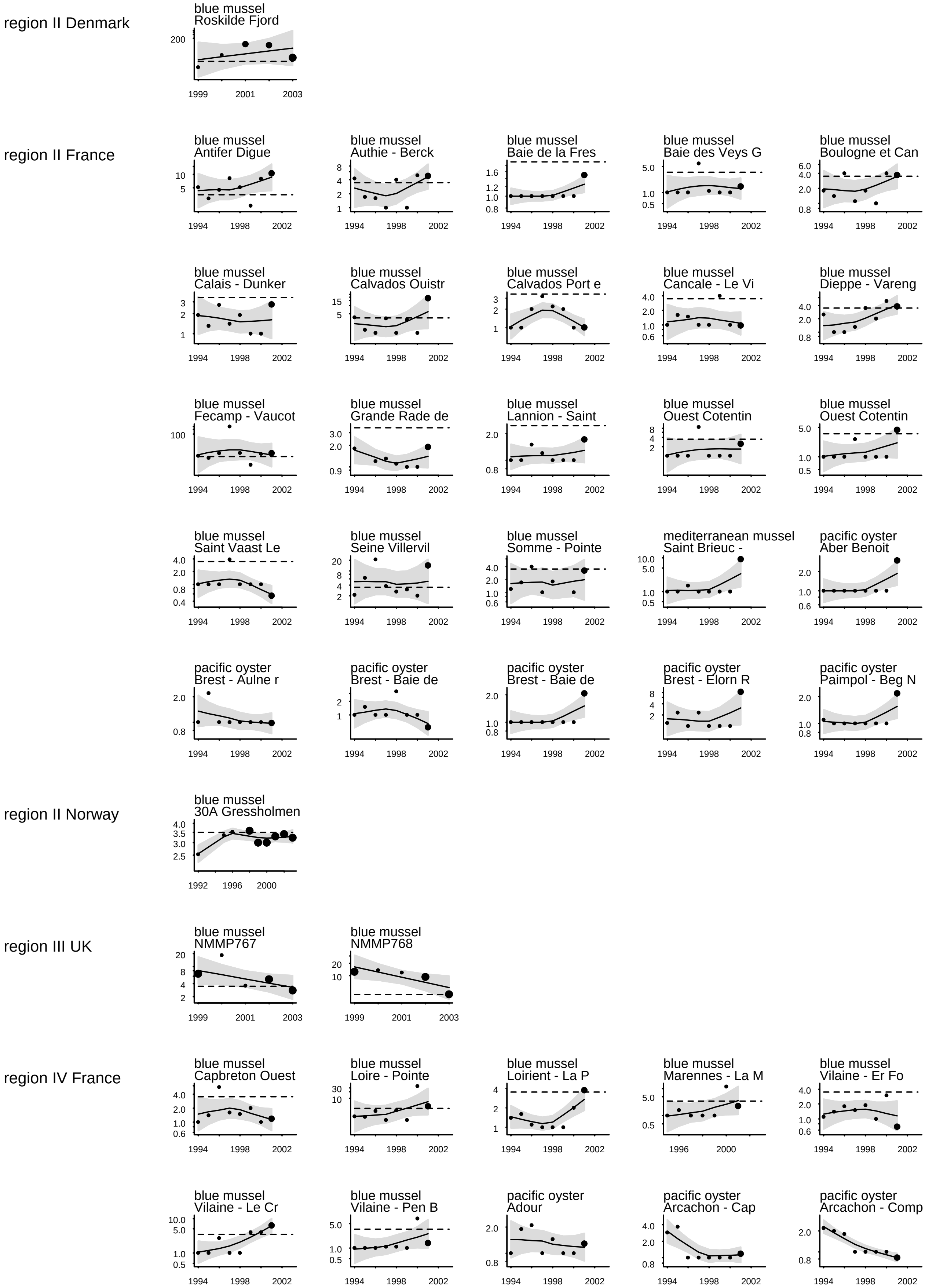


Benzo[a]anthracene ug/kg (continued)

region IV France

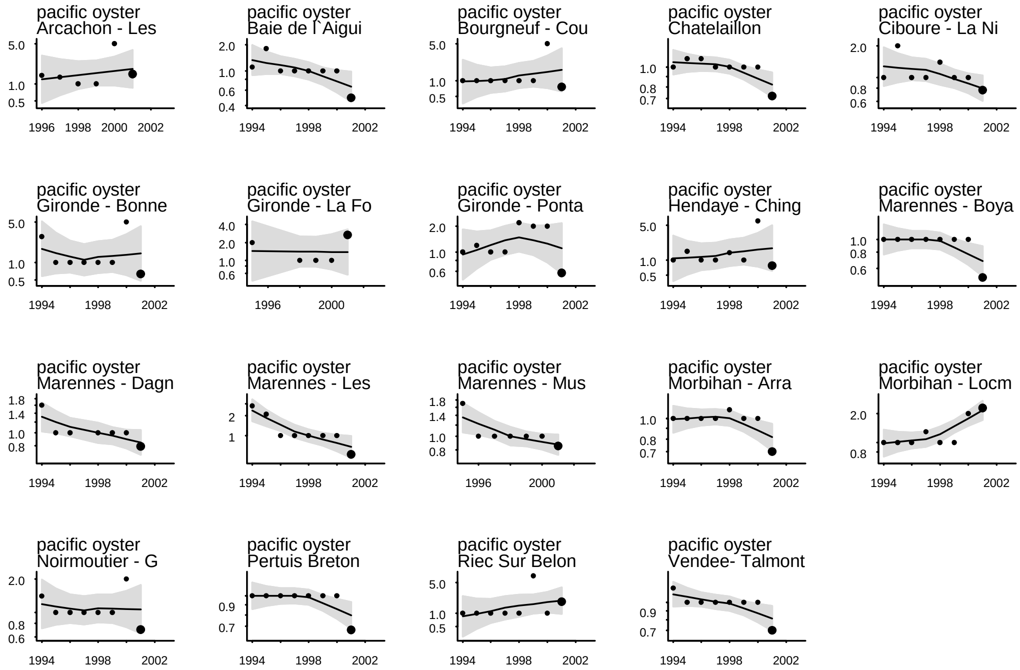


Benzo[a]pyrene ug/kg



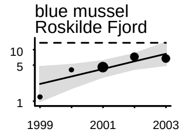
Benzo[a]pyrene ug/kg (continued)

region IV France

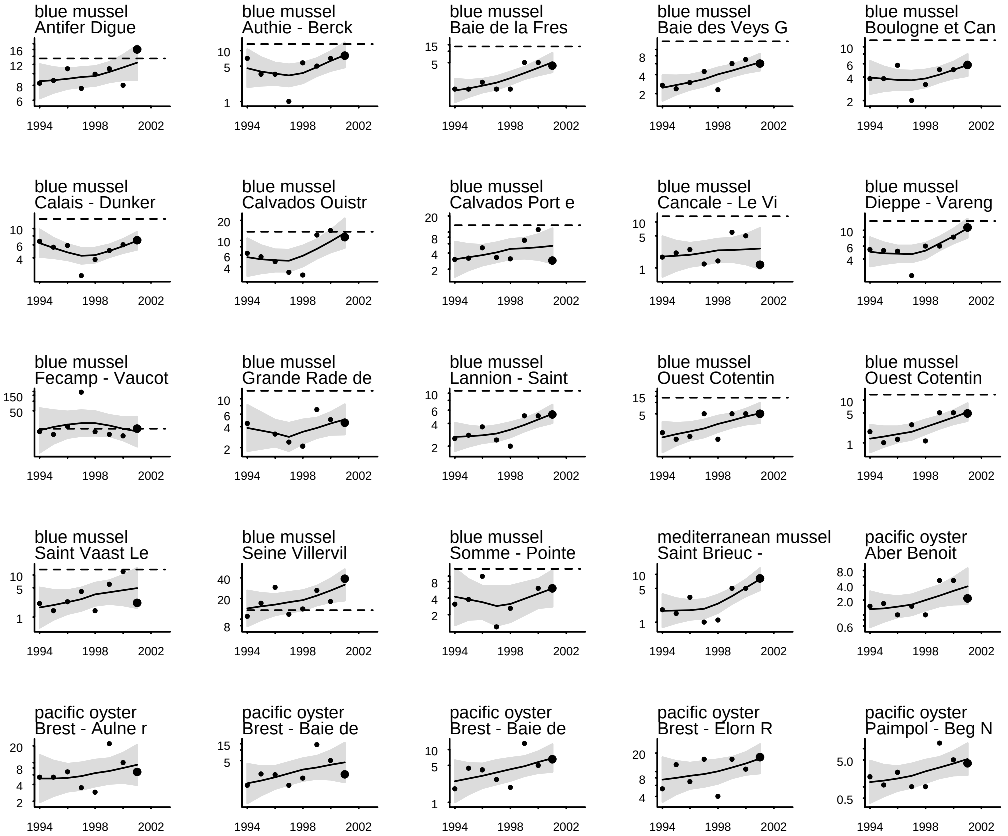


Benzo[ghi]perylene ug/kg

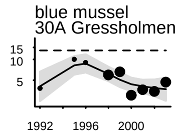
region II Denmark



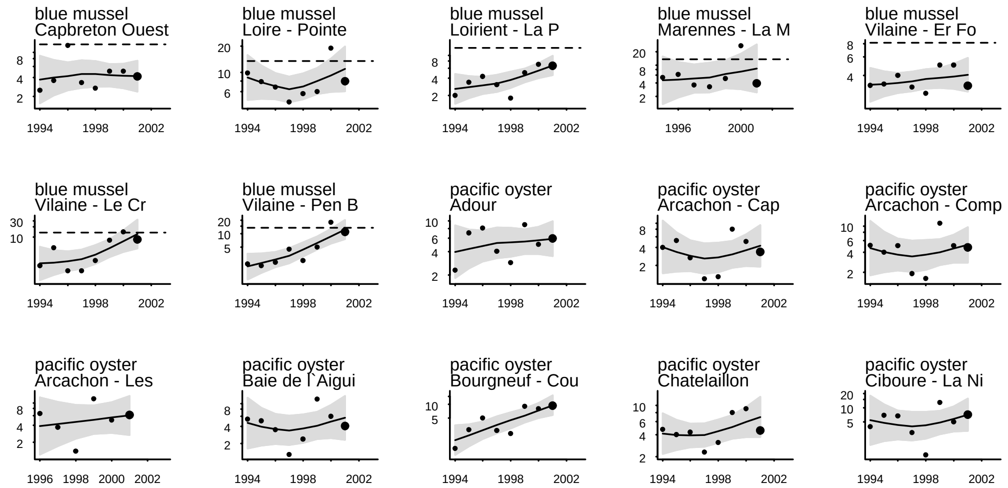
region II France



region II Norway

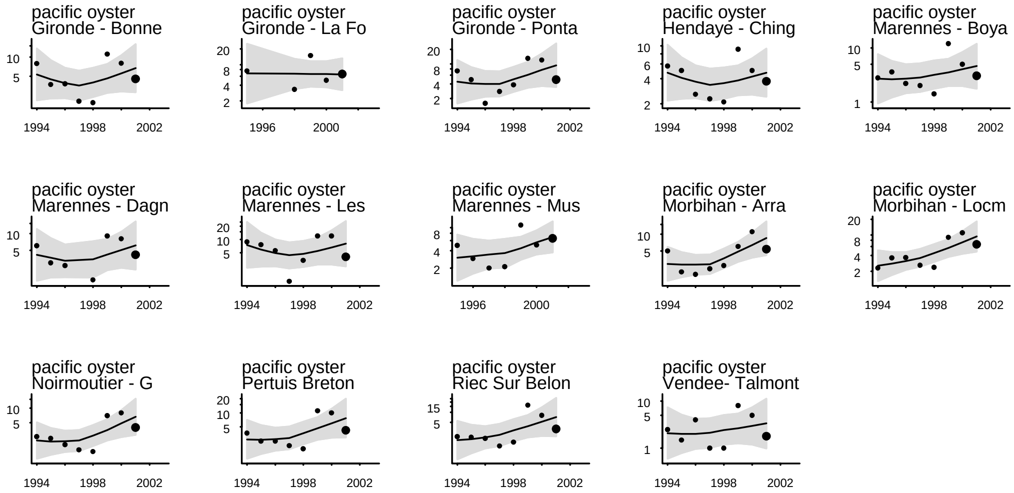


region IV France



Benzo[ghi]perylene ug/kg (continued)

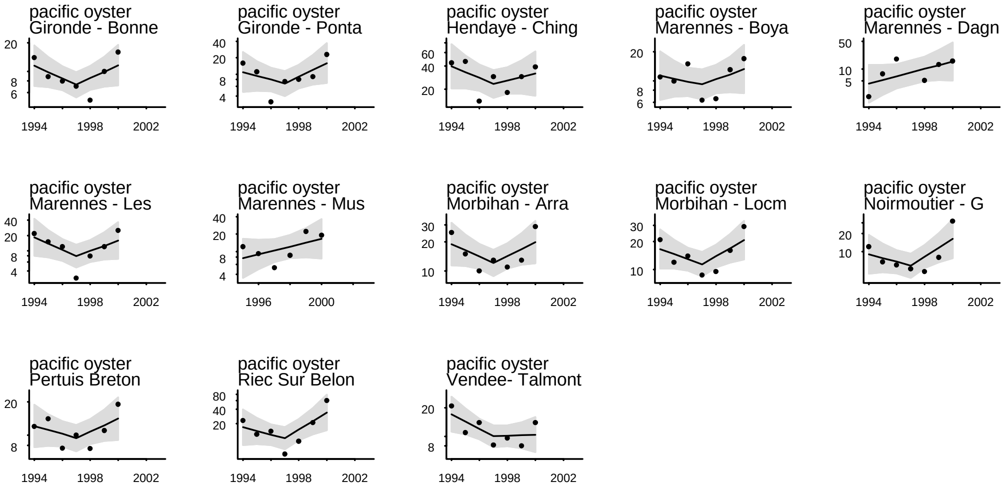
region IV France



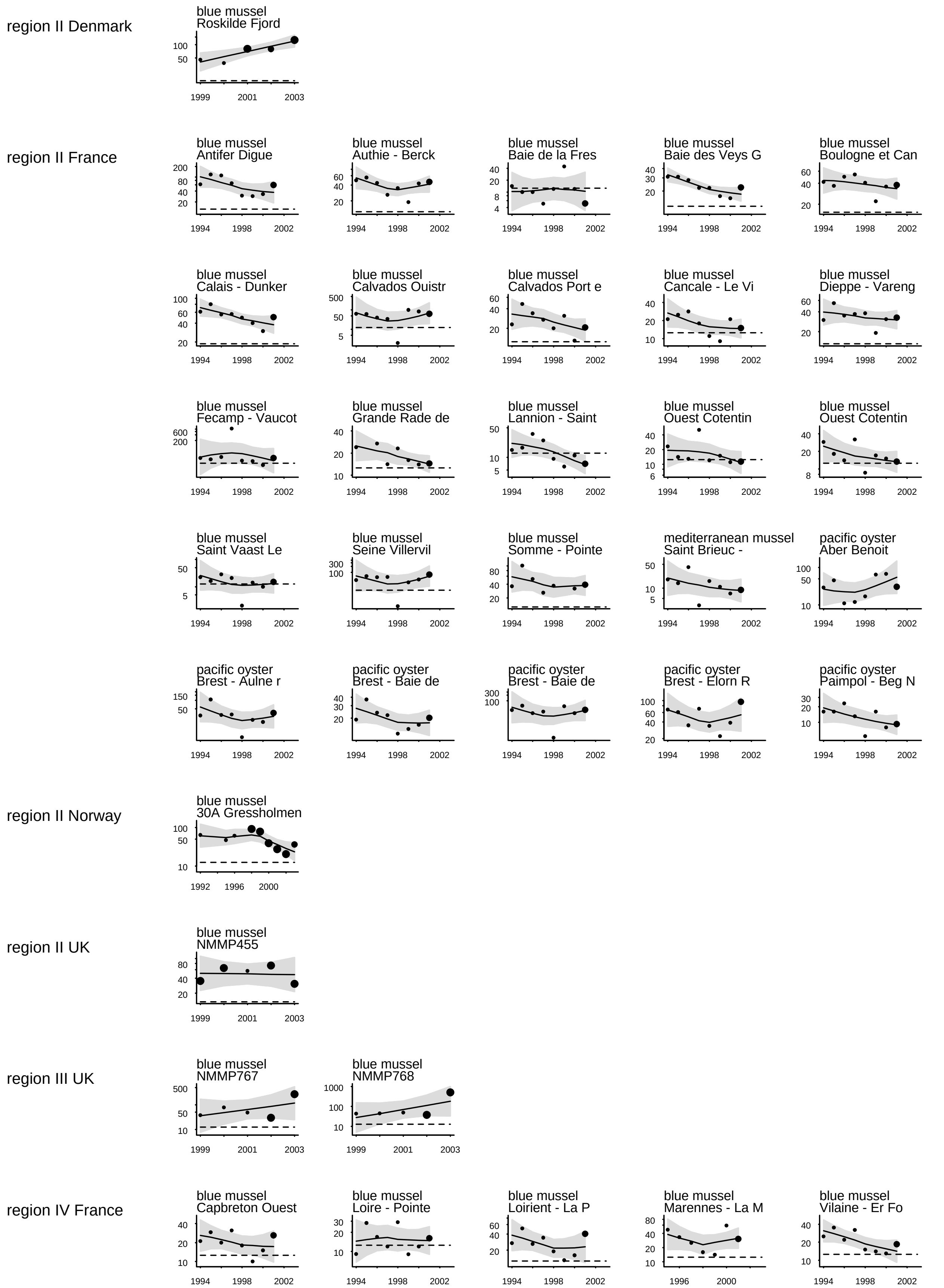
Chrysene ug/kg

Chrysene ug/kg (continued)

region IV France

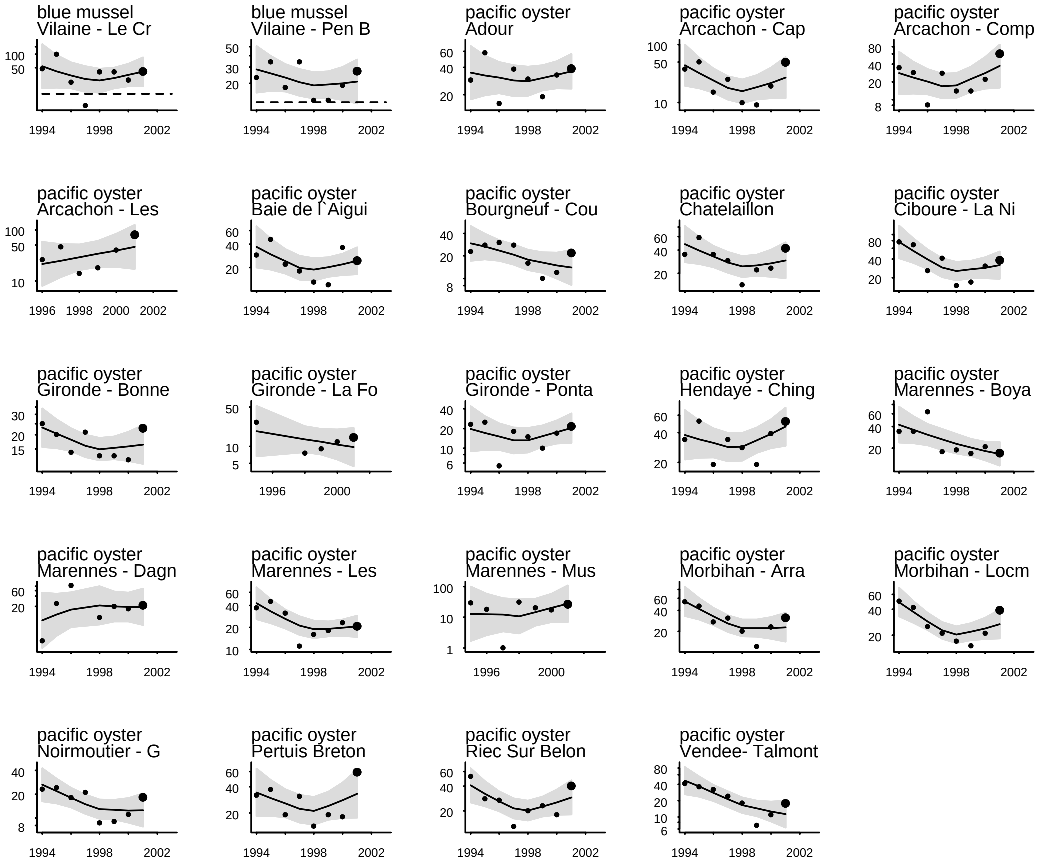


Fluoranthene ug/kg



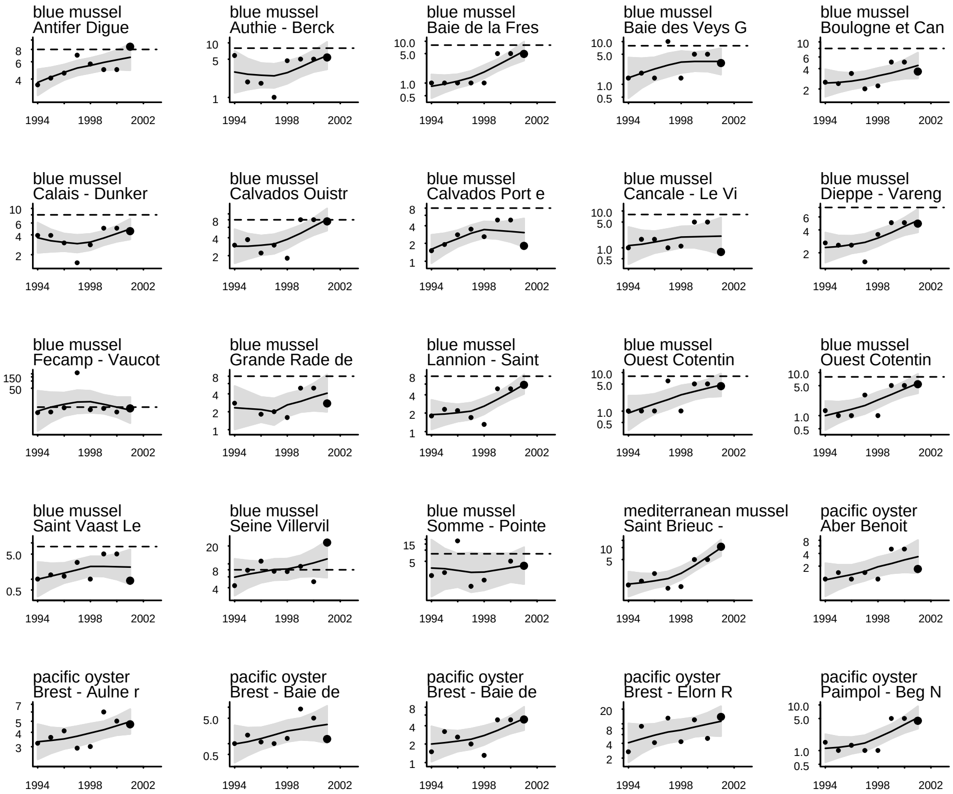
Fluoranthene ug/kg (continued)

region IV France

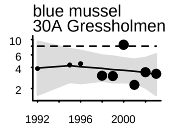


Indeno[123-cd]pyrene ug/kg

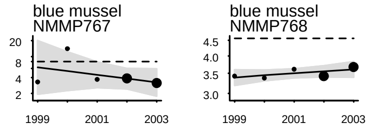
region II France



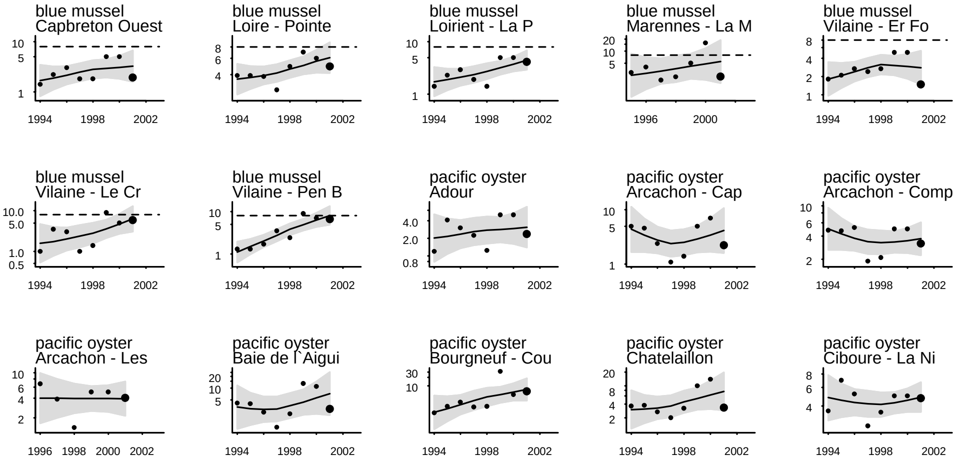
region II Norway



region III UK

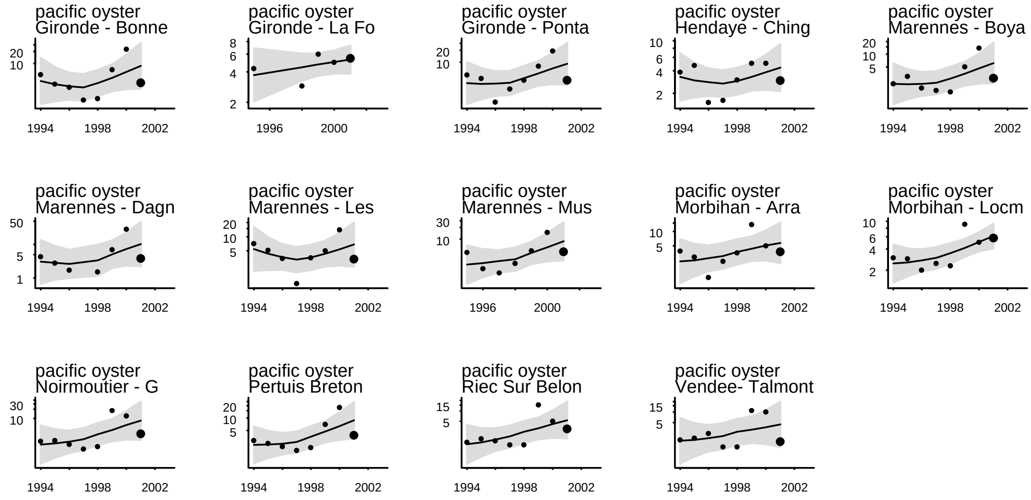


region IV France



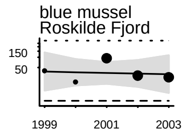
Indeno[123-cd]pyrene ug/kg (continued)

region IV France

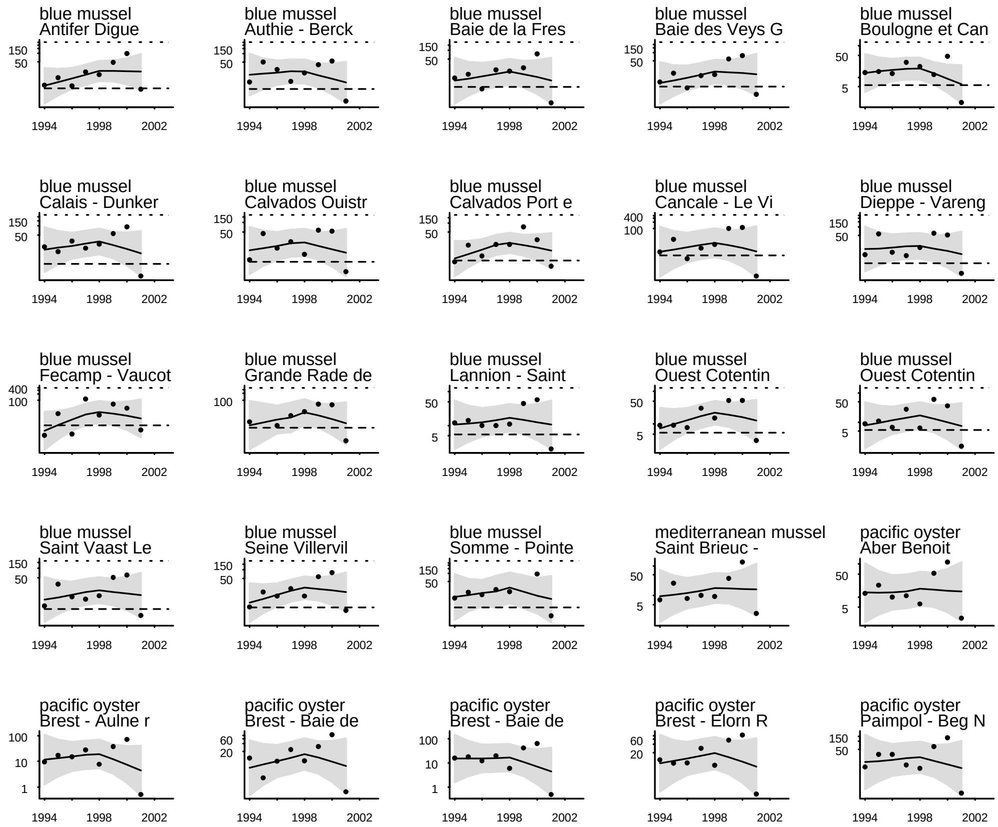


Naphthalene ug/kg

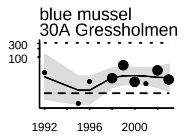
region II Denmark



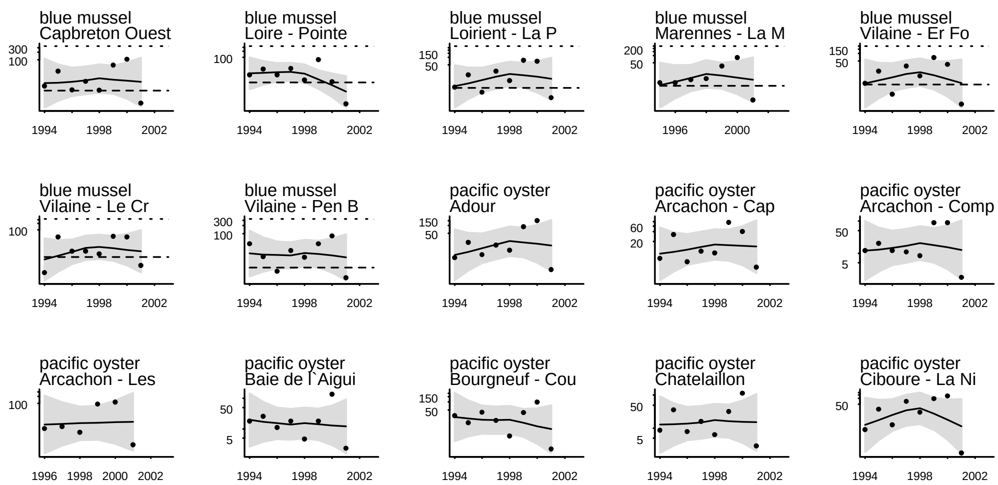
region II France



region II Norway

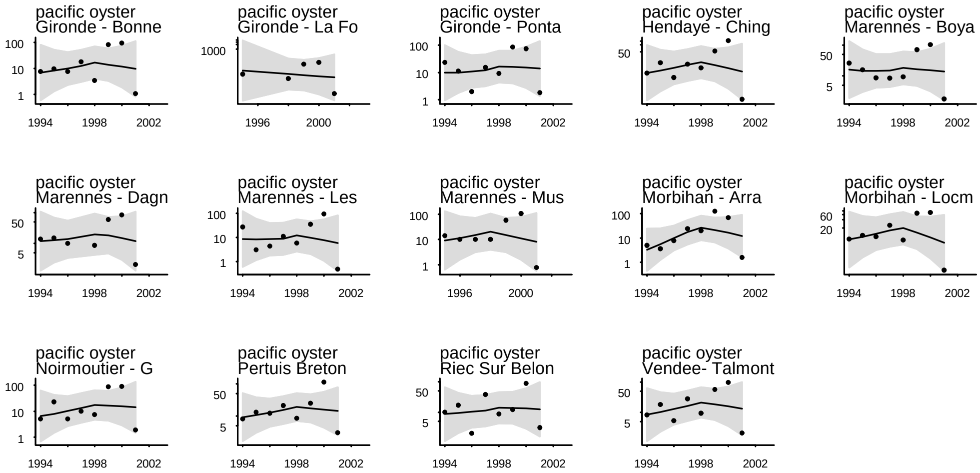


region IV France



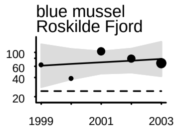
Naphthalene ug/kg (continued)

region IV France

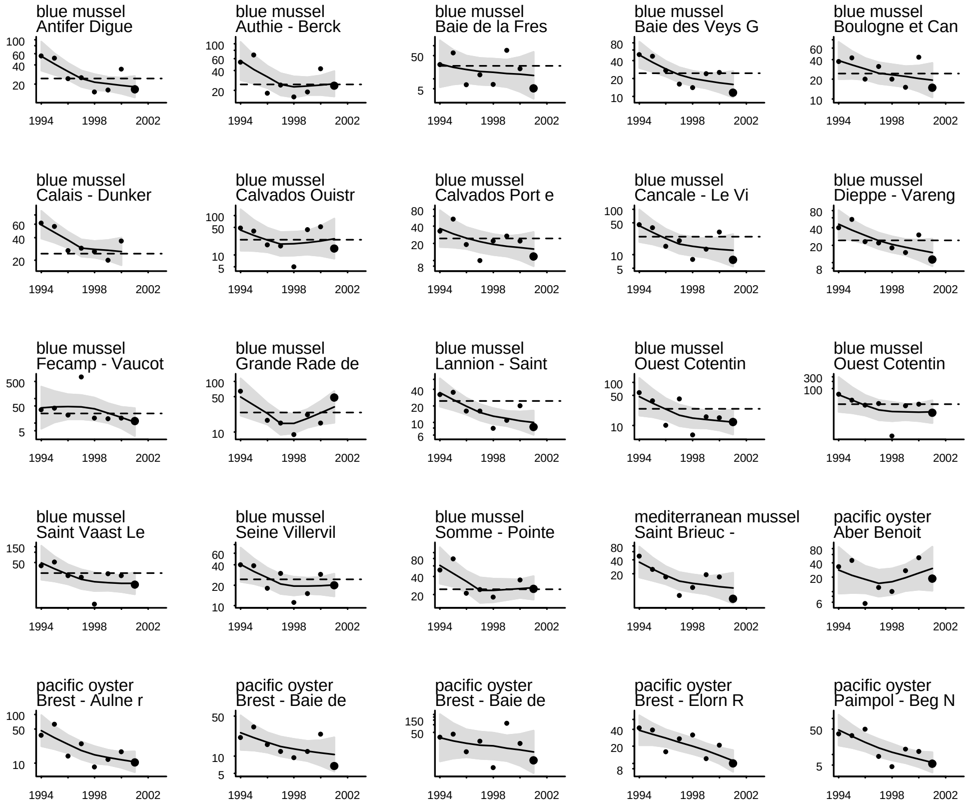


Phenanthrene ug/kg

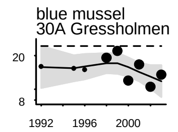
region II Denmark



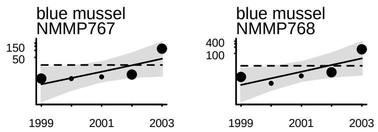
region II France



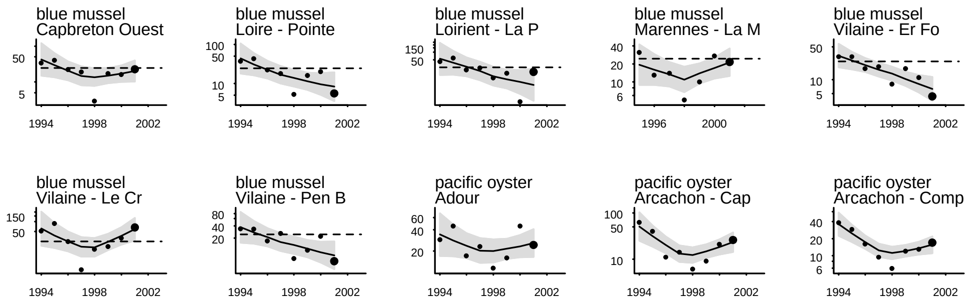
region II Norway



region III UK

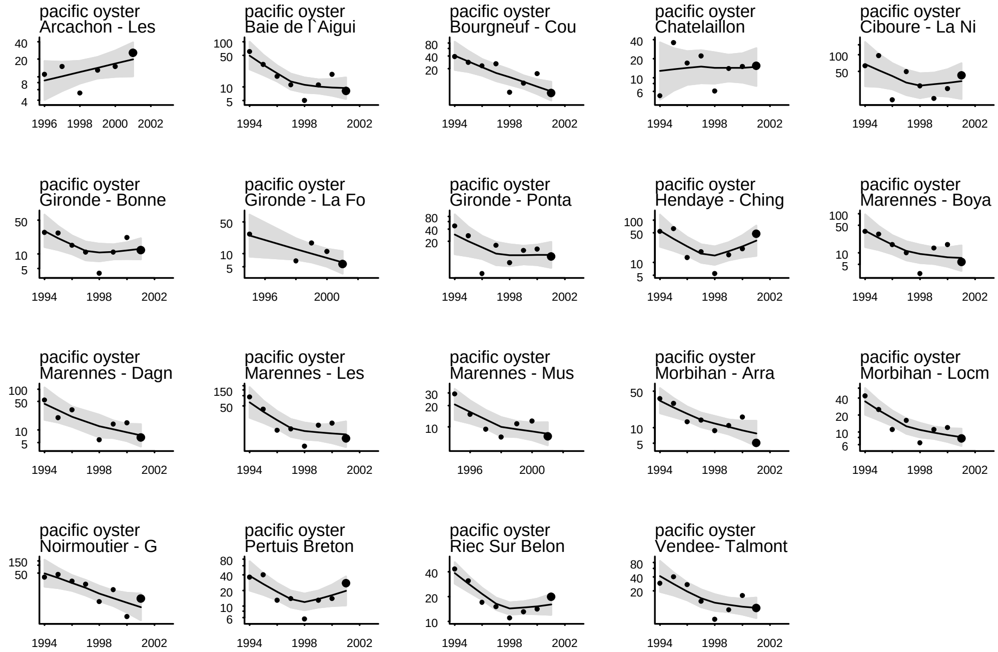


region IV France



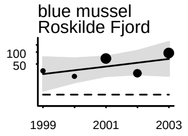
Phenanthrene ug/kg (continued)

region IV France

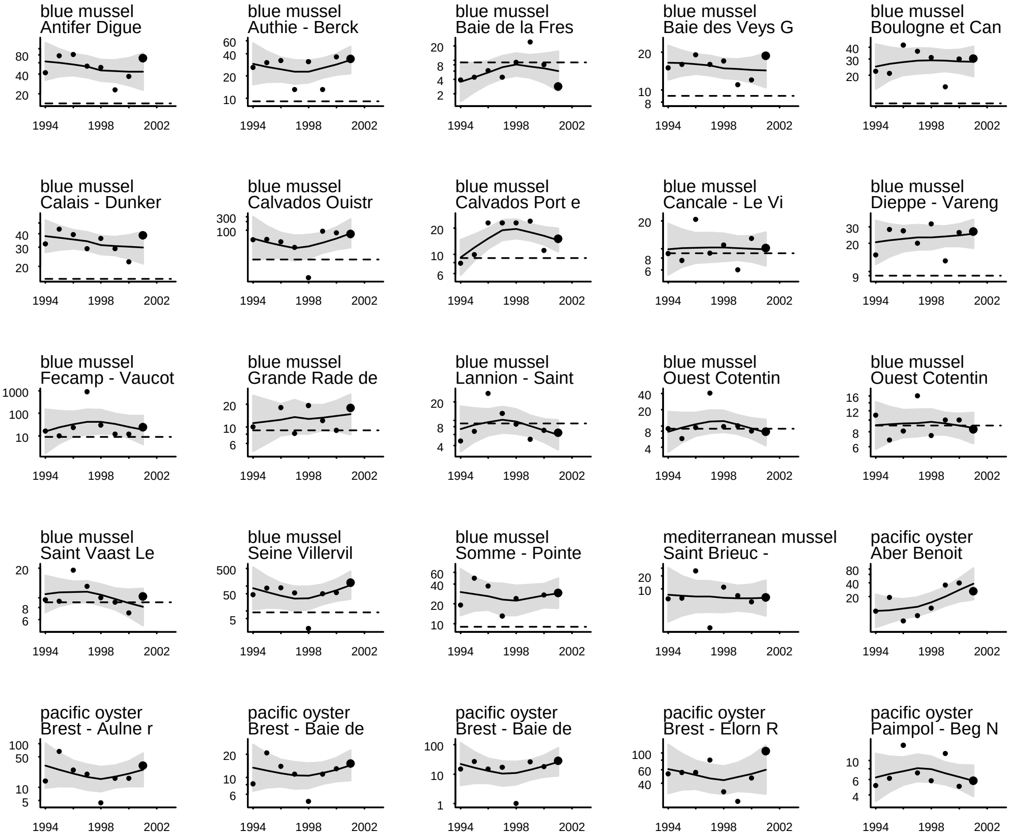


Pyrene ug/kg

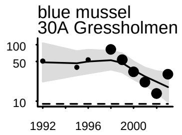
region II Denmark



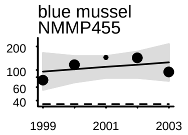
region II France



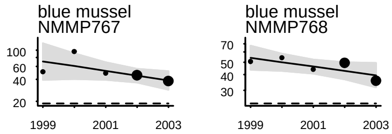
region II Norway



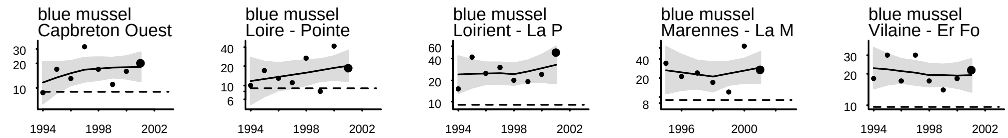
region II UK



region III UK

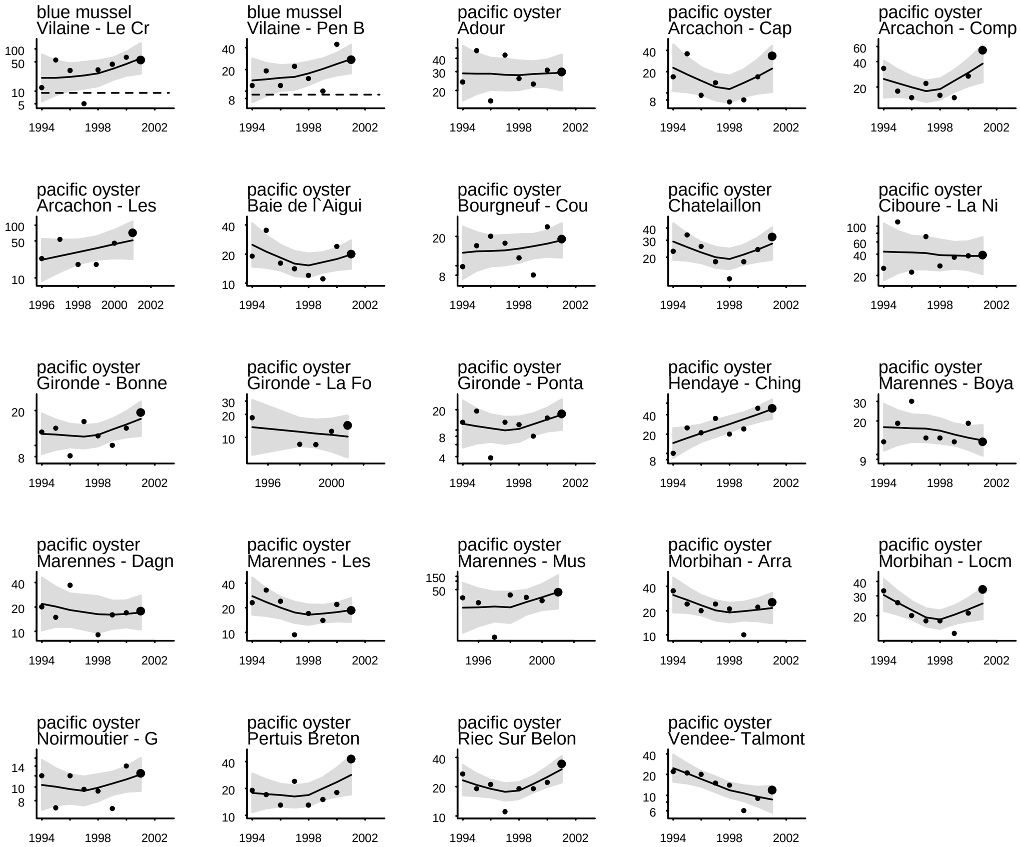


region IV France



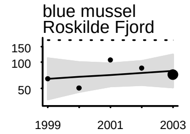
Pyrene ug/kg (continued)

region IV France

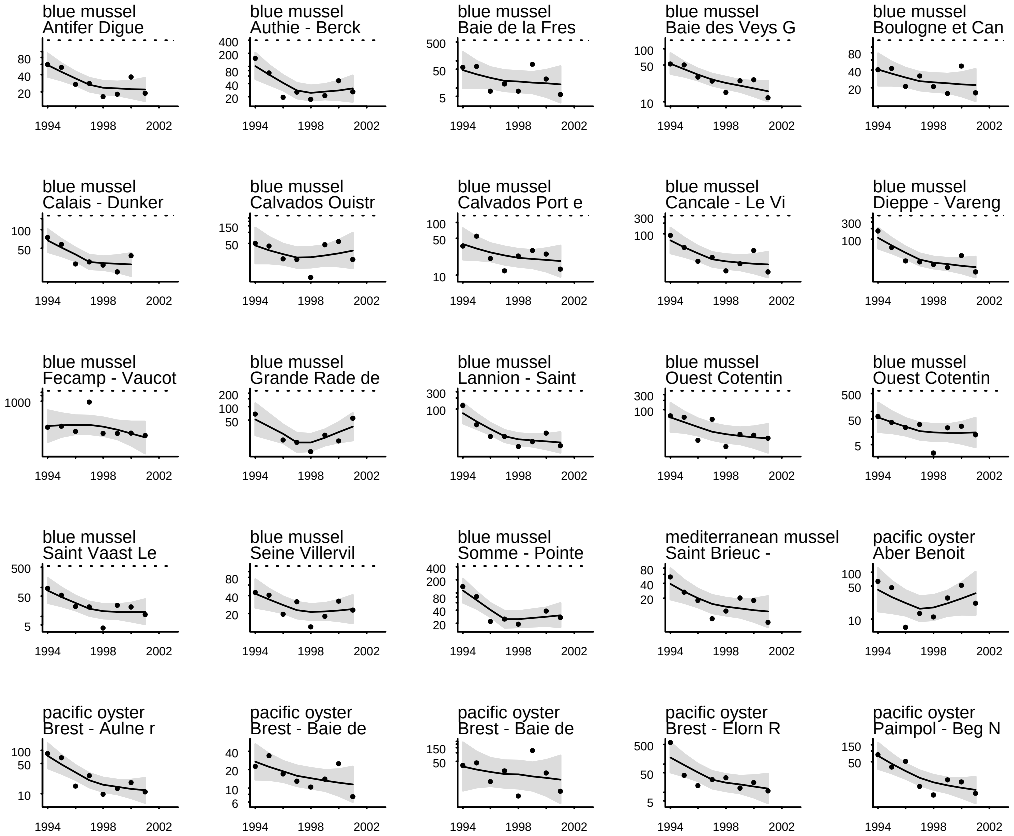


PAH 3 rings ug/kg

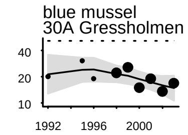
region II Denmark



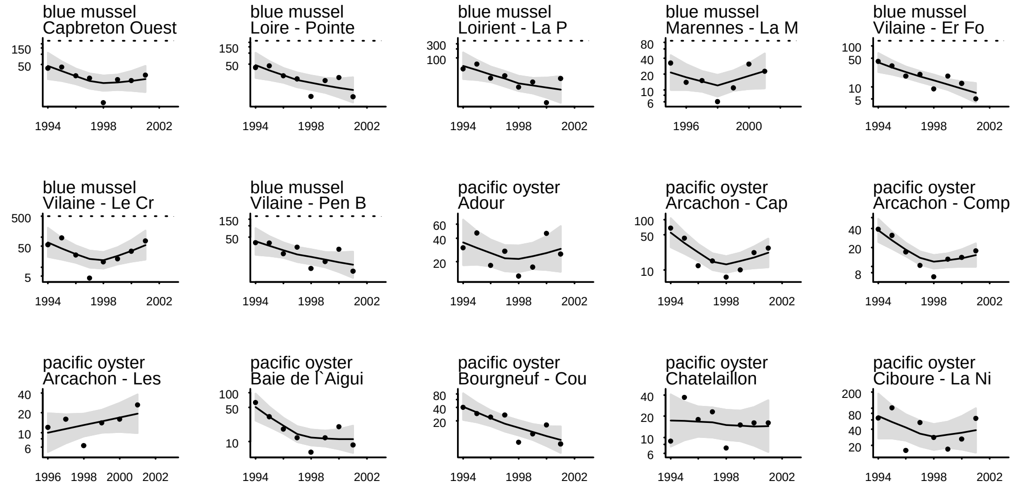
region II France



region II Norway

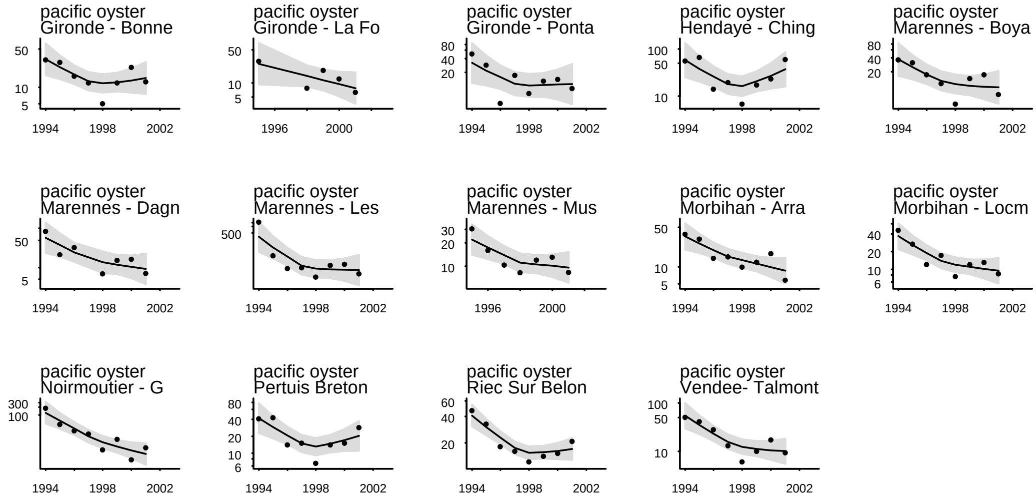


region IV France



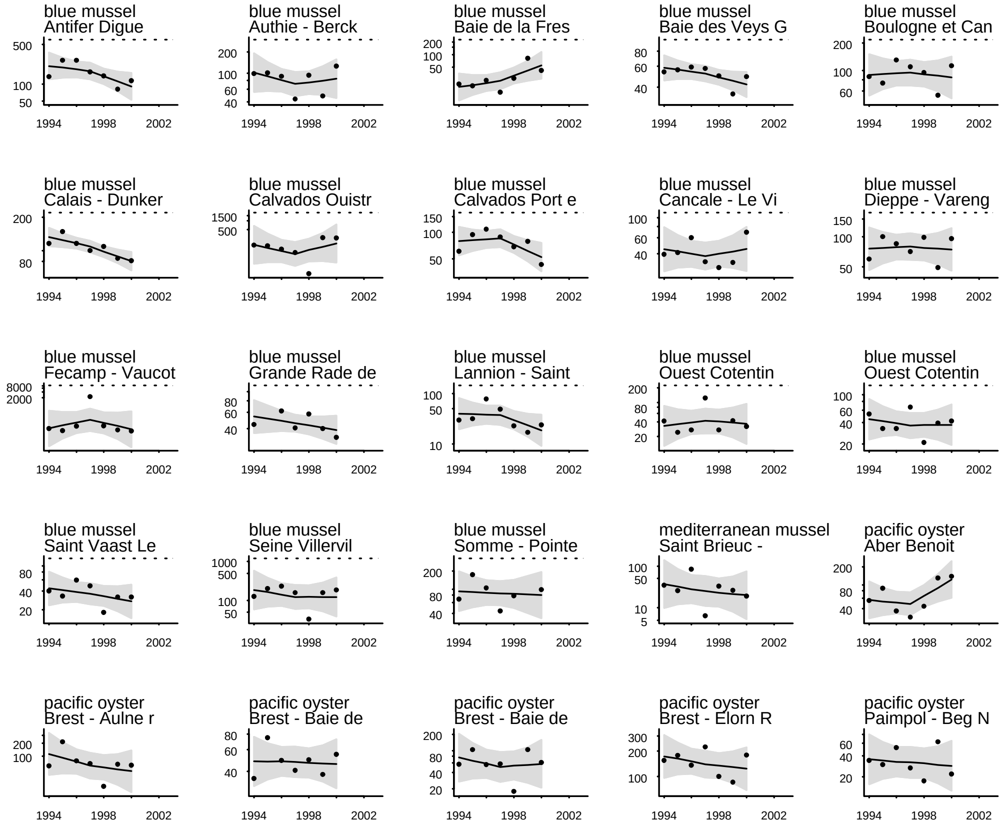
PAH 3 rings ug/kg (continued)

region IV France

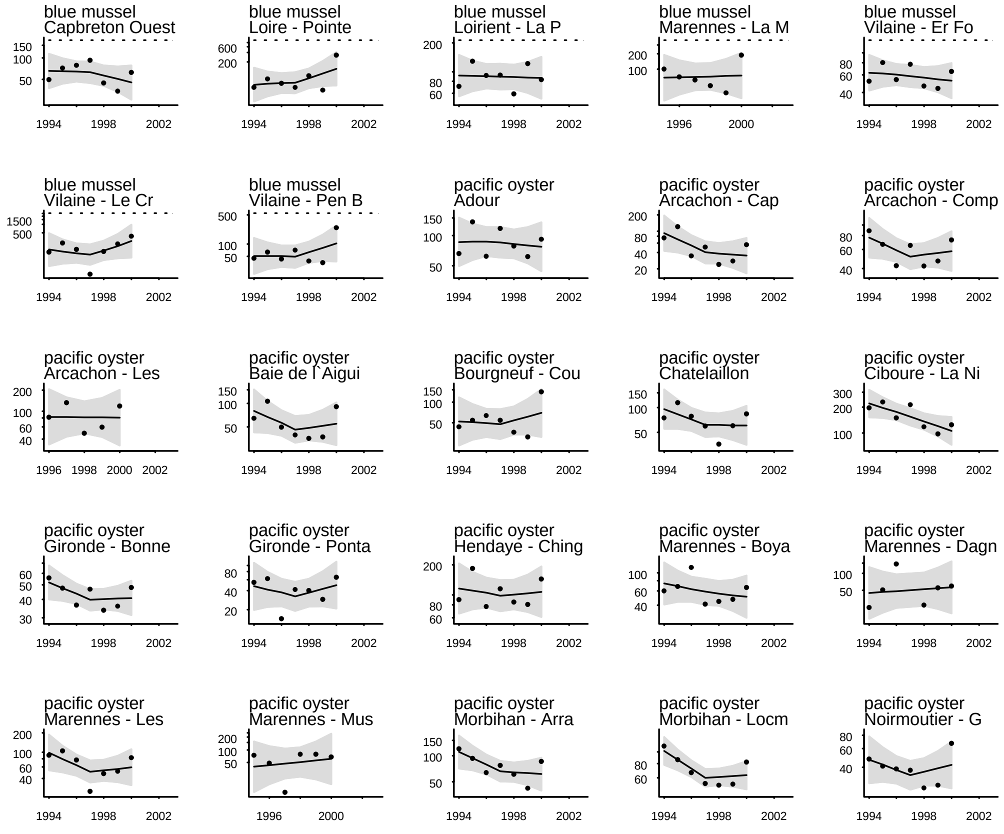


PAH 4 rings ug/kg

region II France

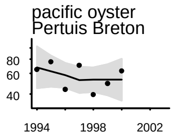


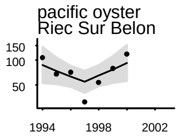
region IV France

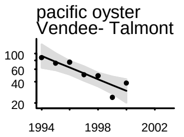


PAH 4 rings ug/kg (continued)

region IV France

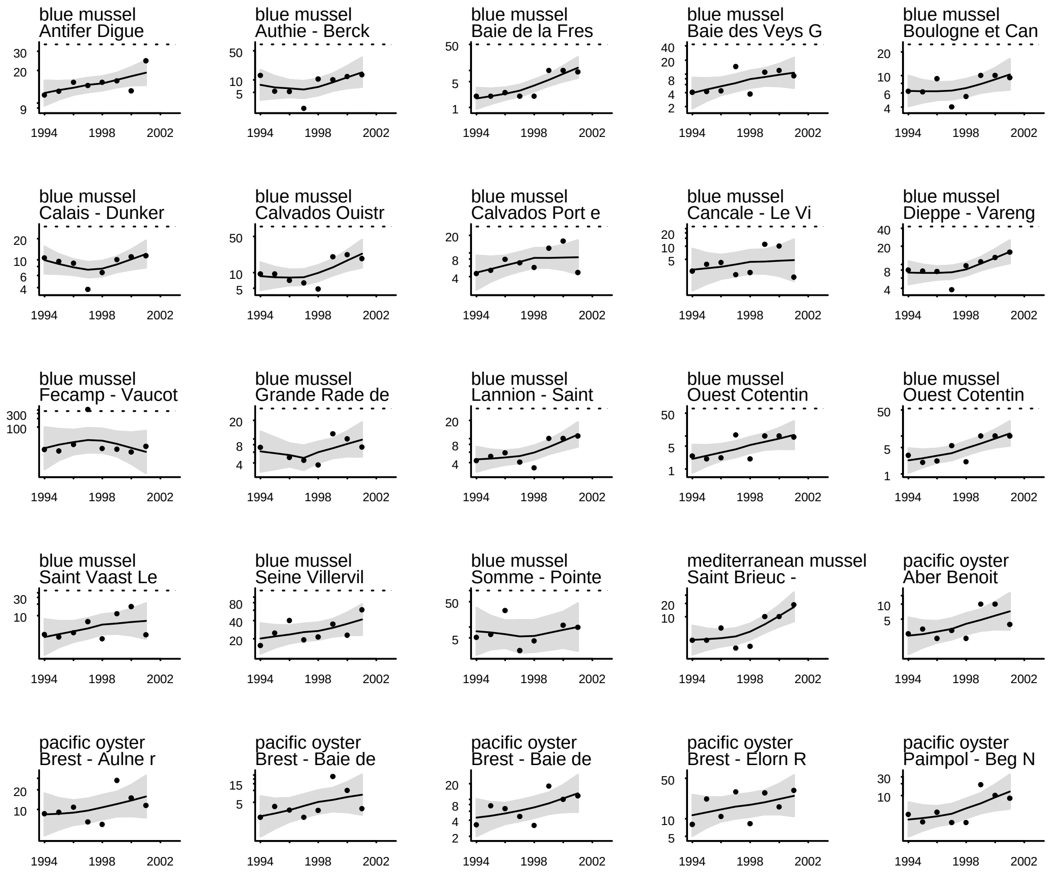




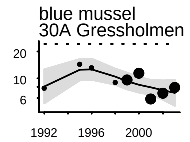


PAH 6 rings ug/kg

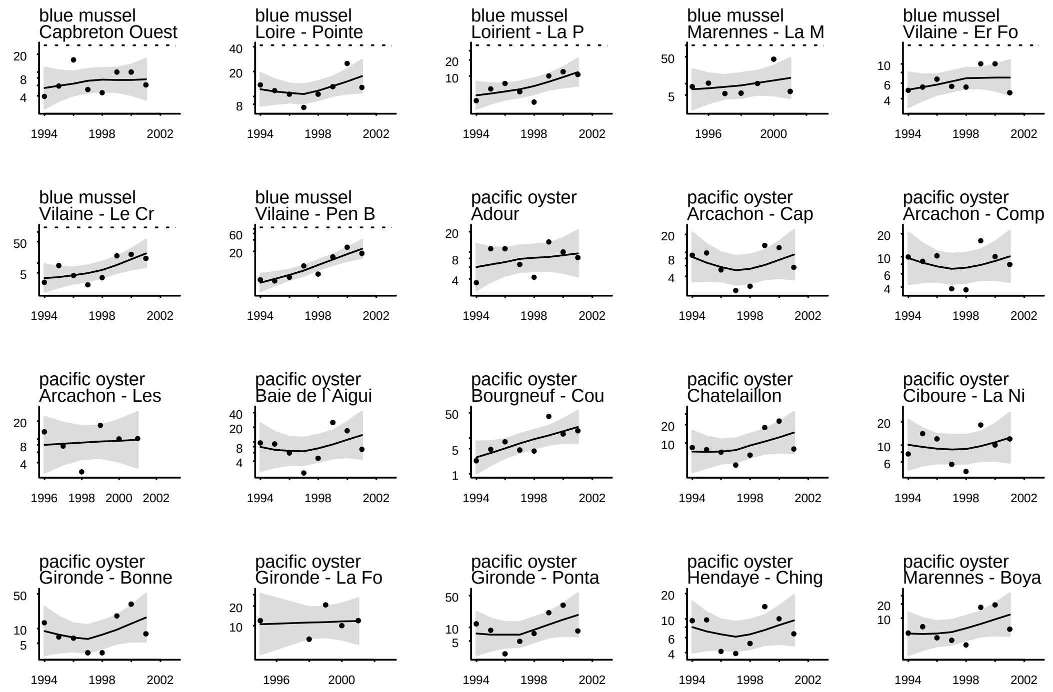
region II France



region II Norway

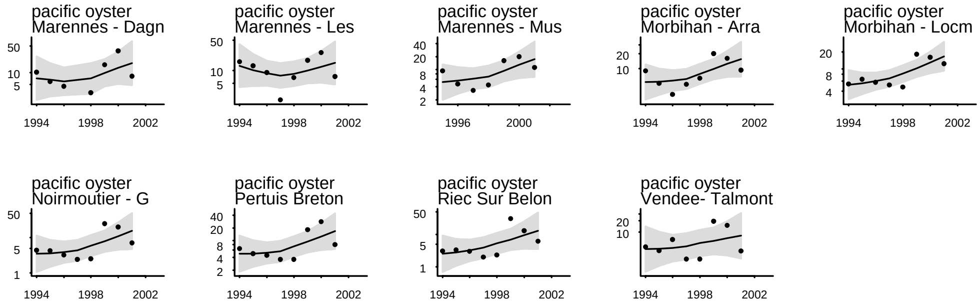


region IV France



PAH 6 rings ug/kg (continued)

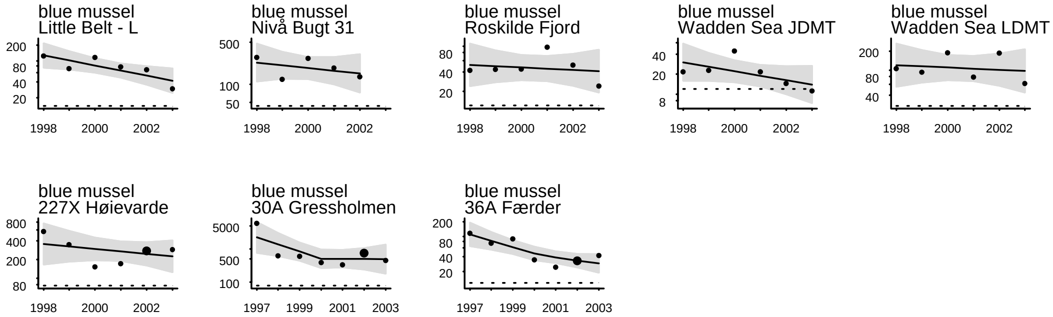
region IV France



Tributyltin ug/kg

region II Denmark

region II Norway



Appendix 12, BAC / EAC ratios for all stations is not yet available.

2005 Assessment of CEMP data
Appendix 13: Sediment trends plots and yearly medians

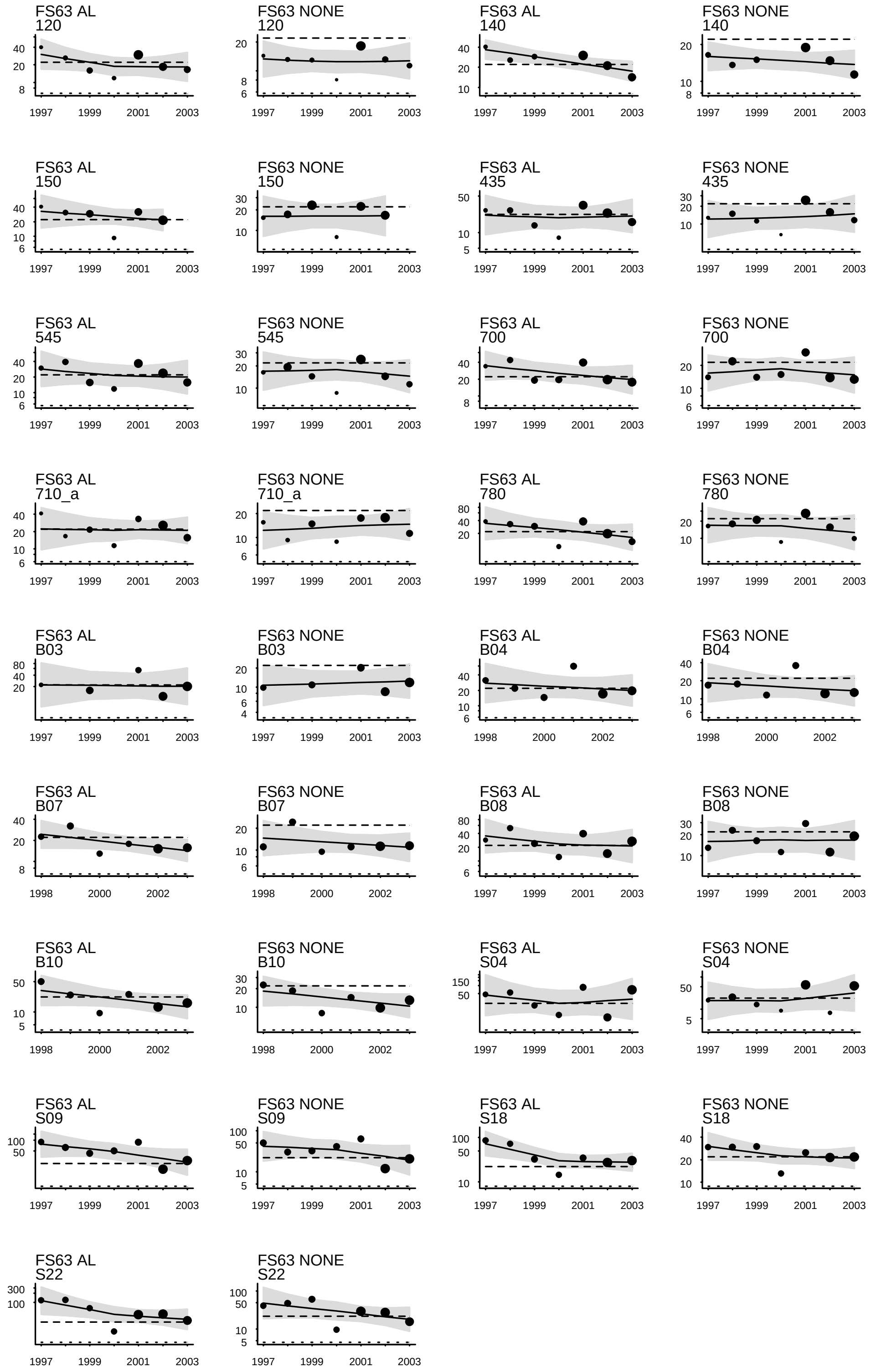
Table of contents

NB: not all figures and contaminants are discussed in main assessment report

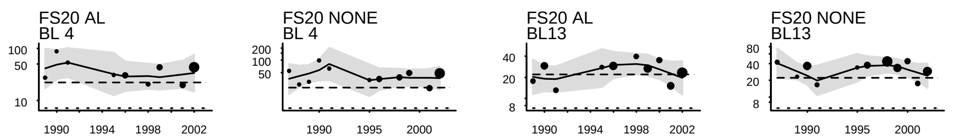
Yearly means for contaminants in sediment can be found in document MON 04/02/09

Arsenic mg/kg

region II Belgium

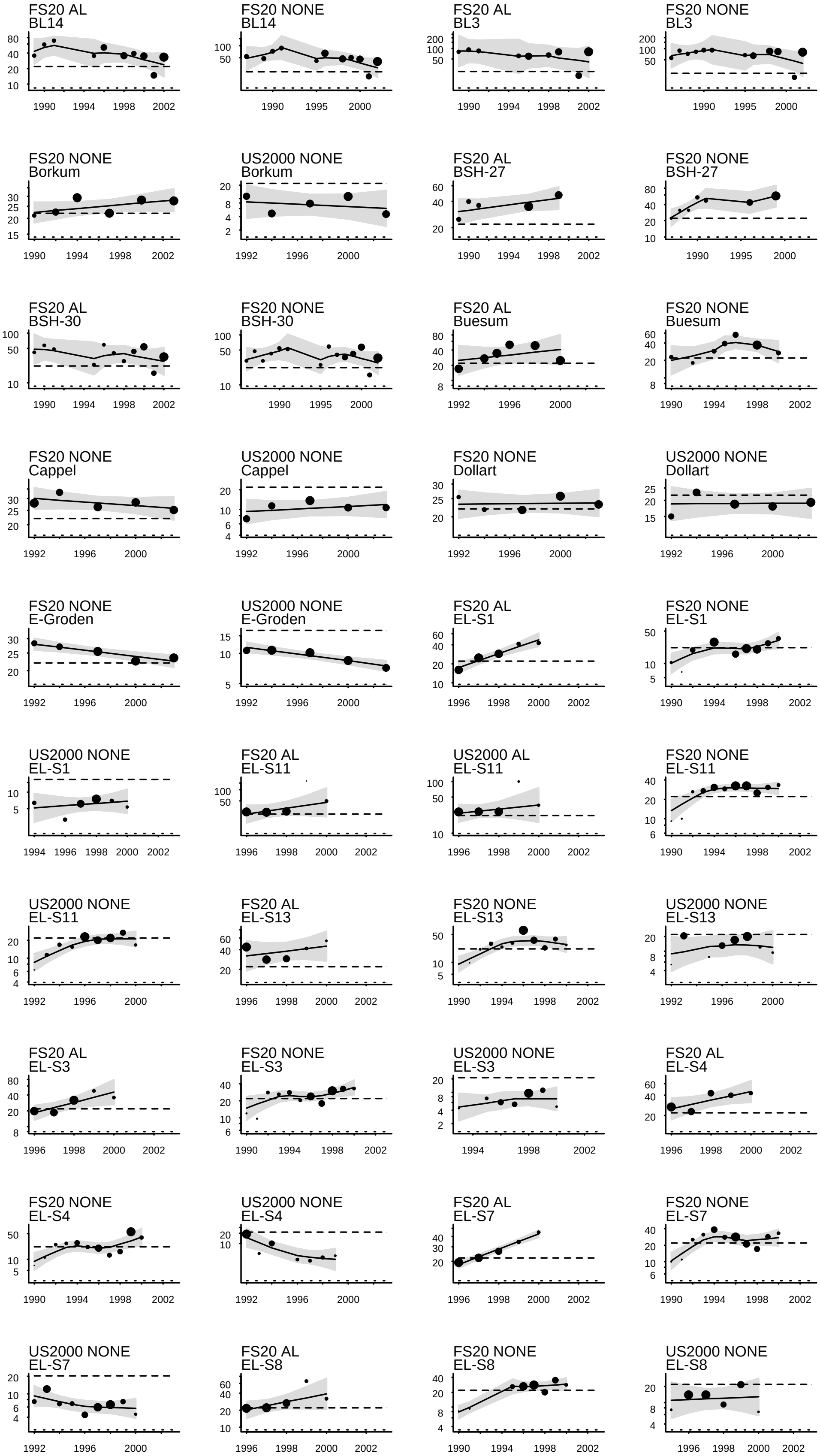


region II Germany



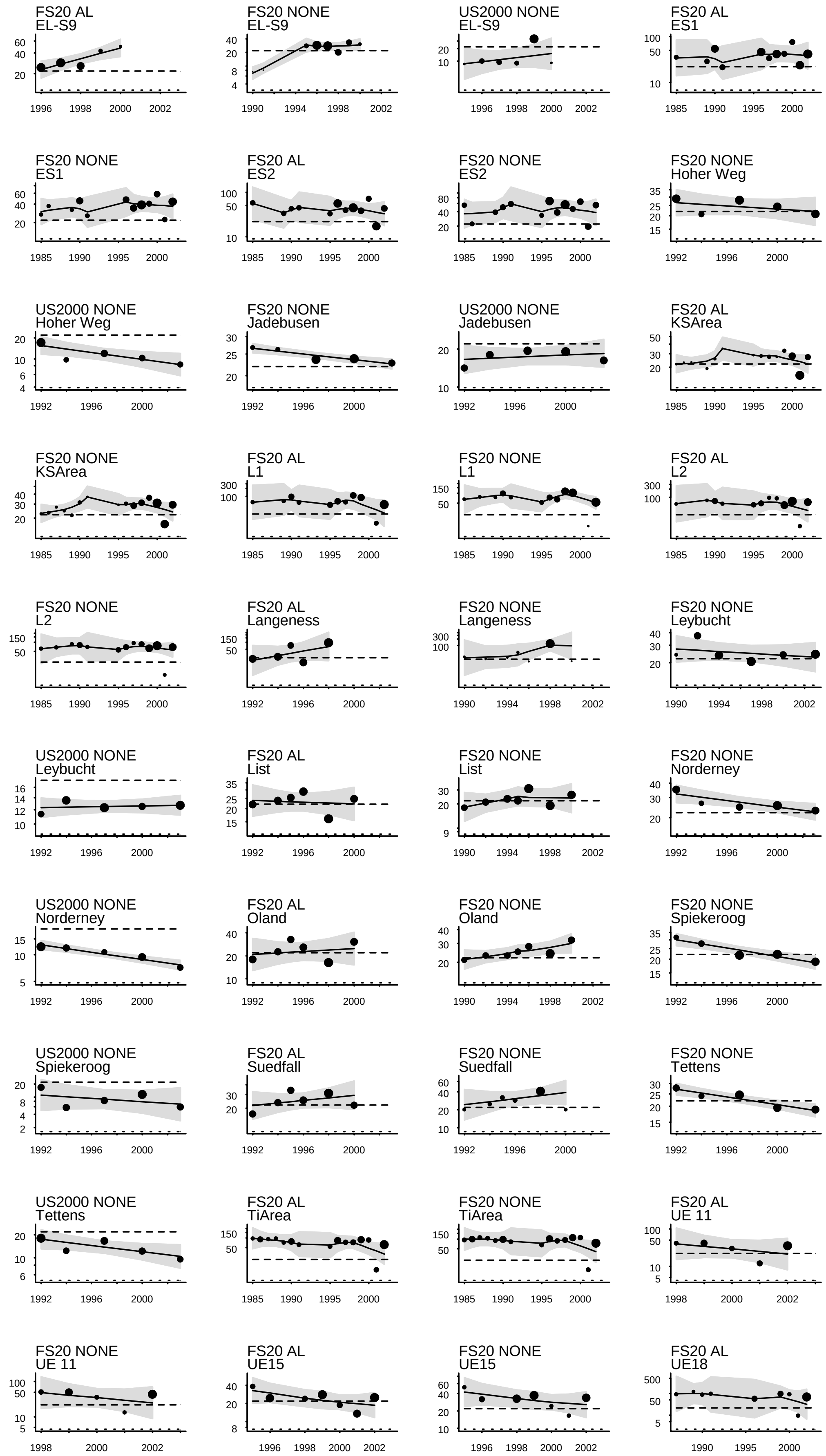
Arsenic mg/kg (continued)

region II Germany



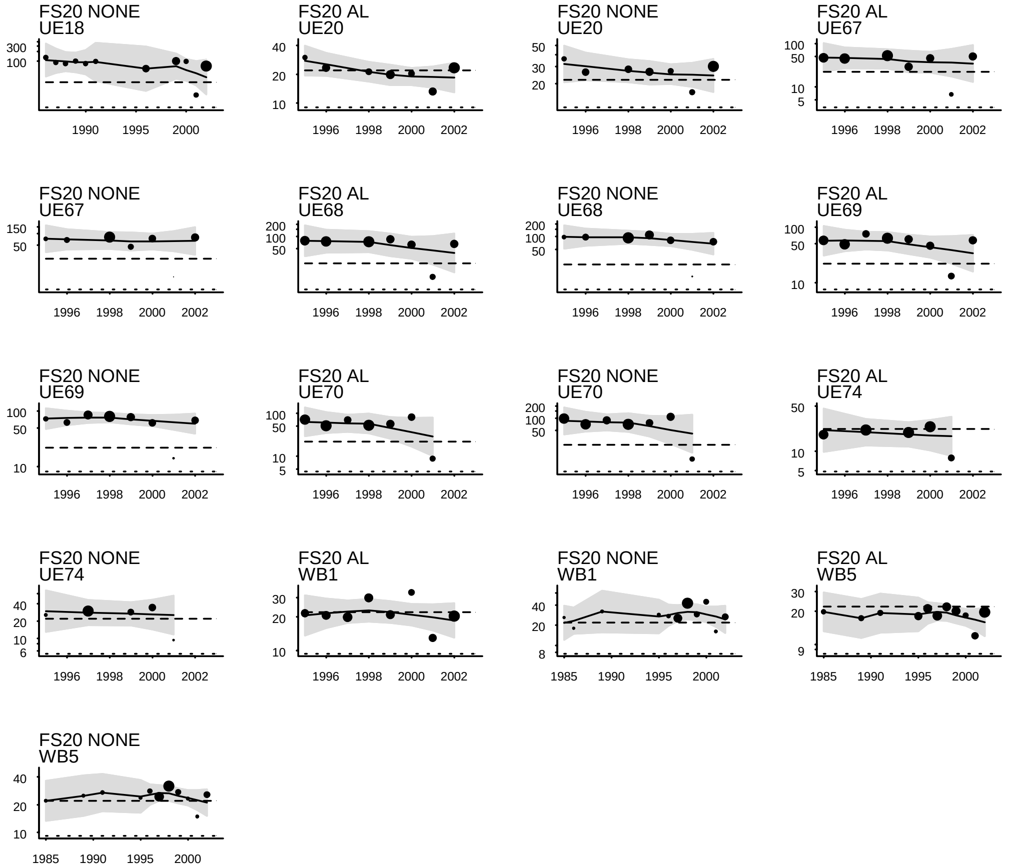
Arsenic mg/kg (continued)

region II Germany

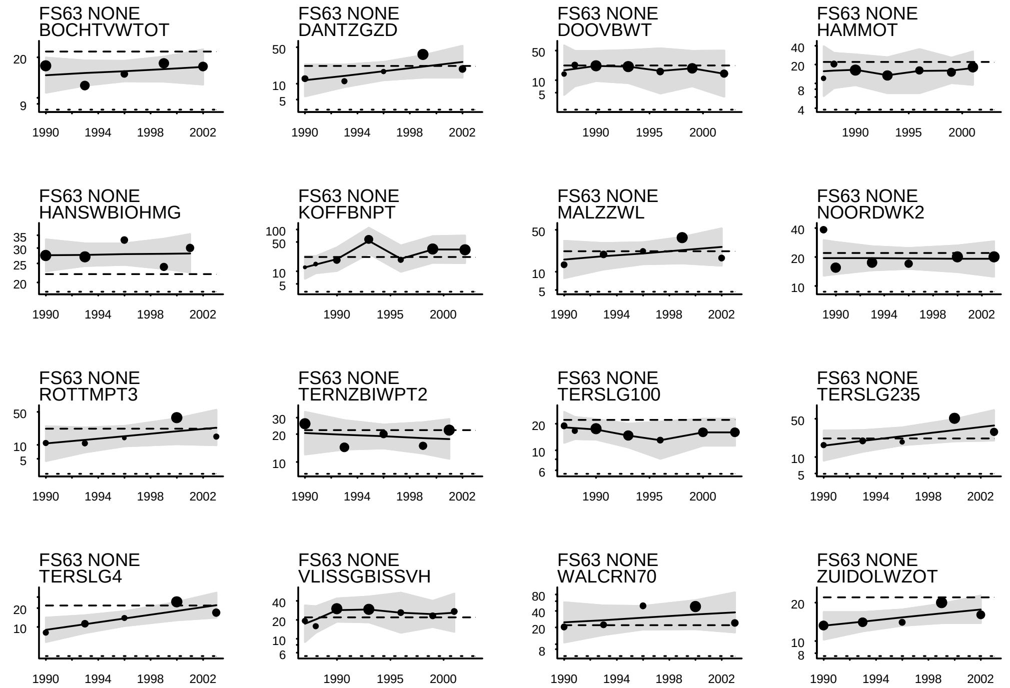


Arsenic mg/kg (continued)

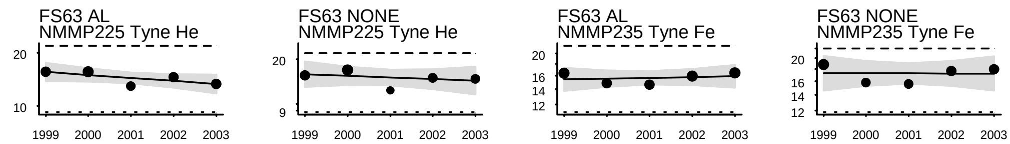
region II Germany



region II Netherlands

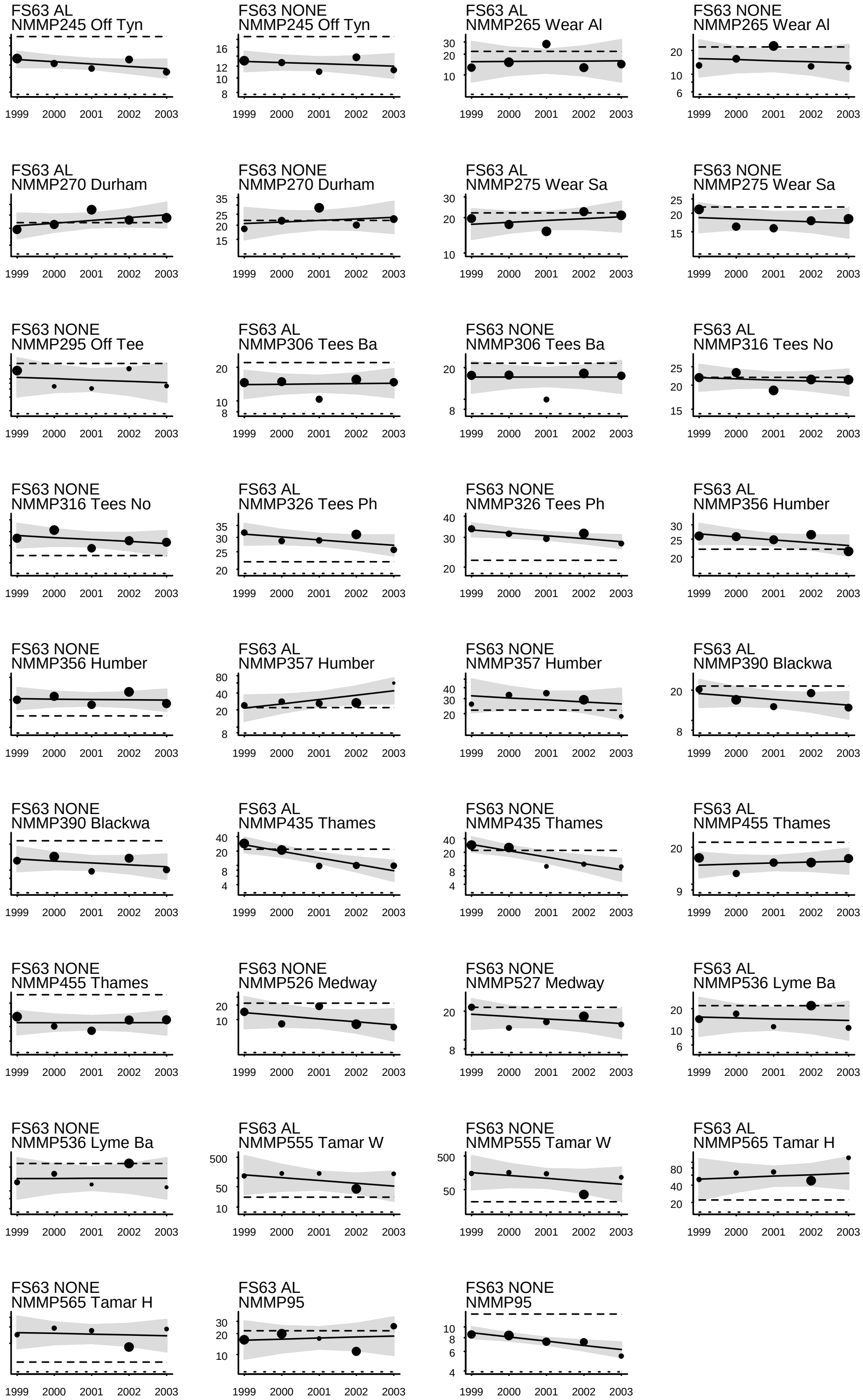


region II UK

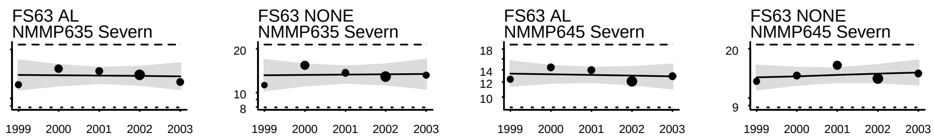


Arsenic mg/kg (continued)

region II UK

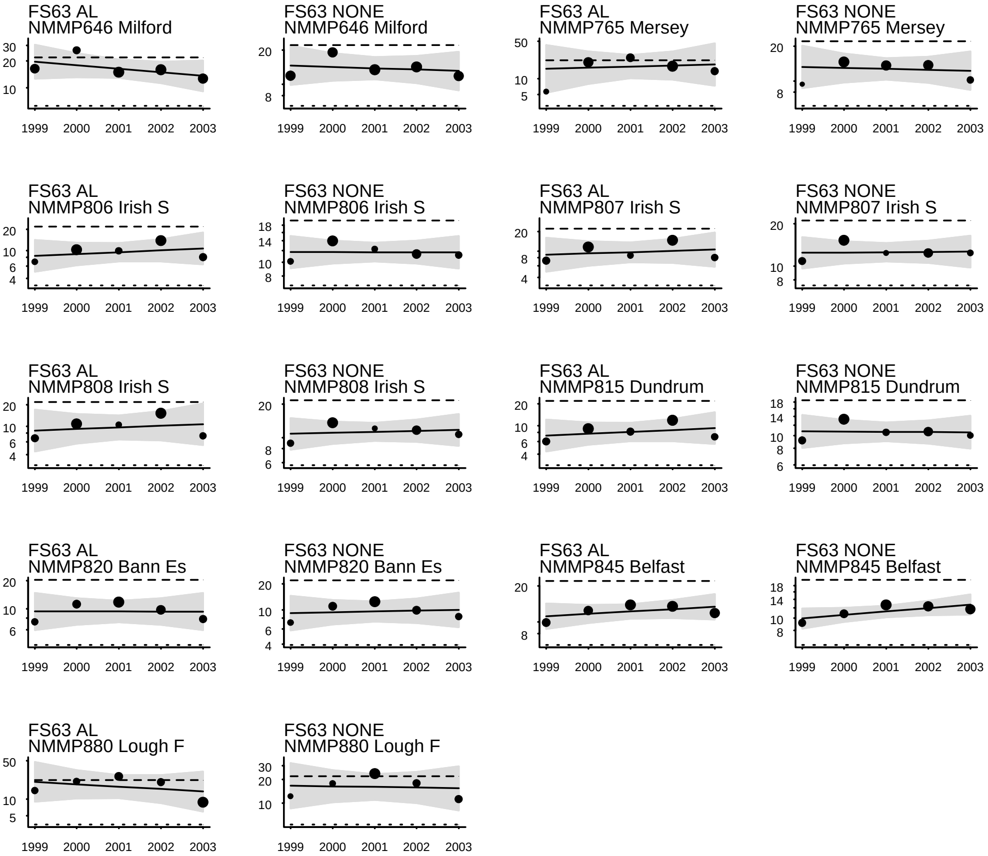


region III UK



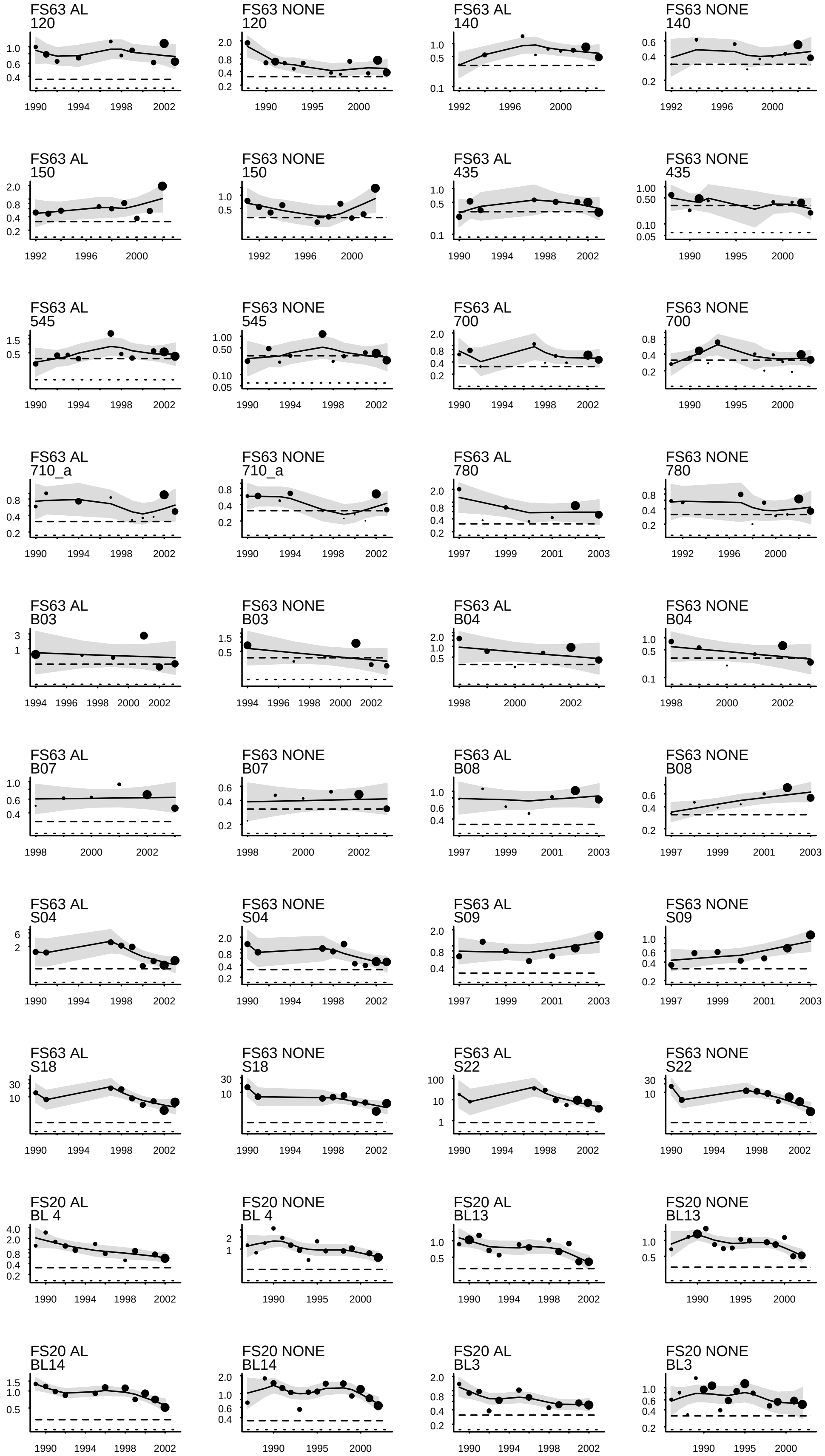
Arsenic mg/kg (continued)

region III UK



Cadmium mg/kg

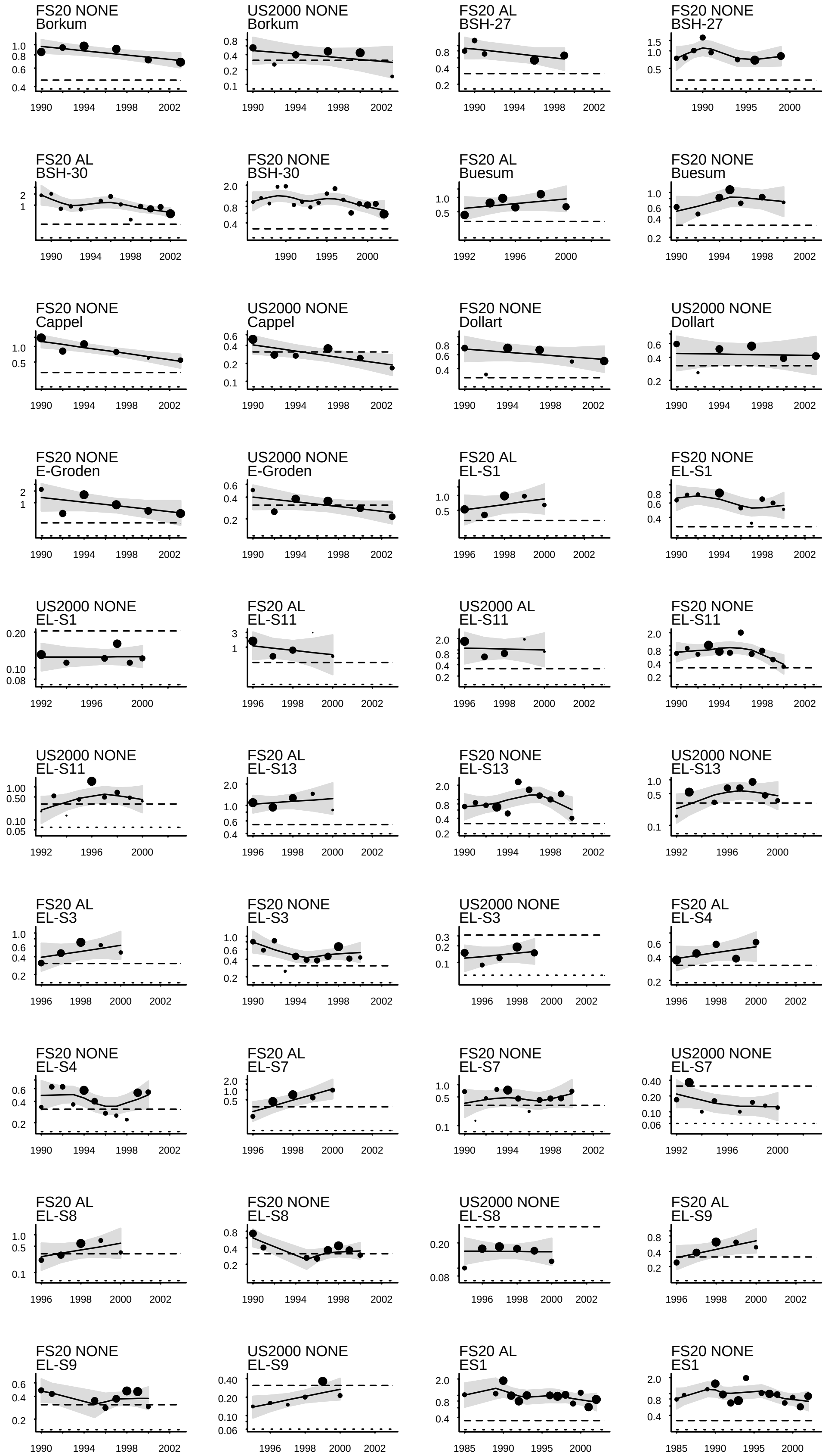
region II Belgium



region II Germany

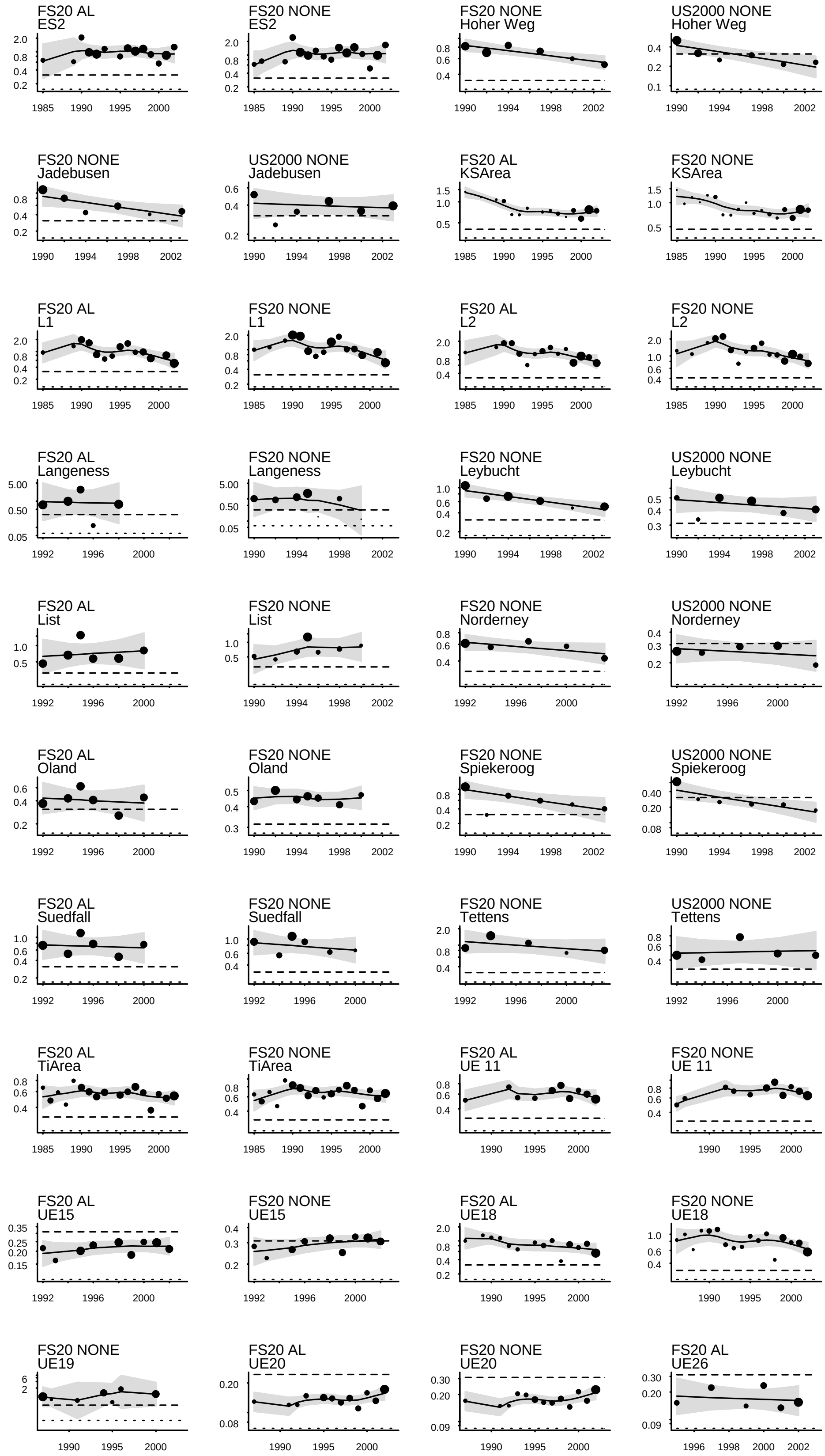
Cadmium mg/kg (continued)

region II Germany



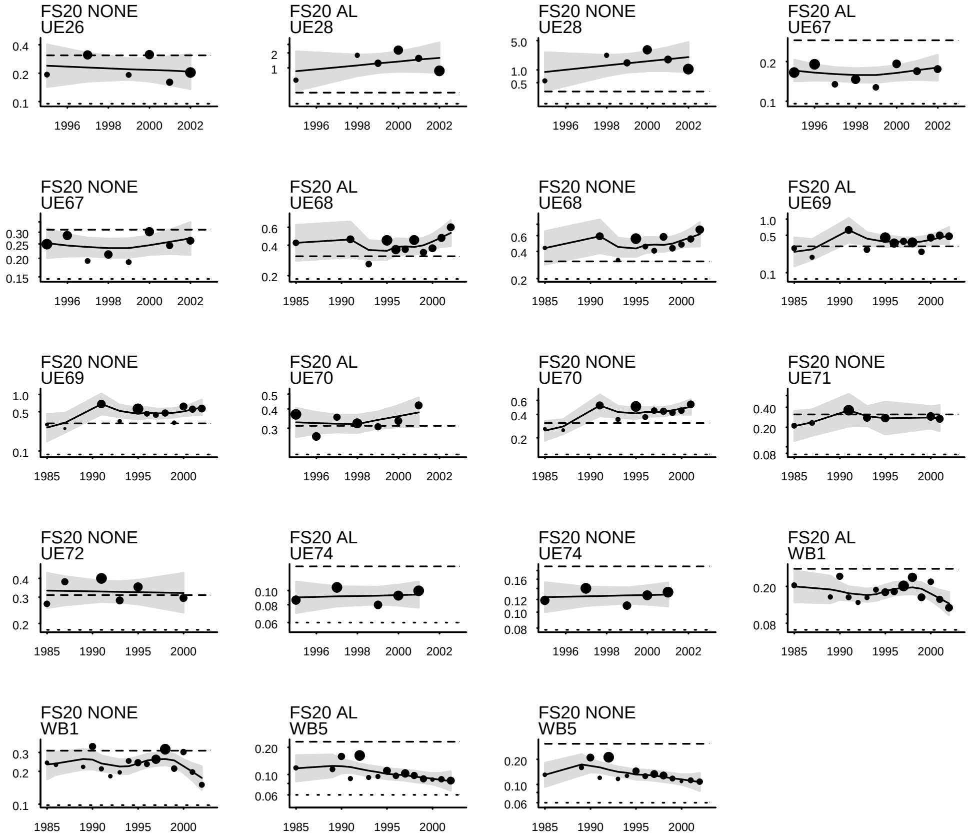
Cadmium mg/kg (continued)

region II Germany

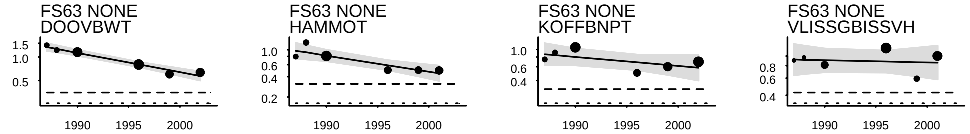


Cadmium mg/kg (continued)

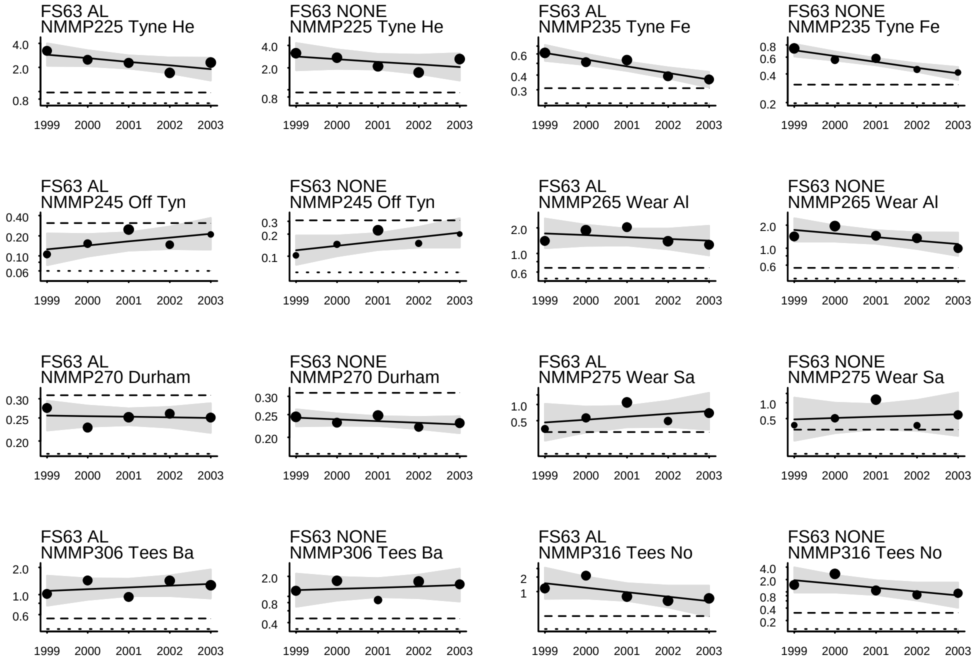
region II Germany



region II Netherlands

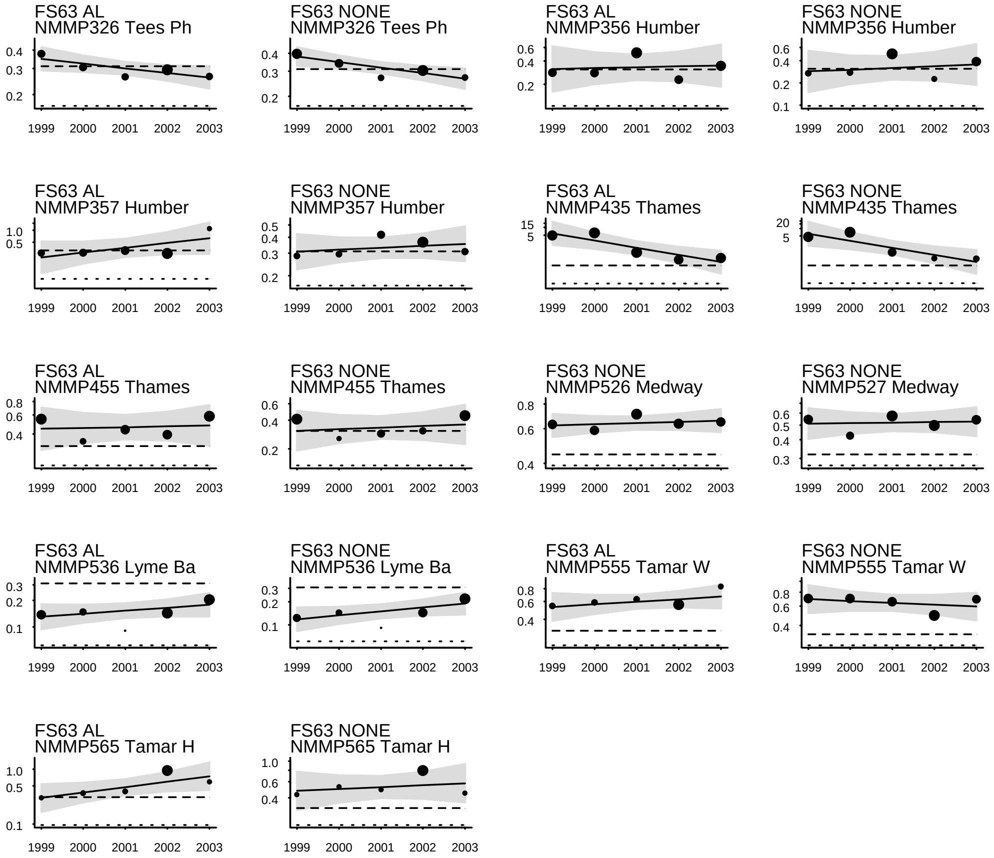


region II UK

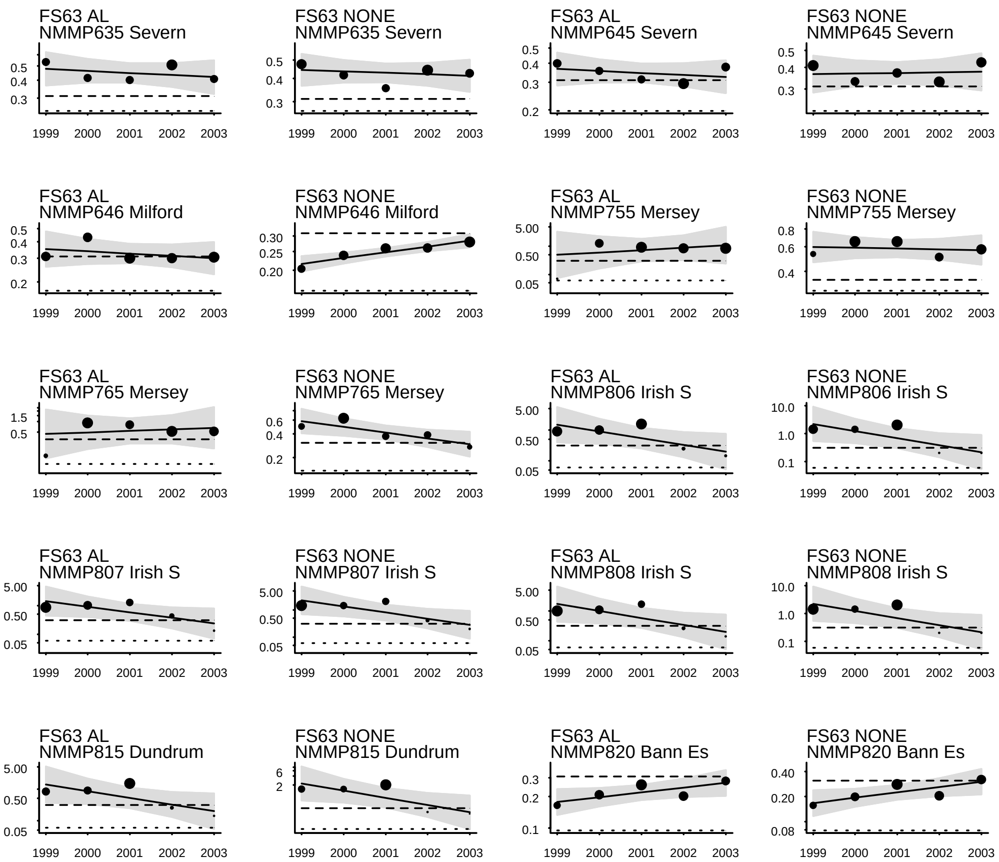


Cadmium mg/kg (continued)

region II UK

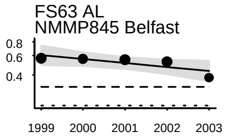


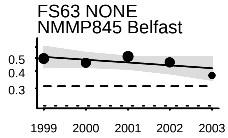
region III UK

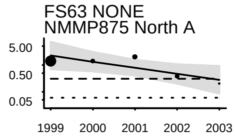


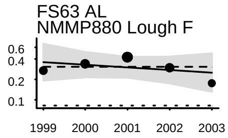
Cadmium mg/kg (continued)

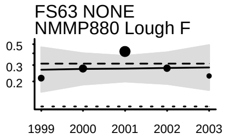
region III UK





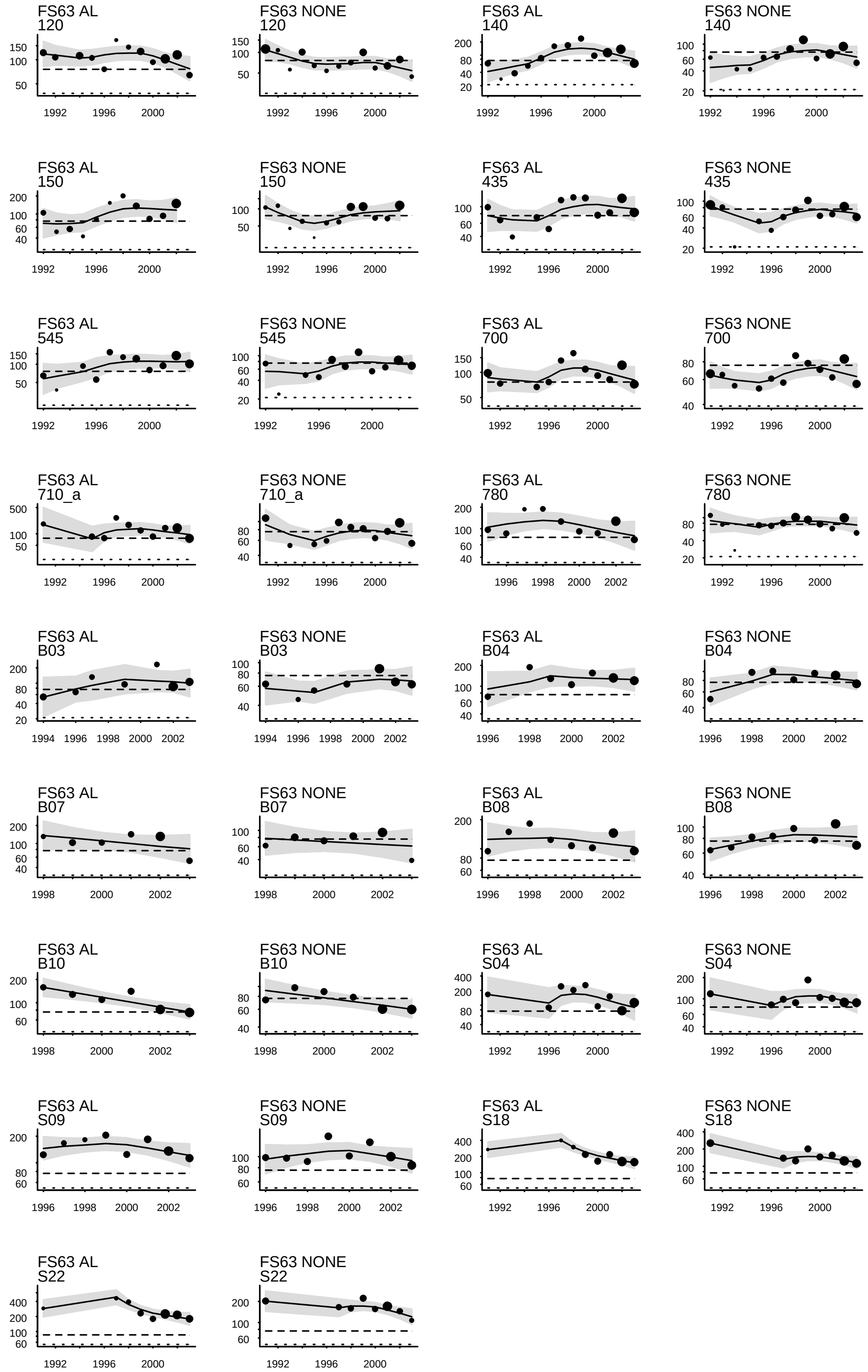




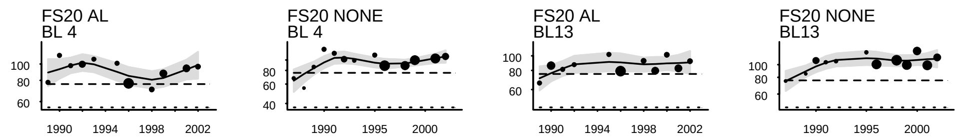


Chromium mg/kg

region II Belgium

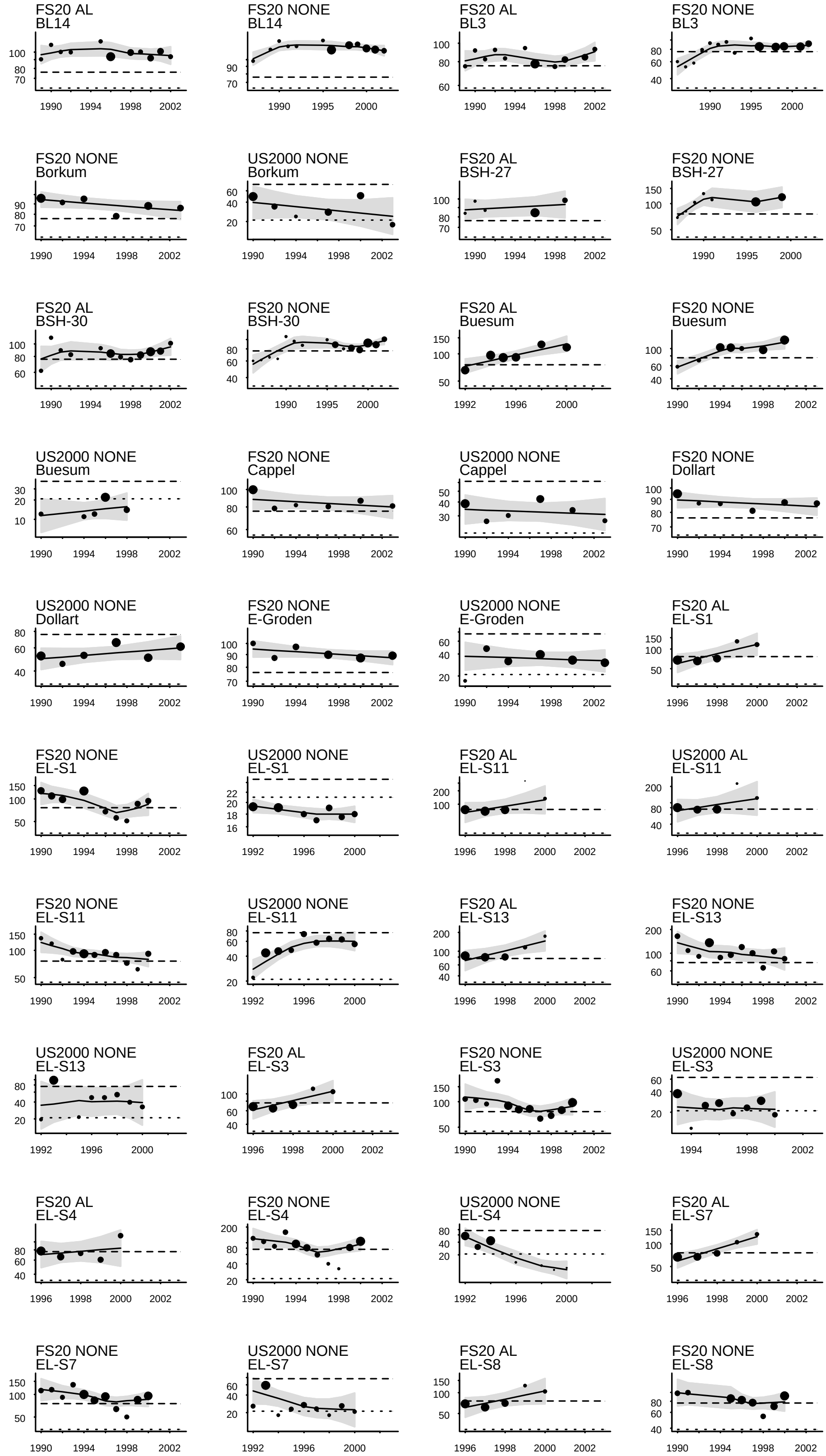


region II Germany



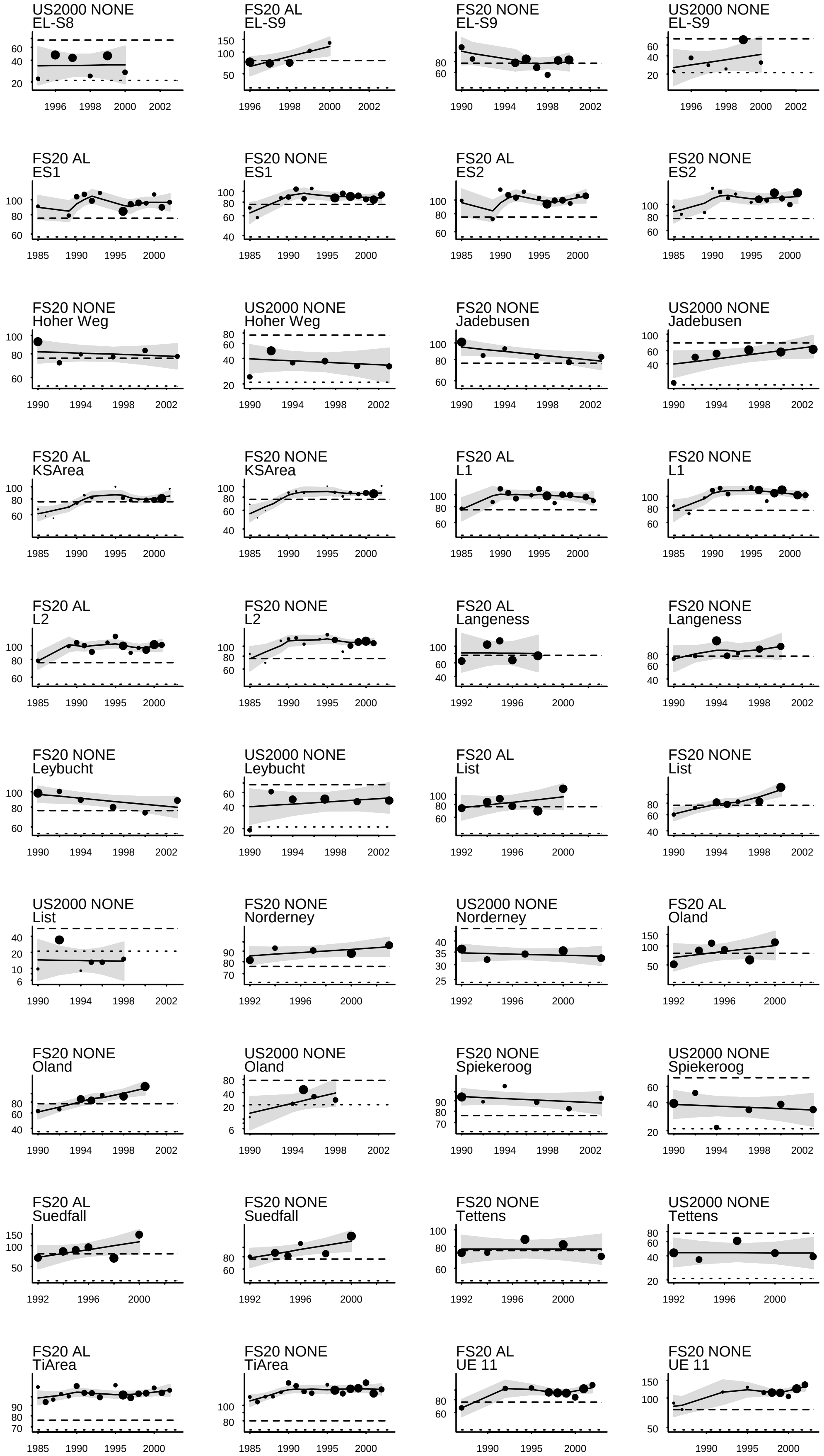
Chromium mg/kg (continued)

region II Germany



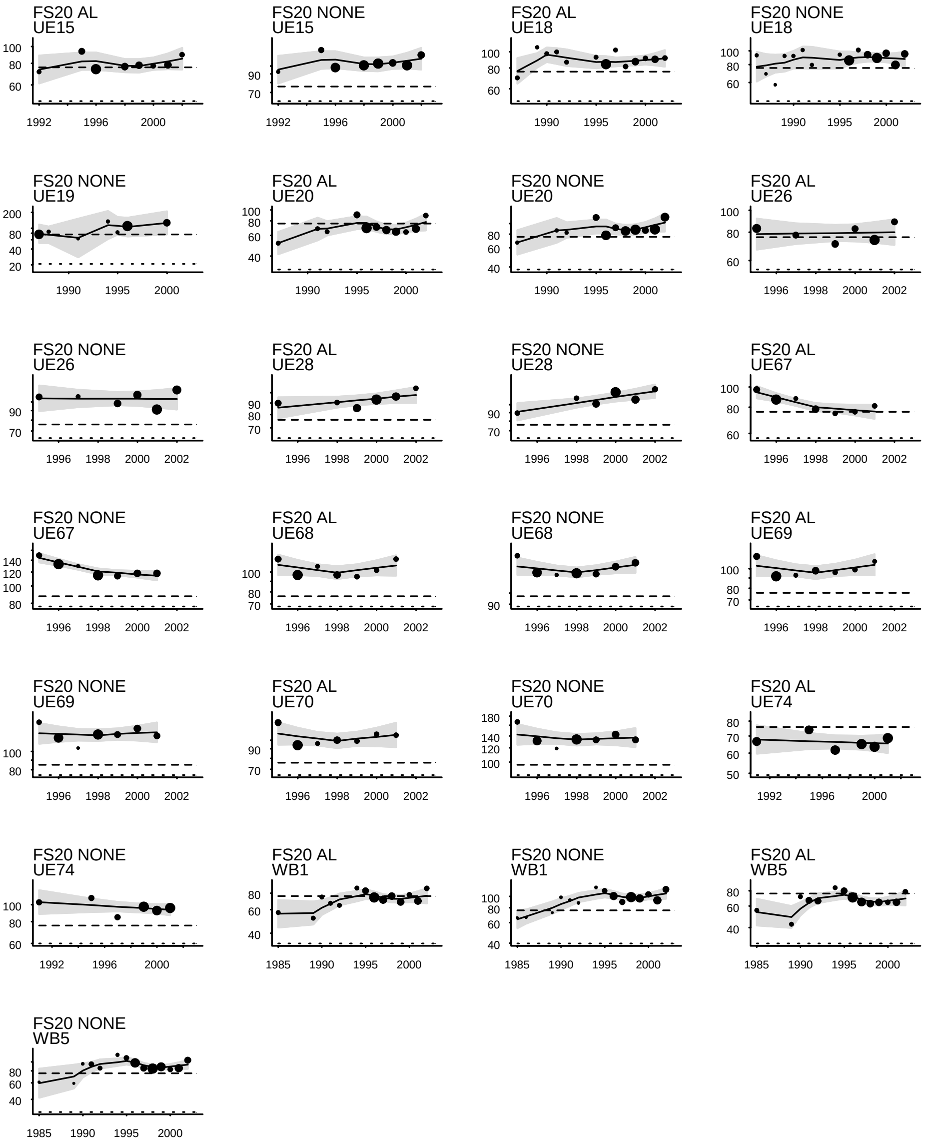
Chromium mg/kg (continued)

region II Germany

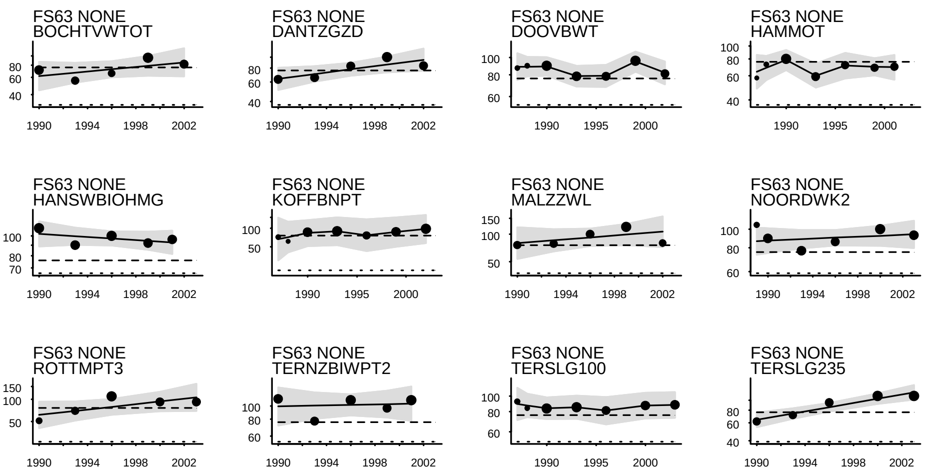


Chromium mg/kg (continued)

region II Germany

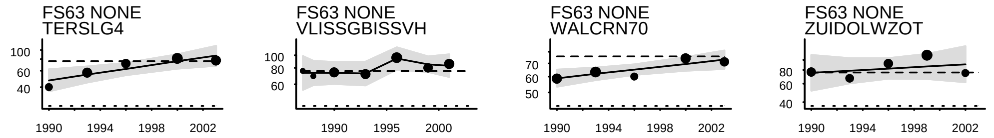


region II Netherlands

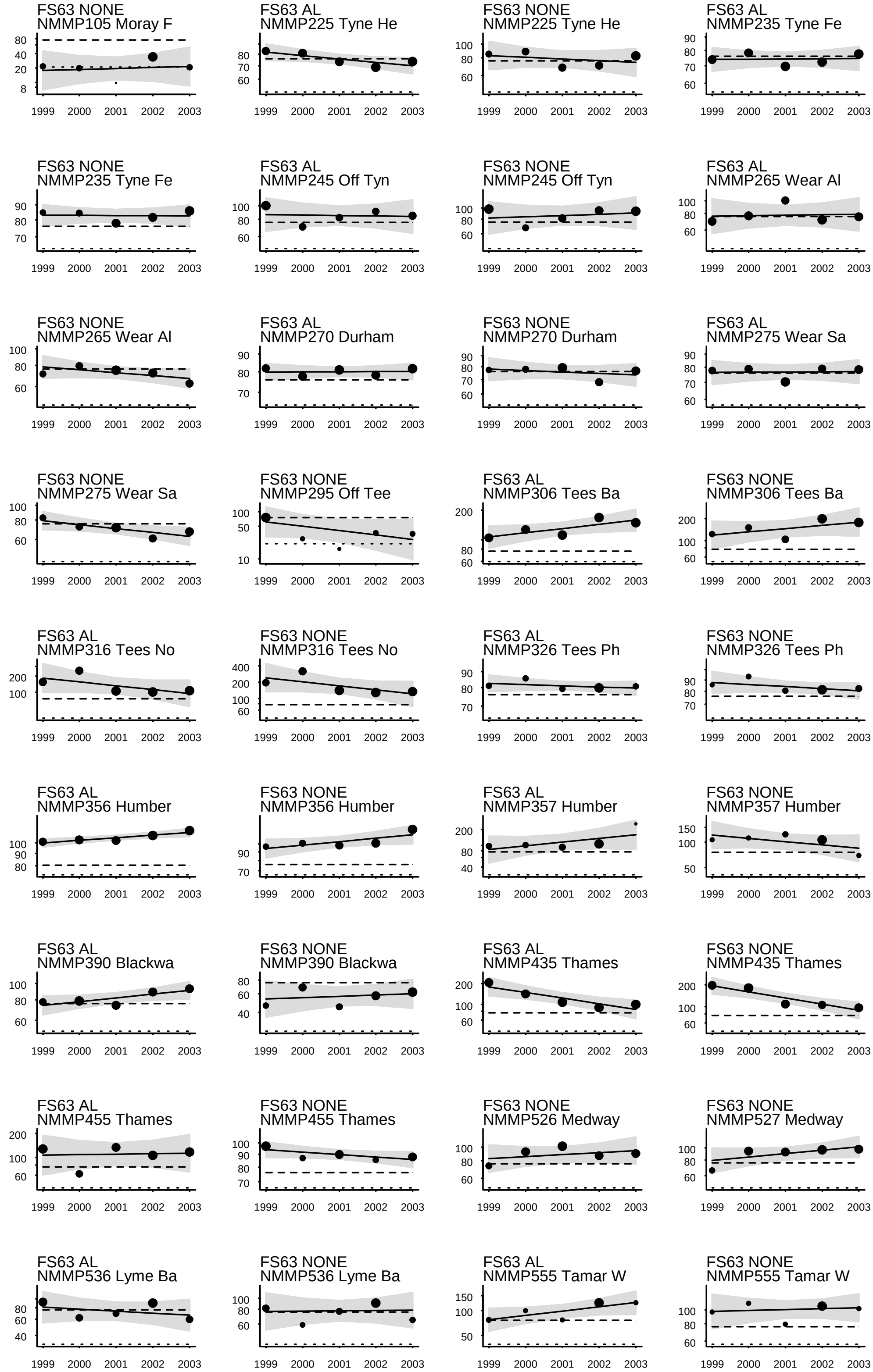


Chromium mg/kg (continued)

region II Netherlands

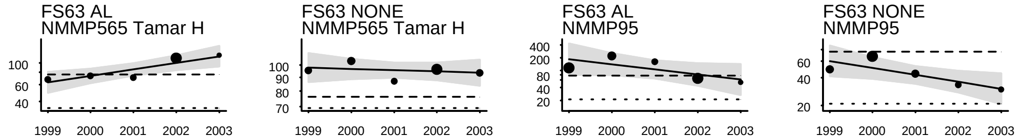


region II UK

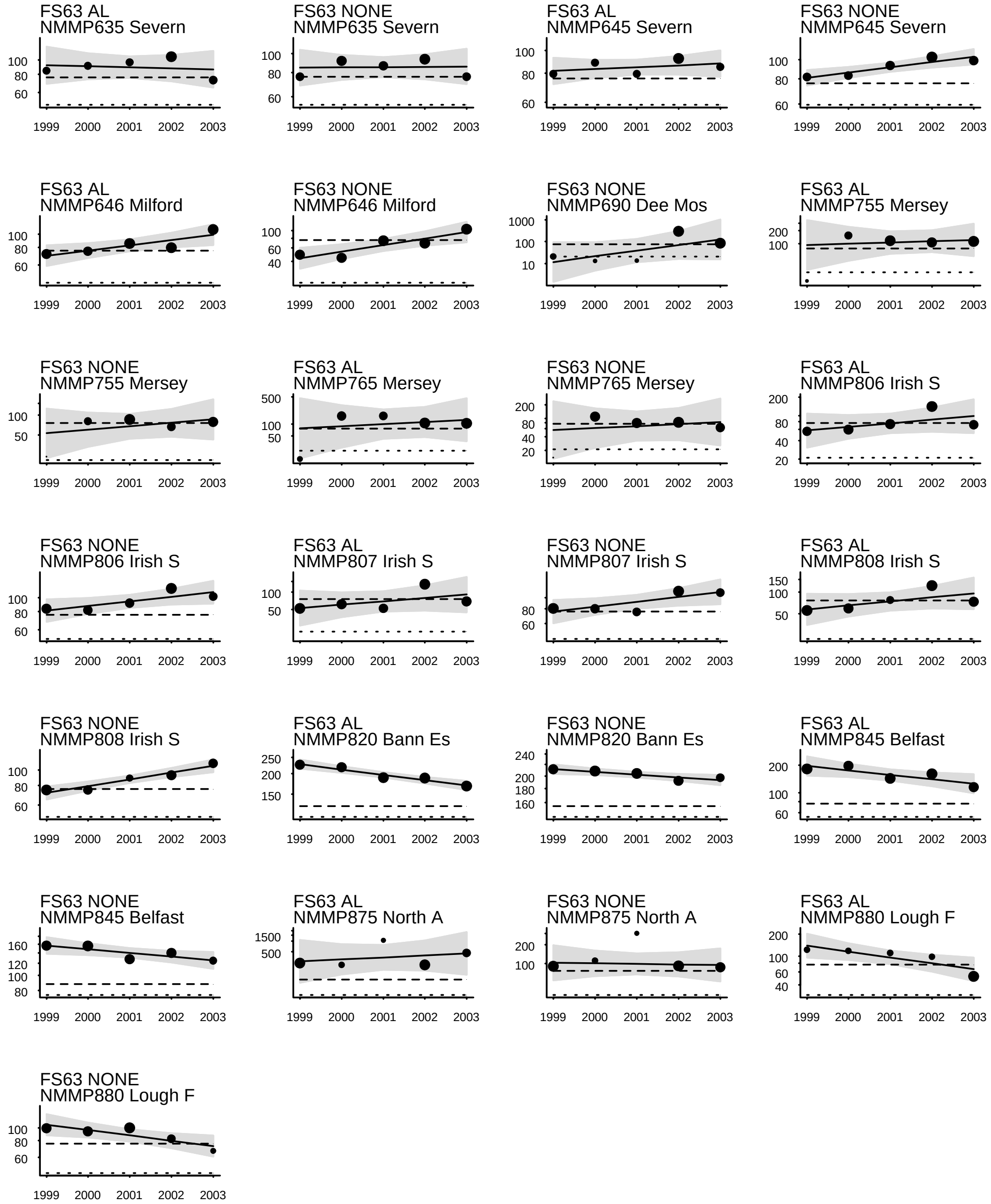


Chromium mg/kg (continued)

region II UK

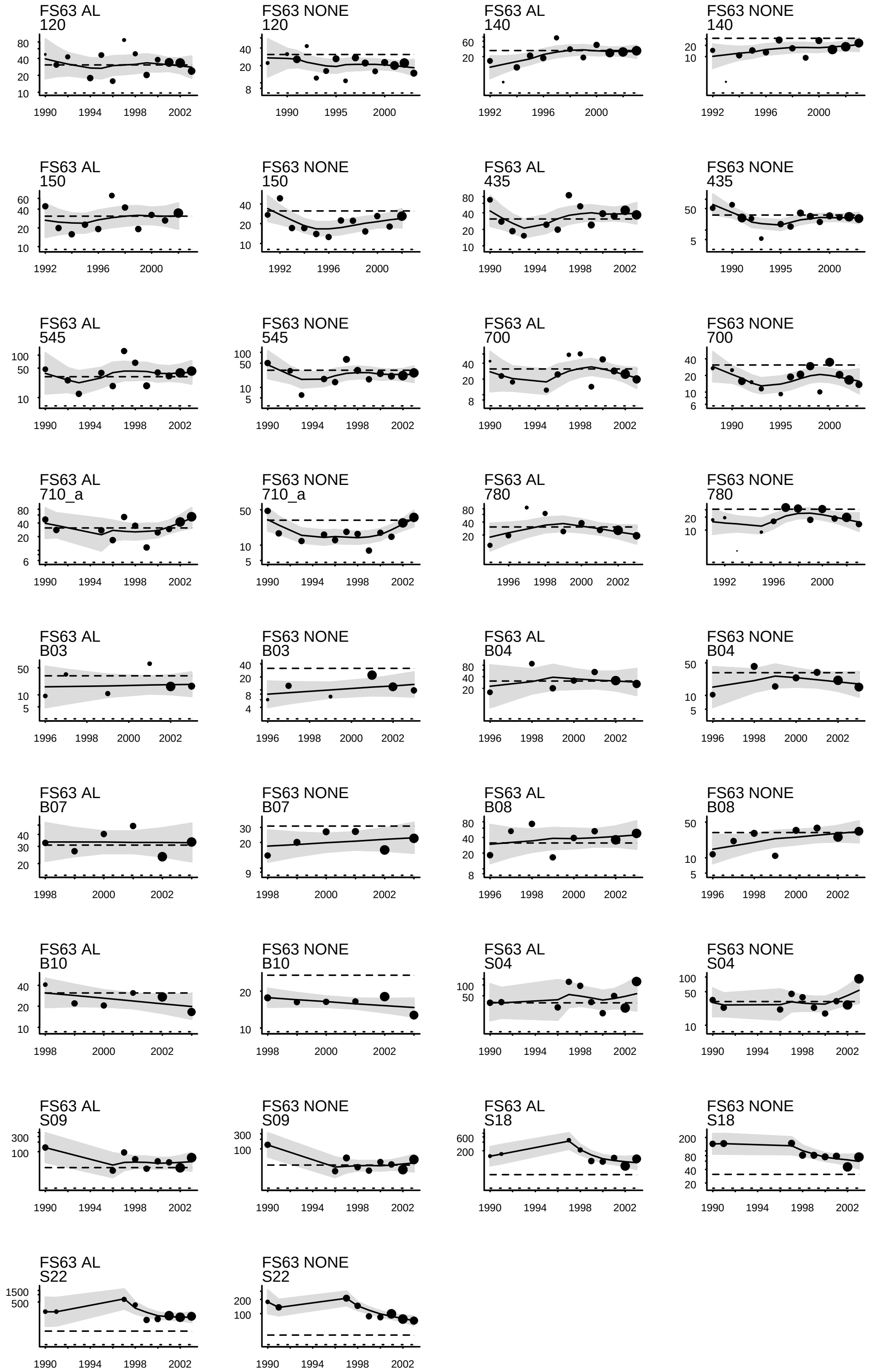


region III UK

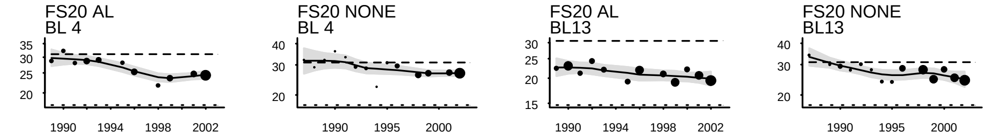


Copper mg/kg

region II Belgium

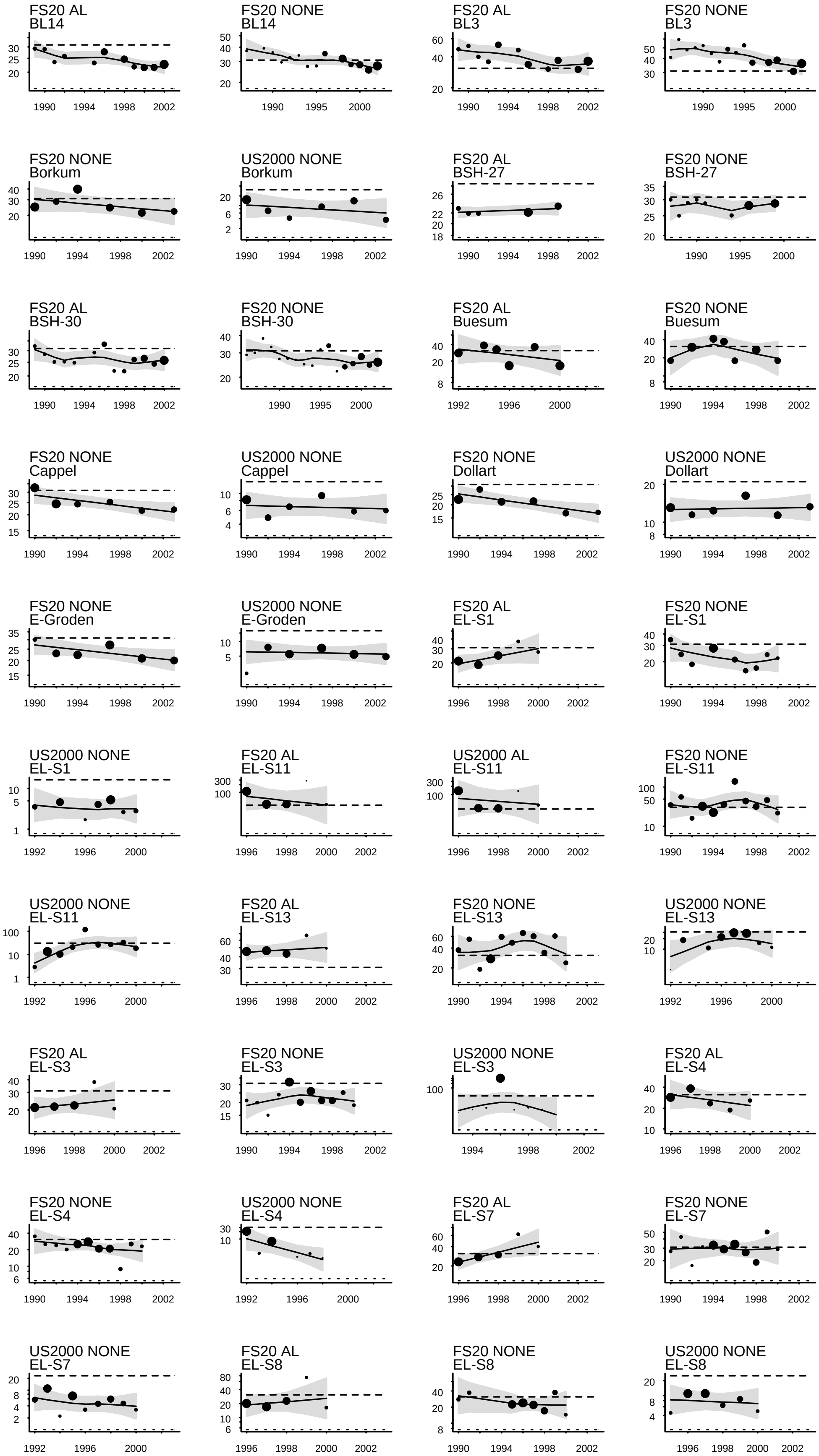


region II Germany



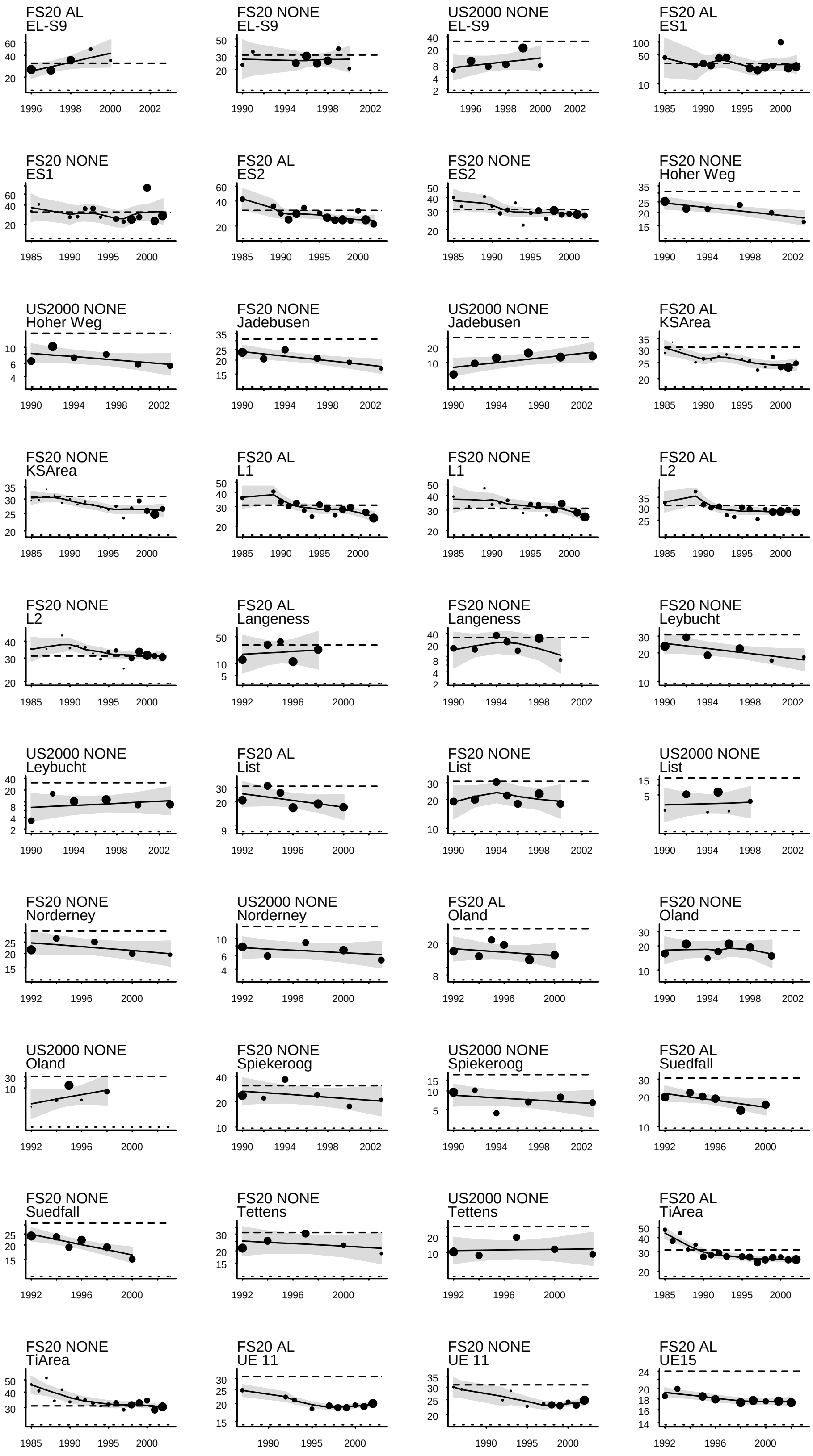
Copper mg/kg (continued)

region II Germany



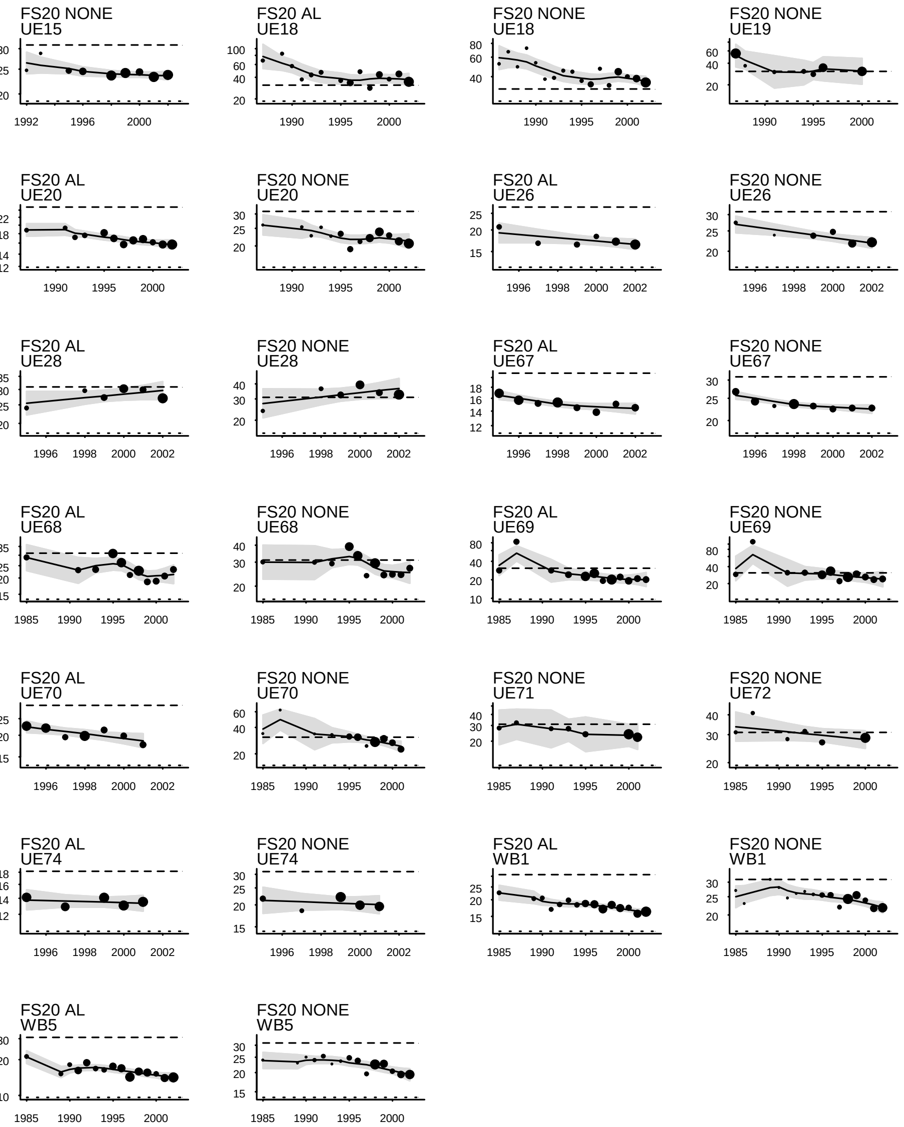
Copper mg/kg (continued)

region II Germany

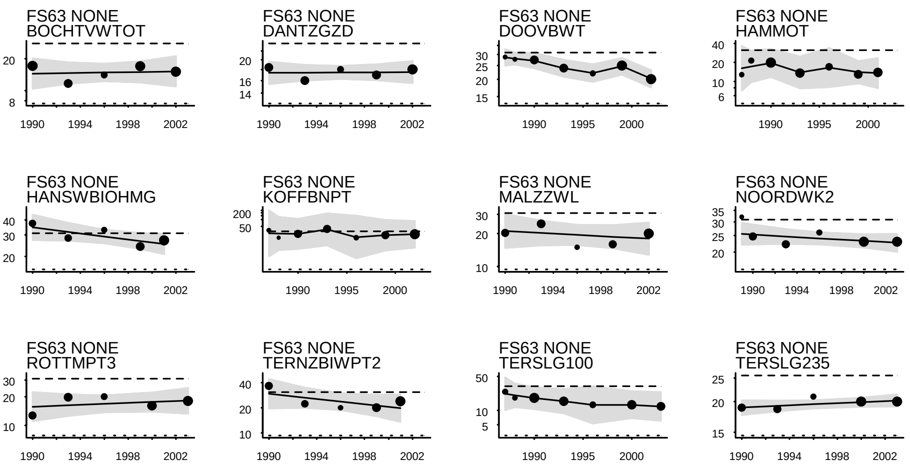


Copper mg/kg (continued)

region II Germany

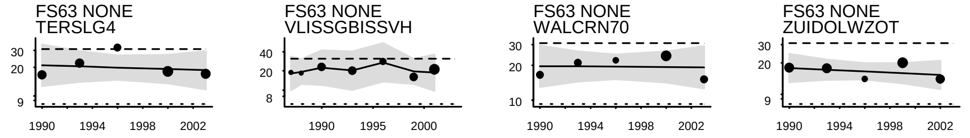


region II Netherlands

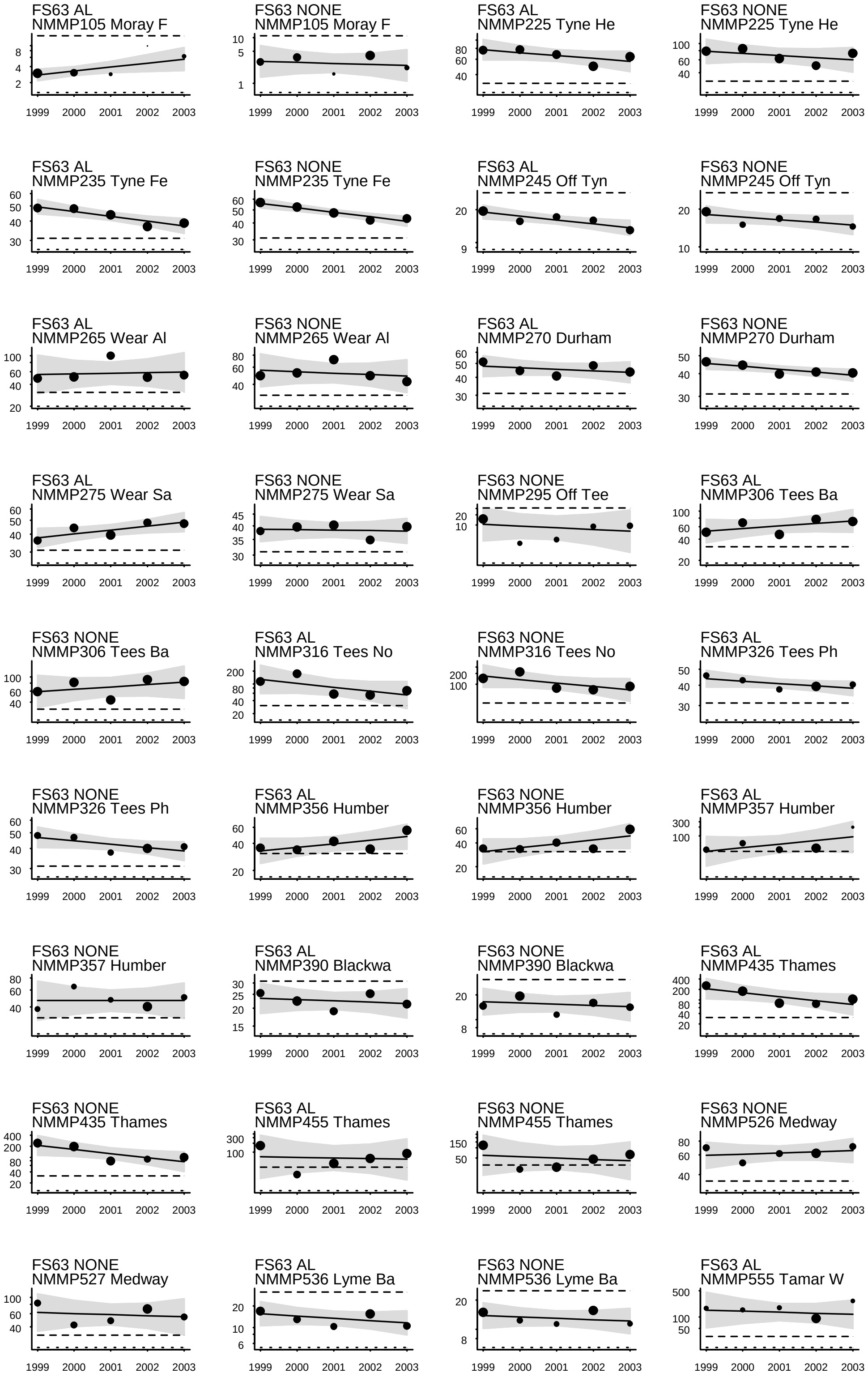


Copper mg/kg (continued)

region II Netherlands

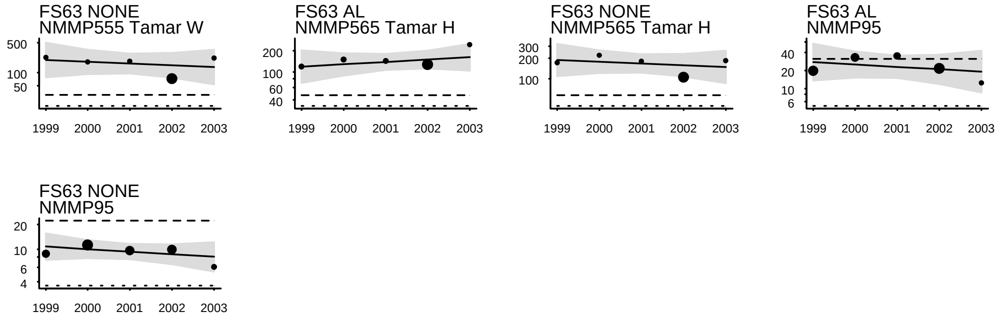


region II UK

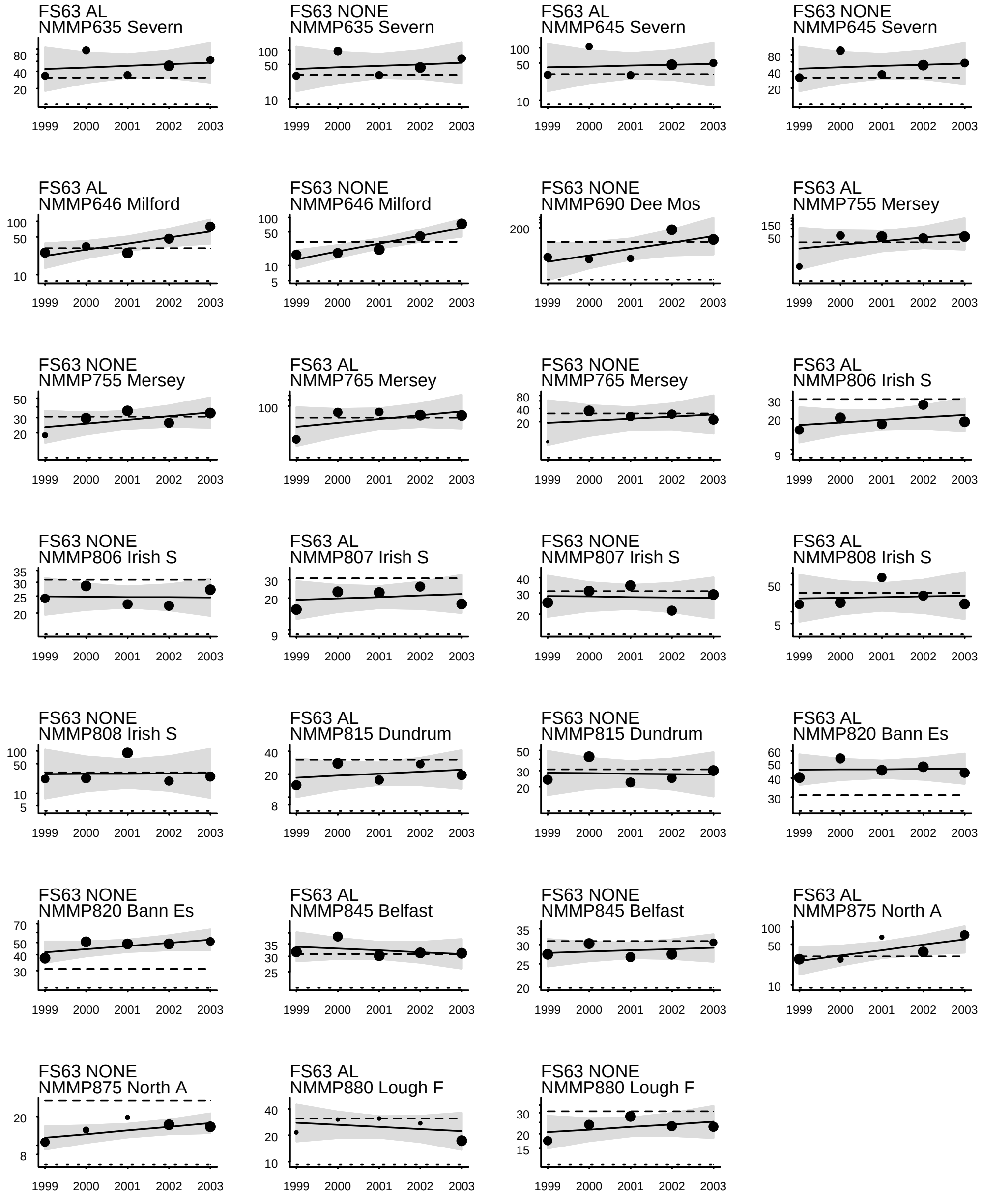


Copper mg/kg (continued)

region II UK

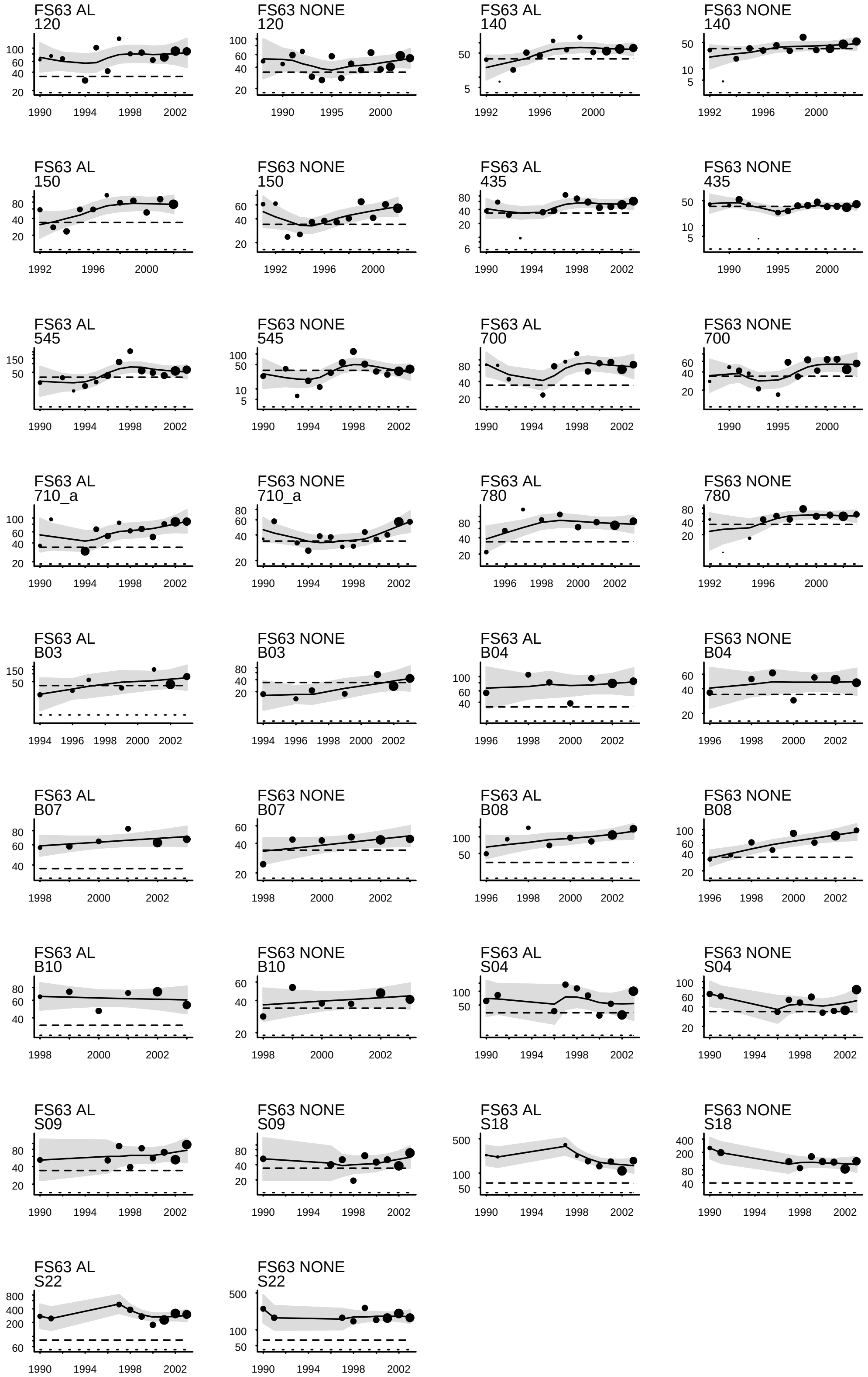


region III UK

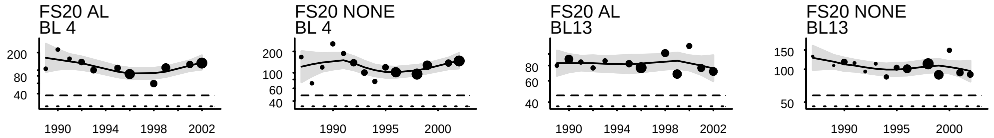


Lead mg/kg

region II Belgium

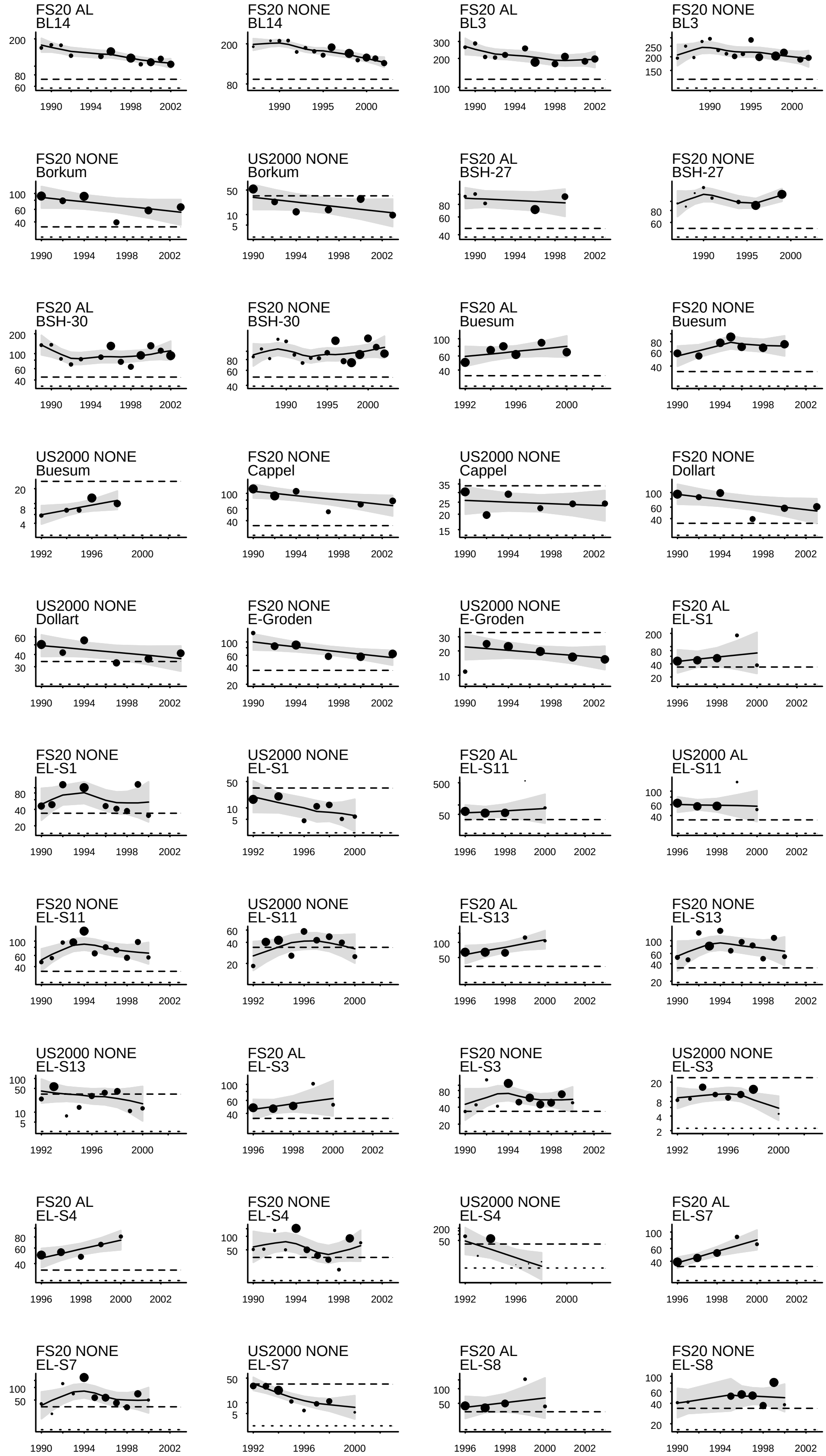


region II Germany



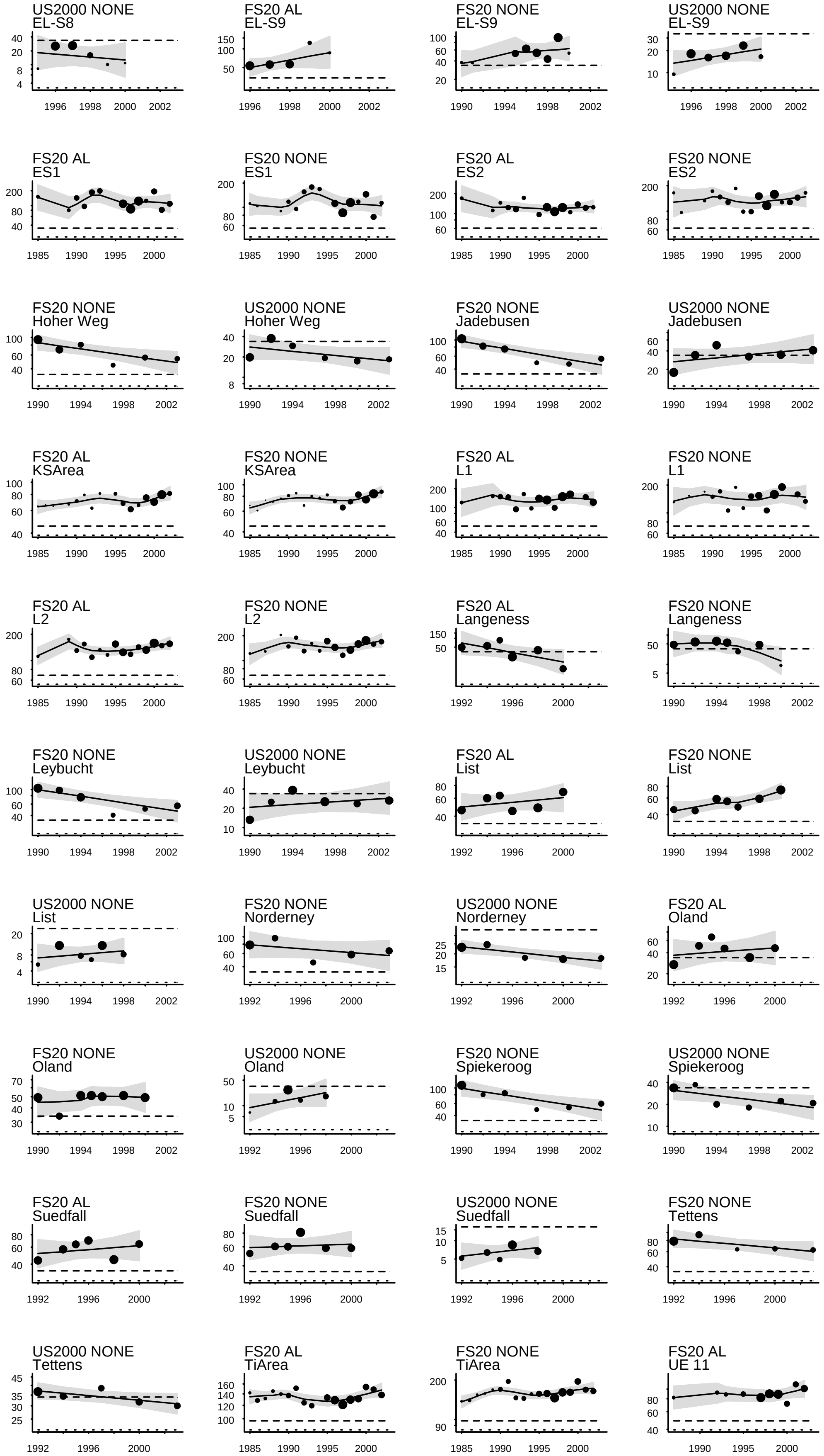
Lead mg/kg (continued)

region II Germany



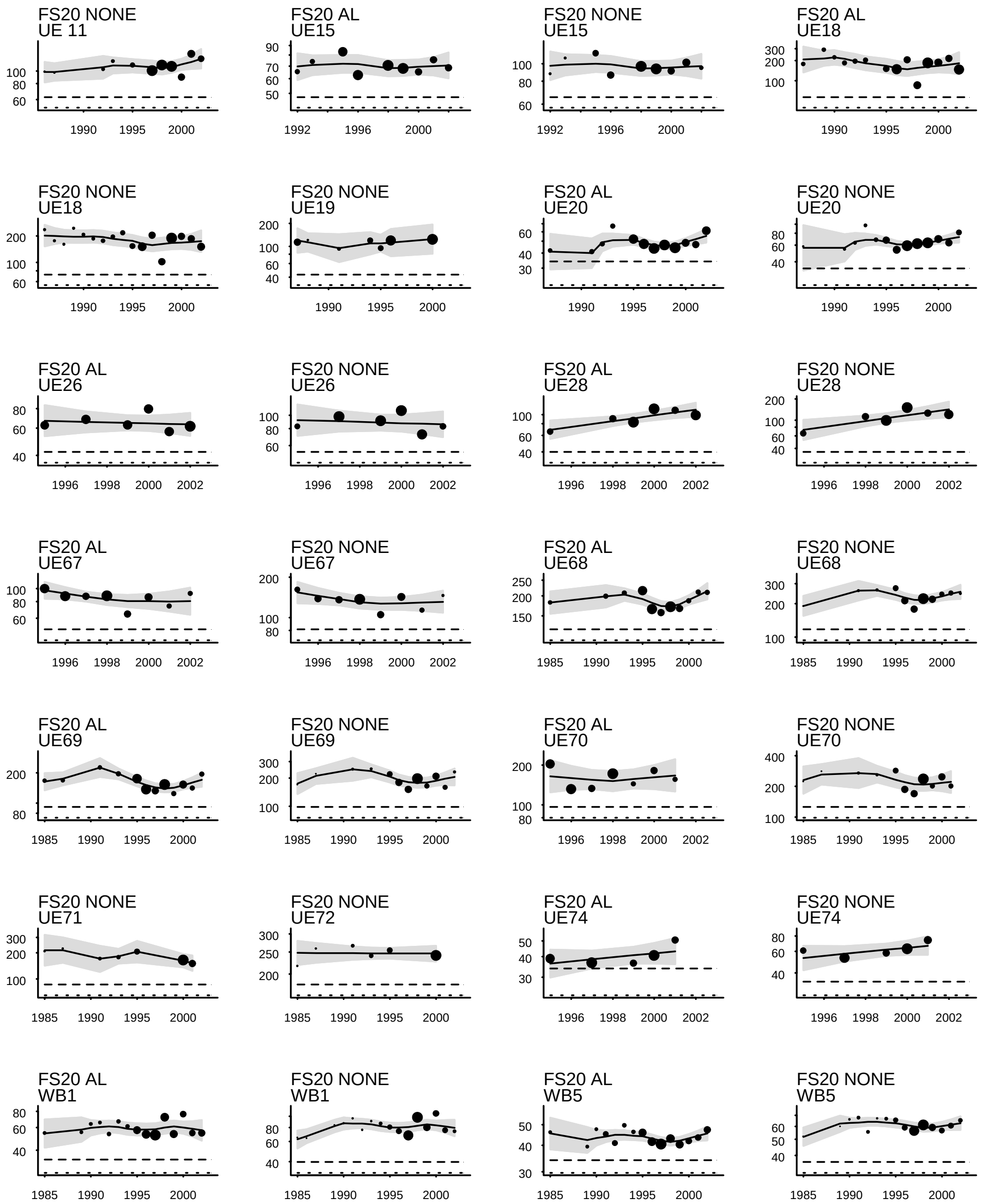
Lead mg/kg (continued)

region II Germany

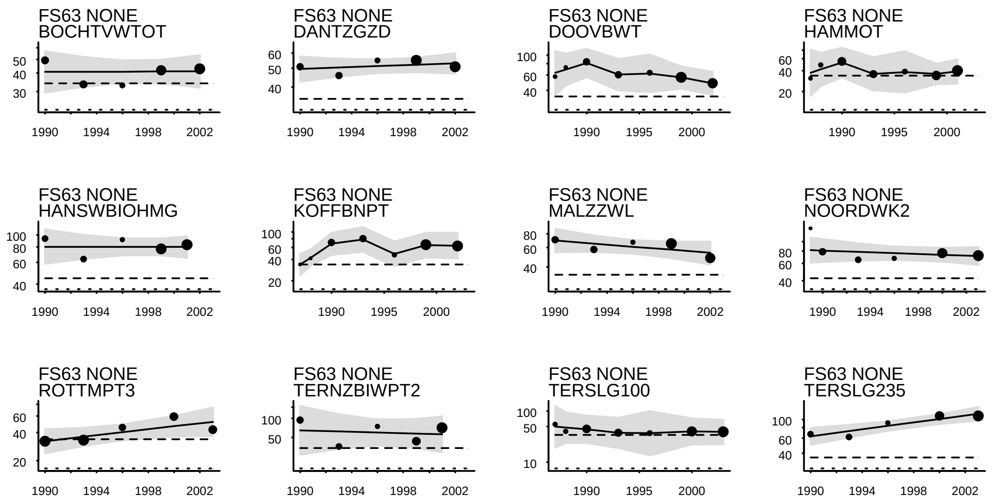


Lead mg/kg (continued)

region II Germany

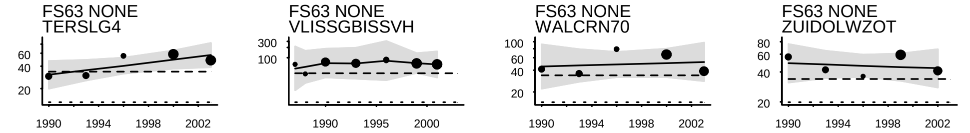


region II Netherlands

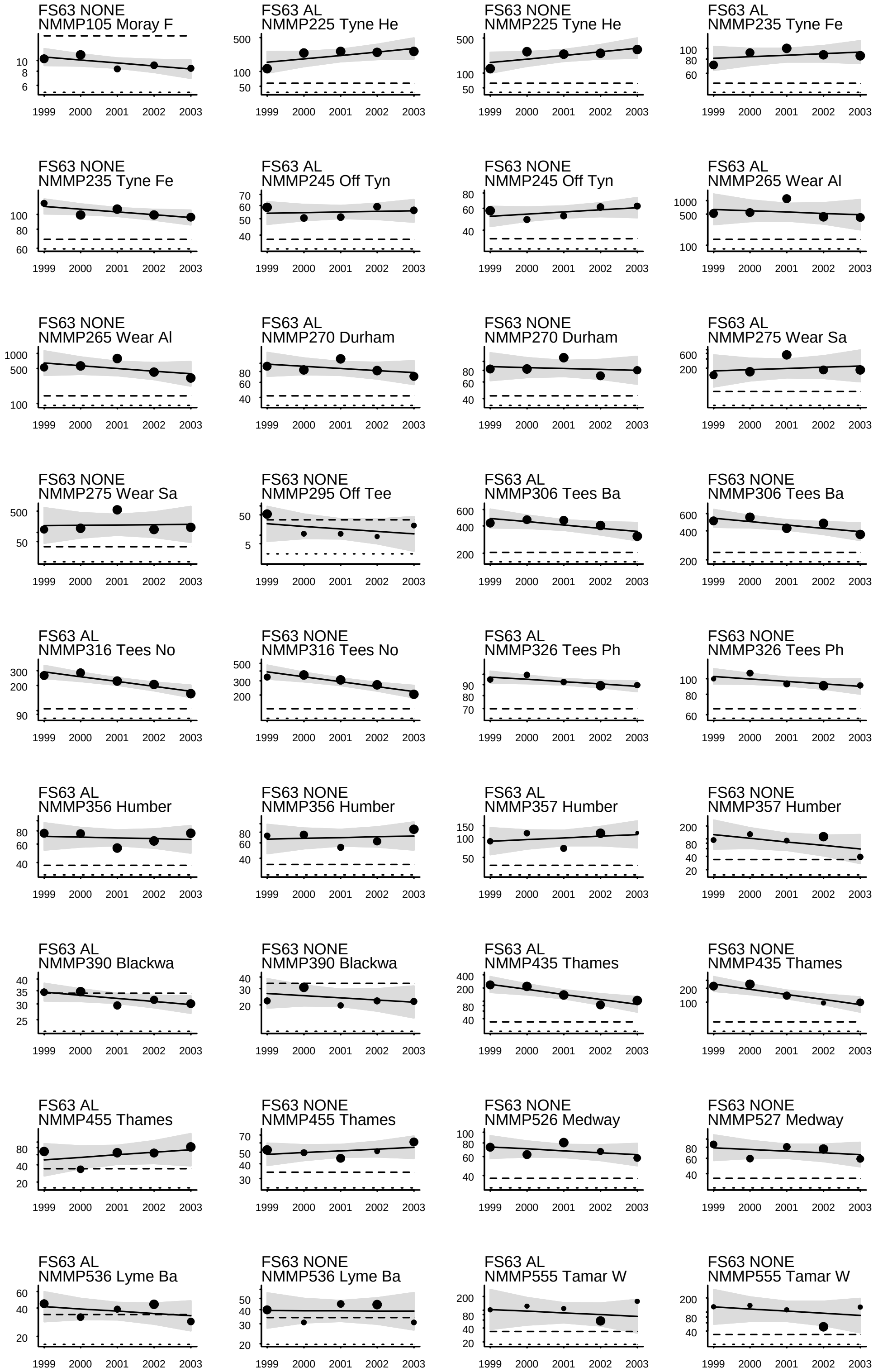


Lead mg/kg (continued)

region II Netherlands

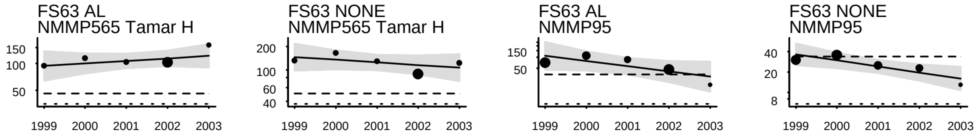


region II UK

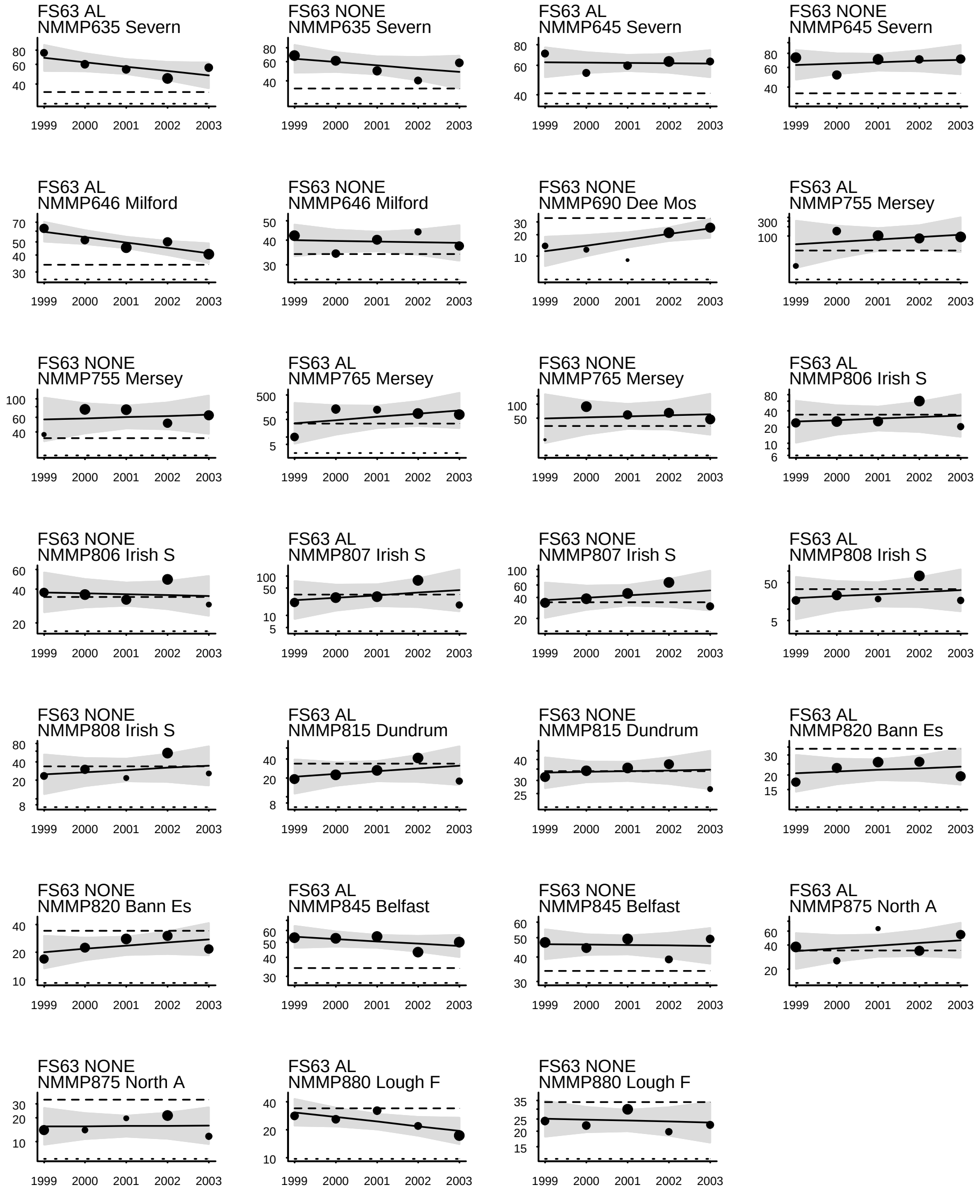


Lead mg/kg (continued)

region II UK

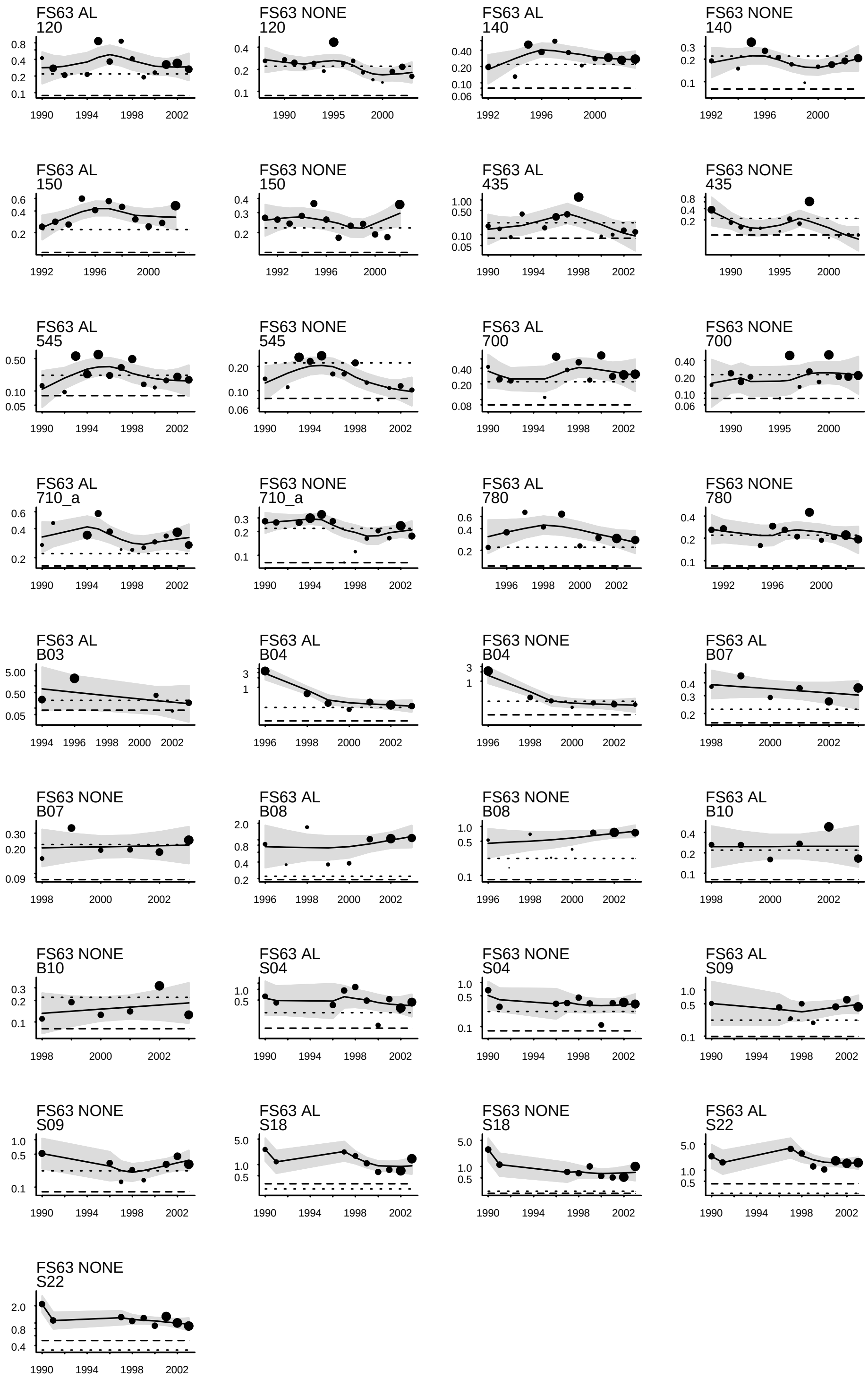


region III UK

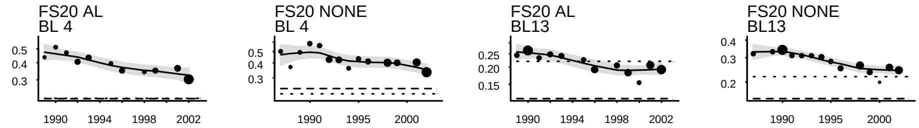


Mercury mg/kg

region II Belgium

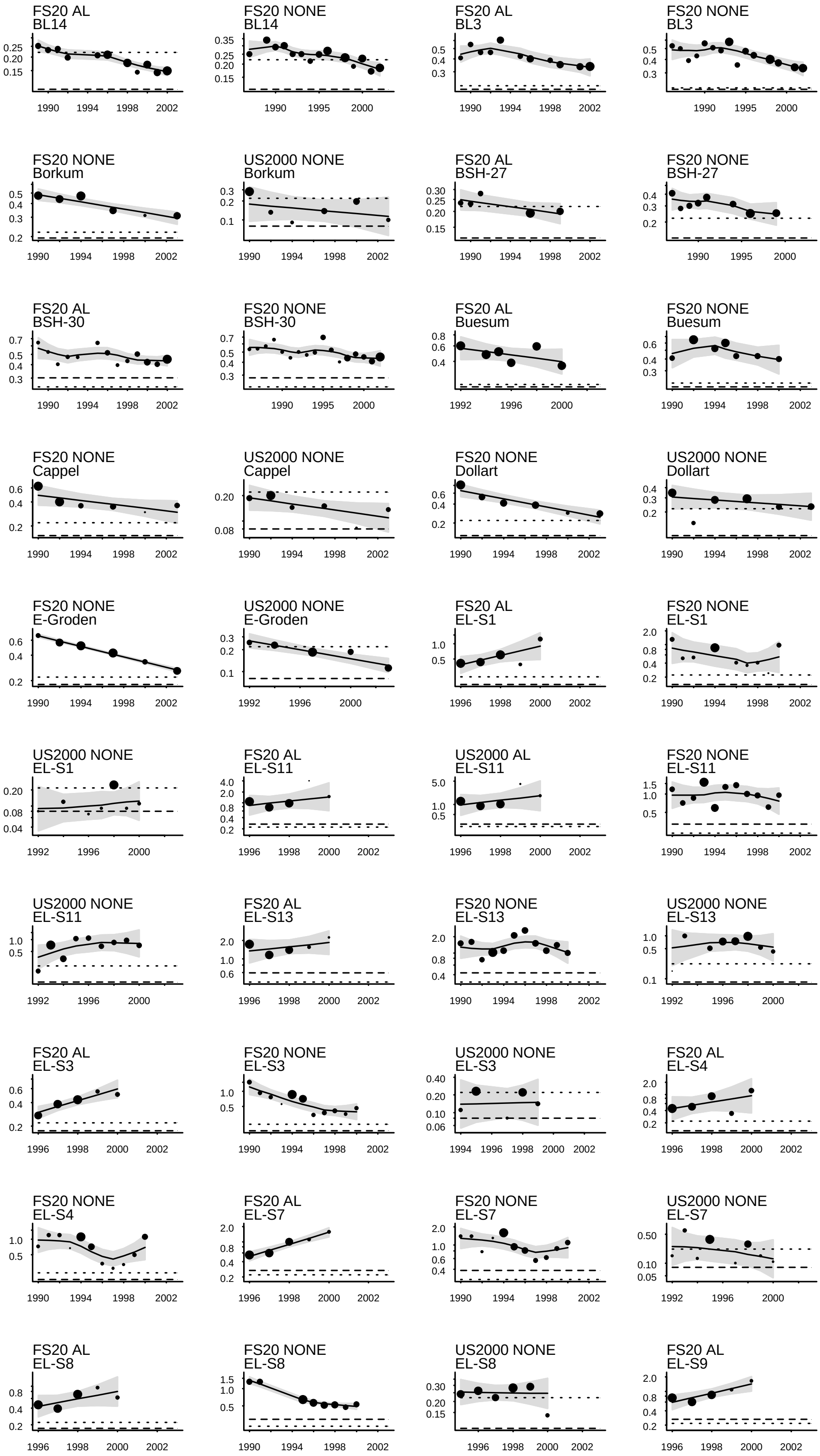


region II Germany



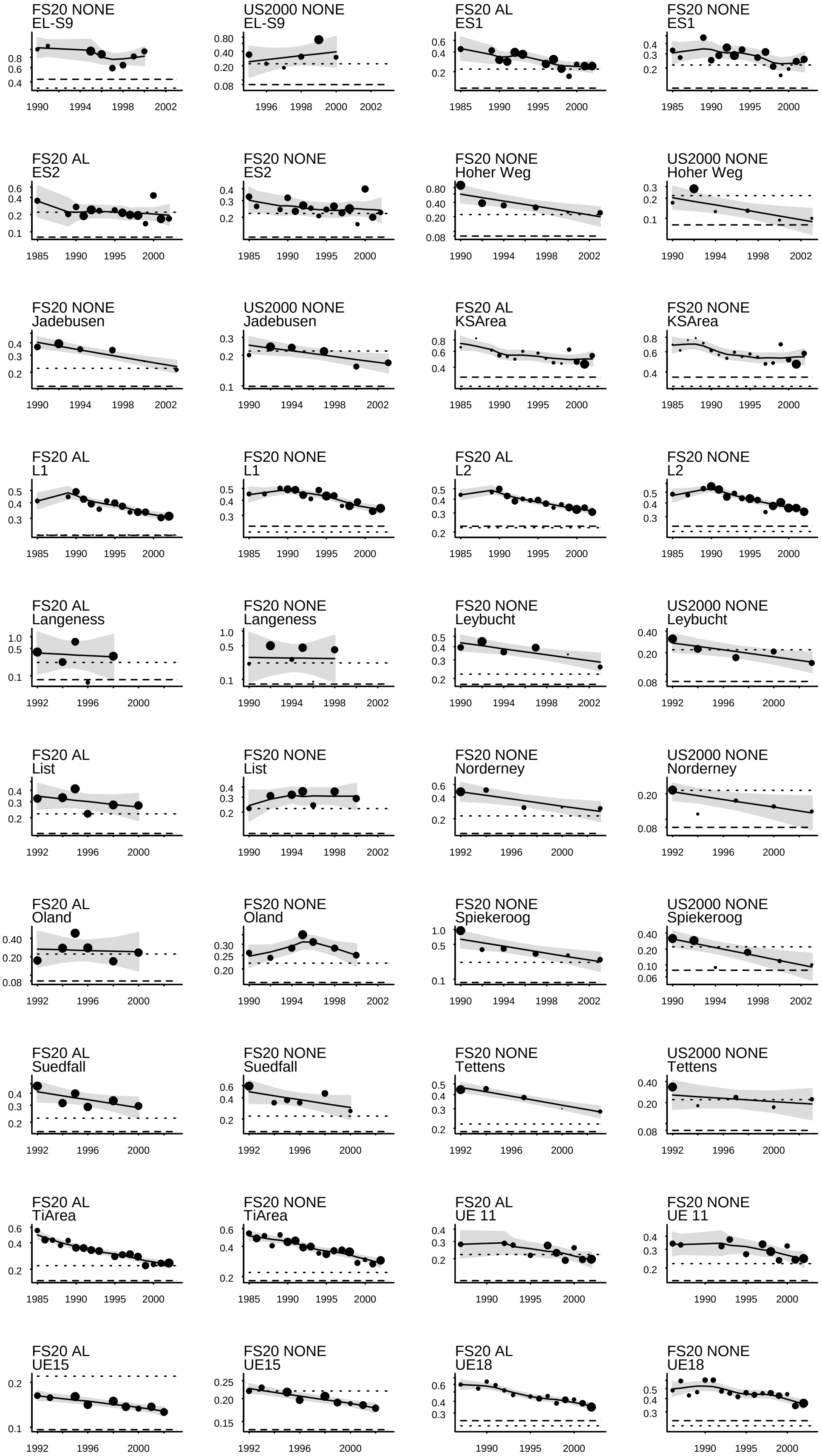
Mercury mg/kg (continued)

region II Germany



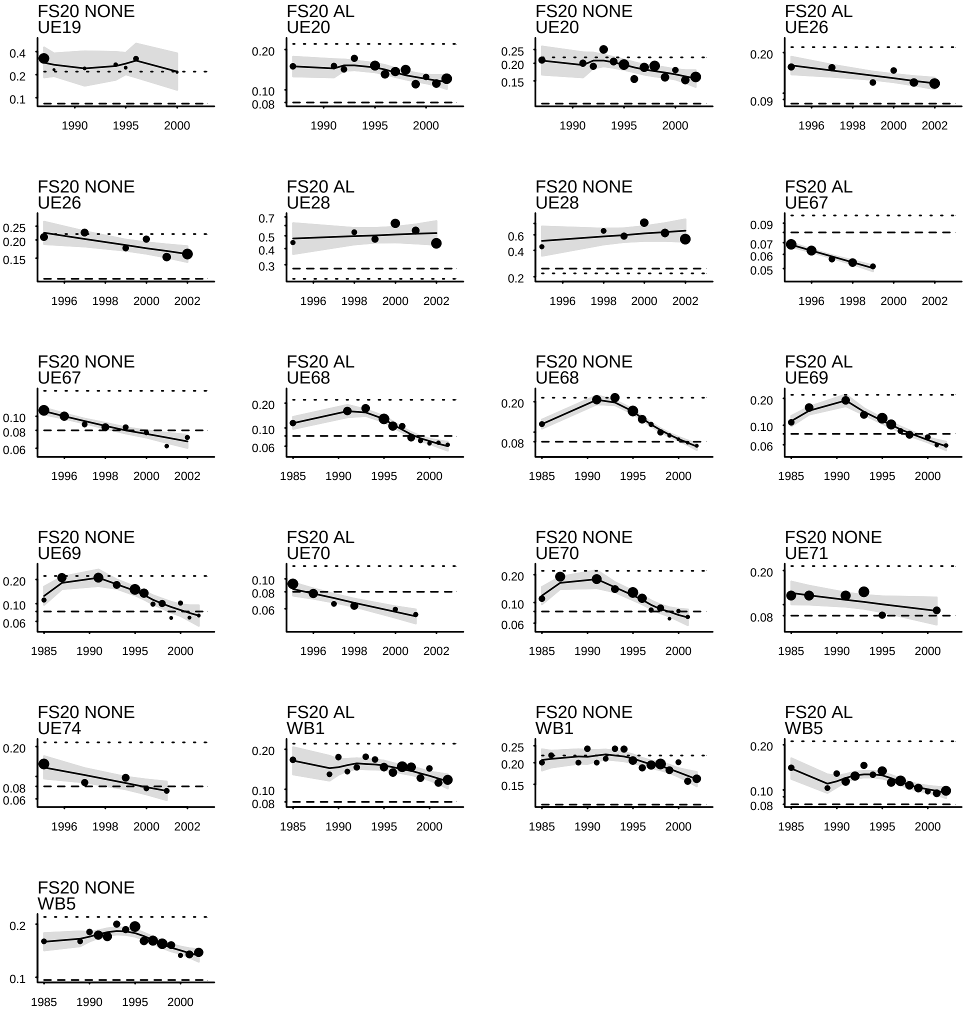
Mercury mg/kg (continued)

region II Germany

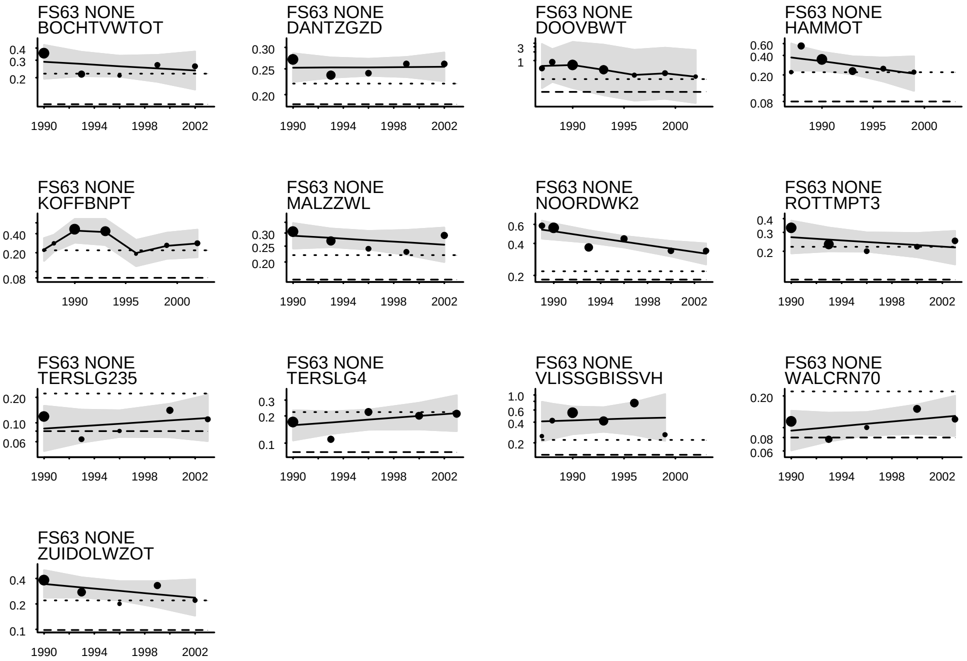


Mercury mg/kg (continued)

region II Germany

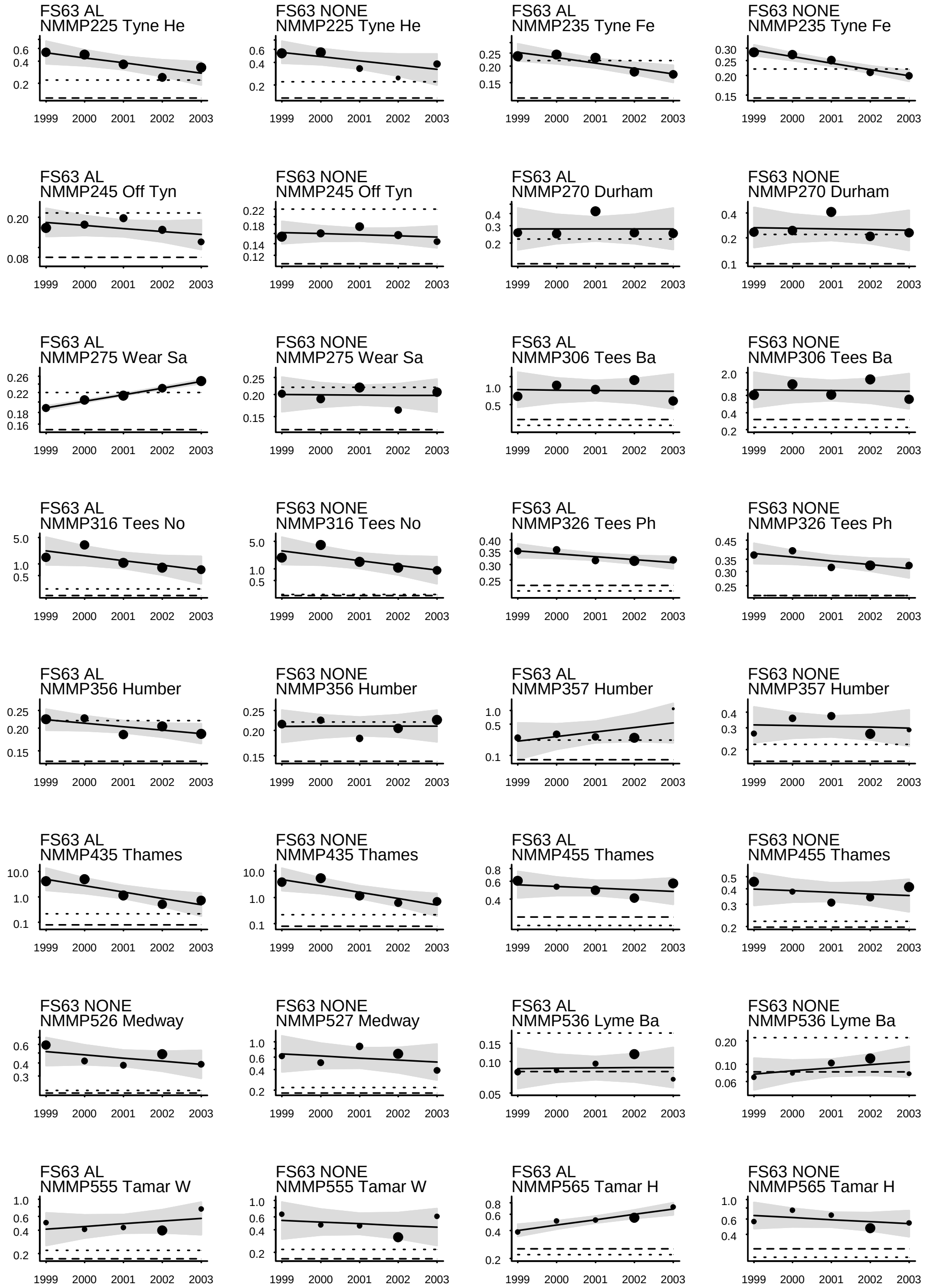


region II Netherlands

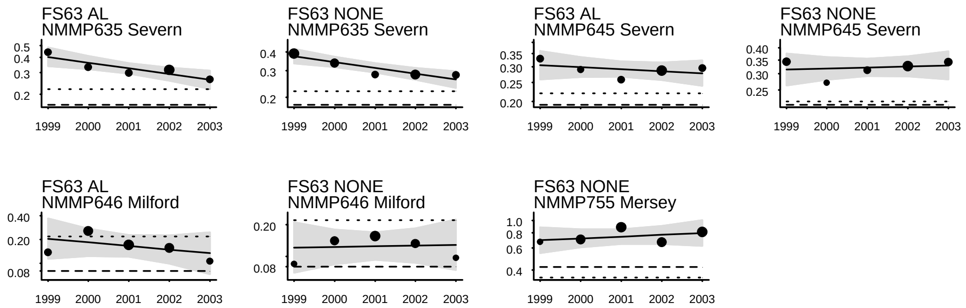


Mercury mg/kg (continued)

region II UK

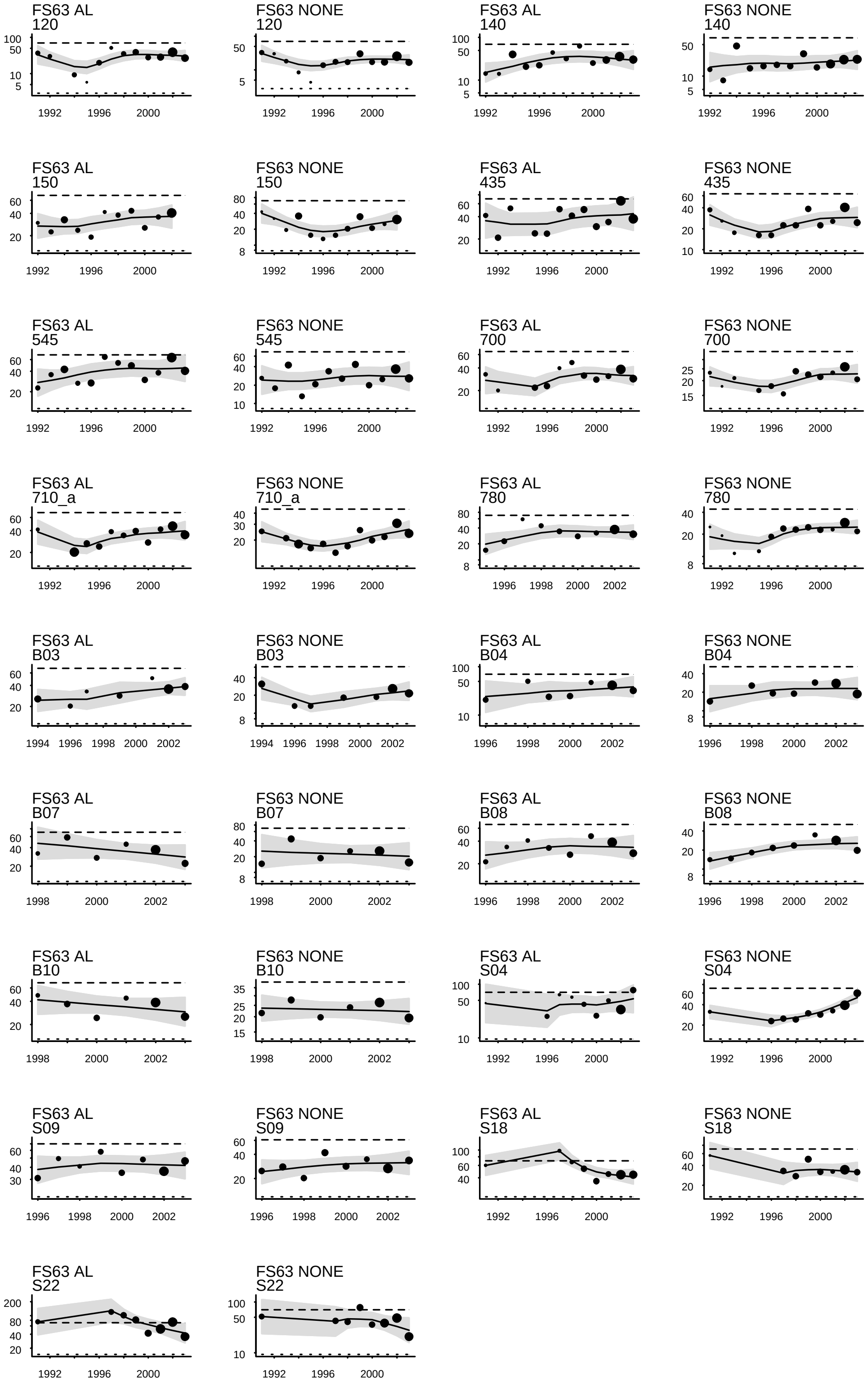


region III UK

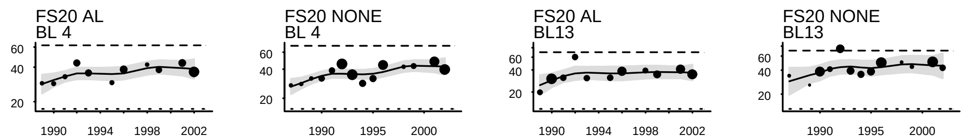


Nickel mg/kg

region II Belgium

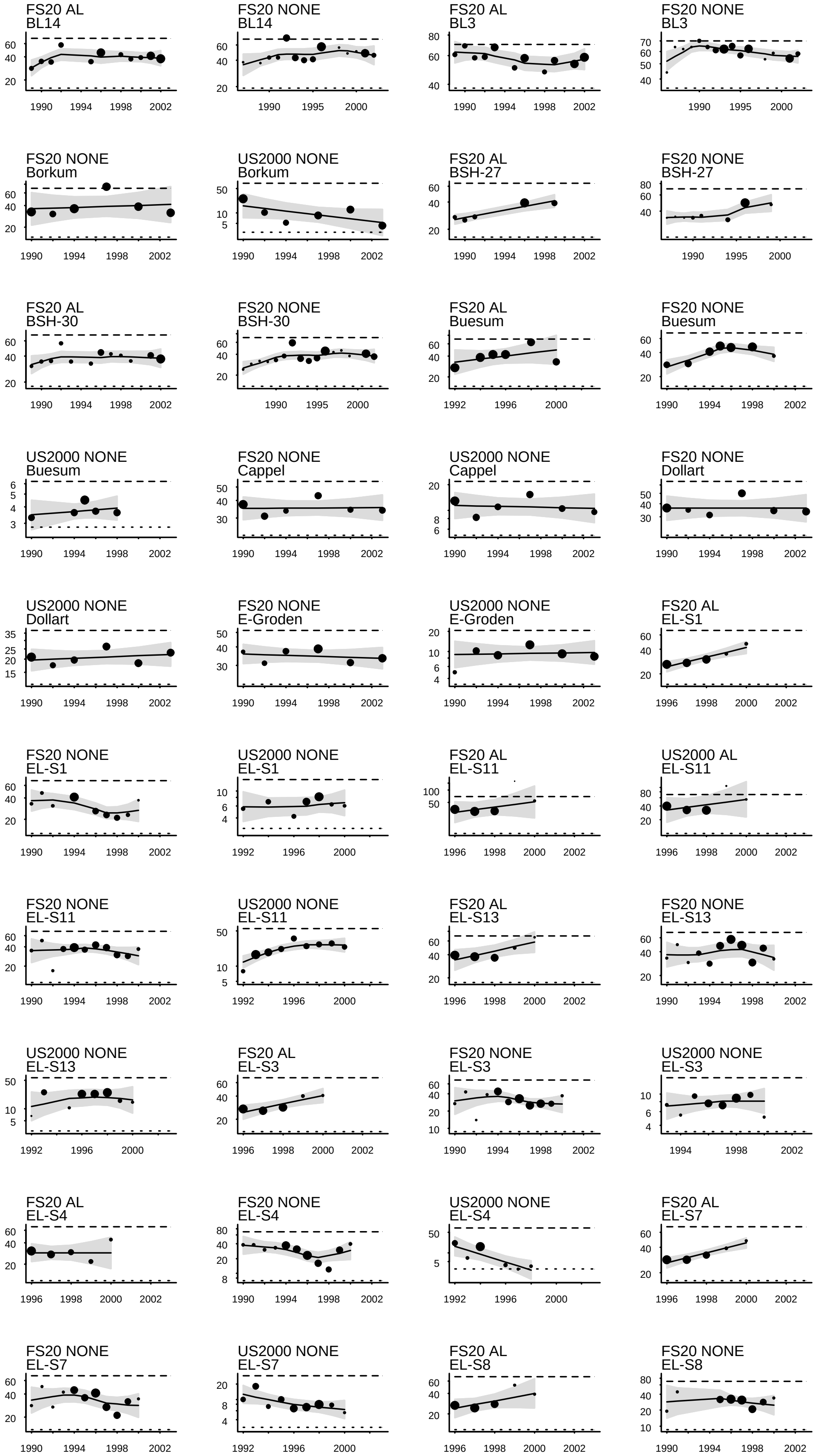


region II Germany



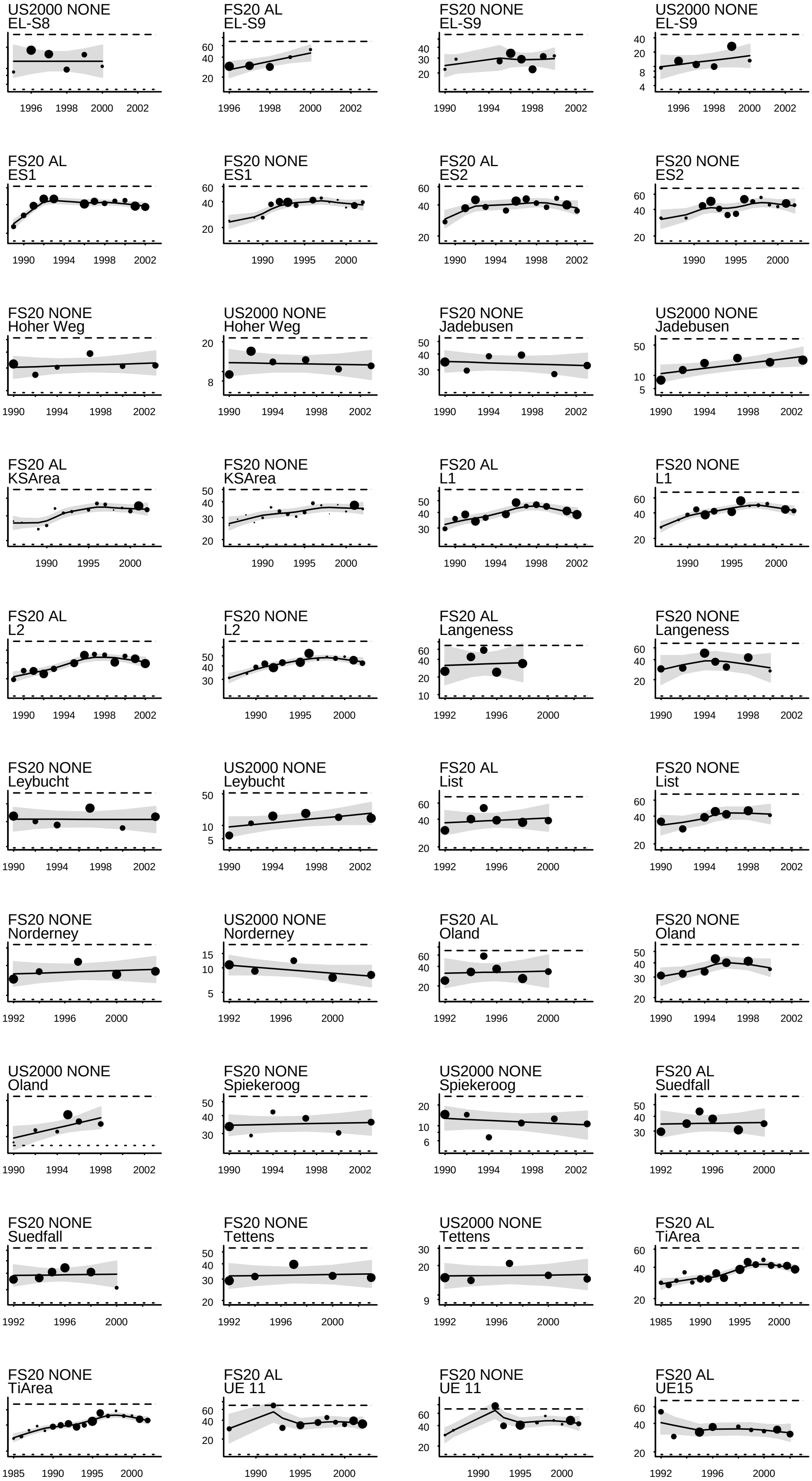
Nickel mg/kg (continued)

region II Germany



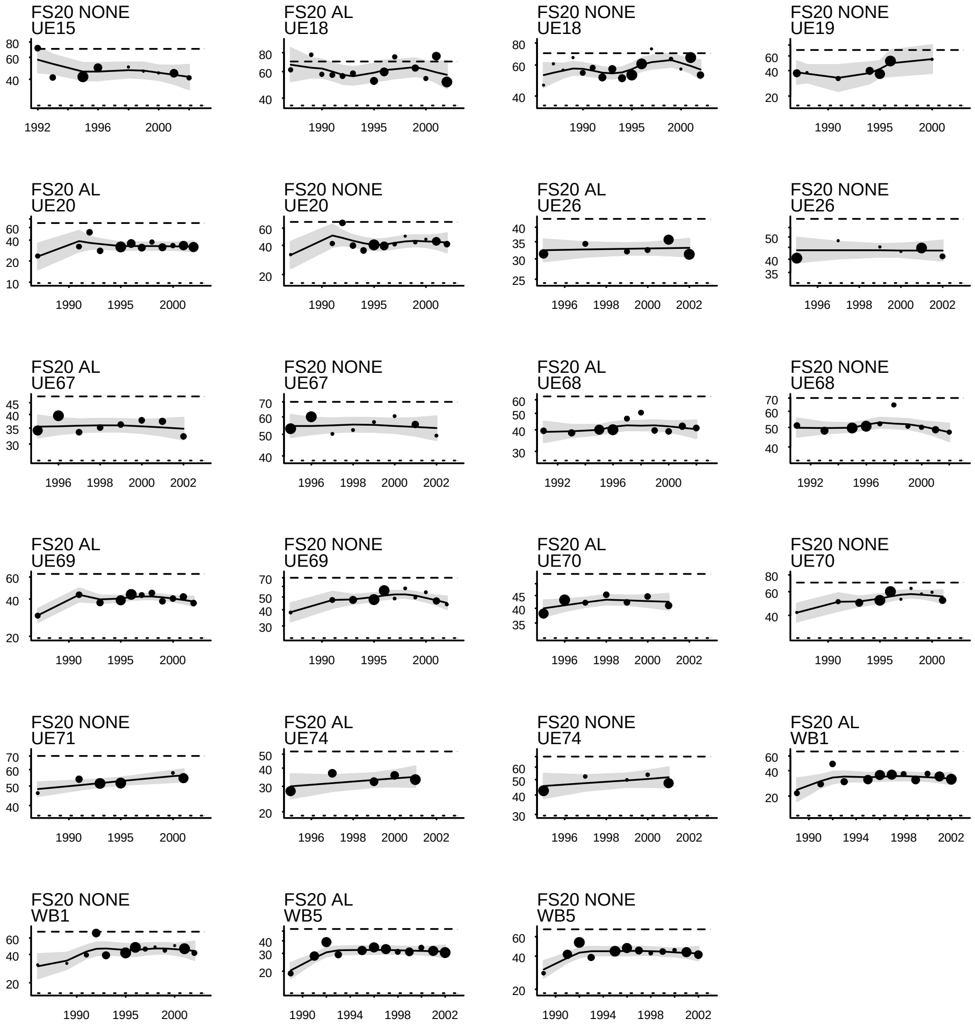
Nickel mg/kg (continued)

region II Germany

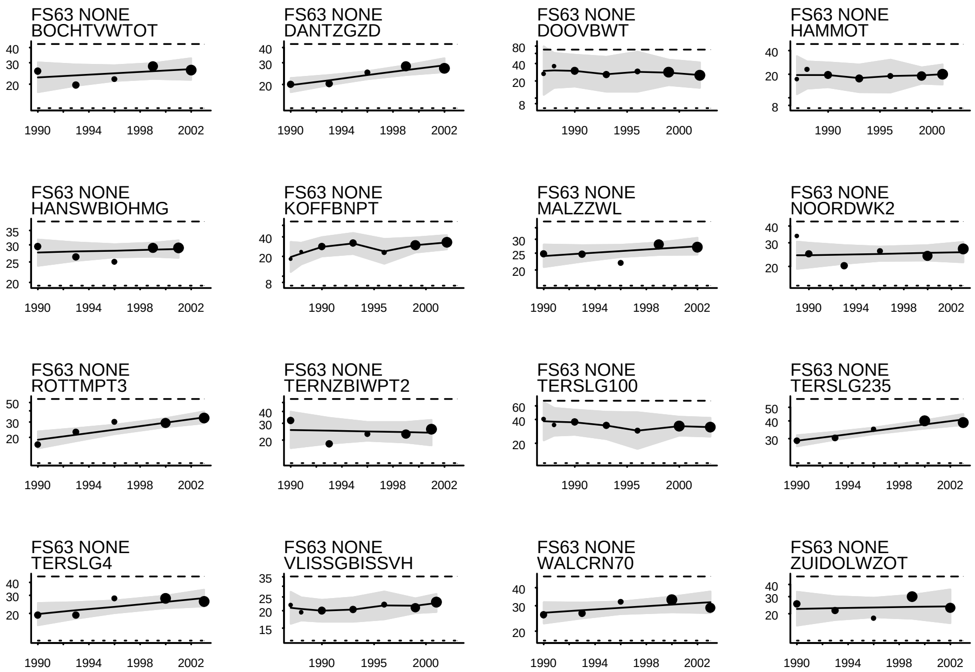


Nickel mg/kg (continued)

region II Germany

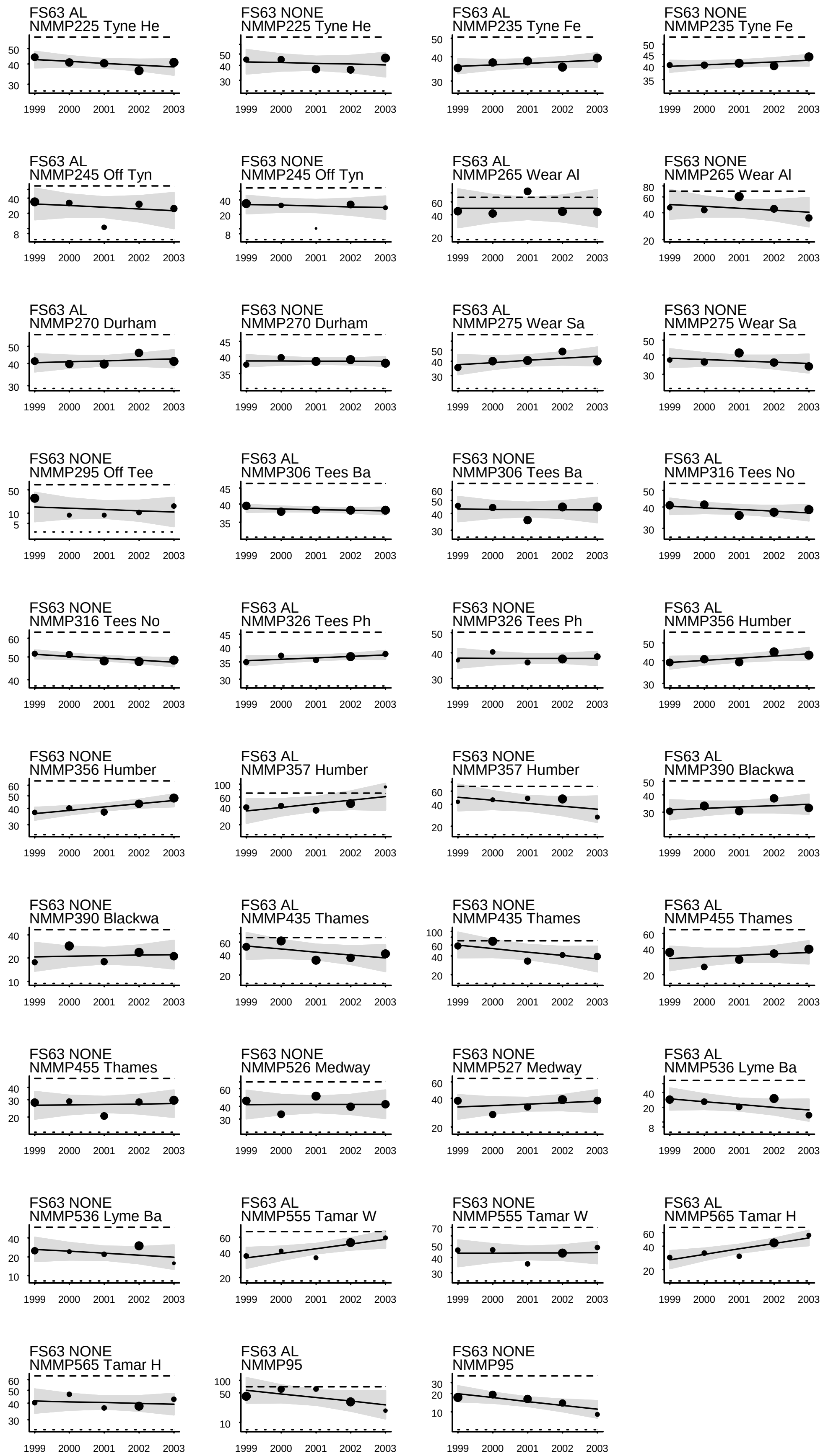


region II Netherlands



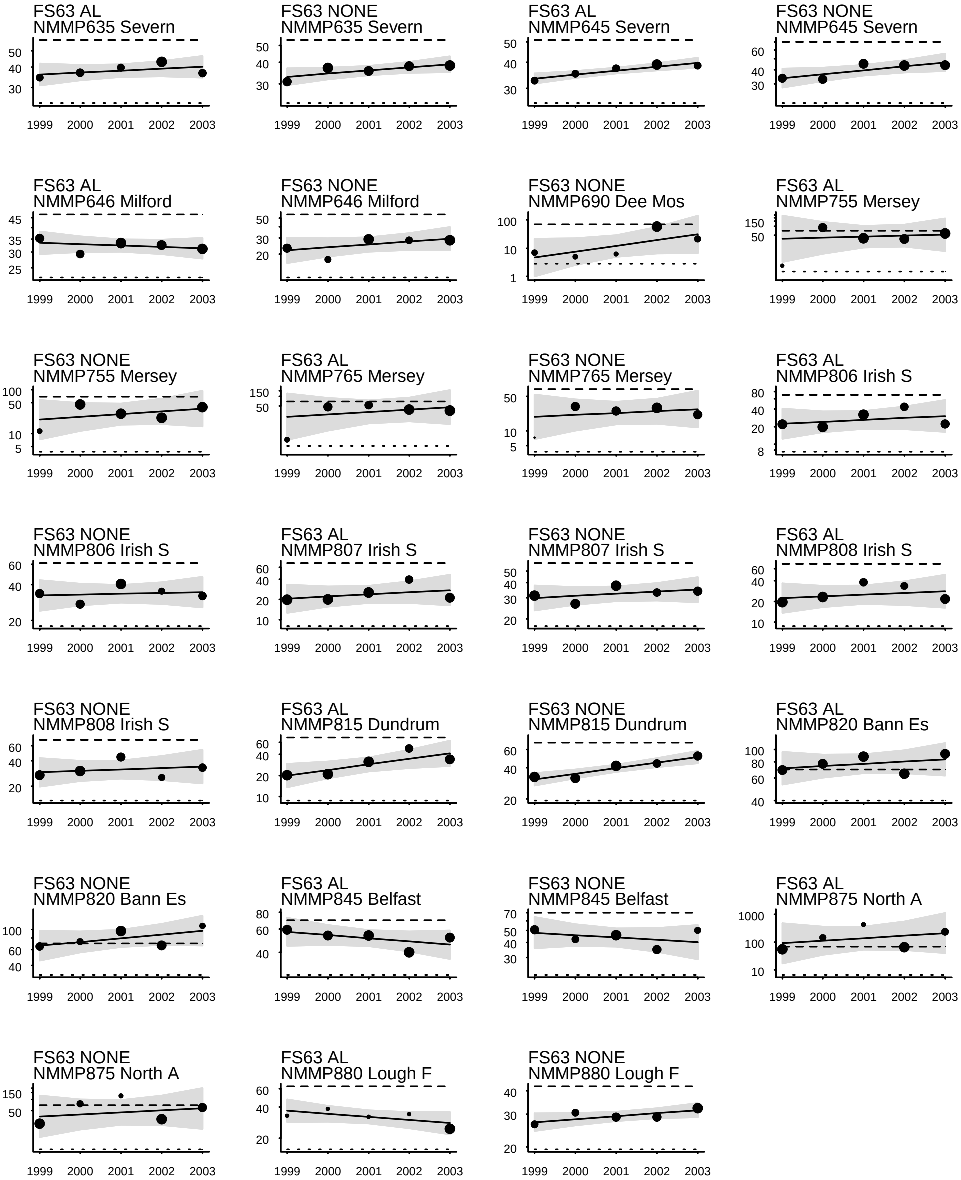
Nickel mg/kg (continued)

region II UK



Nickel mg/kg (continued)

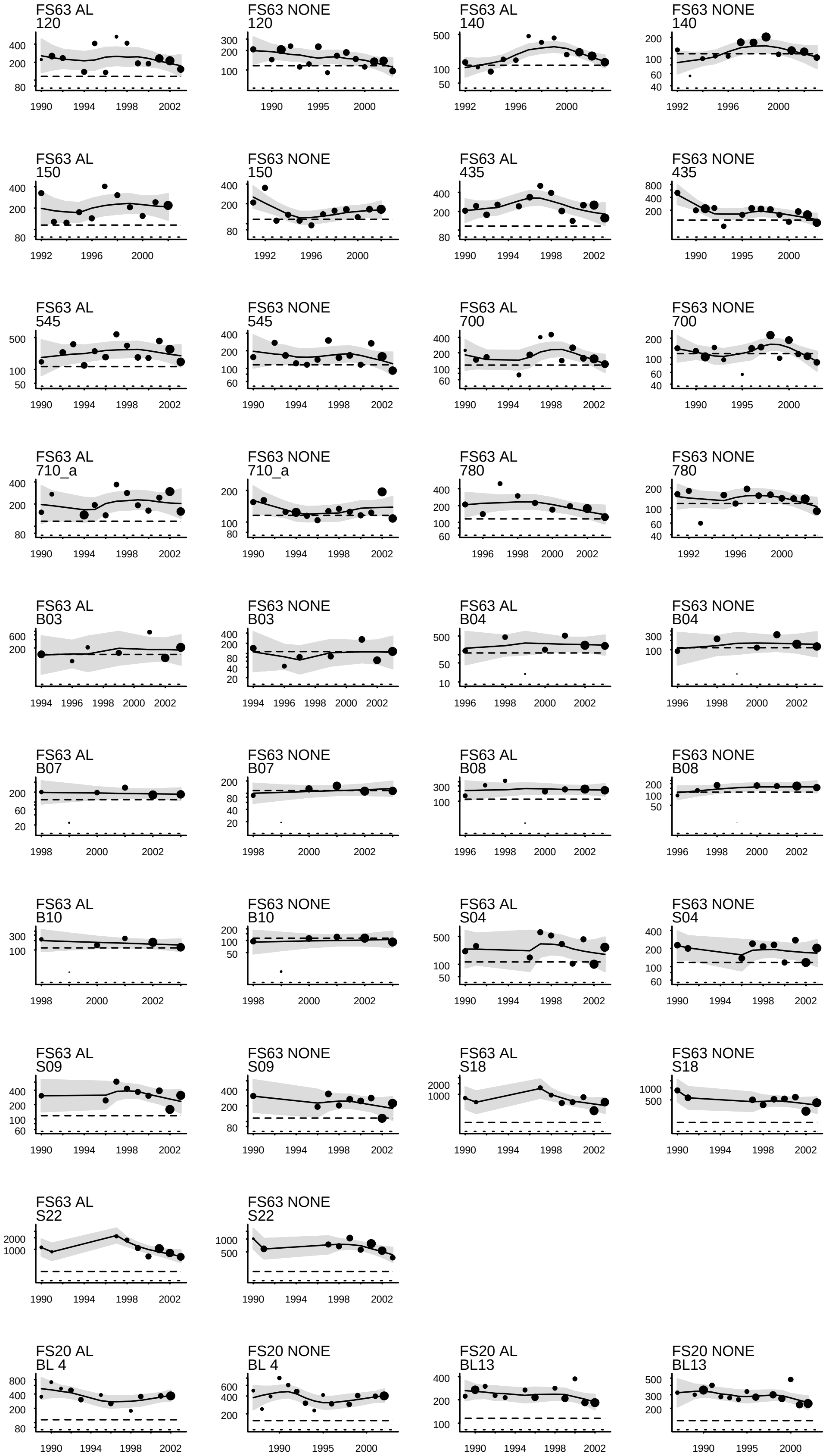
region III UK



Zinc mg/kg

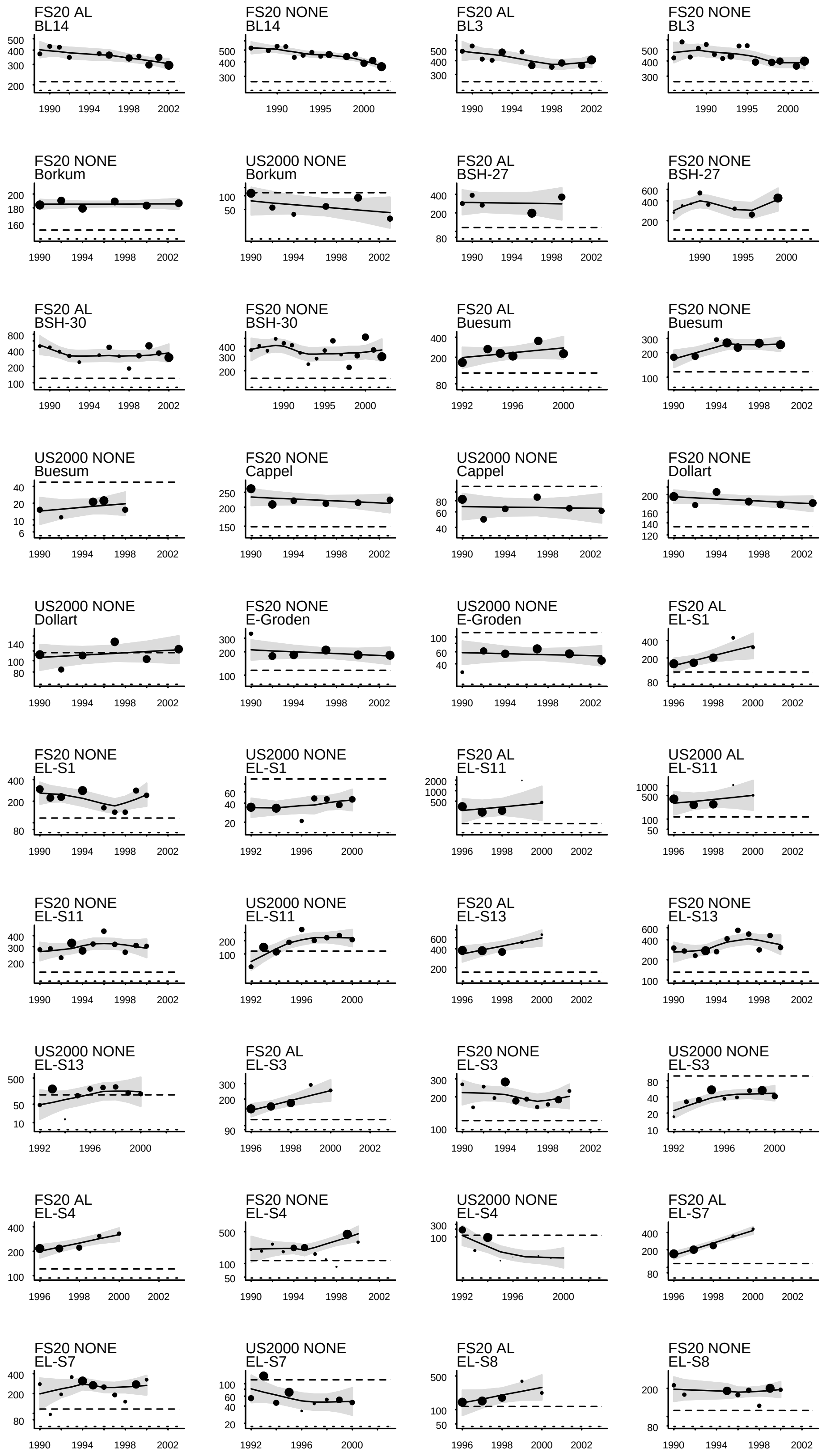
region II Belgium

region II Germany



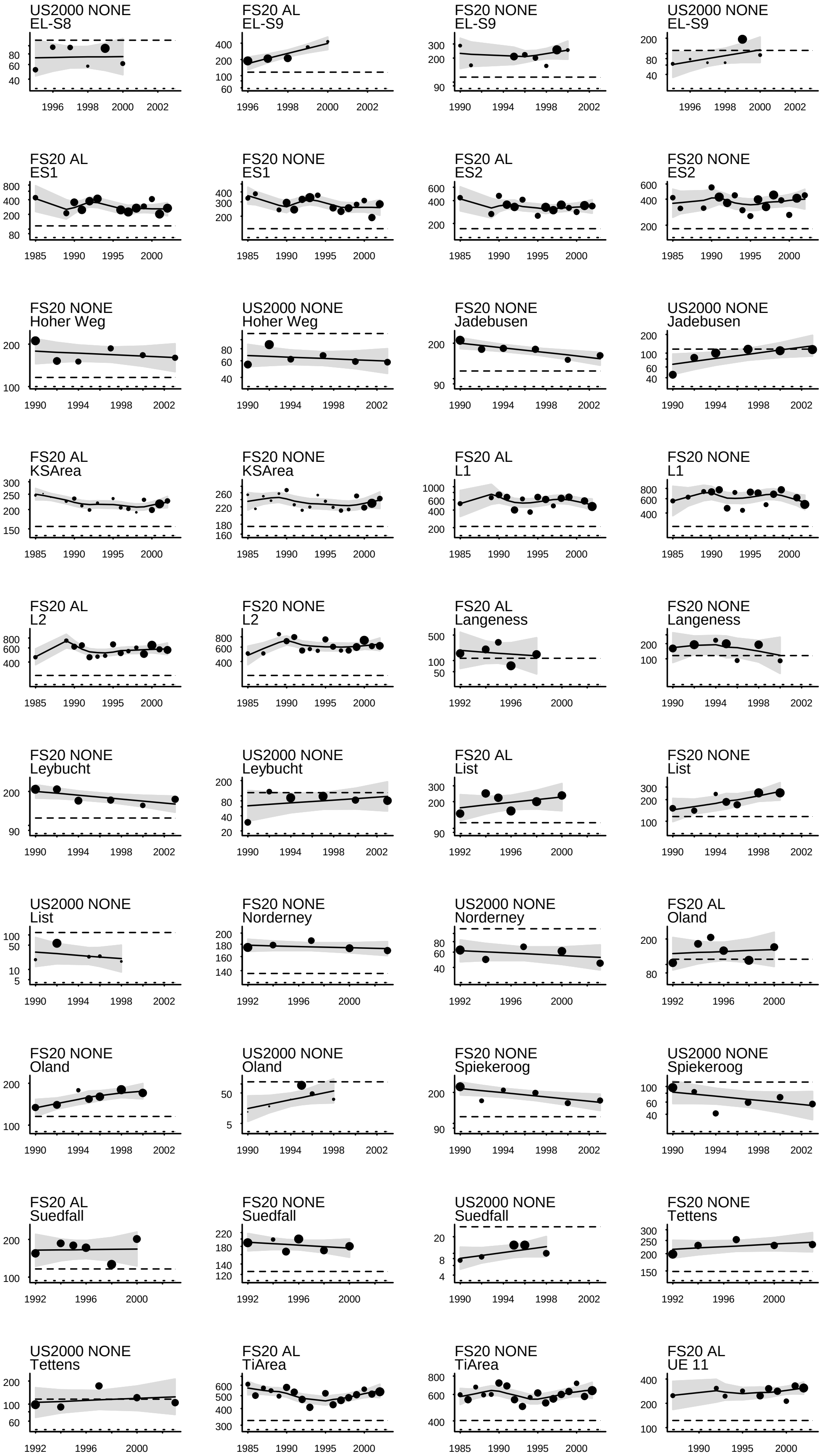
Zinc mg/kg (continued)

region II Germany



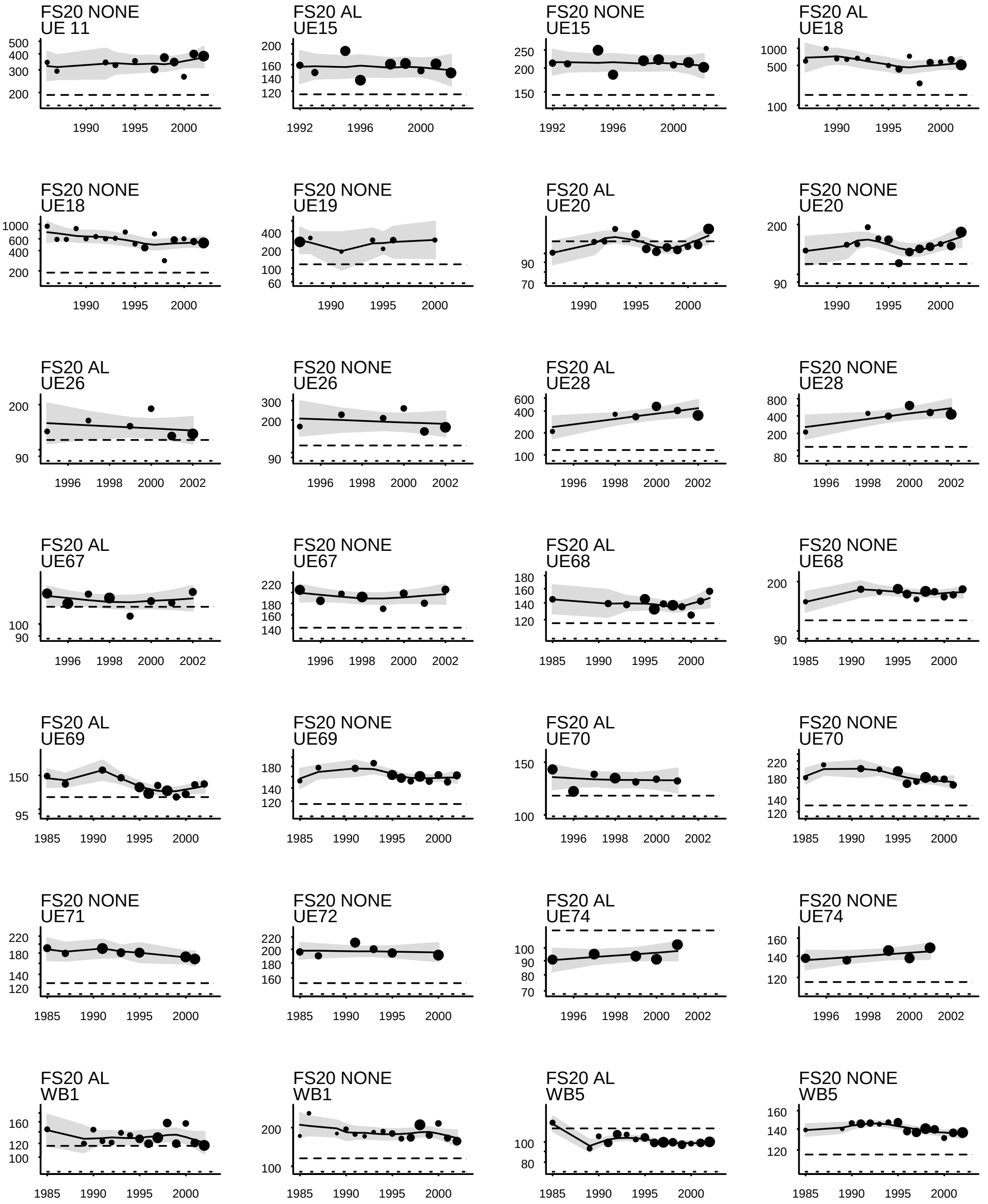
Zinc mg/kg (continued)

region II Germany

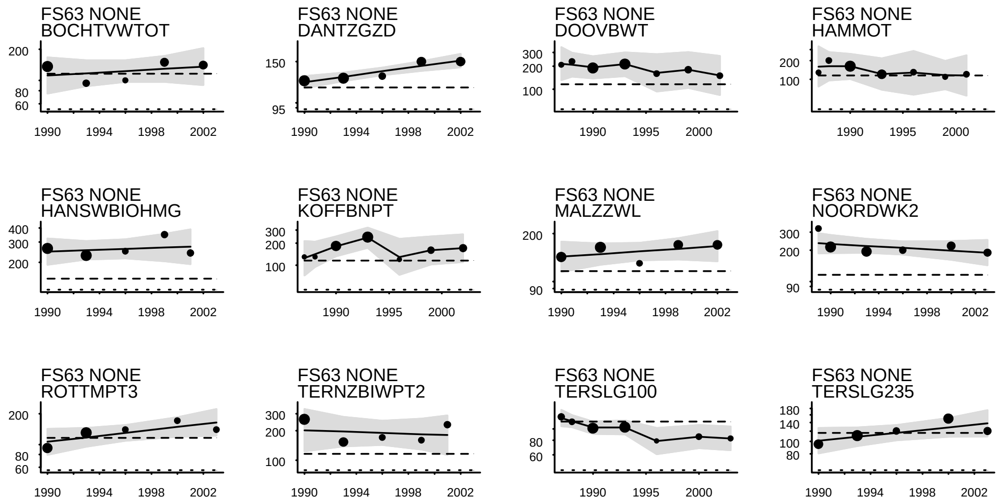


Zinc mg/kg (continued)

region II Germany



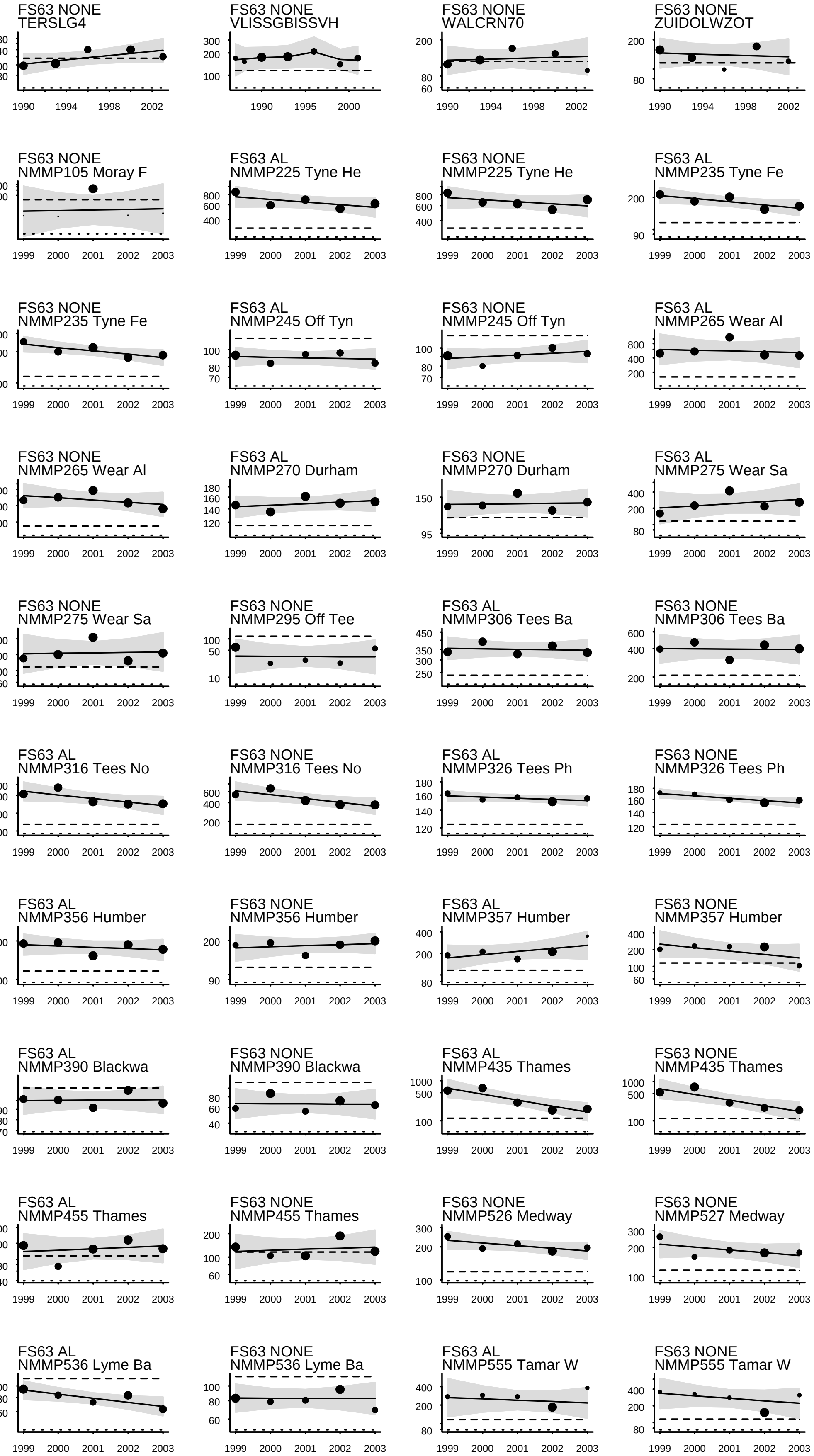
region II Netherlands



Zinc mg/kg (continued)

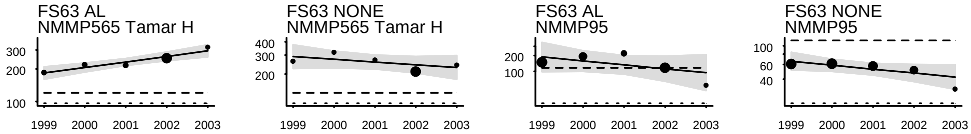
region II Netherlands

region II UK

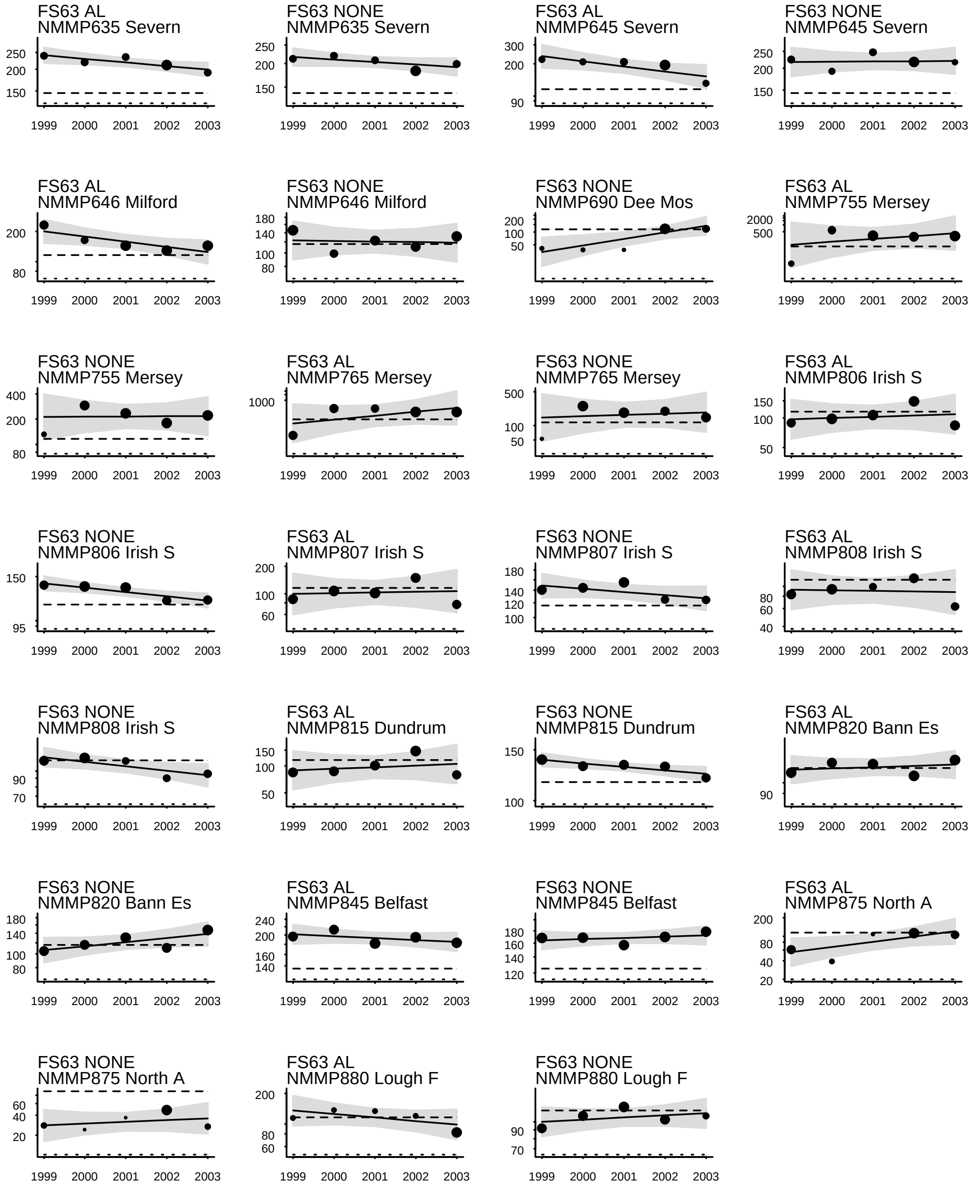


Zinc mg/kg (continued)

region II UK

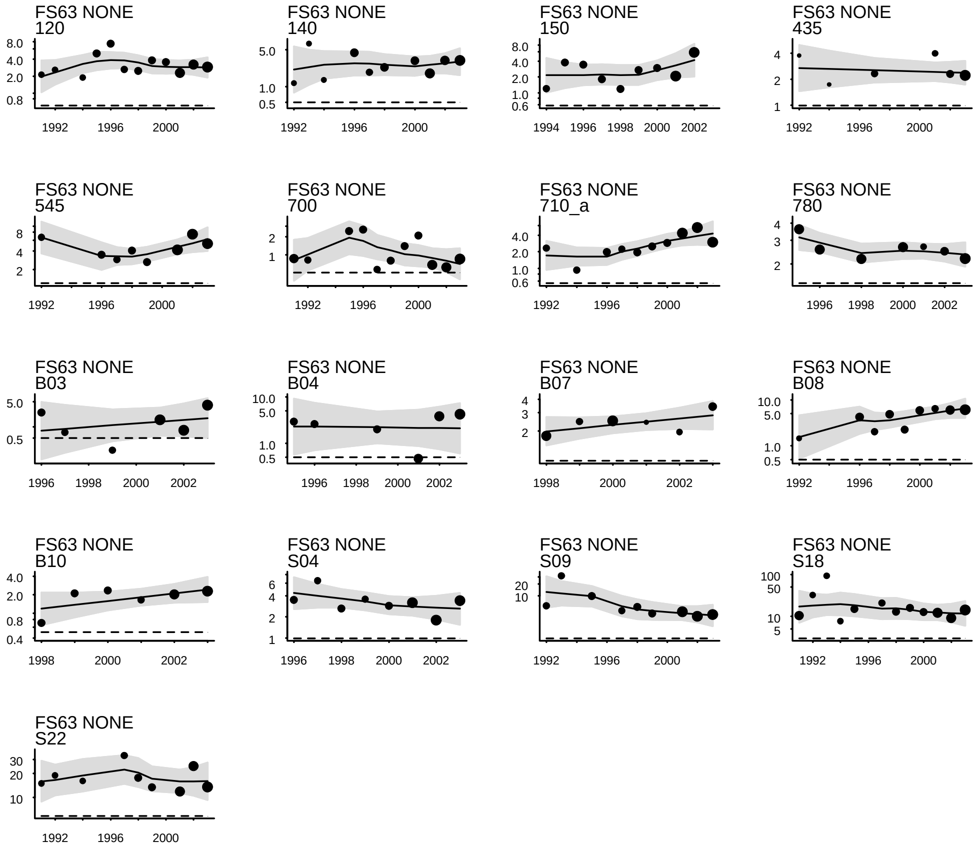


region III UK

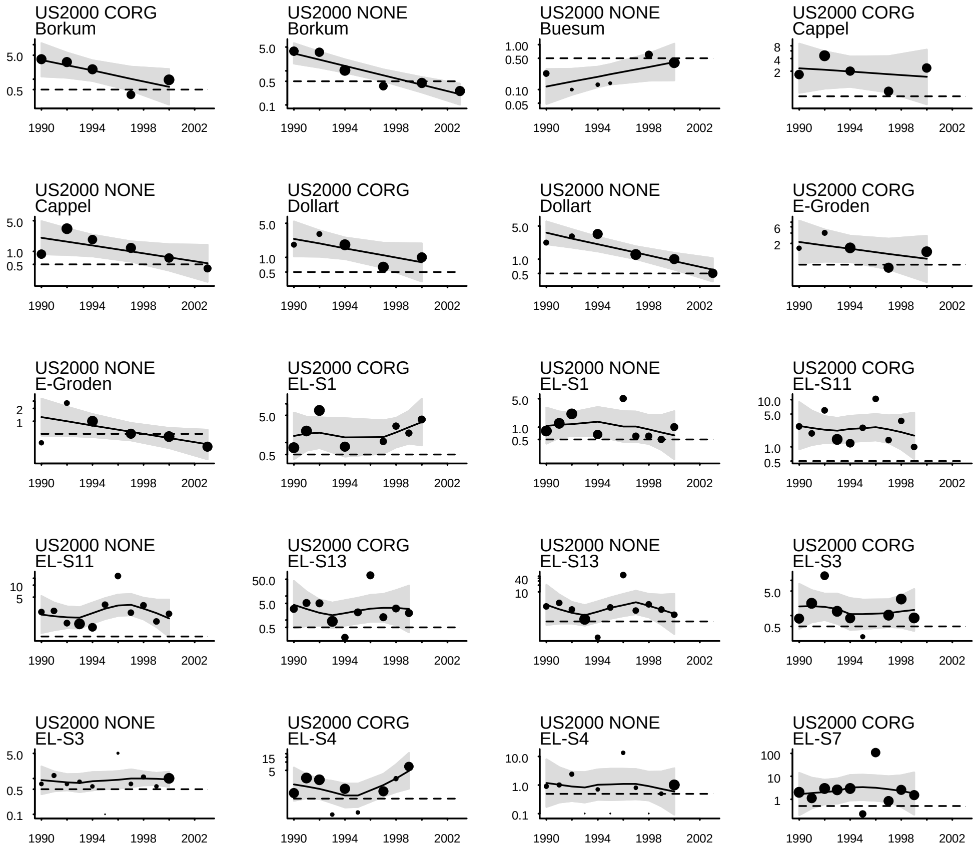


CB153 ug/kg

region II Belgium

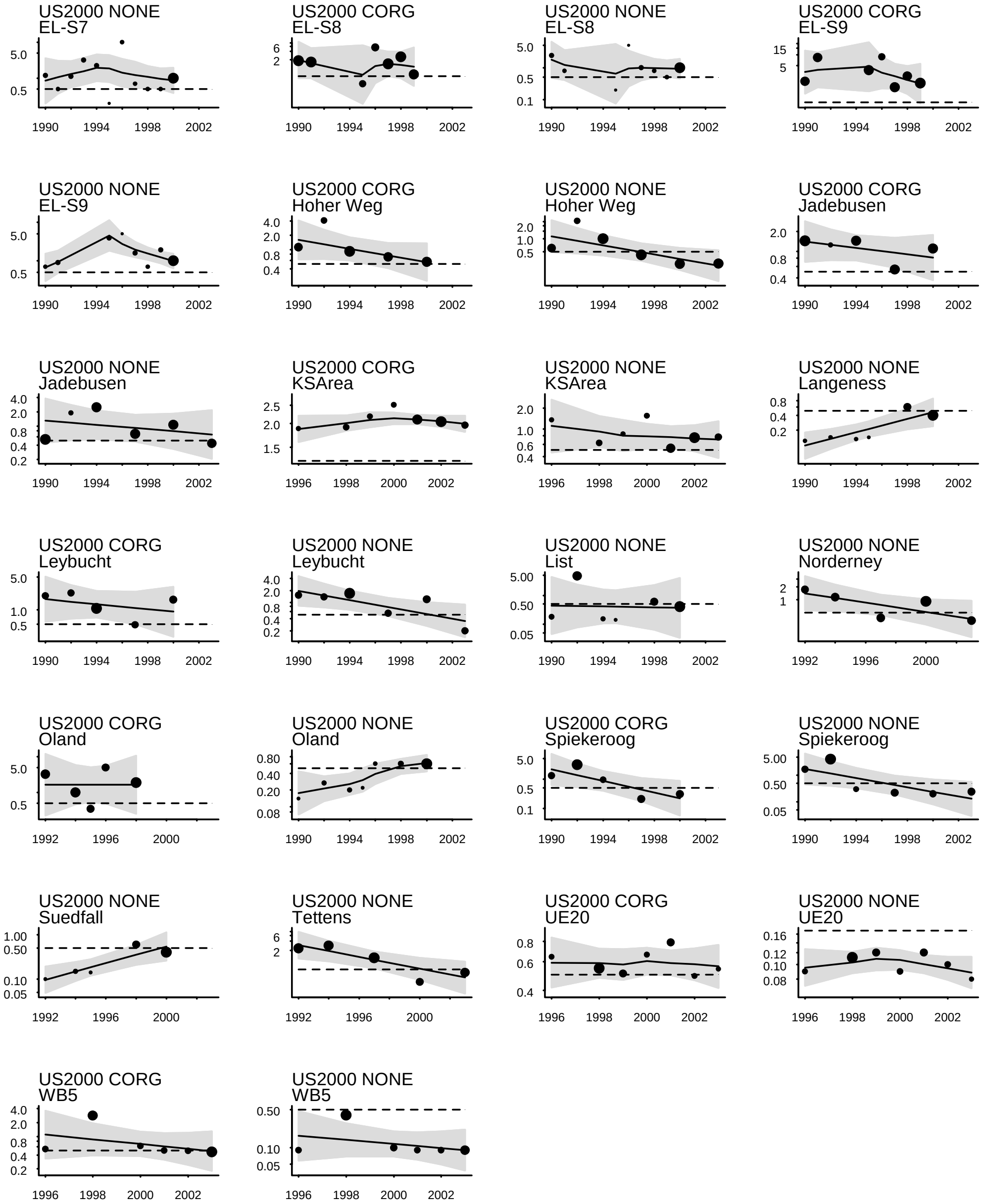


region II Germany

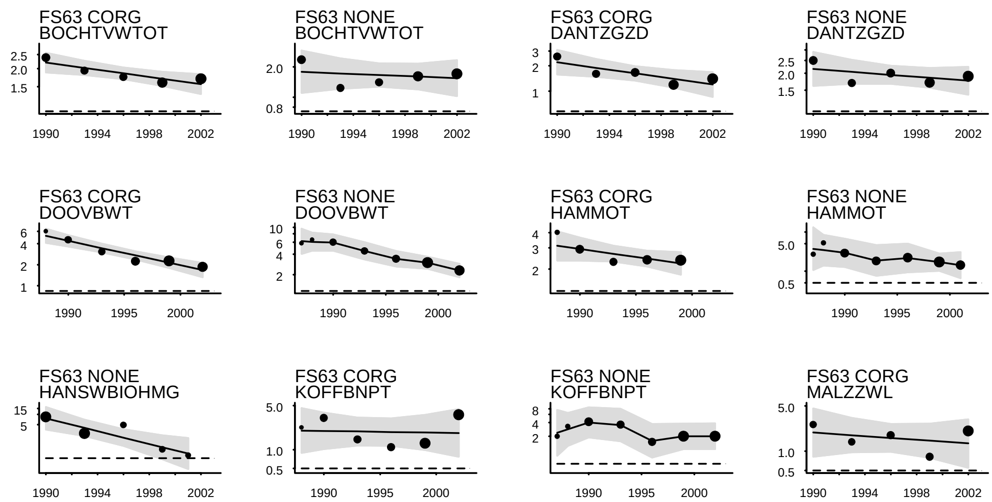


CB153 ug/kg (continued)

region II Germany

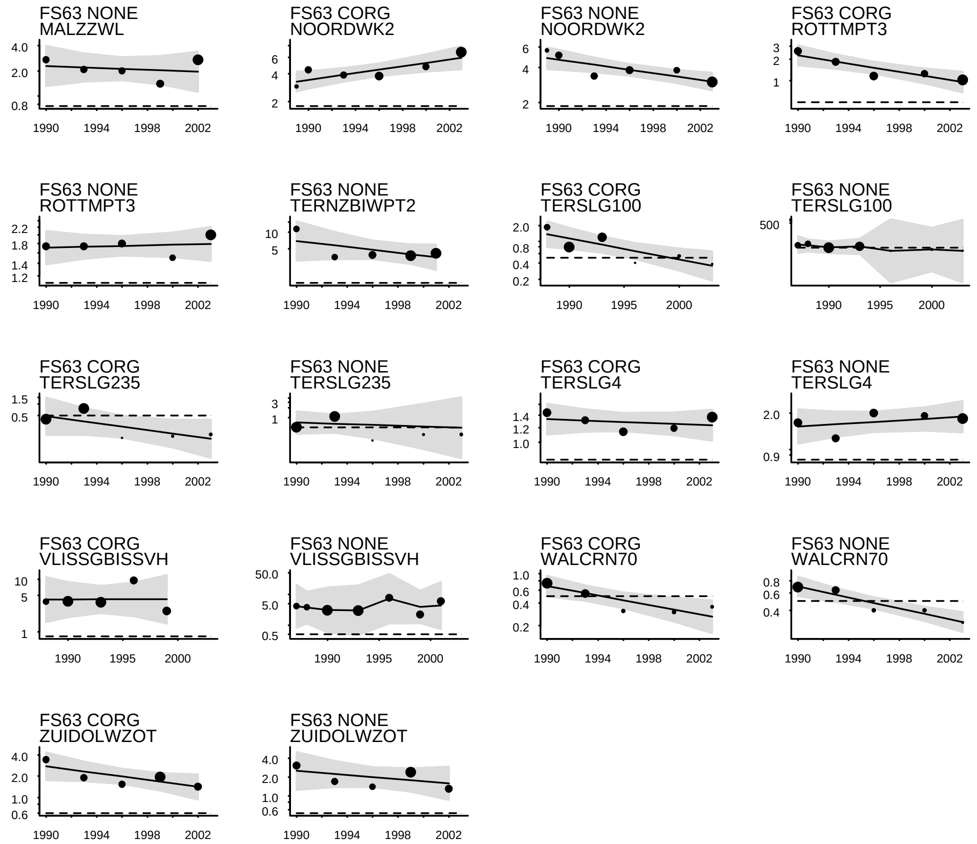


region II Netherlands

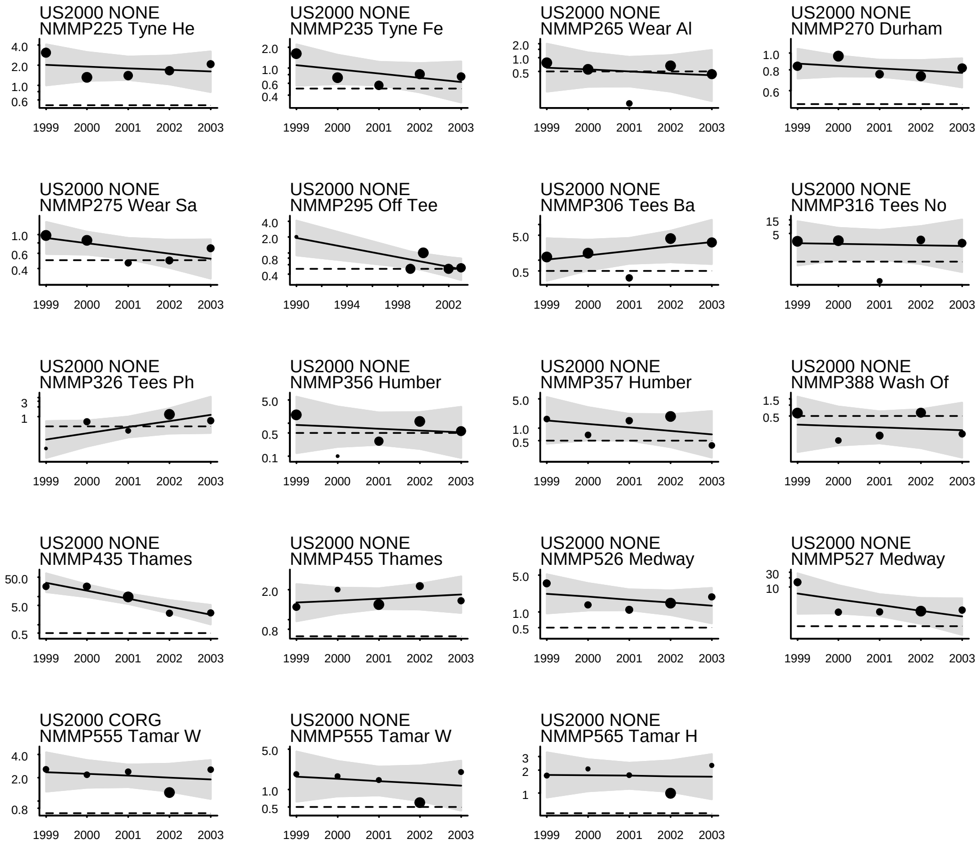


CB153 ug/kg (continued)

region II Netherlands

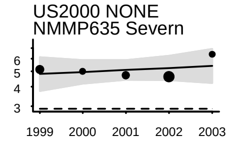


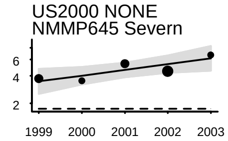
region II UK

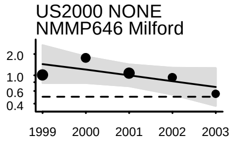


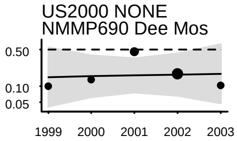
CB153 ug/kg (continued)

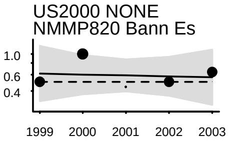
region III UK

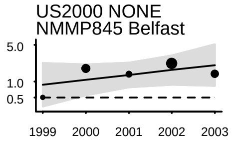


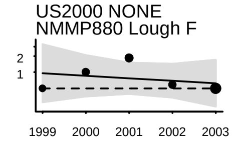






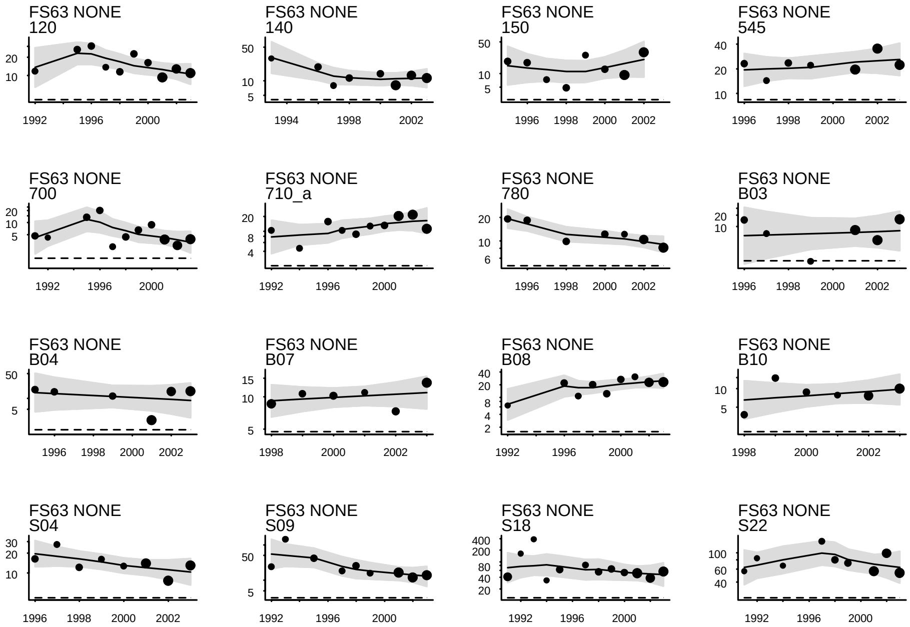




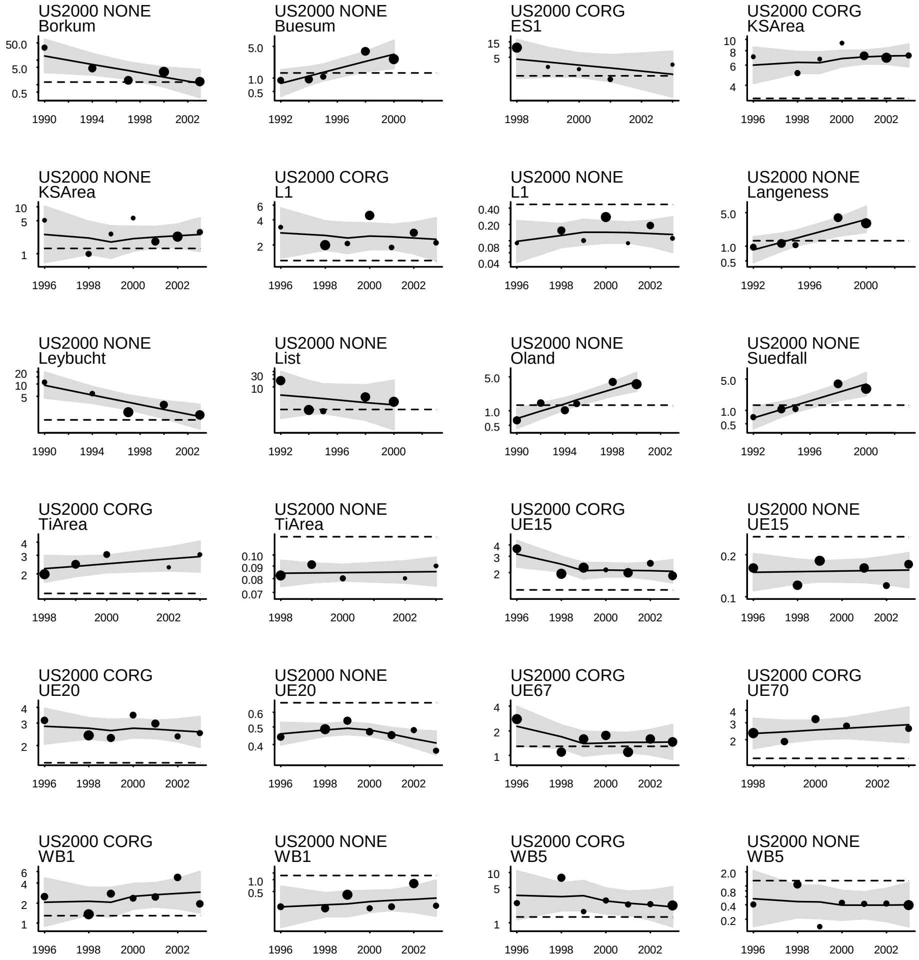


Sum of ICES 7 CBs ug/kg

region II Belgium

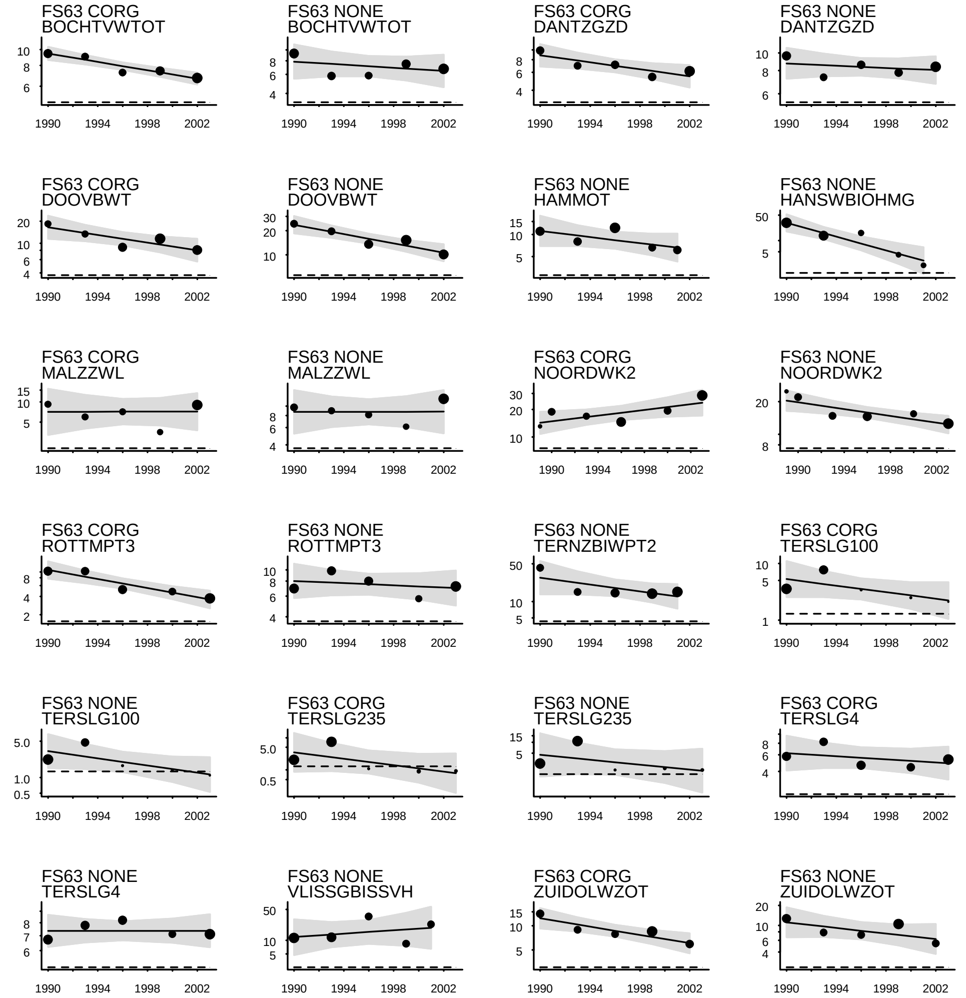


region II Germany

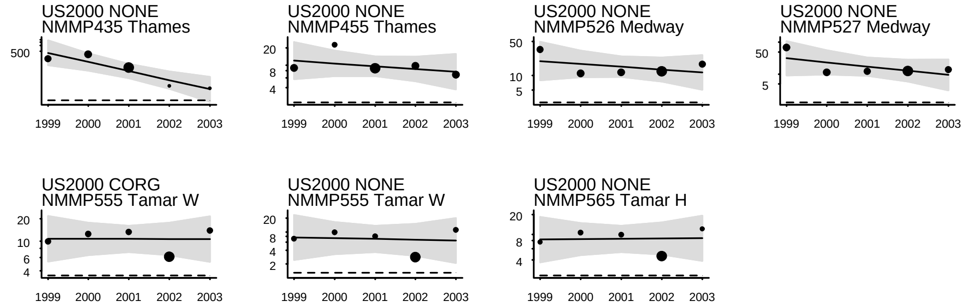


Sum of ICES 7 CBs ug/kg (continued)

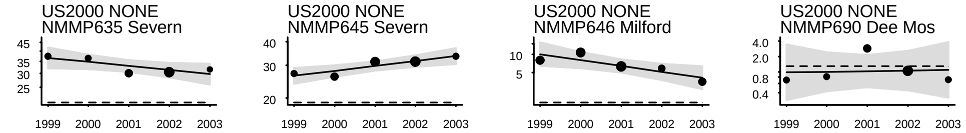
region II Netherlands



region II UK

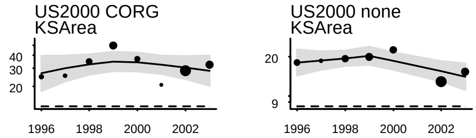


region III UK

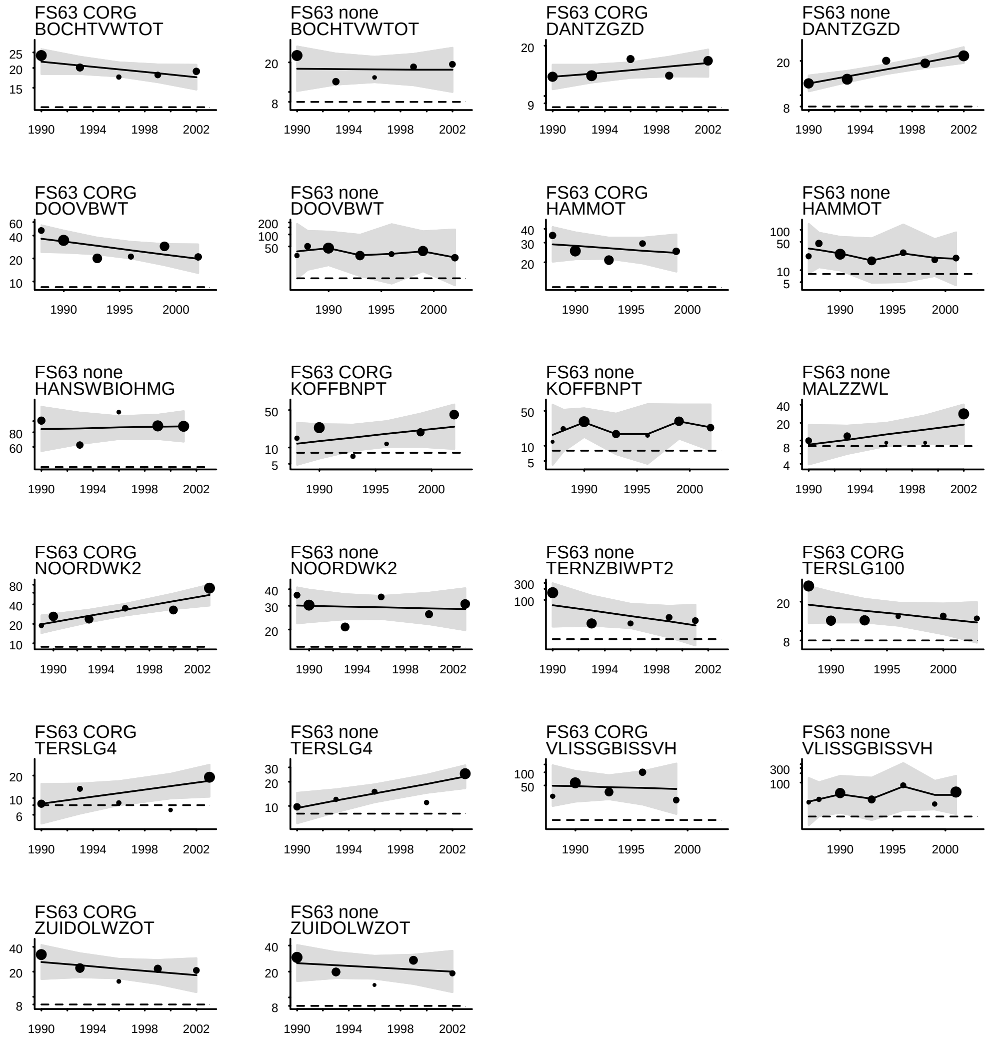


Anthracene ug/kg

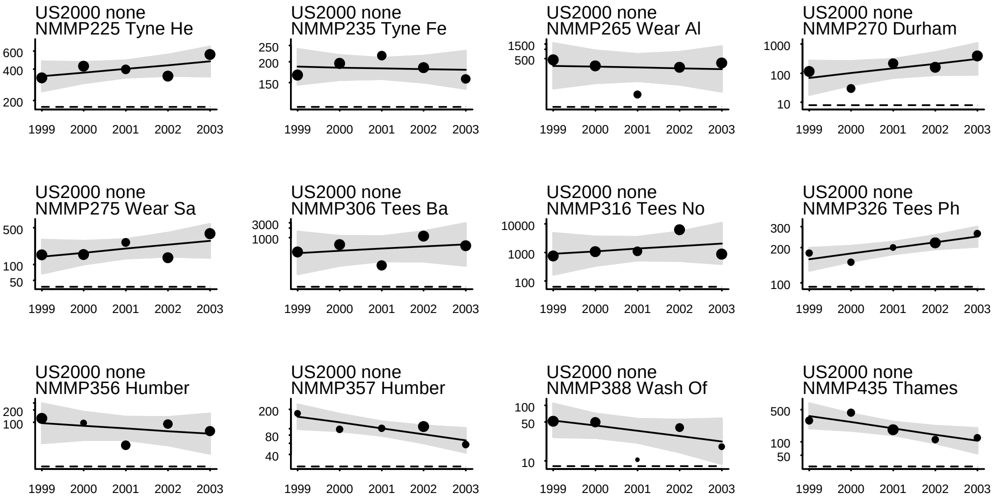
region II Germany



region II Netherlands

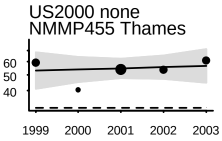


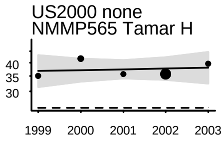
region II UK



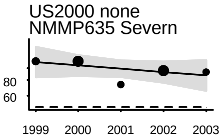
Anthracene ug/kg (continued)

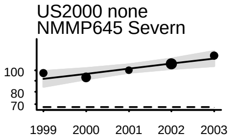
region II UK

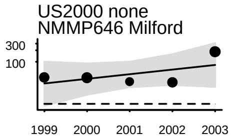


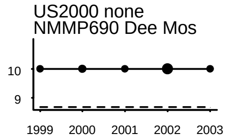


region III UK



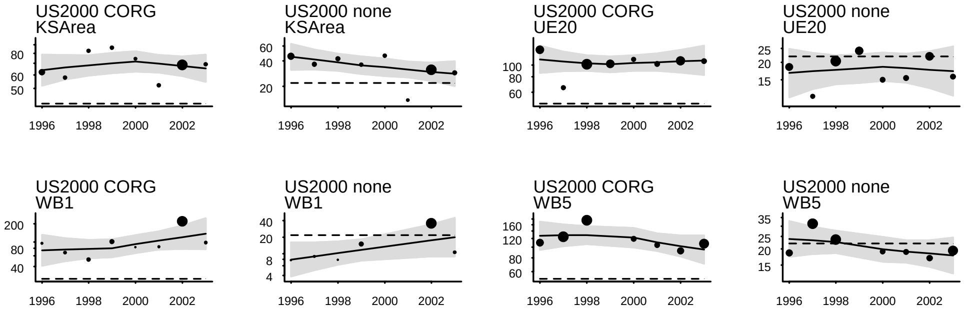




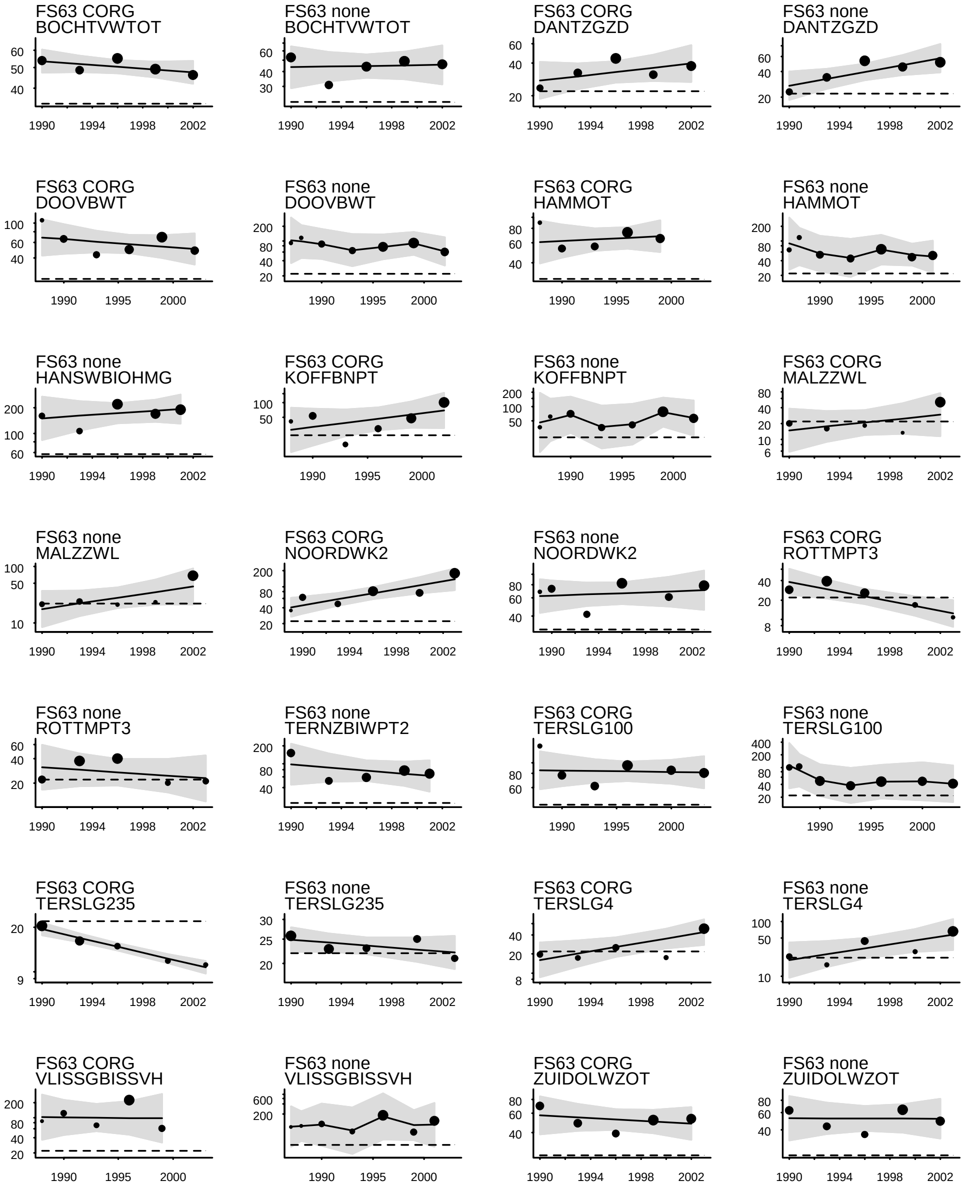


Benzo[a]anthracene ug/kg

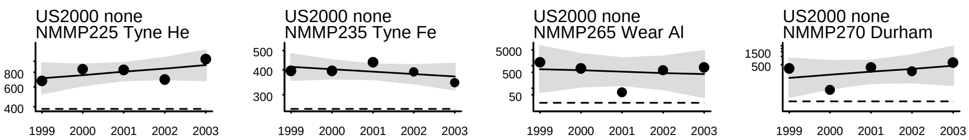
region II Germany



region II Netherlands

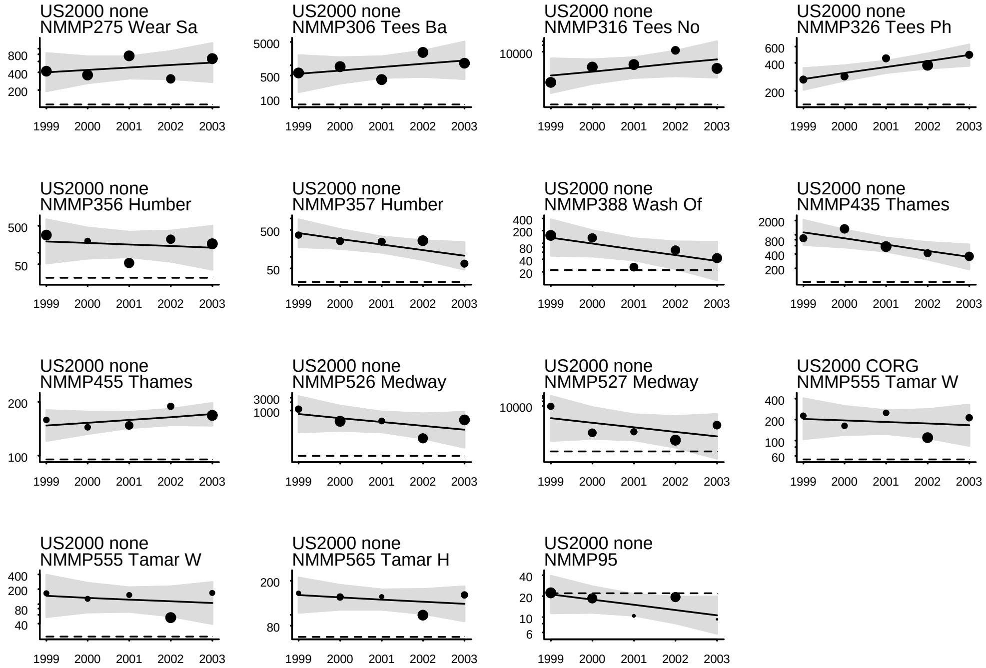


region II UK

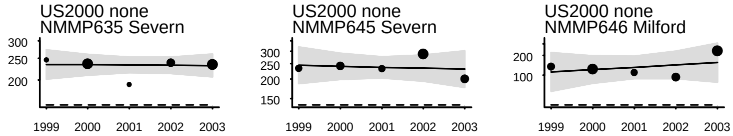


Benzo[a]anthracene ug/kg (continued)

region II UK

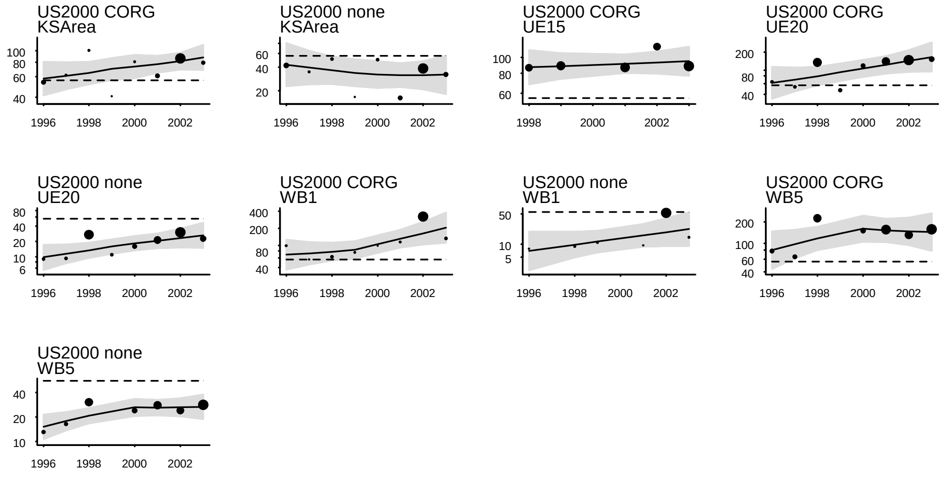


region III UK

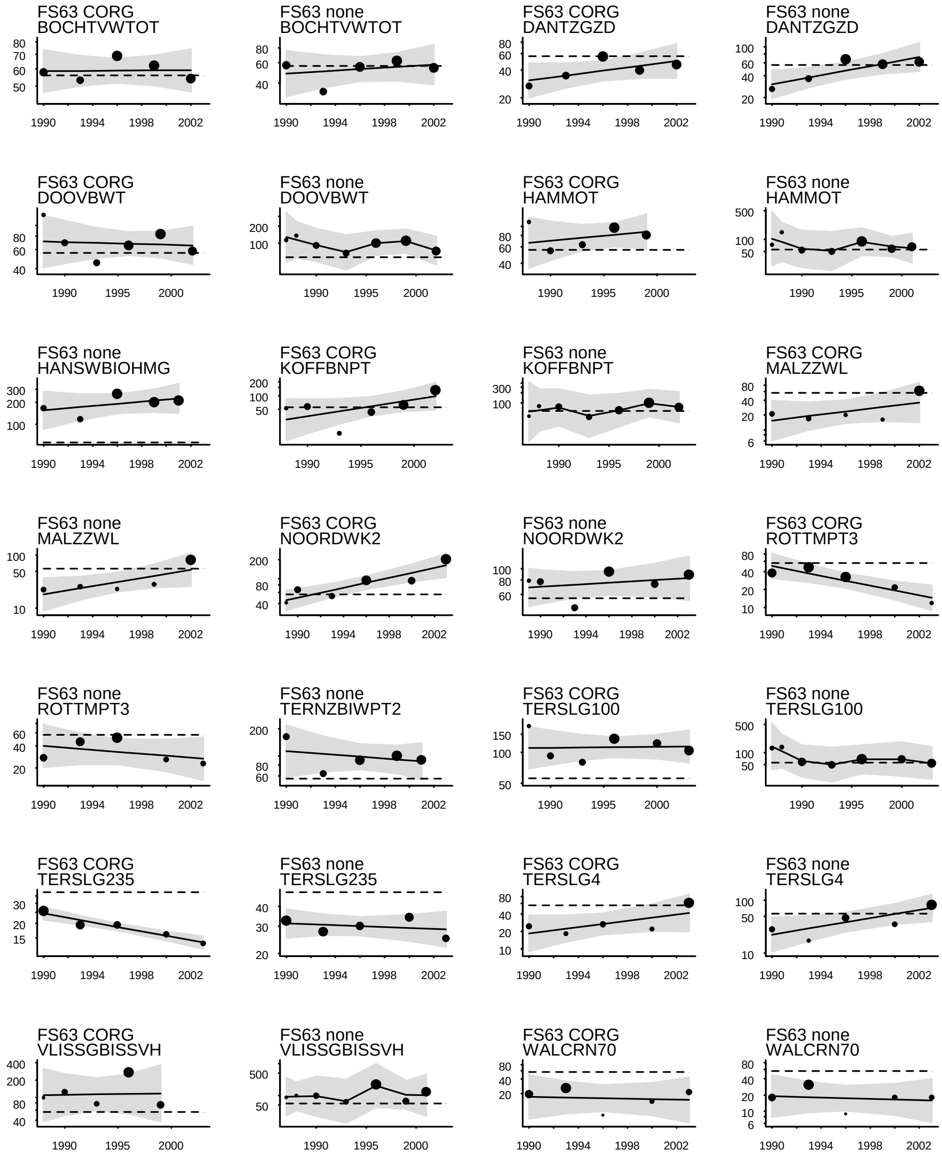


Benzo[a]pyrene ug/kg

region II Germany

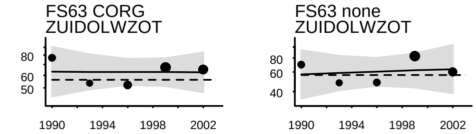


region II Netherlands

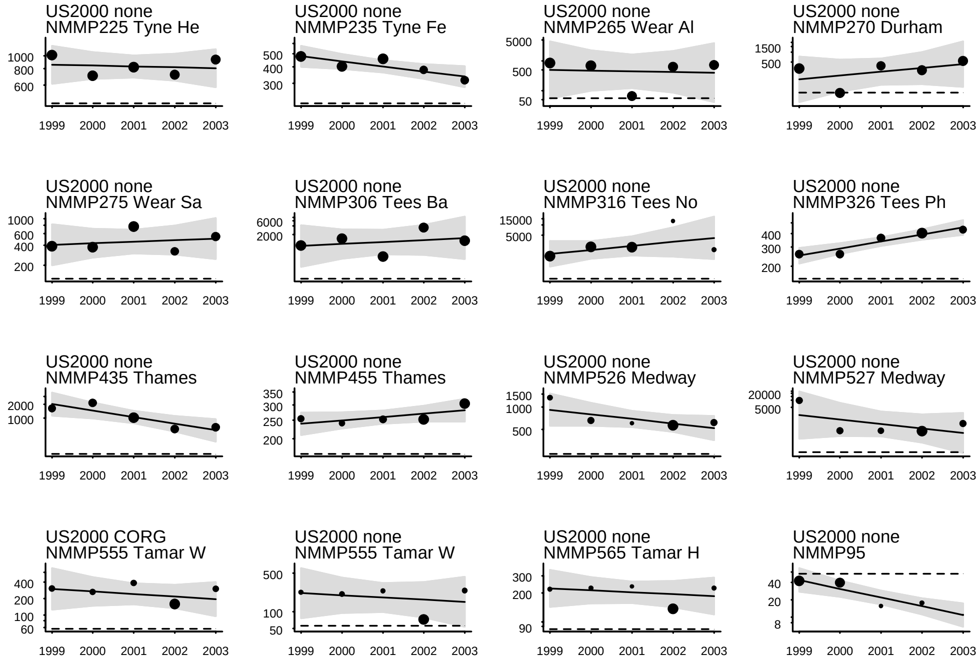


Benzo[a]pyrene ug/kg (continued)

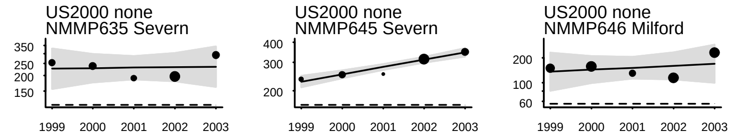
region II Netherlands



region II UK

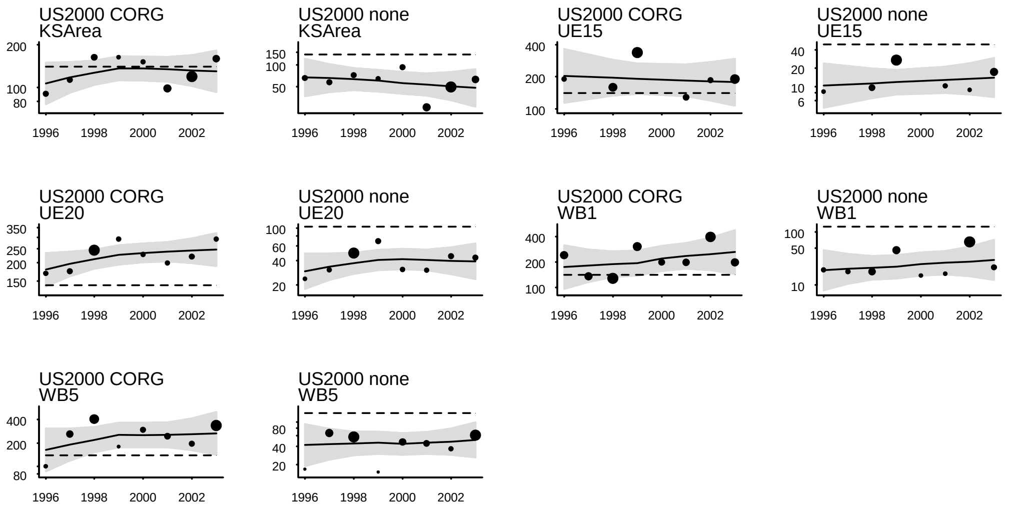


region III UK

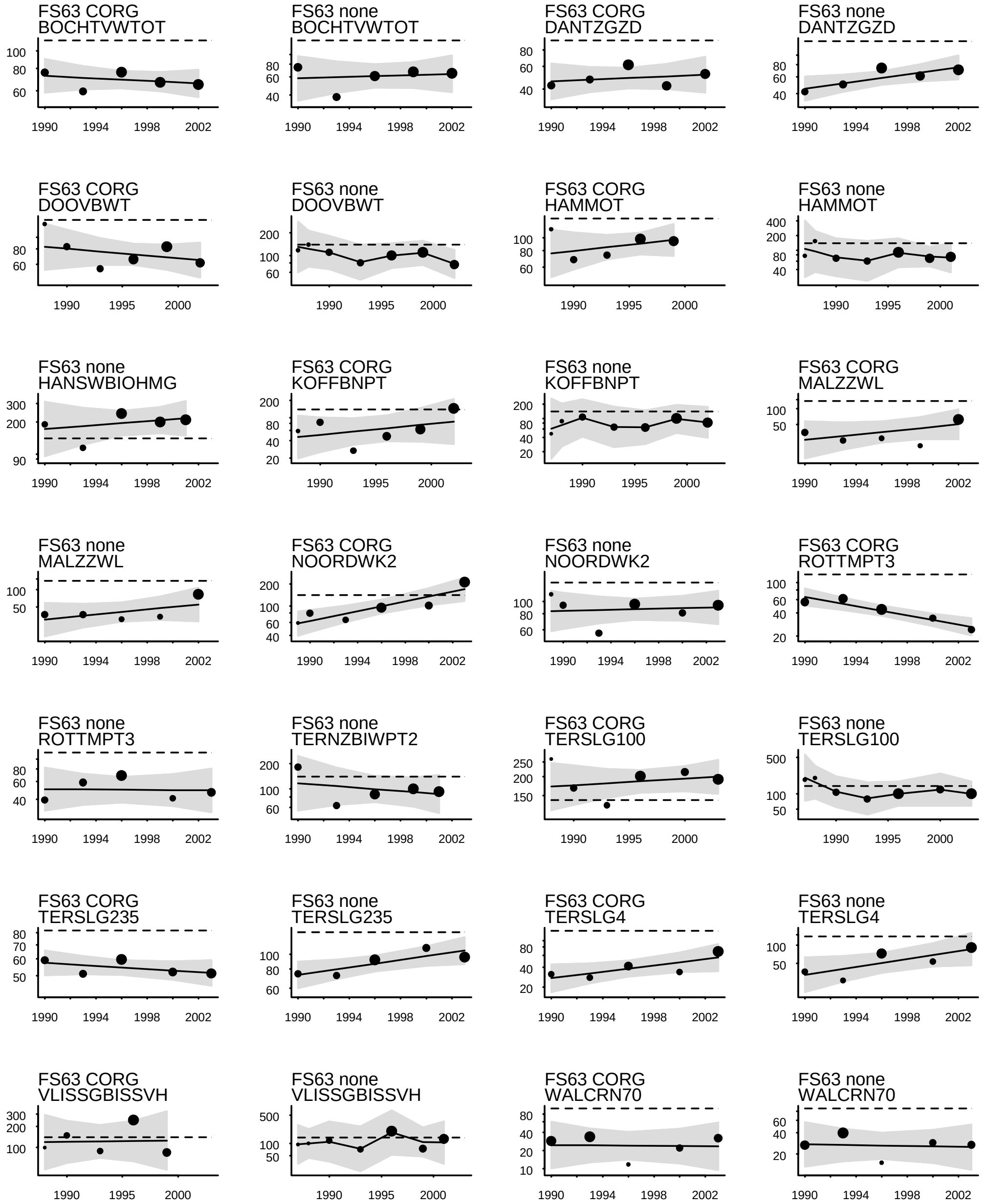


Benzo[ghi]perylene ug/kg

region II Germany

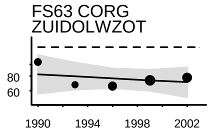


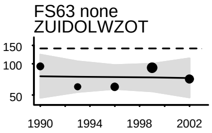
region II Netherlands



Benzo[ghi]perylene ug/kg (continued)

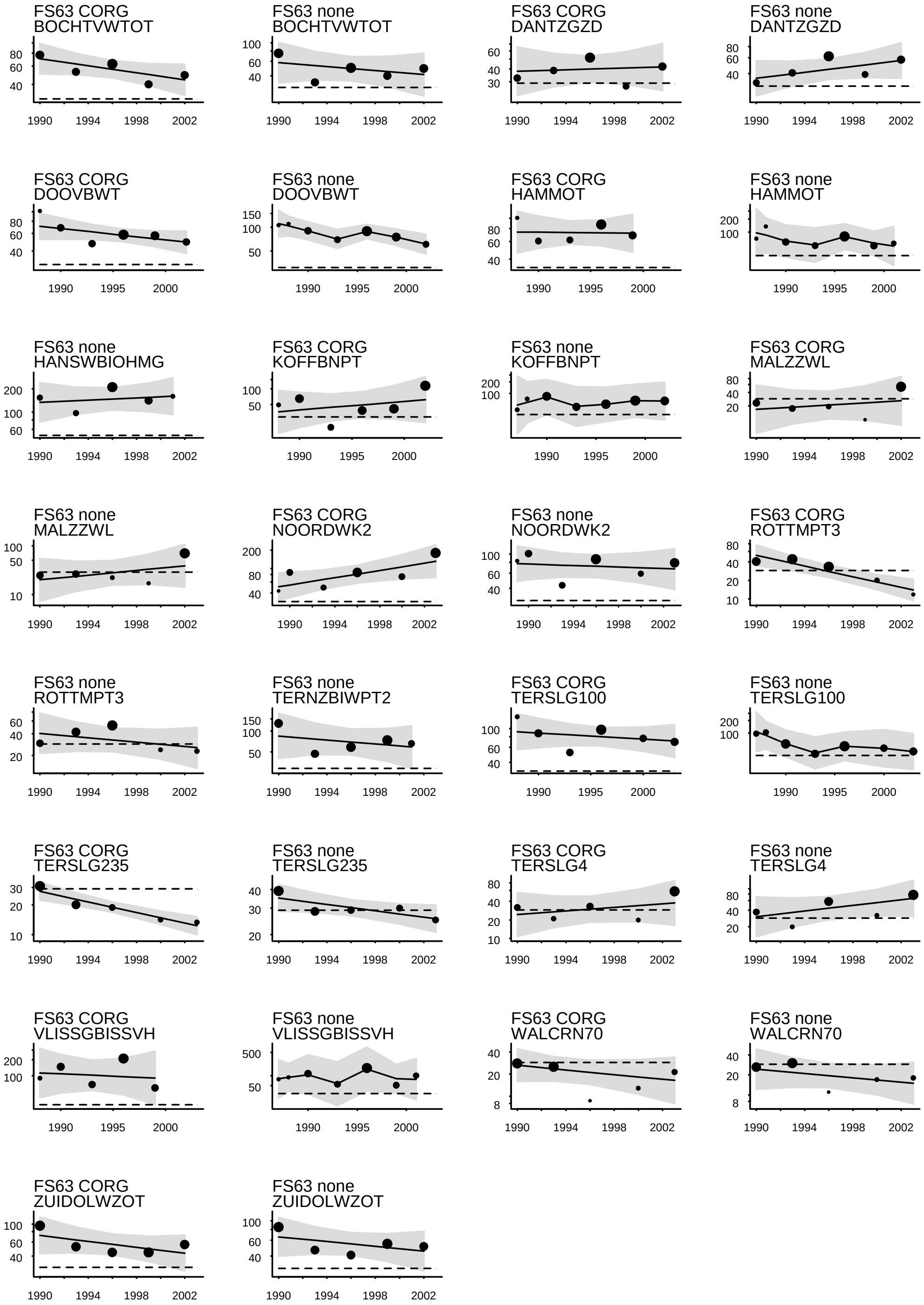
region II Netherlands





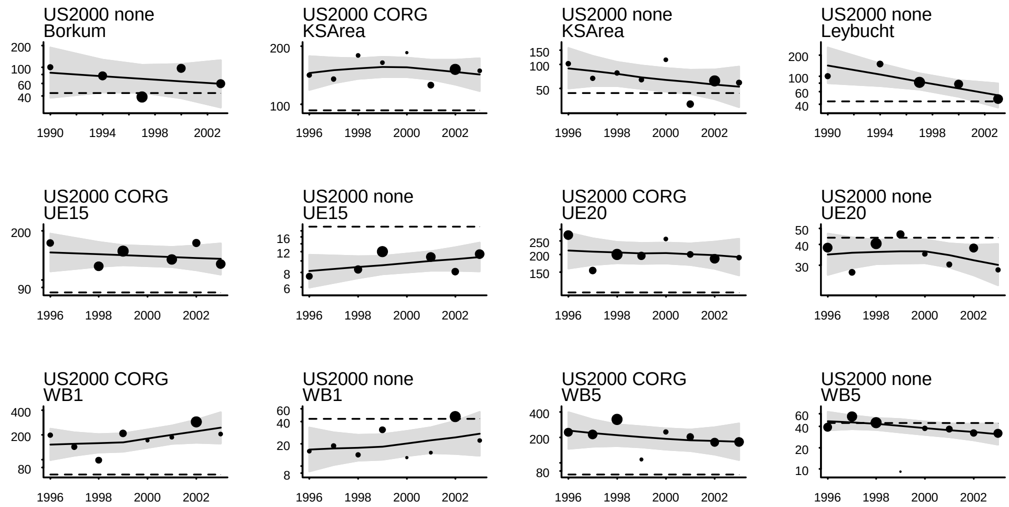
Chrysene ug/kg

region II Netherlands

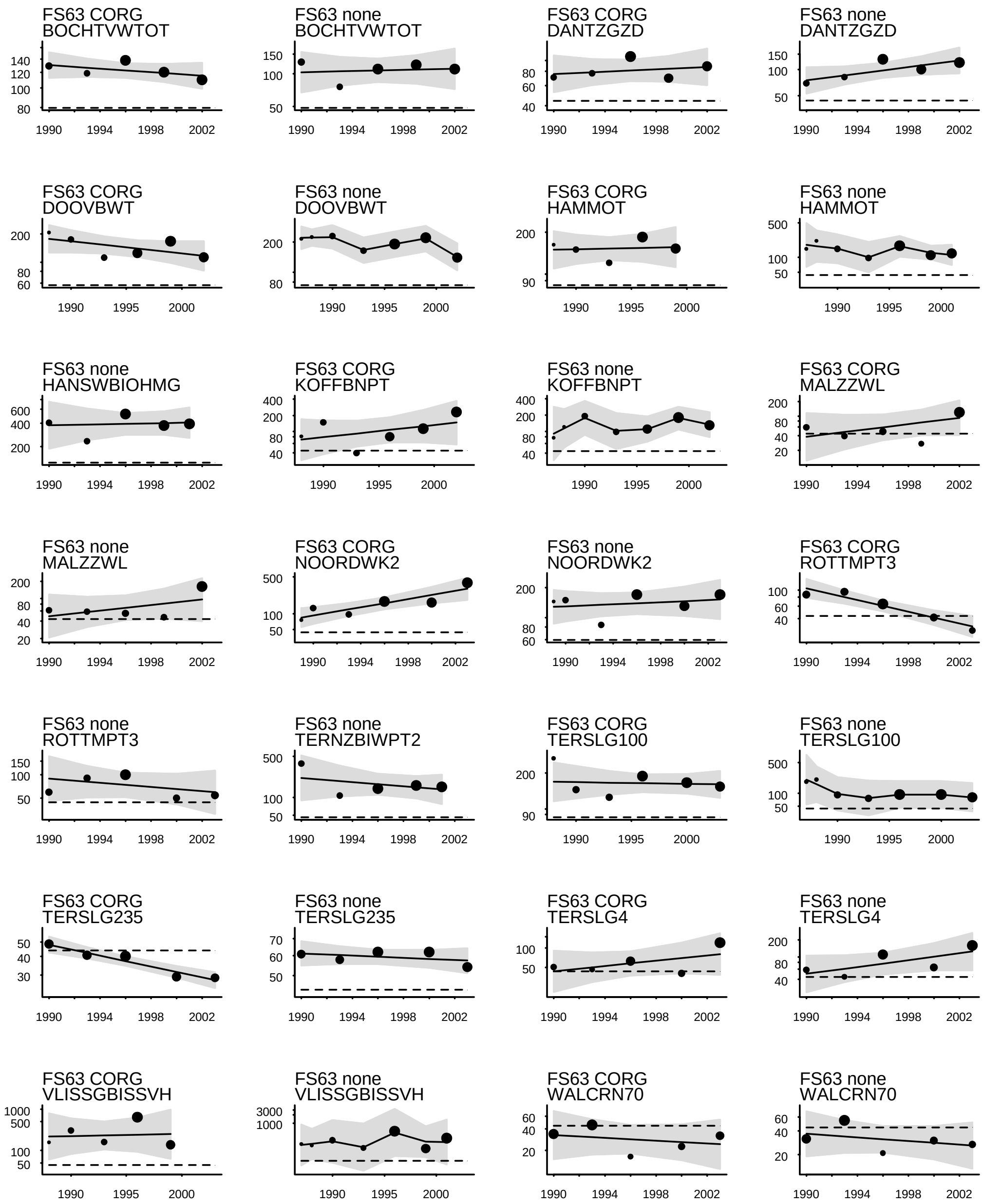


Fluoranthene ug/kg

region II Germany

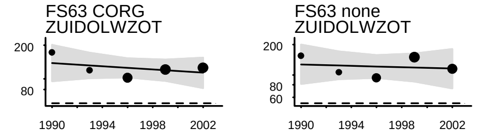


region II Netherlands

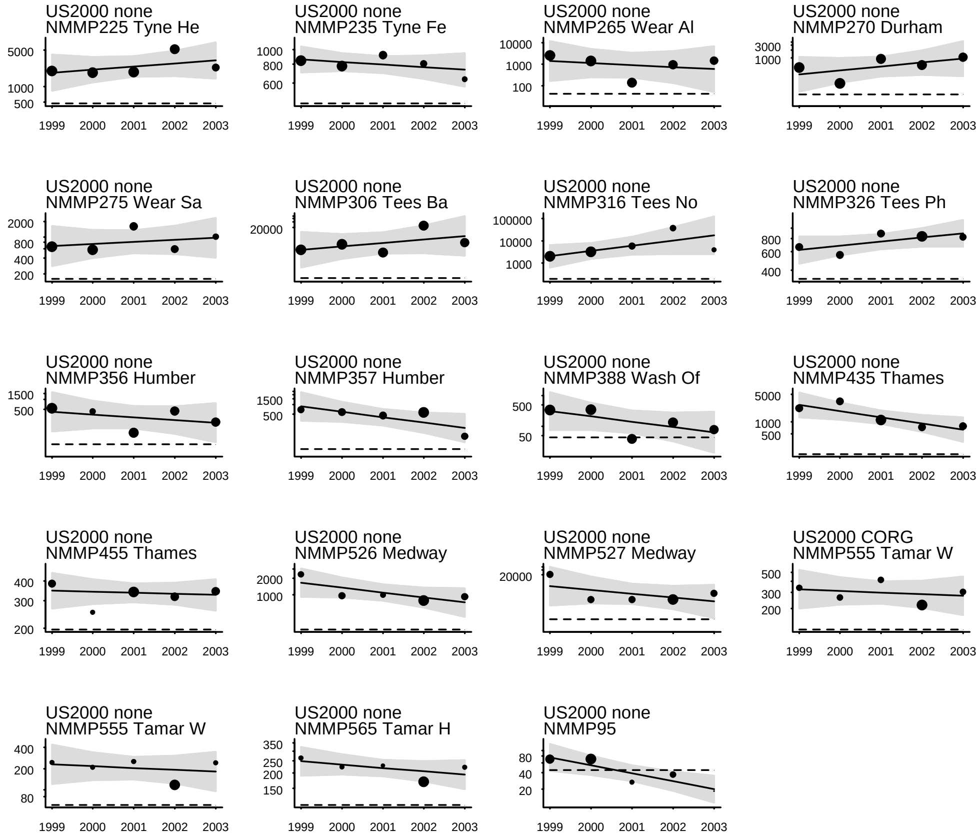


Fluoranthene ug/kg (continued)

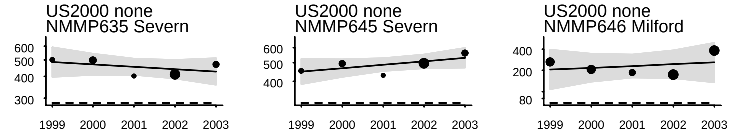
region II Netherlands



region II UK

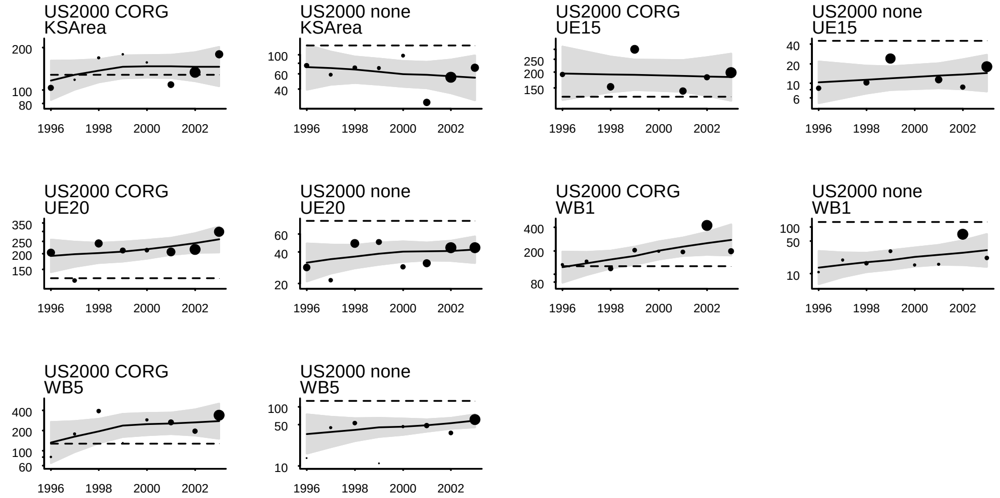


region III UK

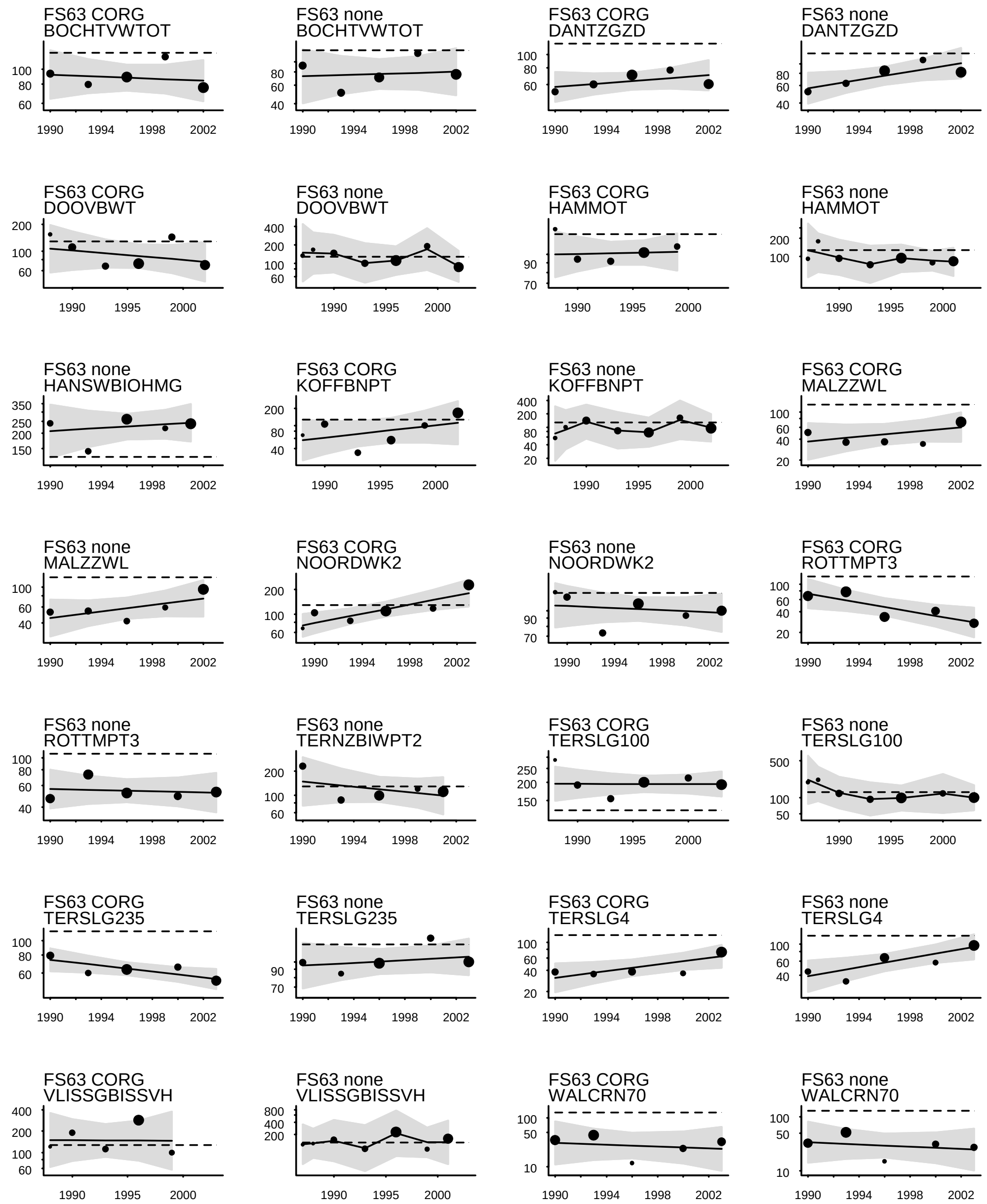


Indeno[123-cd]pyrene ug/kg

region II Germany

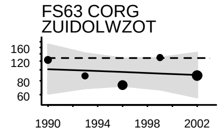


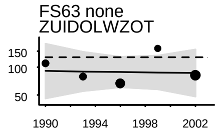
region II Netherlands



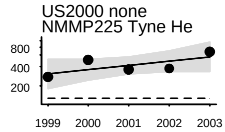
Indeno[123-cd]pyrene ug/kg (continued)

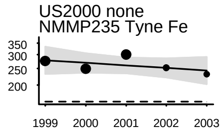
region II Netherlands

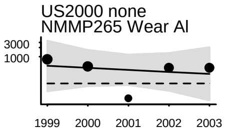


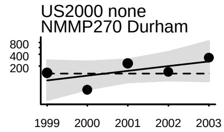


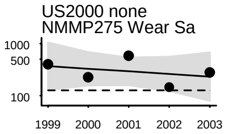
region II UK

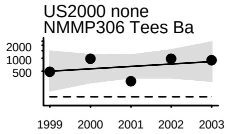


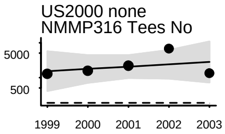


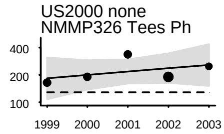


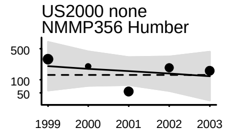


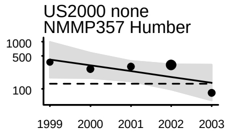


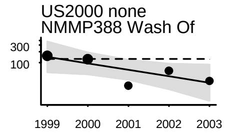


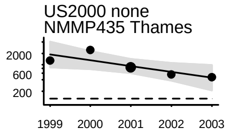


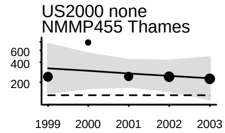


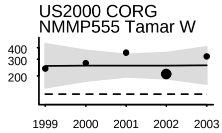


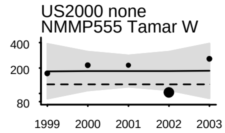


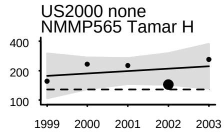


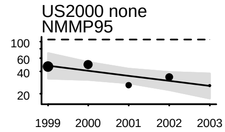




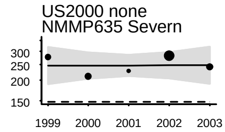


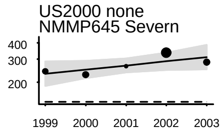


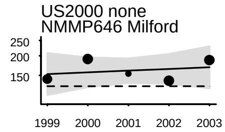


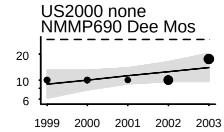


region III UK



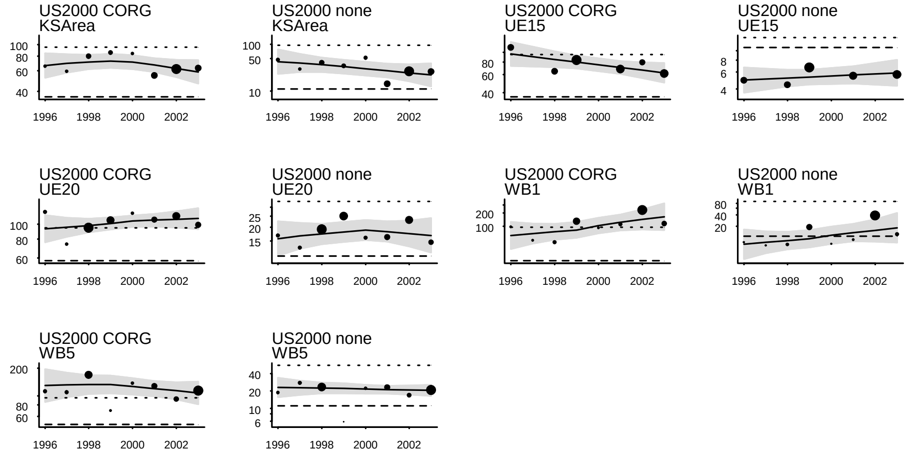






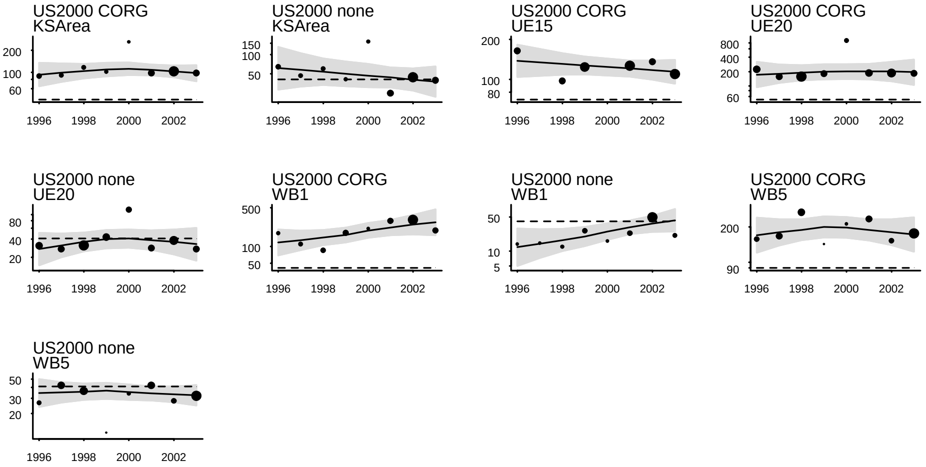
Naphthalene ug/kg

region II Germany

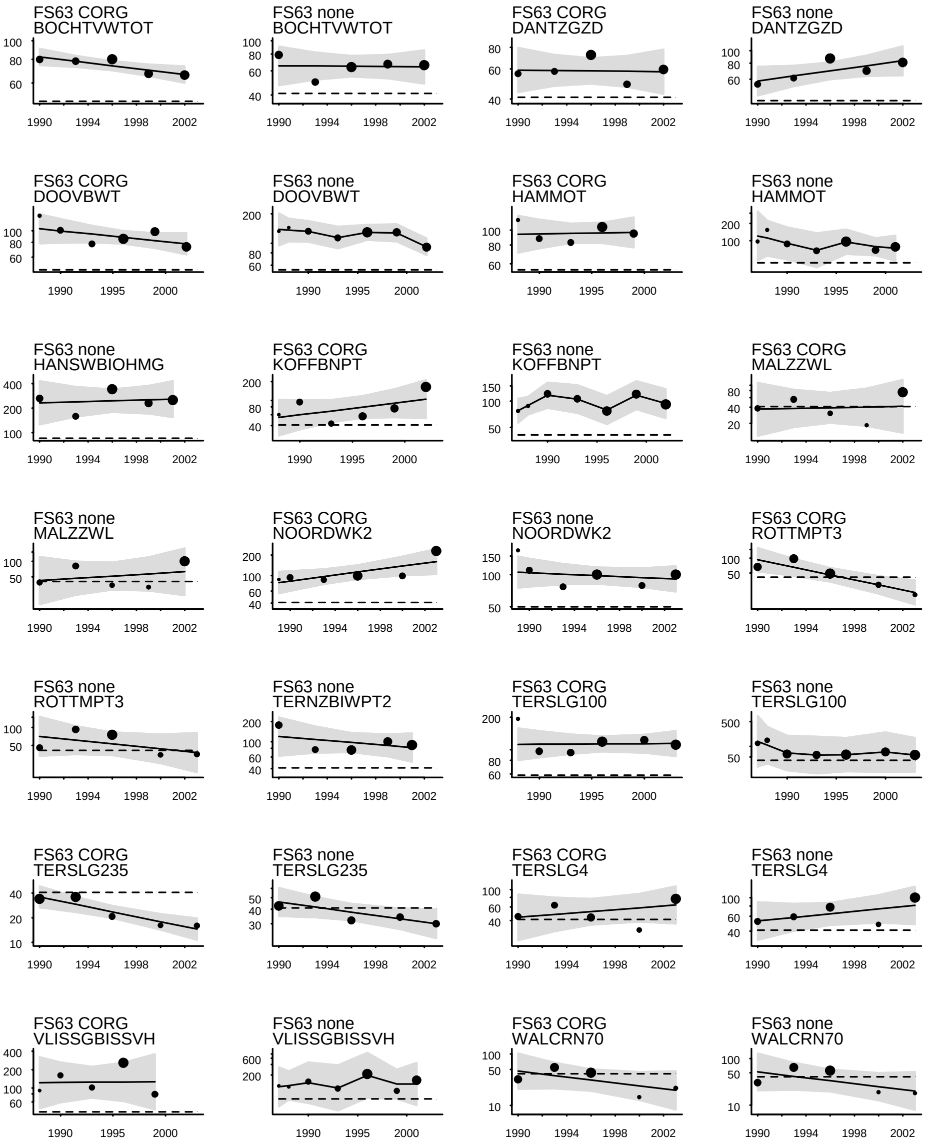


Phenanthrene ug/kg

region II Germany

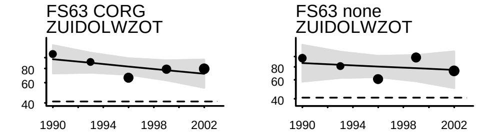


region II Netherlands

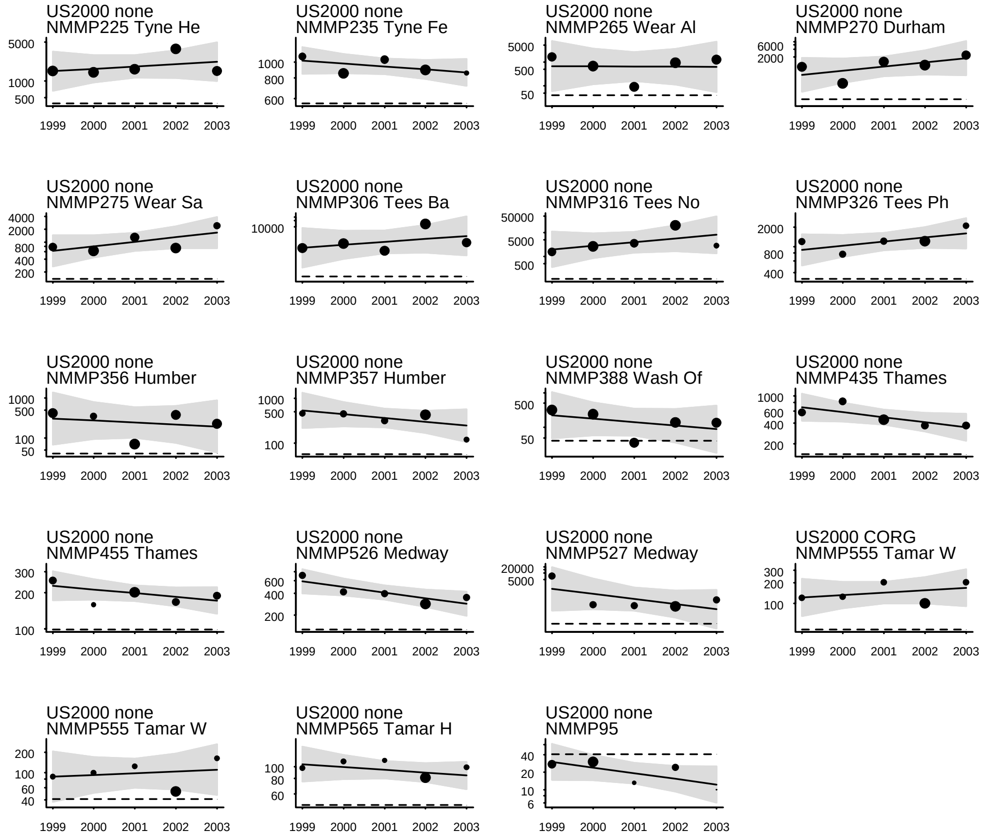


Phenanthrene ug/kg (continued)

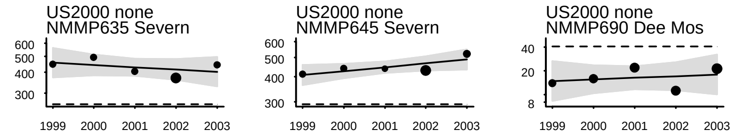
region II Netherlands



region II UK

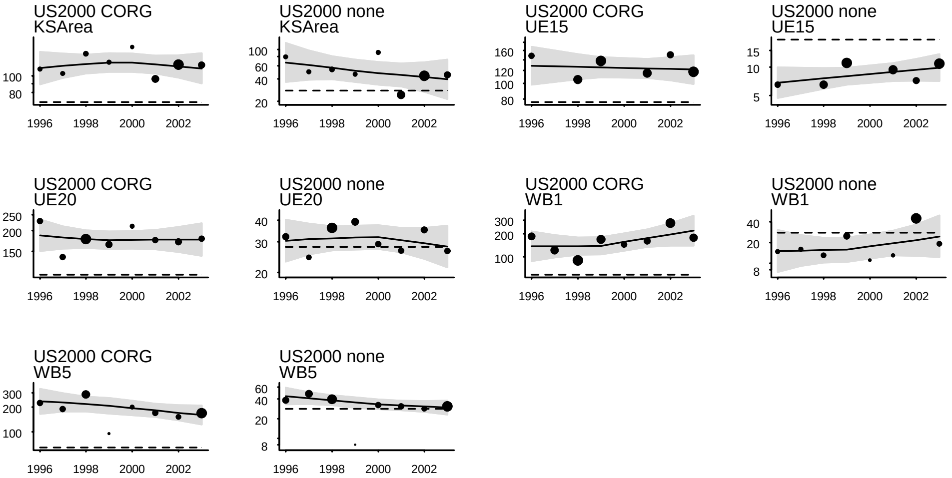


region III UK

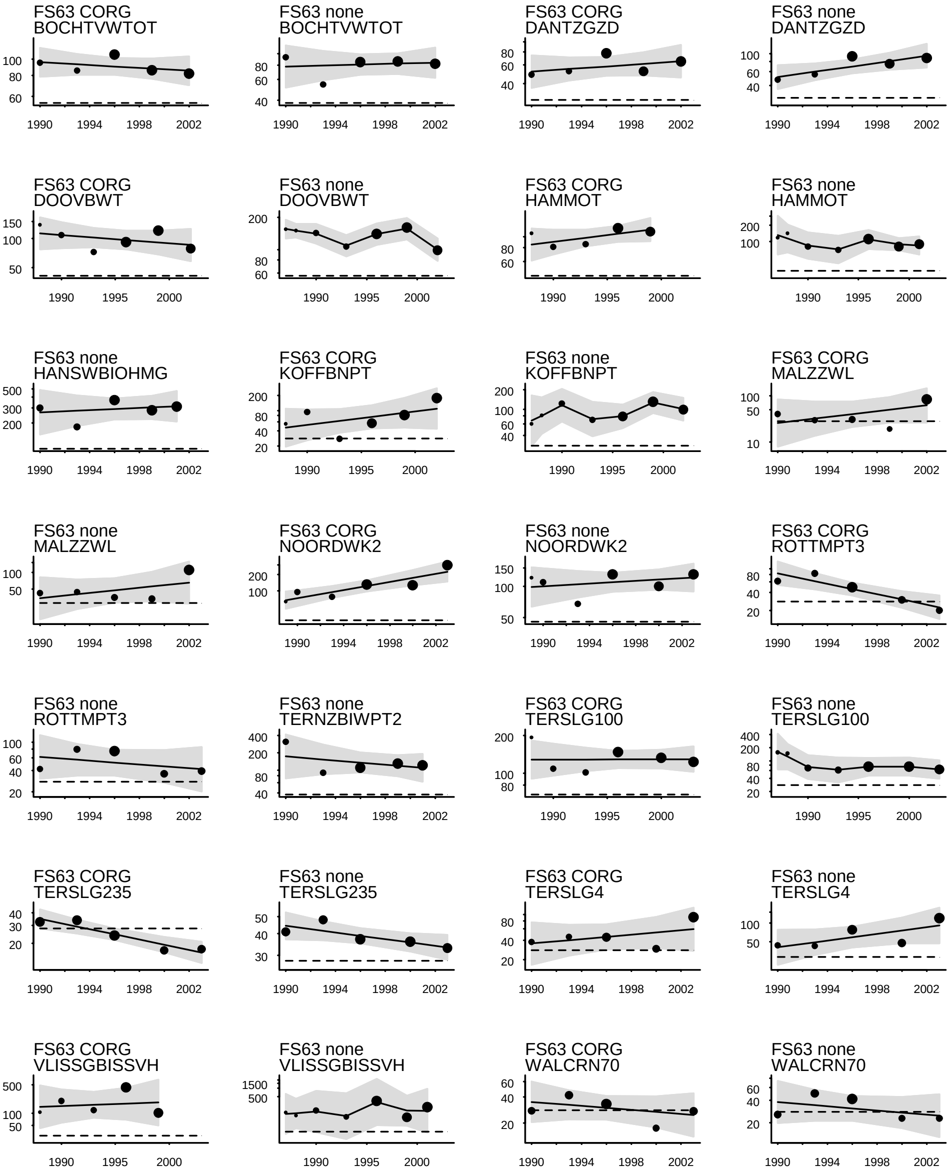


Pyrene ug/kg

region II Germany



region II Netherlands



Pyrene ug/kg (continued)

region II Netherlands

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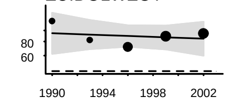
ZUIDOLWZOT



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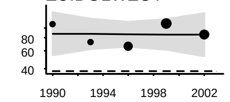

region II UK

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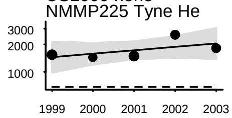
NMMP225 Tyne He



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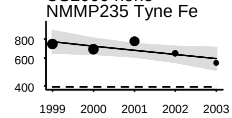
NMMP235 Tyne Fe



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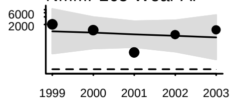
NMMP265 Wear Al



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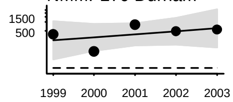

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NMMP275 Wear Sa

US2000 none
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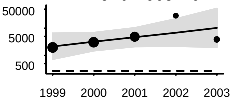

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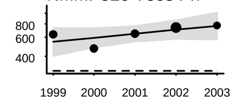

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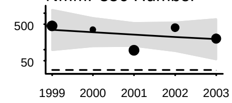

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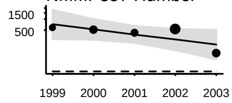

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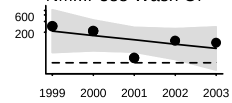

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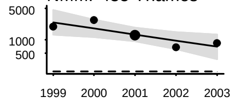

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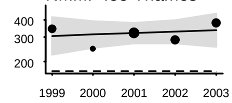

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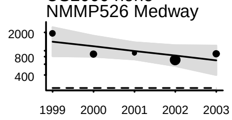

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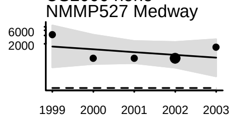

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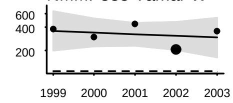

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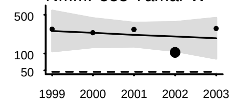

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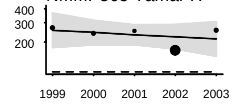

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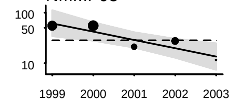

region III UK

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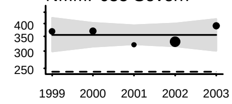

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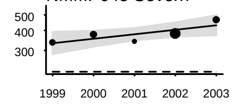

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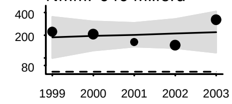

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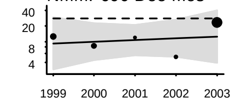
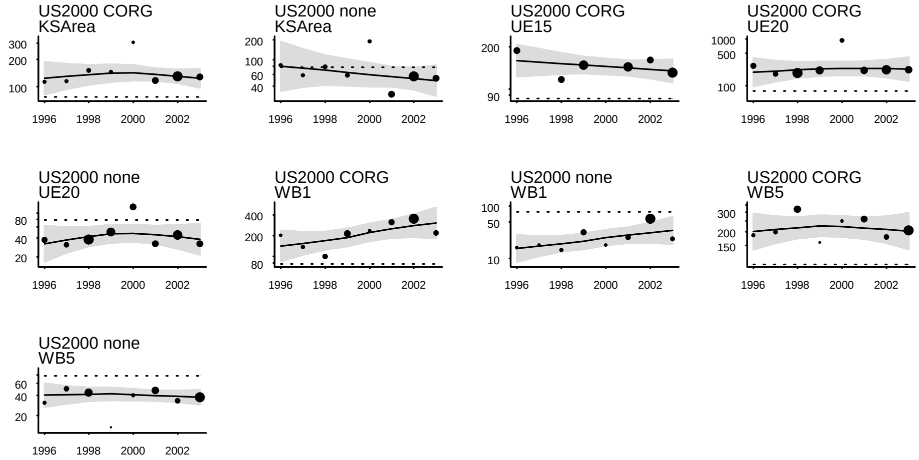
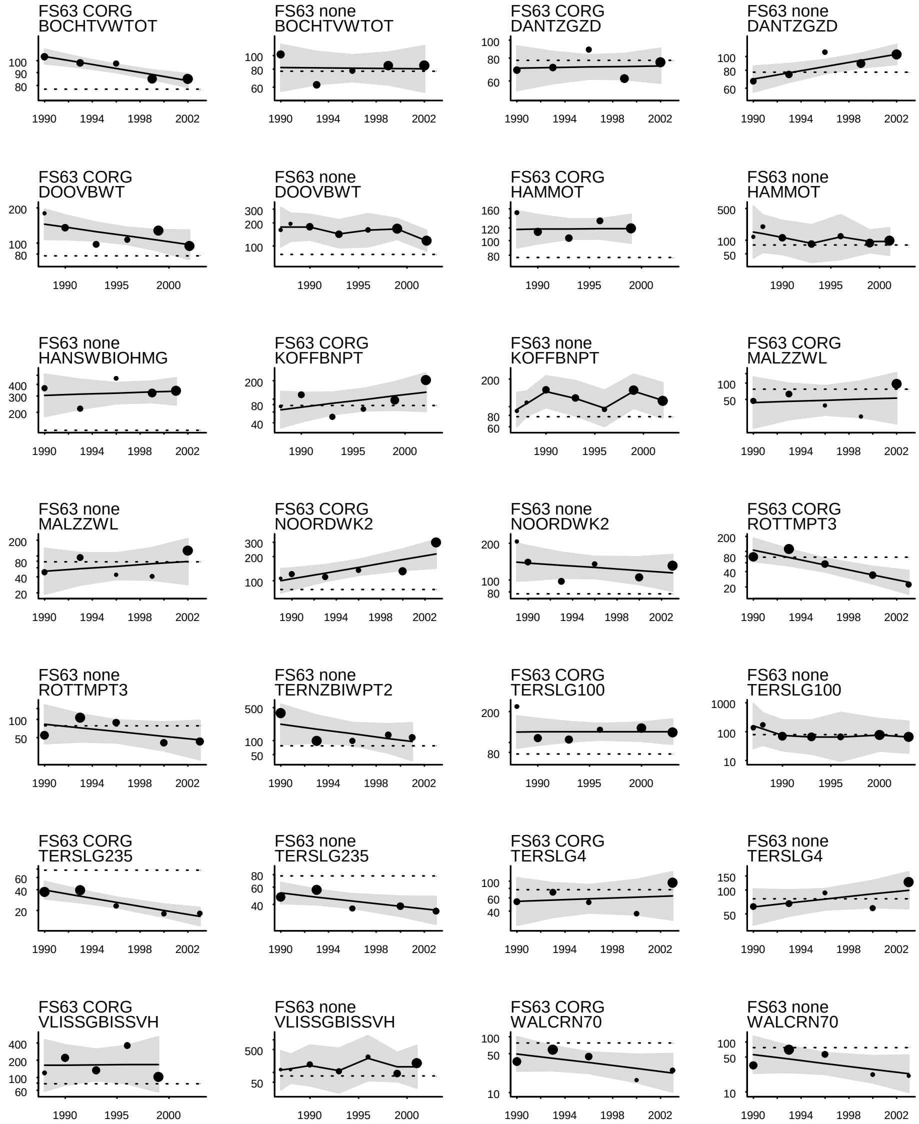


PAH 3 rings ug/kg

region II Germany

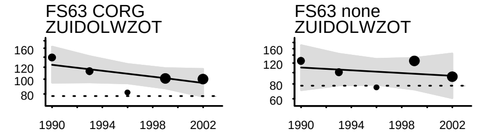


region II Netherlands

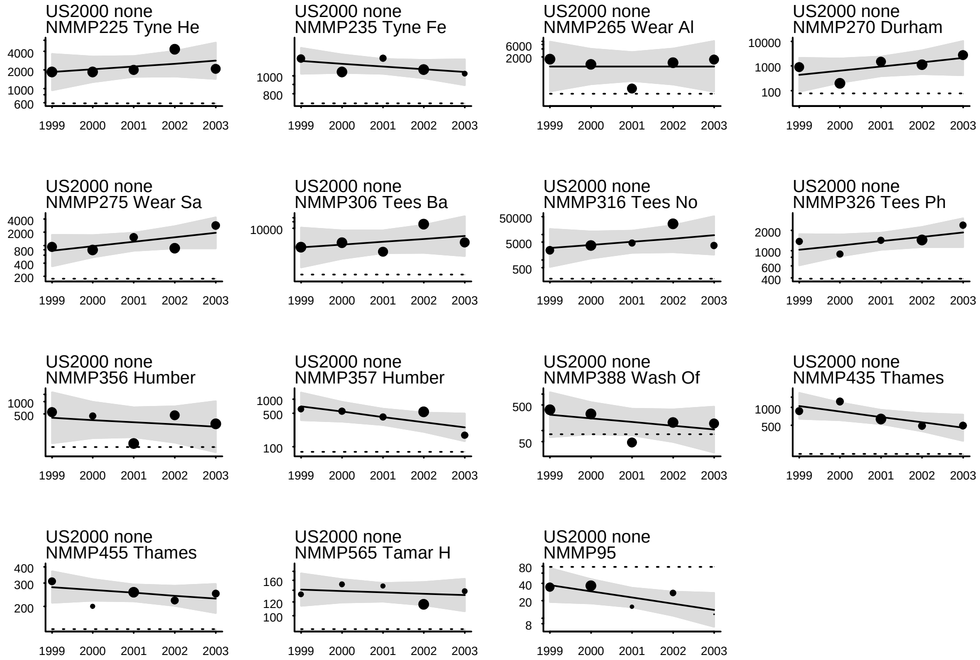


PAH 3 rings ug/kg (continued)

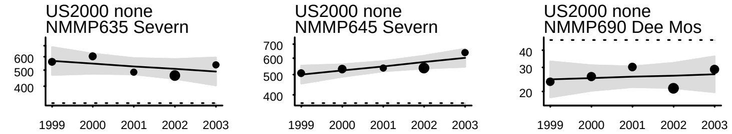
region II Netherlands



region II UK

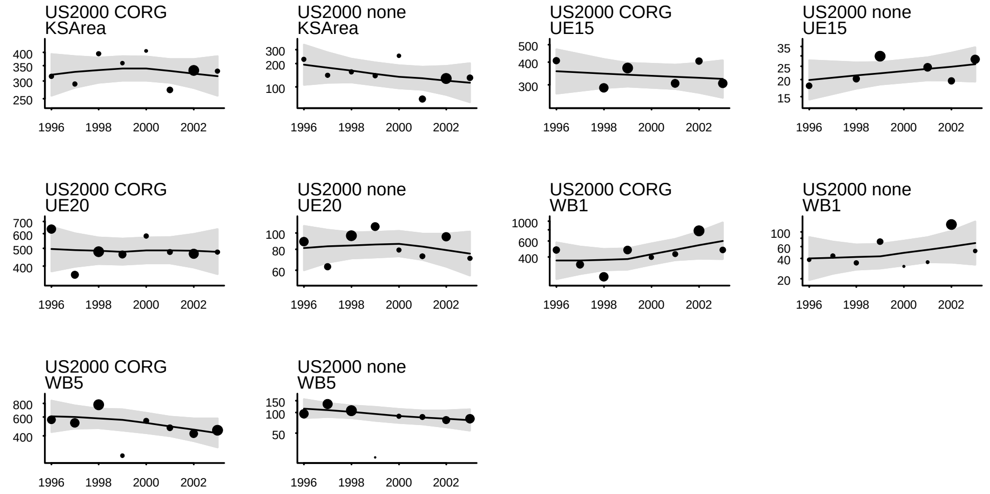


region III UK

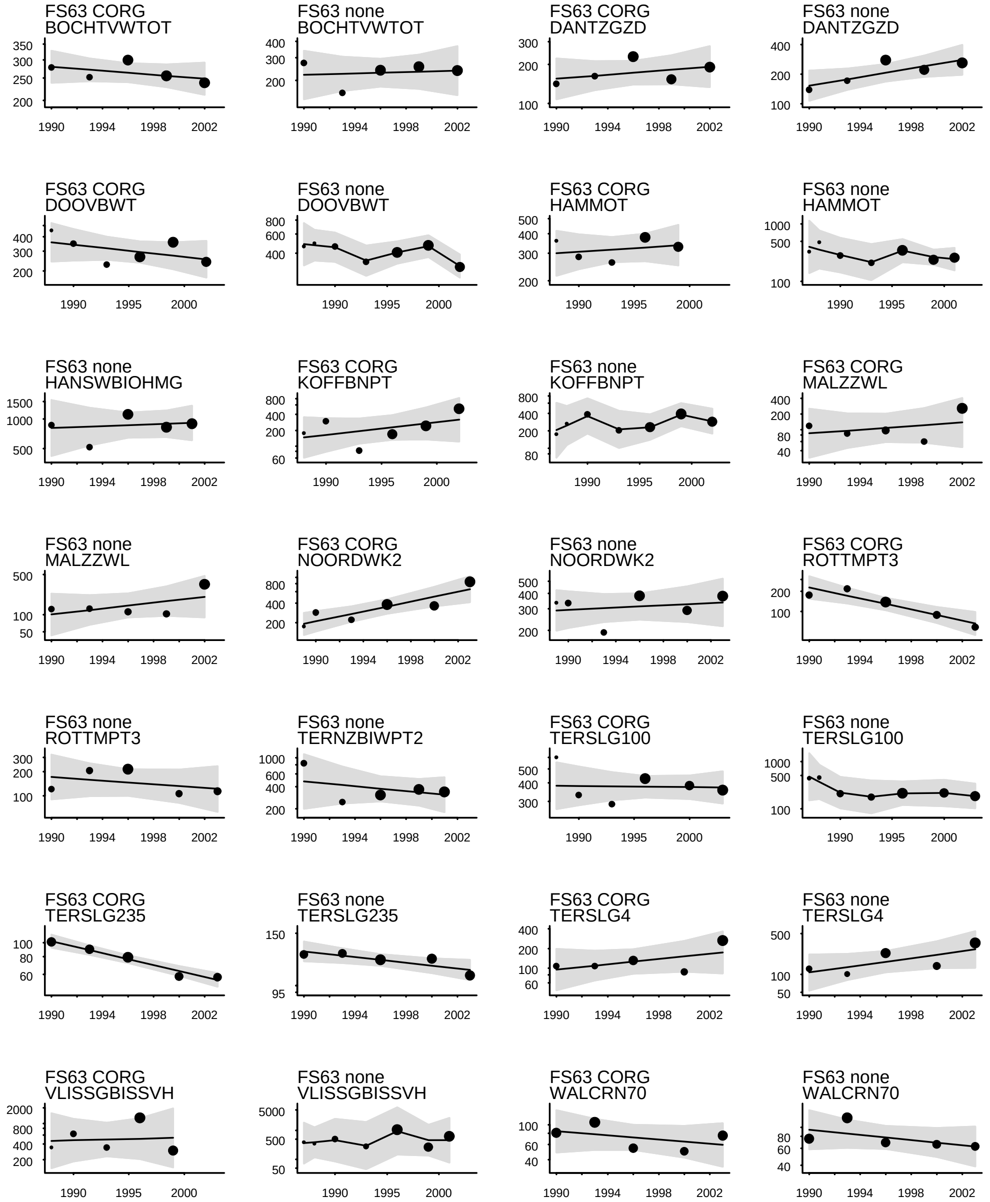


PAH 4 rings (partial) ug/kg

region II Germany

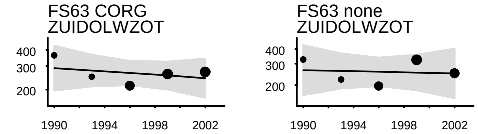


region II Netherlands

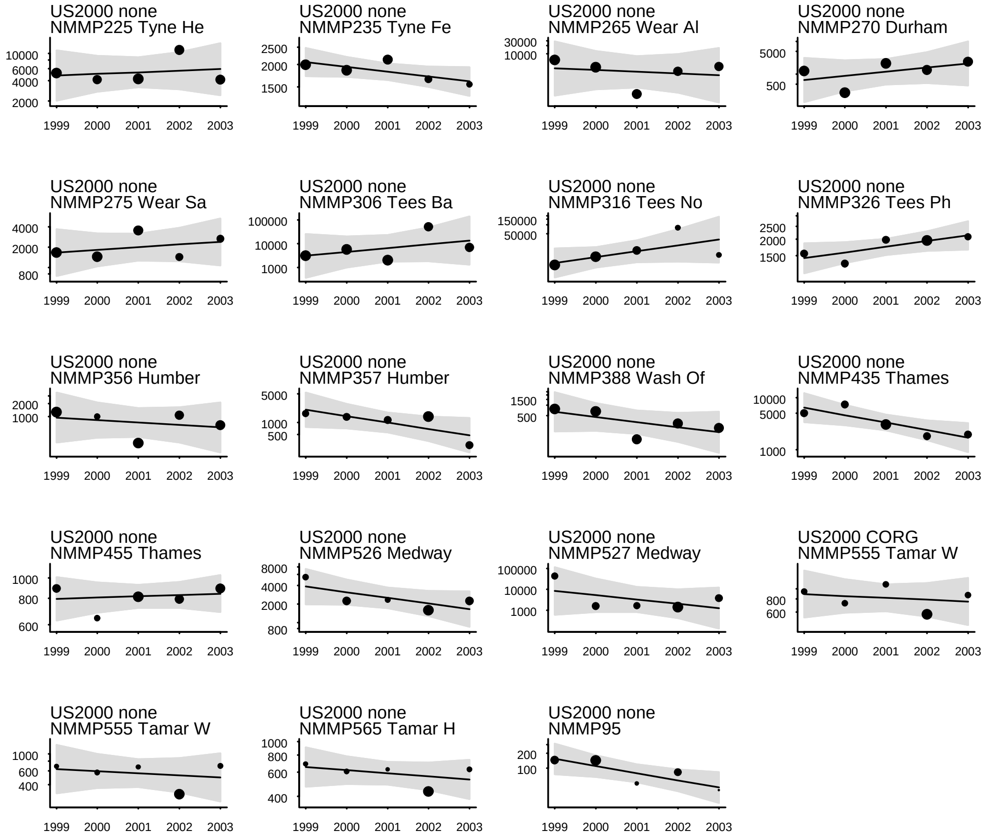


PAH 4 rings (partial) ug/kg (continued)

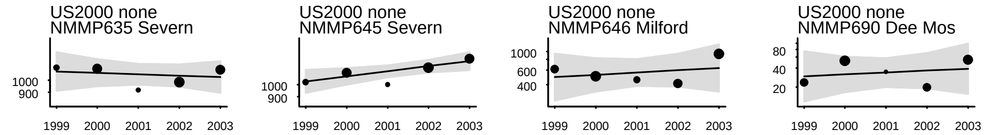
region II Netherlands



region II UK

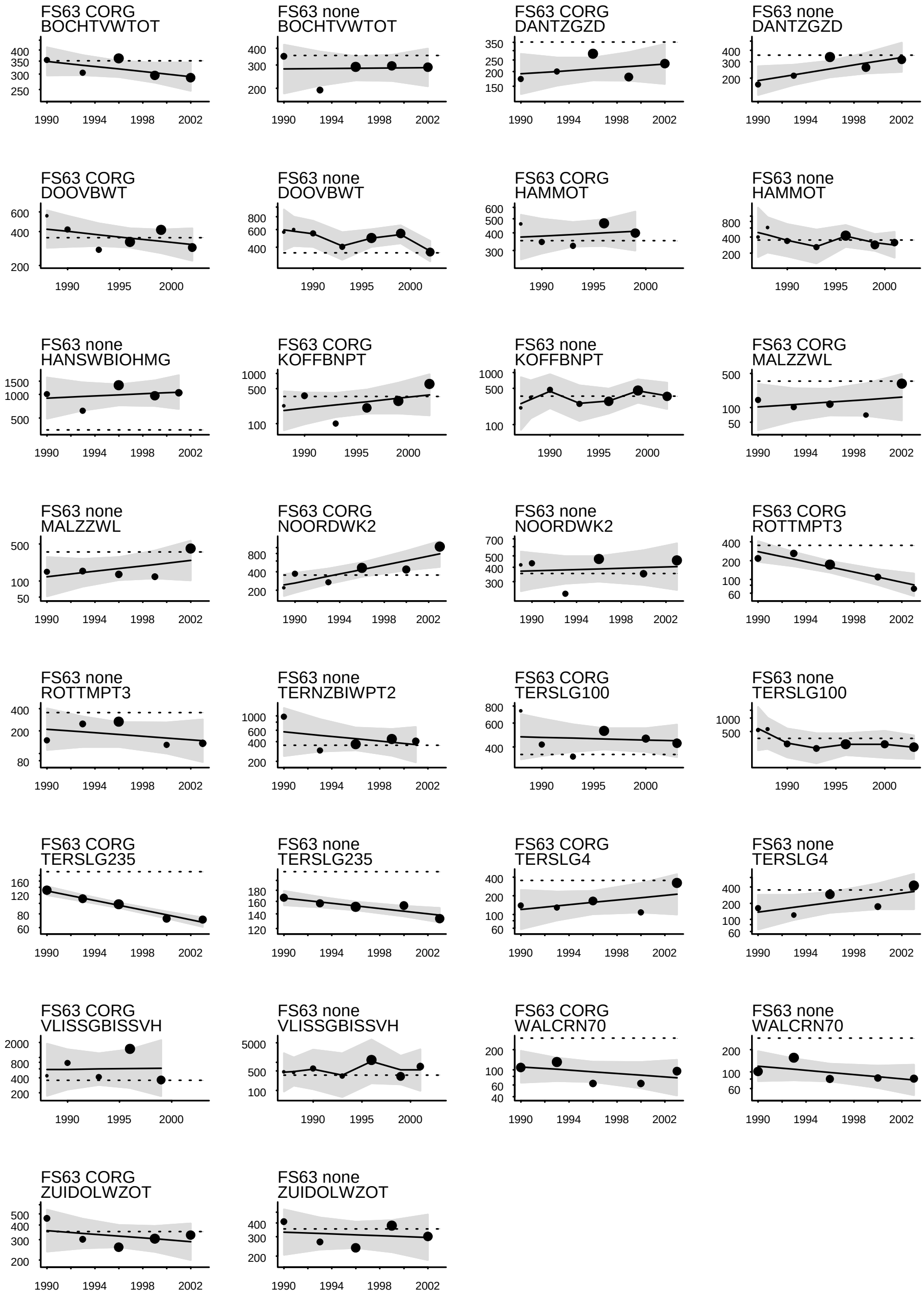


region III UK



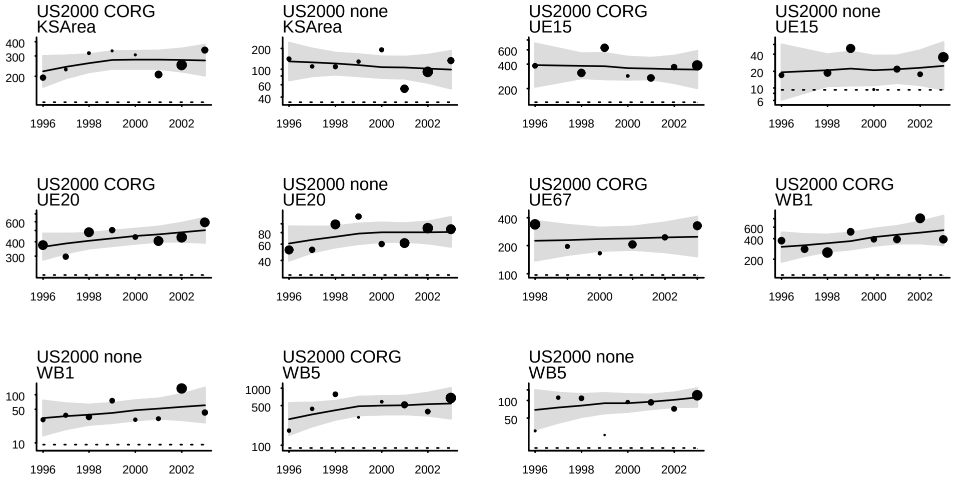
PAH 4 rings ug/kg

region II Netherlands

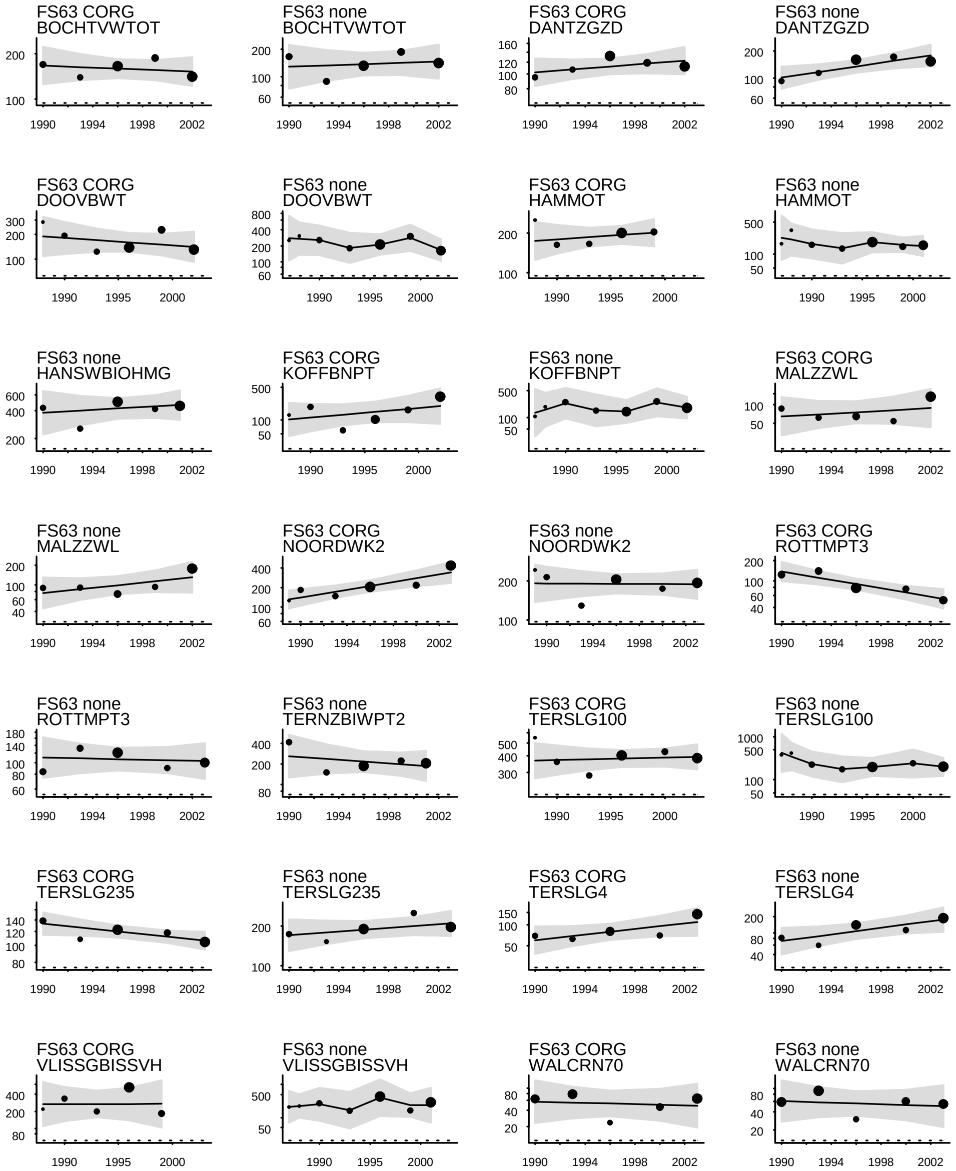


PAH 6 rings ug/kg

region II Germany

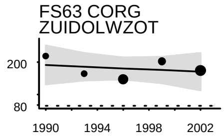


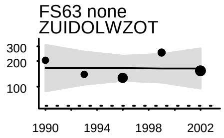
region II Netherlands



PAH 6 rings ug/kg (continued)

region II Netherlands

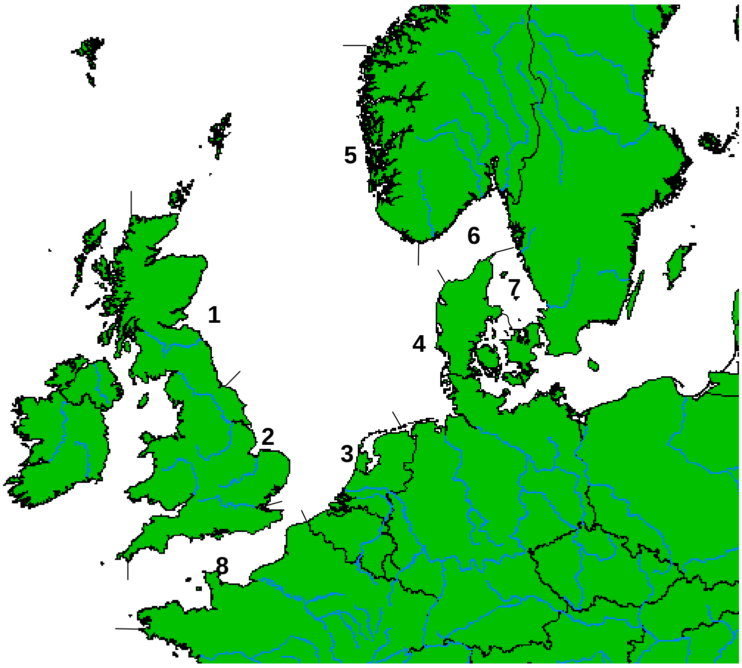




2005 Assessment of CEMP data
Appendix 14: Comparison with RID assessment report

Background

The RID assessment group has looked at time trends (1990-2002) of contaminant inputs to the sea from riverine inputs and direct discharges. Of these contaminants, mercury, cadmium and lead are relevant for MON. Out of 8 coastal regions, 5 (bordering the North Sea) have been looked at and draft reports prepared.



This analysis of changes in RID inputs may be related to changes in contaminant concentrations in biota and sediments as revealed by the CEMP-assessment.

Methods

- The trend assessment is done on yearly data only
- Three kinds of assessment were executed:
  - o assessment of the direct input loads
  - o assessment of the riverine input loads, tested against river flow dependency
  - o assessment of the aggregated direct discharges and riverine input loads
- The trend assessment was carried out with the RTrend program version 3.1.0.1, distributed by the firm Quo Data after the "OSPAR/ICES Workshop on the Application of OSPAR Guidance on Input Trend Assessment and the Adjustment of Loads", held in Dresden, Germany, from 8 to 10 September 2004.

Region 1 (UK North)

The direct discharges could not exactly be assessed in the way prescribed by the guidance as no flow data are available for these loads. Nevertheless, considering that generally, the flow rates for direct inputs in this zone are fairly consistent, and that if there is a significant change in flow, it is due of actual reductions or increases in discharges and associated loads rather than weather dependence. Hence, absolute loads without flow adjustment are considered here in order to add the information contained therein to the overall assessment.

Cadmium sum of direct discharges and riverine input

The pattern of the aggregated direct and riverine loads is non-monotonic descending, an indication that the Mann-Kendall and Theil slope method is recommended for assessment. This test is *significant* and thus one can conclude at a yearly reduction of 7,6%, amounting to a 61,3% reduction over the whole period. The nature of this assessment is somewhat speculative though, as no accompanying flow rates for these loads were available.

Mercury sum of direct discharges and riverine input

The pattern of the aggregated loads is non-monotonic decreasing, and is best assessed with the Mann-Kendall and Theil slope method. As the test is *significant*, the revealed yearly decrease of 6,5% amounting to an overall decrease in input level of 55'3% is conclusive. The nature of this assessment is somewhat speculative though, as no accompanying flow rates for these loads were available.

Lead sum of direct discharges and riverine input

The pattern of the aggregated loads is highly non-monotonic and is thus best assessed with the Mann-Kendall and Theil slope method. As the test is *not significant*, the revealed yearly decrease of 3,8% amounting to an overall decrease in input level of 37,0% is not conclusive. The nature of this assessment is somewhat speculative though, as no accompanying flow rates for these loads were available. These results indicate that the assessment would have benefited from better resolved inputs, which could have been obtained with a higher frequency of monitoring. With the current frequency or methodological approach, it will require a longer time series before any significant trend can be detected.

Conclusions Region 1 (UK North)

Determinant	Assessed load type	Adjustment	Assessment approach Pattern	Method	Trend	Assessment results Significance	Acceptance
Cadmium	Direct	Impossible, flow rates lacking	Monotonic	LOESS level	Downward	YES	**NO** (flow rates lacking)
	Riverine	Not necessary	Non-monotonic	Mann-Kendall and Theil slope	Downward	YES	**YES**
	Aggregated	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	YES	**NO** (direct flow rates lacking)
Mercury	Direct	Impossible, flow rates lacking	Monotonic	LOESS level	Downward	YES	**NO** (flow rates lacking)
	Riverine	A0	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**
	Aggregated	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	YES	**NO** (direct flow rates lacking)
Lead	Direct	Impossible, flow rates lacking	Non-monotonic	Mann-Kendall and Theil slope	Downward	YES	**NO** (flow rates lacking)
	Riverine	A0	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**
	Aggregated	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**

Comments

The acceptance column contains the ultimate evaluation of the direction of the trend for a given determinant and its load type, in accordance with the state of art of the guidance. The evaluation with "YES" or "NO" is based upon the significance of the trend test AND whether a needed adjustment could be applied. Fully acceptable downward trends get a green background colour; those that are indisputably upward get a red background colour. In case of downward trends that showed up in the absence of adequate adjustment, cells get a lighter green background colour to emphasize the speculative nature of the evaluation.

Of 15 determinant-load types that were to be assessed, only 5, the riverine inputs, were accompanied by relevant flow data and could thus be fully assessed. Amongst these only 2 resulted in acceptable trend detections, of which 1 indicates an upward trend: total phosphorus, and the other a downward trend: cadmium.

The direct and aggregated inputs all show a downward pattern that mostly revealed significant, except for aggregated lead and phosphorus loads, but that could not be accepted due to the lack of flow rates for the direct discharges.

Region 2 (UK South)

The direct discharges could not exactly be assessed in the way prescribed by the guidance as no flow data are available for these loads. Nevertheless, considering that generally, the flow rates for direct inputs in this zone are fairly consistent, and that if there is a significant change in flow, it is due to the actual reductions or increases in discharges and associated loads rather than weather dependence. Hence, absolute direct loads without flow adjustment are considered here in order to add the information contained therein to the overall assessment.

Cadmium sum of direct discharges and riverine input

The pattern of the aggregated direct and riverine loads is monotonic descending, an indication that the LOESS level method is recommended for assessment. This test is *highly significant* so that one can conclude at a reduction of 54,5% over the whole period. This assessment is slightly limited because flow rates for the direct inputs were not available.

Mercury sum of direct discharges and riverine input

The pattern of the aggregated loads is sub-monotonic decreasing, and is best assessed with the LOESS level method. As the test is *significant*, the revealed decrease of 63,7% over the assessed period is conclusive. This assessment is slightly limited because flow rates for the direct inputs were not available.

Lead sum of direct discharges and riverine input

The pattern of the aggregated loads is highly non-monotonic and is best assessed with the Mann-Kendall and Theil slope method. As the test is *not significant*, the revealed decrease of 1,1% per year, adding to 12,5% over the assessed period is not conclusive. This assessment is slightly limited because flow rates for the direct inputs were not available.

Conclusions Region 2 (UK South)

Determinant	**Assessed load type**	**Adjustment**	**Assessment approach**		**Assessment results**		
			Pattern	**Method**	**Trend**	**Significance**	**Acceptance**
Cadmium	Direct	Impossible, flow rates lacking	Monotonic	LOESS level	Downward	YES	**NO** (flow rates lacking)
	Riverine	A0	Non-monotonic	Mann-Kendall and Theil slope	Downward	YES	**YES**
	Aggregated	-	Monotonic	LOESS level	Downward	YES	**NO** (direct flow rates lacking)
Mercury	Direct	Impossible, flow rates lacking	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**
	Riverine	A0	Monotonic	LOESS level	Downward	YES	**YES**
	Aggregated	-	Monotonic	LOESS level	Downward	YES	**NO** (direct flow rates lacking)
Lead	Direct	Impossible, flow rates lacking	Monotonic	LOESS level	Downward	YES	**NO** (flow rates lacking)
	Riverine	A0	Non-monotonic	Mann-Kendall and Theil slope	Upward	NO	**NO**
	Aggregated	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**

Comments

The acceptance column contains the ultimate evaluation of the direction of the trend for a given determinant and its load type, in accordance with the state of art of the guidance. The evaluation with "YES" or "NO" is based upon the significance of the trend test AND whether a needed adjustment could be applied. Fully acceptable downward trends get a green background colour; those that are indisputably upward get a red background colour. In case of downward trends that showed up in the absence of adequate adjustment, cells get a lighter green background colour to emphasize the less reliable nature of the evaluation.

Out of 15 determinant-load types that were to be assessed, only 5, the riverine inputs, were accompanied by relevant flow data and could thus be fully assessed. Amongst these only 2 resulted in an acceptable trend detection indicating a downward trend: cadmium and mercury.

Region 3 (Belgium and the Netherlands)

Cadmium sum of direct discharges and riverine input

The pattern of the aggregated direct and riverine loads is non-monotonic descending, an indication that the Mann-Kendall and Theil slope method is recommended for assessment. This test is *not significant* so that one cannot conclude at a yearly reduction of 0,9% amounting to 10,5% over the whole period.

Mercury sum of direct discharges and riverine input

The pattern of the aggregated loads is non-monotonic decreasing, and is best assessed with the Mann-Kendall and Theil slope method. As the test is *significant*, the revealed decrease of 8,9% per year, amounting at 67,4% over the assessed period is conclusive.

Lead sum of direct discharges and riverine input

The pattern of the aggregated loads is non-monotonic and is best assessed with the Mann-Kendall and Theil slope method. As the test is *not significant*, the revealed decrease of 1,8% per year, adding up to 19,3% over the assessed period is not conclusive.

Conclusions Region 3 (Belgium and the Netherlands)

Determinant	Assessed load type	Adjustment	Assessment approach		Trend	Assessment results	
			Pattern	Method		Significance	Acceptance
Cadmium	Direct	-	Monotonic	LOESS level	Downward	YES	**YES**
	Riverine	A0	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**
	Aggregated	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**
Mercury	Direct	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**
	Riverine	A0	Non-monotonic	Mann-Kendall and Theil slope	Downward	YES	**YES**
	Aggregated	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	YES	**YES**
Lead	Direct	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**
	Riverine	A0	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**
	Aggregated	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**

Comments

The acceptance column contains the ultimate evaluation of the direction of the trend for a given determinant and its load type, in accordance with the state of art of the guidance. The evaluation with "YES" or "NO" is based upon the significance of the trend test AND whether a needed adjustment could be applied. Fully acceptable downward trends get a green background colour; those that are indisputably upward get a red background colour.

Out of 15 determinant-load types that had to be assessed, 7 resulted in acceptable trend detections. Amongst those, 6 resulted in detecting downward trends: direct discharges of cadmium, riverine and aggregated inputs of mercury, riverine and aggregated inputs of total nitrogen and direct discharges of total phosphorus. One upward trend was detected: direct discharges of total nitrogen.

Region 4 (Germany and Denmark)

Cadmium sum of direct discharges and riverine input

The trend pattern of the aggregated loads is non-monotonic and hence, the Mann-Kendall test for trend detection is recommended while the Theil slope will give an estimate of the annual trend magnitude. Although the Mann-Kendall test is significant for a downward trend, the estimate of an annual decrease of these loads with 4,60% is rather tentative for the reason pointed out above. Based on the Theil slope, an equally tentative decrease in the order of around 40% over the considered period is found. For the apparently obvious downward trend in the yearly loads, *no statistical conclusive support* was found. More investigations into the causes of the yearly variability are needed so that a suitable adjustment method can be devised. Furthermore, it could also be considered if some revision of the monitoring program for cadmium would be needed in order to admit a reliable assessment in the future.

Mercury sum of direct discharges and riverine input

The trend pattern of the aggregated loads is clearly monotonic and hence the LOESS level method for trend detection is recommended. This test is *highly significant* and indicates a reduction of 67,6% of the input level of 2002 compared to 1990.

Lead sum of direct discharges and riverine input

The trend pattern of the unadjusted loads is non-monotonic and hence, the Mann-Kendall test for trend detection is recommended while the Theil slope will give an estimate of the annual trend magnitude. The Mann-Kendall test is *not significant*, so the apparent annual downward trend indicated by the Theil slope of 5,8% is not conclusive. Sampling frequency or a review of the monitoring policy might be advisable in order to increase the ability to detect a significant trend in the future.

Conclusions Region 4 (Germany and Denmark)

Determinant	Assessed load type	Adjustment	Assessment approach		Assessment results		
			Pattern	Method	Trend	Significance	Acceptance
Cadmium	Direct	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	YES	**YES**
	Riverine	Necessary but method not available	Non-monotonic	Mann-Kendall and Theil slope	Downward	YES	**NO** (adjustment lacking)
	Aggregated	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	YES	**NO** (adjustment lacking)
Mercury	Direct	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**
	Riverine	Not necessary	Monotonic	LOESS Level	Downward	YES	**YES** (data gaps)
	Aggregated	-	Monotonic	LOESS Level	Downward	YES	**YES** (data gaps)
Lead	Direct		Non-monotonic	Mann-Kendall and Theil slope	Downward	YES	**YES** (data gaps)
	Riverine	Not necessary	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**
	Aggregated	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**

Comments

The Acceptance column contains the ultimate evaluation of the direction of the trend for a given determinant and its load type, in accordance with the state of art of the guidance. The evaluation with "YES" or "NO" is based upon the significance of the trend test AND whether a needed adjustment could be applied. Fully acceptable downward trends get a green background colour; those that are indisputably upward get a red background colour. In case of downward trends that showed up in the absence of adequate adjustment, cells get a lighter green background colour to emphasise the speculative nature of the evaluation.

The overall view is that downward trends are very common amongst the tested determinants but that they are only acceptable in a limited number of cases. Out of 15 determinant-load types that had to be assessed, 5 resulted in fully acceptable downward trend detections: direct discharges of cadmium, all load types of total nitrogen and direct discharges of total phosphorus. Riverine inputs and aggregated loads of mercury are provisionally acceptable as decreasing, the restriction being that there are gaps in the datasets. The downward trend for riverine inputs and aggregated loads of cadmium cannot be accepted as the appropriate adjustment method is lacking to assess these loads.

Region 5 (Norway)

Cadmium sum of direct discharges and riverine input

The pattern of these loads is strongly non-monotonic so that the Mann-Kendall and Theil slope method is recommended. The test is *not significant* and the revealed 7,3% yearly reduction of the loads amounting to an overall 59,5% reduction over the whole period is not confirmed.

Mercury sum of direct discharges and riverine input

The trend pattern of these loads is highly non-monotonic with high inter-annual variability. In this case, the Mann-Kendall and Theil slope method is recommended. As this test is *not significant* for an upward trend, the estimate of the increase of the loads with 1,9% per year amounting to 25,2% over the considered period is not confirmed.

Lead sum of direct discharges and riverine input

The pattern of the aggregated loads is monotonic and is best assessed with the LOESS level method. As the test is *highly significant*, the revealed decrease of 72,3% over the assessed period is conclusive.

Conclusions Region 5 (Norway)

Determinant	Assessed load type	Adjustment	Assessment approach Pattern	Method	Trend	Assessment results Significance	Acceptance
Cadmium	Direct	-	Non-monotonic	Mann-Kendall and Theil slope	Upward	NO	**NO**
	Riverine	Not necessary	Non-monotonic	Mann-Kendall and Theil slope	Downward	YES	**YES**
	Aggregated	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**
Mercury	Direct	-	Monotonic	LOESS Level	Downward	YES	**YES**
	Riverine	A0	Monotonic	LOESS Level	Upward	YES	**YES**
	Aggregated	-	Non-monotonic	Mann-Kendall and Theil slope	Upward	NO	**NO**
Lead	Direct	-	Non-monotonic	Mann-Kendall and Theil slope	Downward	NO	**NO**
	Riverine	Not necessary	Monotonic	LOESS Level	Downward	YES	**YES**
	Aggregated	-	Monotonic	LOESS Level	Downward	YES	**YES**

Comments

The acceptance column contains the ultimate evaluation of the direction of the trend for a given determinant and its load type, in accordance with the state of art of the guidance. The evaluation with "YES" or "NO" is based upon the significance of the trend test AND whether a needed adjustment could be applied. Fully acceptable downward trends get a green background colour; those that are indisputably upward get a red background colour.

Out of 15 determinant-load types that had to be assessed, 8 resulted in acceptable trend detections. Amongst those, 4 resulted in detecting downward trends: riverine inputs of cadmium, direct discharges of mercury, riverine and aggregated inputs of lead. Four upward trends were detected: riverine inputs of mercury, direct discharges of total nitrogen and riverine inputs and aggregated loads of total phosphorus.

Aggregated results for cadmium, mercury and lead for Regions 1-5

This acceptance Table contains the ultimate evaluation of the direction of the trend for a given determinant, in accordance with the state of art of the guidance. The evaluation with "YES" or "NO" is based upon the significance of the trend test AND whether a needed adjustment could be applied. Fully acceptable downward trends get a green background colour. In case of downward trends that showed up in the absence of adequate adjustment, cells get a lighter green background colour to emphasize the speculative nature of the evaluation. The reduction over the whole period is given between brackets.

	Region 1 (UK N)	Region 2 (UK S)	Region 3 (B + NL)	Region 4 (D + DK)	Region 5 (N)
Cadmium	**NO (61%)** (direct flow rates lacking)	**NO (55%)** (direct flow rates lacking)	**NO**	**NO (40%)** (adjustment lacking)	**NO**
Mercury	**NO (55%)** (direct flow rates lacking)	**NO (64%)** (direct flow rates lacking)	**YES (67%)**	**YES (68%)** (data gaps)	**NO**
Lead	**NO**	**NO**	**NO**	**NO**	**YES (72%)**

2005 Assessment of CEMP data
Appendix 15: Summary of the significant upward and downward trends for metals and organic contaminants in biota

Region I

up-metals: As Dvergasteinn Alftafjõrdur (IS). Cd Hvalfjördur (IS), Cu Svolvær

down-metals: Cu Varangerfjord, Hg – NO: Varangerfjord and Skogerøy, Pb – IS: Straumur-Straumsvik, Grimsey, NO: Skogery.

down-organics: There is no clear relationship for the significance of trends between CB153 and the related ΣCB7 CB153 IS Hvalfjördur, NO 10B Varanger. γ-HCH IS(1), NO(4)

Region II

up-metals: As Germany: Suedfall Norderane Helgoland, Denmark Roskilde Fjord, Pb DK: Wadden sea (2) and Roskilde fjord, F: Sein cap de la Heve, Zn: DE - Roskilde Fjord 65, Elbe Outer, Weser Inner, Borkum (=<1998), BE-BCP, NO 36A Færder, 53B Inner Sørfjord SE- Fladen (2), NL- TERSLNWT40

up-organics: ANT: FR Calvados Ouistreham. BGHIP all FR – 7 stations (not regular trend – possible methods error). BAP FR (1) (not regular trend – possible methods error) CHR FR Baie de la Fresnaye. FLU DE Roskilde Fjord 65. IND FR Ouest Cotentin - Pirou Nord, Ouest Cotentin – Breville, Lannion - Saint Michel en Grev, Dieppe – Varengeville, Calvados Ouistreham, Baie de la Fresnaye, Antifer Digue, Saint Brieuc - Pointe de Rosel, Paimpol - Beg Nod and Brest - Baie de Roscanvel. CB153 and ΣCB7 NO, UK NMMP105 (Moray Firth Offshore).

down-metals: As – Germany: Norderney, outer Elbe (2) Weser, Baltrum, Borkum; Cd – Bay of Seine (e.g. Antifer digue) phosphogypsum cessation midnineties. Germany: Borkum, outer Jade, Norway Strandebarm. Cr – Germany: outer Elbe, Borkum; Sweden: Fladen (2); Ni: DK-Little Belt, SE: Väderöarna, Fladen; Hg – all time series from France (2), Belgium (2) Netherlands (5) and Germany (6, especially Elbe region). Mixed results for Norway, Sweden and Denmark., Pb NO: all 11 time series. Zn: FR-Seine Villerville, Baie de la Fresnaye, DE-Suedfall, Helgoland, NO-Eitrheimsneset, Kvalnes, Krossanes, Ranaskjær, Sande (east side)NL- IJMDWT80 and BORKND30

down-organics: ANT: all in FR Saint Vaast-Le Moulard, Ouest Cotentin-Breville, Cancale-Le Vivier sur Mer, Baie des Veys Gefosse and Baie de la Fresnaye, Saint Brieuc-Pointe de Rosel, Paimpol-Beg Nod, Brest-Aulne rive droite, BAA FR Calvados Port de Bessin. CHR FR Calvados Port de Bessin and N (30A, abruptly last 2 years). FLU FR Lannion - Saint Michel en Grev; Calais - Dunkerque - Oye Plage and Baie des Veys Gefosse. PHE FR (7). CB153 and ΣCB7 SE (Fladen), NO (Færder) Southern North Sea (DK, DE, NL, BE in particular Wadden sea. γ-HCH DE (Elbe, 5 time series), B (BCP, 4 time series) DK (2 stations, Wadden Sea and Little belt). Dieldrin

Region III

up-metals: Hg – UK NMMP station 796 (Morecomb Bay offshore)

up-organics:

down-metals: Cd – Dublin Bay, Cr – UK NMMP site 768 (St. Bees Cumbria Coast), Pb – UK: NMMPstations 765 (Mersey Channel) and 766 (Ribble 11 mile post)

down-organics: ΣCB7 IR (Cork West Passage/RIngaskiddy. γ-HCH: IR (Cork and Dublin)

Region IV

up-metals:

up-organics: BGHIP all FR – 5 stations (not regular trend – possible methods error) BAP FR (2) (not regular trend – possible methods error) CHR FR Vilane Er Fosse. IND FR Vilaine-Pen Be, Lorient-La Potée de Beure Morbihan–Locmariaquer. PYR FR Hendaye-Chingoudy

down-metals: Cd – Ria of Vigo (ES), Hg: F (Riec-sur-Belon, Hendaye – Chingoudy and Arcachon - Les Jacquets) and ES (Pontevedra, Arosa and La Coruña), Pb F: all 3, ES all 4, Zn Fr Hendaye-Chingoudy.

down-organics: ANT all in FR: Riec sur Belon, Pertuis Breton-Rive doux, Morbihan-Locmariaquer, Morbihan-Arradon, Marennes-Mus de Loup, Gironde-Pontaillal, Gironde-Bonne Anse, Chatelaillon, Bourgneuf-Coupelasse, Baie de l'Aiguillion, Arcachon-Cap Ferret, Adour, Vilaine-Er Fosse and Loire-Pointe de Chemoulin. BAP FR (5) (not regular trend – possible methods error) FLU FR Vendée- Talmont. PHE FR (12). PYR FR Vendée-Talmont. CB153 and ΣCB7 hhv. 14 and 17 along the FR and ES. γ-HCH F - Marennes - Mus de Loup, Marennes – Boyardville, Gironde – Pontaillal and Gironde - Bonne Anse (mussel) and Vilaine Pen Be.