Assessment and Monitoring Series

2006/2007 CEMP Assessment: Trends and concentrations of selected hazardous substances in the marine environment

OSPAR Commission
2007

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

This 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. This is one of a series of annual scientific assessments of data collected under the Coordinated Environmental Monitoring Programme that OSPAR has agreed to make during the period of preparation of the next Quality Status Report in 2010 in order to keep monitoring data under more regular scrutiny and provide a more up-to-date evidence base for policy making. This annual assessment of OSPAR marine monitoring data confirms the conclusion from the trend assessments published in 2005 and 2006 that there are widespread downward trends in the concentrations of hazardous substances in the North East Atlantic.

The assessment concentrated on aspects of the CEMP data which would potentially contribute to the QSR 2010. For example, emphasis was given to data collected within the last ten years (i.e. the period of greatest significance to QSR 2010) whereas previous assessments had covered longer periods. New aspects of the assessment included the consideration of ratios between contaminants (PAHs, CBs, and HCH isomers) as possible indicators or sources of contamination, and assessment of data on tributyltin concentrations in biota.

The assessment concentrated on biota rather than sediments, as there were relatively few new data for sediments that could be made readily available to the assessors at this time, although developments in ICES database procedures and MON data handling should enable sediments to be considered again in 2007.

The focus on concentrations in biota highlighted the need for revised assessment criteria for contaminants in biota, as has been discussed in previous reports. As new advice was not available to MON, MON undertook an analysis of a compilation of data from stations considered by Contracting Parties to represent remote or pristine locations and developed proposals for BCs and BACs from these data. The new values were generally higher than those in the 2005 Agreement. They were used on a trial basis in the assessment, and as might be expected a larger proportion of the data were found to be at or below background level. It is important that decisions are made as to which BC and BAC values should be used in the assessment work for QSR 2010. The use of the revised BACs did still highlight hotspots of high concentrations of contaminants. In some cases these could readily be ascribed to inputs from known point sources, but in other cases the reasons were not clear. The absence of revised EAC values for biota is a significant weakness for the assessment of the environmental significance of the concentrations observed.

A total of 2968 time series of data were assessed, which were drawn from data collected at widely spaced monitoring stations in OSPAR Regions I, II, III and IV, and varied in length from 3 to 10 years. 68% of the time series were 7 or more years long, and 62% of the stations were in Region II, but the results are similar in all four regions. The hazardous substances assessed include metals, polycyclic aromatic hydrocarbons (PAH), chlorinated biphenyls (CBs) and TBT.

Statistically significant trends, showing either increasing or decreasing concentrations, were found in 498 time series. The majority (360 (72%)) showed downward trends. 138 (28%) showed increasing trends. The following results are particularly important for chemicals identified by OSPAR for priority action:

a. the majority of the statistically significant trends of concentrations of mercury (17 out of 31), cadmium (25 out of 40) and lead (32 out of 44) in biota show decreasing concentrations;

b. all but one of the statistically significant trends for lindane (77) and all the trends for HCB (18), and the large majority of statistically significant trends for p,p'-DDE (27 out of 30) in biota show decreasing concentrations;

c. the large majority of statistically significant trends for CB 153 (representative of the CB group) (37 out of 43) in biota show decreasing concentrations. However, concentrations of PCBs in biota remain relatively high in most OSPAR regions suggesting that there may be a residual problem;

d. a limited number of statistically significant increasing (10) and decreasing (6) trends for benzo[a]pyrene in biota do not suggest the widespread downward trends visible for other contaminants[1];

e. 25% of the time series for TBT in biota showed significant trends, and all (8) were downward.

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

For the large majority of time series, no statistically significant trends could yet be detected. The restriction of the data analysis to the last 10 years will have reduced the power of the monitoring data to show trends. The dynamic nature of the marine environment produces much statistical “noise”, which means that the power of programmes to detect trends increases with the length of the monitoring time series. Continued monitoring to extend the time series will help to clarify the position.

As mentioned above, MON undertook a short exercise to proposed new Background Concentrations and Background Assessment Concentrations (BAC) in shellfish for the contaminants covered by this assessment, to represent the background levels of hazardous substances that would be expected in the absence of human-induced contamination. These were used on a trial basis in the assessment, and comparisons were made 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 and PAHs are above background levels. For example:

a. for lead, 39% of concentrations in blue mussels in the last year of each time series were below the BAC, and for cadmium 71% were below the BAC.

b. for mercury, 36% of concentrations in blue mussels in the last year of each time series were below the BAC, as were 20% of concentrations of mercury in fish;

c. for the PAH benzo[a]pyrene 64% of concentrations in shellfish in the last year of each time series were below background levels.

For CBs and TBT (which are man made synthetic substances), the ultimate OSPAR aim is concentrations close to zero. In no case was the concentration of CB153 in shellfish in the latest year of time series significantly less than the BAC. The same was true for TBT.

The text of the report emphasises those locations where significant upward or downward trends in concentrations have been found. In some cases, Contracting Parties have been able to identify reasons why the observed trends are occurring and such explanatory comments have been included in the report. Where no comment is made, this indicates that the relevant Contracting Party did not provide explanatory comment.

In general the results are consistent with the trend assessments of CEMP data published in 2005 and 2006 even though the assessment is based on a much more targeted selection of data from the ICES database, covering only the last 10 years. Many of the differences in the outcome of this assessment compared with previous reports can be attributed to these modifications, and to the trial use of revised assessment criteria.

Récapitulatif

Cette évaluation confirme d’une manière générale, les conclusions à savoir que les travaux d’OSPAR ont des effets positifs importants sur la qualité du milieu marin de l’Atlantique du Nord-est. Elle fait partie d’une série d’évaluations scientifiques annuelles des données recueillies dans le cadre du Programme coordonné de surveillance continue de l’environnement (CEMP), qu’OSPAR est convenue d’élaborer durant la période préparatoire du prochain bilan de santé en 2010. Le but de ces évaluations annuelles est d’étudier de plus près et plus régulièrement les données de surveillance et de fournir des justifications actualisées, sur lesquelles pourra se fonder la prise de décisions politiques. Cette évaluation annuelle des données de surveillance marine soutient la conclusion des évaluations sur la tendance publiées en 2005 et 2006, c'est-à-dire une tendance générale à la baisse de concentrations de substances dangereuses dans l’Atlantique du Nord-Est.

L’évaluation a mis l’accent sur les aspects des données CEMP qui sont particulièrement pertinents au QSR 2010. Elle insiste, par exemple, sur les données recueillies pendant les dix dernières années, c’est-à-dire durant la période la plus significative pour le QSR 2010, alors que les évaluations précédentes se sont portées sur une période plus étendue. Elle comporte également de nouveaux aspects, par exemple l’étude des ratios entre les contaminants (HAP, CB, et isomères de HCH) en tant qu’indicateurs éventuels ou de sources de contamination, et l’évaluation des données sur les teneurs en tributylétain dans le milieu vivant.

L’évaluation s’est axée sur le milieu vivant plutôt que les sédiments, car peu de nouvelles données étaient prêtes pour mettre à la disposition aux évaluateurs en temps voulu. Toutefois, les avancées dans les procédures de la base de données CIEM et du traitement des données MON devraient permettre l’étude des sédiments en 2007.

L’emphase sur les teneurs dans le milieu vivant a souligné le besoin de revoir les critères d’évaluation pour les contaminants dans le milieu vivant, tels que considérés dans les rapports précédents. Du fait que l’on n’a pas donné de nouveaux conseils au Groupe de travail OSPAR surveillance continue (MON), le MON a entrepris une analyse d’une compilation des données provenant des stations que les Parties contractantes considèrent représentatives de lieux reculés ou vierges. Il a préparé des propositions pour des teneurs ambiantes (BC) et des teneurs d'évaluation ambiante (BAC) à partir de ces données. Les nouvelles valeurs étaient généralement supérieures à celles convenues par l'accord de 2005. Elles ont été utilisées à titre expérimental dans l'évaluation. Comme on pouvait s'y attendre, une proportion plus importante de données se trouvait à un niveau ambiant ou inférieur. Il est donc important de décider lesquelles des valeurs BC et BAC doivent être utilisées dans les travaux d'évaluation du QSR. L'utilisation des BAC remaniées met encore en évidence des points chauds à teneurs élevées en contaminants. Dans certains cas on pourrait les attribuer à des apports provenant de sources ponctuelles connues, mais d'en d'autres cas les raisons ne sont pas claires. L'absence des valeurs EAC remaniées pour le milieu vivant représente une lacune importante de l'évaluation de l'impact environnemental des teneurs observées.

Au total, 2968 séries temporelles de données ont été évaluées pour ce rapport. Ces données proviennent de stations de surveillance disséminées dans les Régions I, II, III et IV d'OSPAR. Les séries temporelles s'étendent sur 3 à 10 ans, 68% d'entre elles portent sur sept ans ou plus, et 62% des stations sont situées dans la Région II, mais les résultats sont similaires dans les quatre régions. Les substances dangereuses qui ont été évaluées sont entre autres, les métaux, les hydrocarbures aromatiques polycycliques (HAP) les biphényles chlorés (CB) et le tributylétain (TBT).

On a observé des tendances statistiquement significatives, qui révèlent des teneurs soit en hausse soit en baisse, dans 498 séries temporelles. La majorité de ces séries (360 (72%)) révèlent des tendances à la baisse, alors que 138 séries (28%) révèlent des tendances à la hausse. Les résultats suivants sont particulièrement importants pour les produits chimiques identifiés par OSPAR comme devant faire l'objet de mesures prioritaires:

a. la majorité des tendances statistiquement significatives des teneurs en mercure (17 sur 31), en cadmium (25 sur 40) et en plomb (32 sur 44) dans le milieu vivant révèlent des tendances en baisse;

b. toutes les tendances statistiquement significatives pour le lindane, à l'exception d'une (77) et toutes les tendances pour le HCB (18), et la grande majorité des tendances statistiquement significatives pour le p,p'-DDE (27 sur 30) dans le milieu vivant révèlent des teneurs en baisse;

c. la grande majorité des tendances statistiquement significatives pour le CB 153 (représentatif du groupe des CB) (37 sur 43) dans le milieu vivant montrent des teneurs en baisse. Les teneurs en PCB dans le milieu vivant restent cependant relativement élevées dans la plupart des régions OSPAR, ce qui semble indiquer qu'un problème persiste;

d. un nombre limité de tendances statistiquement significatives, à la hausse (10) et à la baisse (6) pour le benzo[a]pyrène dans le milieu vivant ne semble pas refléter la tendance générale à la baisse que l'on relève pour les autres contaminants[2];

e. 25% des séries temporelles pour le TBT dans le milieu vivant révèlent des tendances significatives qui sont toutes (8) à la baisse.

La grande majorité des séries temporelles ne présentent pas de tendances statistiquement significatives. Le fait que l'on limite l'analyse des données aux dix dernières années restreint la possibilité pour les données découlant de la surveillance de révéler des tendances. Le dynamisme naturel du milieu marin produit beaucoup de "bruits" statistiques ce qui signifie que la capacité des programmes à détecter des tendances augmente avec la durée des séries temporelles de surveillance. Une surveillance continue qui prolongerait les séries temporelles permettrait de clarifier la situation.

Tel qu'il a été fait mention ci-dessus, le MON a entrepris une étude brève sur les propositions de nouvelles teneurs ambiantes et teneurs d'évaluation ambiantes dans les crustacés pour les contaminants couverts par cette évaluation, afin de représenter les niveaux ambiants des substances dangereuses auxquelles on pourrait s'attendre dans l'absence d'une contamination due à l'homme. Celles-ci ont été utilisées à titre d'essai dans l'évaluation. Une comparaison entre les teneurs de la dernière année de chaque série temporelle et les teneurs ambiantes révisées a été effectuée. Elle révèle que dans la plupart des cas les teneurs en métaux lourds et en HAP sont supérieures aux niveaux ambiants. Par exemple:

a. pour le plomb, 39% des teneurs dans la moule bleue sont en dessous des teneurs d'évaluation ambiantes pour la dernière année de chaque série temporelle et pour le cadmium, 71% sont en dessous des teneurs d'évaluation ambiantes.

[2] Les composés de HAP proviennent de sources diverses, notamment les poêles à bois, les écoulements de revêtement goudronné des routes et les incinérateurs de déchets municipaux.

b. pour le mercure, 36% des teneurs dans la moule bleue sont en dessous des teneurs d'évaluation ambiantes pour la dernière année de chaque série temporelle, il en est de même pour 20% des teneurs en mercure dans le poisson;

c. pour le HAP benzo[a]pyrène 64% des teneurs dans les crustacés sont inférieures aux niveaux ambiants pour la dernière année de chaque série temporelle.

Dans le cas des CB et du TBT (qui sont des substances synthétiques), l'objectif ultime d'OSPAR est de parvenir à des teneurs proches de zéro. En aucun cas, la teneur en CB153 ou en TBT dans les crustacés ne s'est révélée significativement inférieure à la teneur d'évaluation ambiante la toute dernière année de la série temporelle.

Le texte du rapport insiste sur les lieux qui ont révélé des tendances significatives à la hausse ou à la baisse des teneurs. Dans certains cas les Parties contractantes ont pu déterminer les raisons qui expliquent ces tendances et les commentaires correspondants figurent dans le rapport. Lorsqu'il n'y a aucun commentaire, ceci signifie que la Partie contractante concernée n'a pas fourni d'explications.

D'une manière générale, les résultats correspondent à ceux des évaluations de tendances des données de la base de données CEMP publiées en 2005 et 2006, bien que l'évaluation se fonde sur des données dont la sélection est beaucoup plus ciblée, portant sur la base de données CIEM et uniquement sur les dix dernières années. De nombreuses différences entre les résultats de cette évaluation et des rapports précédents sont dues à ces modifications, et à l'utilisation expérimentale de critères d'évaluation révisés.

1. Introduction

1. This report is the second in a series of annual assessments of trends and concentrations in data reported by OSPAR Contracting Parties under the Co-ordinated Environmental Monitoring Programme (CEMP). It follows the first comprehensive trend assessment of CEMP data in 2005 (publication number: 2005/235), and the first annual CEMP assessment report (publications number 2006/288). The key methods used in these assessments, such as data screening procedures, quality assurance assessment, statistical methodology, data assessment criteria and station lists were described in the 2005 CEMP assessment (OSPAR publication 2005/235).

2. The CEMP can be described as that part of monitoring under the OSPAR Joint Assessment and Monitoring Programme where the national contributions overlap and are co-ordinated (reference number: 2005-5). It covers temporal trend and spatial monitoring programmes for concentrations of selected chemicals and nutrients, and for biological effects. Supporting documentation for the CEMP includes guidelines for monitoring, quality assurance tools and assessment tools.

3. The aim of this and future annual assessments is to test and further improve methodologies developed for trend assessments and to update information on the quality of the marine environment in relation to CEMP determinands. These assessments provide a framework for continuing improvements to methods and procedures for the next overall CEMP data assessment in 2008/2009, and for the report on the quality status of the OSPAR maritime area in 2010.

4. The annual assessments will focus on specific items or contaminants under the CEMP. The present assessment concentrates on trends in the concentrations in biota of metals (cadmium, copper, lead, mercury and zinc), TBT, organic contaminants (PCB congeners 118 and 153, the PAHs fluoranthene, benzo[a]pyrene, benzo[ghi]perylene, anthracene and phenanthrene and pesticides α-HCH, γ-HCH (lindane), p,p'-DDE and HCB).

5. The assessment has been prepared by the OSPAR Working Group on Monitoring (MON) and is based upon data reported by Contracting Parties to ICES and held in the ICES Environmental databases.

2. Overview maps of stations from which data was assessed

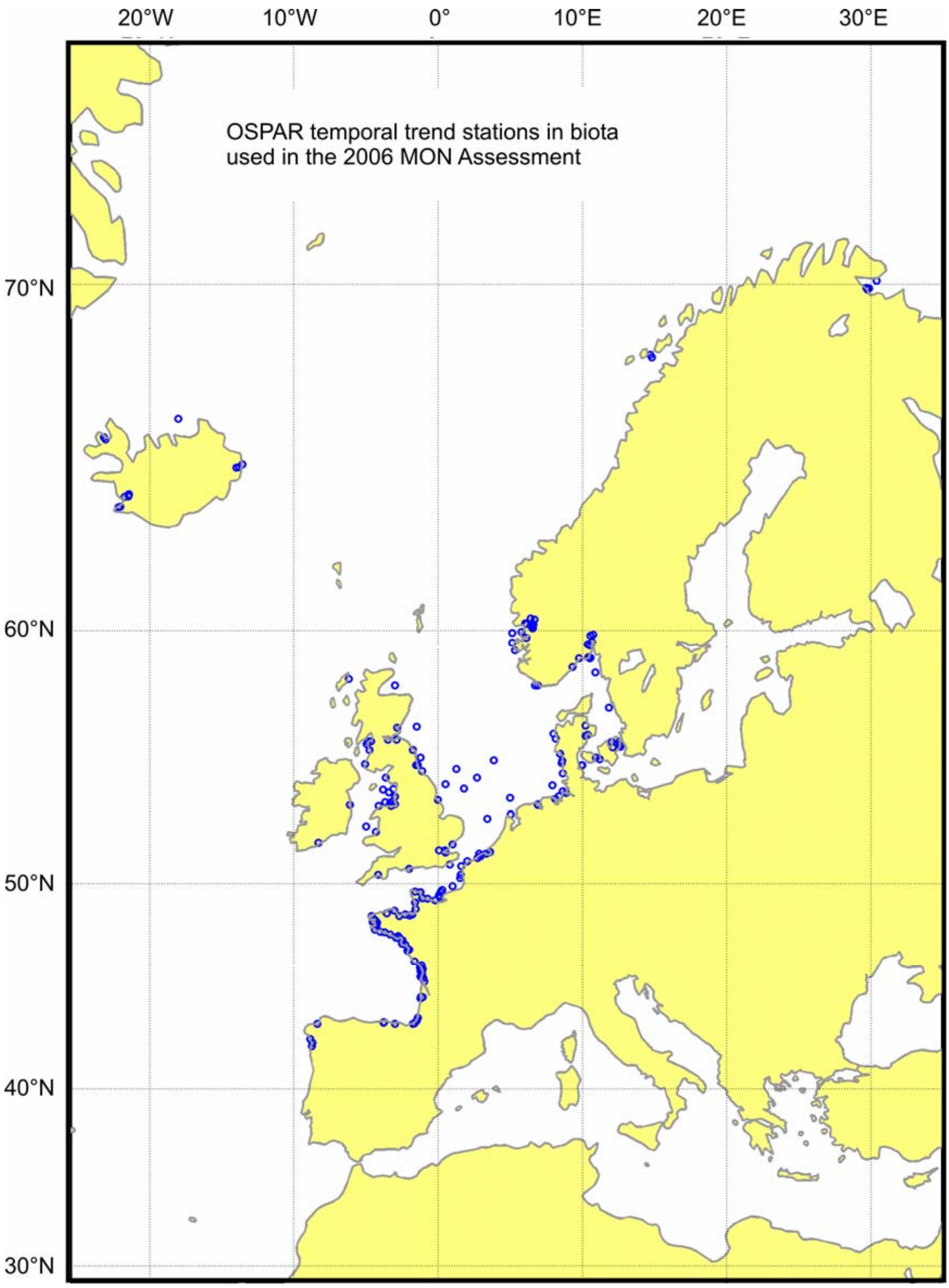

Figure 2.1. Overview map showing CEMP temporal trend monitoring stations for contaminants in biota.

3. Methods and preparation of the assessment

3.1 Selection of parameters for assessment

6. The assessment covers the following hazardous substances which are included as mandatory determinands under the CEMP:

a. ***mercury, cadmium, lead and zinc in biota***. Mercury, cadmium and lead are heavy metals included in the OSPAR List of Chemicals for Priority Action. To provide broader information on environmental trends concentrations of zinc have been assessed to give an indication of whether increases of cadmium in biota are linked to uptake in areas where the bioavailability of zinc is reduced;

b. ***tributyl tin (TBT) and copper in biota.*** TBT is included in the group of organic tin compounds on the OSPAR List of Chemicals for Priority Action. Concentrations of copper in biota have has been assessed to give an indication of whether substitution of TBT in anti-fouling treatments for *inter alia* copper-based treatments is leading to increases in copper in the marine environment;

c. ***the PAHs fluoranthene, benzo[a]pyrene, and benzo[ghi]perylene, in biota, and the ratio of phenanthrene to anthracene***. PAHs are included as a group of substances on the OSPAR List of Chemicals for Priority Action. Fluoranthene has been selected for assessment because it can be quantified well using the most regularly used analytical methods and was found at relatively high concentrations (compared to other PAH compounds) in the 2005 CEMP assessment. Benzo[a]pyrene has been selected because of its recognised toxicological importance, and it is generally one of the more abundant PAHs. Benzo[ghi]perylene and phenanthrene are representatives of higher and lower condensed PAHs, respectively, and can be used to study the behaviour of PAHs in the environment. The ratio of phenanthrene to anthracene can be used to investigate the pyrogenic or petrogenic origin of PAHs;

d. ***the polychlorinated biphenyl congener CB118 and CB153* in biota**. PCBs are included as a group of substances on the OSPAR List of Chemicals for Priority Action. CB153 was selected to represent PCBs because it is generally present in the highest concentration and correlates well with other analysed PCBs. CB118 has primarily been selected on the basis that it is representative of the more toxicologically relevant mono-ortho/planar PCBs. Additionally, the ratio of CB118/CB153 was examined to investigate potential differences in sources.

7. The assessment also covers the following pesticides and other organochlorine compounds:

a. **γ-HCH (lindane) and α-HCH in biota**: the group of hexachlorocyclohexane isomers is included in the OSPAR List of Chemicals for Priority Action. The ratio of these isomers can be used to investigate the potential differences in sources;

b. **p,p'-DDE in biota**: p,p'-DDE is a metabolite of the pesticide DDT which is frequently used as a marker for DDT contamination;

c. **Hexachlorobenzene in biota (HCB)**: HCB is a priority hazardous substance under the Water Framework Directive.

8. No assessment of sediment data was done because of insufficient additional data since the 2005/2006 assessment. Although it had been planned to make an assessment of imposex data this will now be done as part of the next annual CEMP assessment in 2007/2008. The development of an overview of concentrations of PFOS in the marine environment was not possible due to a lack of data.

3.2 Methods used for assessment

9. This annual assessment was mainly prepared using the methods for data screening, treatment of quality assurance information, choice of bases, temporal trend assessment and assessment against

background concentrations used during the 2004/2005 CEMP Assessment (OSPAR Commission, 2005a)[3] and further developed during the 2005/2006 CEMP assessment.

10. These methods are documented in the 2005 CEMP Assessment Report and are currently being incorporated into a CEMP Assessment Manual, which is intended to be published in due course.

3.3 Use of Assessment Criteria

11. In addition to temporal trend analyses, the main assessment criteria applied to CEMP data are Background Concentrations (and associated Background Assessment Concentrations) and Environmental Assessment Criteria. OSPAR's current agreement on background concentrations (BCs) (OSPAR Agreement 2005/06) includes values for Background Reference Concentrations for metals in biota that were originally adopted in 1997. It was originally planned to update these values after the QSR 2000 in the light of new knowledge, but output from this task was not available prior to MON 2006. Therefore, MON concluded that it might assist with the process if they collated data on the concentrations of metals and PAHs in fish and shellfish from areas considered by Contracting Parties to be remote and/or pristine, and proposed updated values for background concentrations in mussels for the PAHs and metals covered in this assessment. The corresponding Background Assessment Concentrations (BACs) have been recalculated and applied in the assessment, as described and tabulated in Annex 1 of this report. The BCs and BACs for mussels have also been applied to pacific oyster and sand gaper, but with some adjustments for metals (Section 4.2). There were insufficient data to estimate new BCs for metals and PAHs in fish, so the 1997 BRCs for mercury in fish muscle was applied in the assessment.

12. Environmental Assessment Criteria (EACs) were not used in this assessment. Further work through SIME has been arranged to address the problems with the proposed set of updated EACs that were identified during the 2004/05 assessment. The results of the current review process will be an important element in the interpretation of CEMP data for the QSR 2010 report.

3.4 Presentation of assessments

13. The assessments of each parameter comprise an assessment text drawing out the main conclusions:

a. a map:

(i) The estimated mean concentration (in ug/kg) in the final year of each time series is shown on the maps by the colour of the symbol (circle or triangle) through reference to the legend accompanying the map.

(ii) The presence of significant linear time trends over the last 10 years is indicated by the shape of the symbol. Circular symbols indicate that no significant trend was found. Triangles indicate significant increasing or decreasing trends, by pointing upwards or downwards, respectively.

b. a table showing, by OSPAR region and species group, the number of time series, the number of significant linear trends and the number of time series where the mean concentration in the final year is significantly below the BAC (or BRC).

c. a figure showing the mean concentration in the final year of each time series, by OSPAR region. Time series for which the mean concentration is significantly below the BAC (BRC) are shown by filled circles; open circles indicate mean concentrations that are not significantly below the BAC (BRC).

d. time trend graphs for selected time series. Time series were selected either because they showed a significant change in concentration in the last ten years (1996 – 2005) or because the upper confidence limit on the mean concentration in the final year exceeded the BAC (BRC). When it was not possible to plot all time series, priority was given to with the largest change in concentrations or whose final year exceeded the BAC (BRC) the most.

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[3] *OSPAR Commission (2005a) 2005 Assessment of data collected under the Co-ordinated Environmental Monitoring Programme (CEMP). OSPAR Commission 2005, 115pp + appendices*

14. In the explanatory texts on the assessment, the following phrases have been used to explain statistical results:

a. "*trends"* refer to linear trends, significant at the 5% level,

b. "*mean concentrations are at background"* or "*mean concentrations are close to zero"* means that the upper confidence limit on the fitted mean concentration in the last year of monitoring is below the BAC.

4. Assessment of selected contaminants in biota

4.1 Species covered by the assessment

15. An overview of species in which concentrations of hazardous substances were assessed and for each the number of time series assessed in each Contracting Party is given in Table 4.1. The blue mussel is the most common species for which data are held in the ICES databases being collected from about 60% of the 218 sampling localities under the CEMP. It is, however, only collected in coastal areas. Data for four other shellfish were available. Flounder and European dab were the most used of the 7 indicator fish species, for which contaminants in both liver and muscle were assessed. Some of the stations from which fish were taken were located in areas representative of the open sea or coastlines remote from point sources. Time series varied in length within the period 1978-2005. Only time series that included recent data (from 2001-2005) were assessed.

Picture 1 Dense growth of mussels (*Mytilus edulis*) on intertidal rocks, Peanmeanach, Invernessshire, Scotland.

Picture 2 Wide diversity of fresh sea food from the Convention area (and beyond) in a supermarket in Aberdeen, Scotland.

Table 4.1 Overview of the species in which concentrations of hazardous substances were assessed and for each the number of time series assessed in each Contracting Party (li – liver; mu – mussel)

		Species-tissue																			
		blue	mediter.	pacific	sand	shrimp	cod		dab		flounder		herring		megrim		plaice		whiting		
Region	**Country**	**mussel**	**mussel**	**oyster**	**gaper**	**(crangon)**	**li**	**mu**	**li**	**mu**	**li**	**mu**	**li**	**mu**	**li**	**mu**	**li**	**mu**	**li**	**mu**	**Total***
	Iceland	11																			*11*
	Norway	6					2	2									2	2			*9*
I		**17**					**2**	**2**									**2**	**2**			***20***
	Belgium	3				1	1	1			1	1									*4*
	Denmark	22			3						4	4					1	1			*28*
	France	20	2	6																	*28*
	Germany	3							2	2	4	4									*8*
	Netherlands								3	3	3	3									*6*
	Norway	16					6	6	3	3	4	4			2	2					*25*
	Sweden	2					1						2	2							*2*
	UK	14							9	10	12	11					2	2			*29*
II		**80**	**2**	**6**	**3**	**1**	**8**	**7**	**17**	**18**	**28**	**27**	**2**	**2**	**2**	**2**	**3**	**3**			***130***
	Ireland	4															1				*5*
	UK	14							9	9	3	3					5	5	1	1	*25*
III		**18**							**9**	**9**	**3**	**3**					**6**	**5**	**1**	**1**	***30***
	France	9		22																	*31*
	Spain	7																			*7*
IV		**16**		**22**																	***38***
Total		**131**	**2**	**28**	**3**	**1**	**10**	**9**	**26**	**27**	**31**	**30**	**2**	**2**	**2**	**2**	**11**	**10**	**1**	**1**	***218***

*) Unique station positions. Note that more than one species-tissue can be collected at one station

4.2 Trends of metals and organometal(s)

16. Metals occur naturally within the environment at background concentrations. BCs and BACs have been proposed for mussels as tools to identify sites where environmental concentrations are close to background. BCs are similarly used for mercury concentrations in fish muscle. Blue mussels account for half the stations sampled under the CEMP. Three other mollusc species, Pacific oyster, Mediterranean mussel and Sand gaper have been analysed, all of which are coastal species. Data were also available for shrimp and seven fish species, three flatfish and four roundfish, some of which are classified as being more representative of open sea areas.

17. This assessment particularly highlights trends from 1996 until present. The following text provides an overview highlighting those time trends with the steepest slopes, associated trends, and locations showing the highest contaminant concentrations. For cadmium, lead, zinc and TBT downward trends were dominant.

18. In previous assessments, time series were said to be 'close to background' if the upper confidence limit on the mean concentration in the final monitoring year was below the BRC. In this assessment, newly established BACs for mussels replace the old BRCs (section 3.3). The BACs for copper and lead are about 50% greater than the corresponding BRCs; those for cadmium, mercury and zinc are about three times greater. The implication is that it should be expected that many more time series are assessed as close to background, simply because the assessment criteria have changed. Note, however, that the new BCs for copper and lead are similar to the old BRCs (those for cadmium, mercury and zinc are about double) so some care is needed when evaluating the new assessment criteria.

19. The BCs and BACs for mussels were converted for application to pacific oysters based on French monitoring data [Claisse *et al*., in press)[4]] and to sand gaper based on Danish data from Odense Fjord where both blue mussels and sand gaper are found (Aertebjerg et al, 2003[5]). The conversion factors are given in Table 4.2. A more thorough review of these factors is proposed for MON 2007.

metal	pacific oyster	sand gaper
cadmium	2.5	0.33
copper	10	3
zinc	15	1
lead	1	3
mercury	1	1
TBT	1	1

Table 4.2. Conversion factors for BCs and BACs in pacific oyster and sand gaper. For example, the BC and BAC for cadmium in pacific oyster are 2.5 times the corresponding values for mussels.

20. In the last monitoring year, concentrations in shellfish were close to background in 97% of zinc time series, 71% of cadmium time series, 39% of lead time series, 36% of mercury time series, 23% of copper time series and 0% of TBT time series. Mercury concentrations in fish muscle were close to background in 20% of time series.

4 Claisse et al., in press.- Surveillance du Milieu Marin. Travaux du RNO. Edition 2006. Ifremer et Ministère de l'Ecologie et du Développement Durable Bulletin RNO 2006. ISSN 1620-1124.

5 Ærtebjerg, G., Bendtsen, J., Carstensen, J., Christiansen, T., Dahl, K., Dahllöf, I., Ellermann, T., Gustafsson, K., Hansen, J.L.S., Henriksen, P., Josefson, A.B., Krause-Jensen, D., Larsen, M.M., Markager, S.S., Ovesen, N.B., Ambelas Skjøth, C., Strand, J., Söderkvist, J., Mouritsen, L.T., Bråten, S., Hoffmann, E. & Richardson, K. (2005): Marine områder 2004 - Tilstand og udvikling i miljø- og naturkvaliteten. NOVANA. Danmarks Miljøundersøgelser. - Faglig rapport fra DMU 551: 94 s. (elektronisk).

4.2.1 Cadmium in biota

21. A total of 230 time series for cadmium, covering twelve species, were available for assessment. Mean concentrations were close to background at 71% of shellfish stations. The BC was recalculated based on new data *(see chapter 3.3)* resulting in an increase of that value and an increase in the BAC to 1940 ug/kg dry weight. As a result more concentrations were assessed as below the BAC. Most region II and region IV shellfish concentrations are below the BACs. The mean concentration graph suggests that concentrations in region I are generally above those of region II and IV.

22. There were trends in 17% of time series, mostly downwards. This is consistent with a downward trend in the annual discharges of cadmium of 5% reported by OSPAR Commission 2005b[6], and decreases of atmospheric deposition of cadmium of 25% between 1998 and 2002 (OSPAR Commission 2005c)[7].

23. For the last ten years, there were significant downward trends at 11 French, 10 Norwegian, 2 UK, 1 Irish, 2 Netherlands and 2 Icelandic stations. The steepest decrease was 31%/year in flounder at Strandebarm (western Norway) in Region II. Downward trends were found in Pacific oysters at 7 French stations in Region IV. For blue mussels, downward trends were found in Region III in the Clyde (UK) and at St Bees, Cumbria (UK) Dublin Bay (Ireland); in Region I at Mjófjördur and Grimsey (Iceland). For fish, downward trends were found in Region I at Varangerfjord (Norway) in cod; and in Region II at 3 Norwegian stations in cod, flounder and megrim and in common dab at Dogger Bank (UK).

24. The steepest upward trends in the last ten years were 26%/year in plaice offshore the Tay and Forth estuaries (UK) in Region II, 19%/year in Blue mussels in Roskilde Fjord (Denmark) and 14%/year in common dab from Mersey (UK). There were also upward trends, of between 4% and 10%/year, at Gressholmen (Norway), Hvalfjördur (Iceland), Audierne-penhors, Douarnenez-kernel and Saint Brieuc-pointe de roselier (France), and Pontevedra and Vigo (Spain).

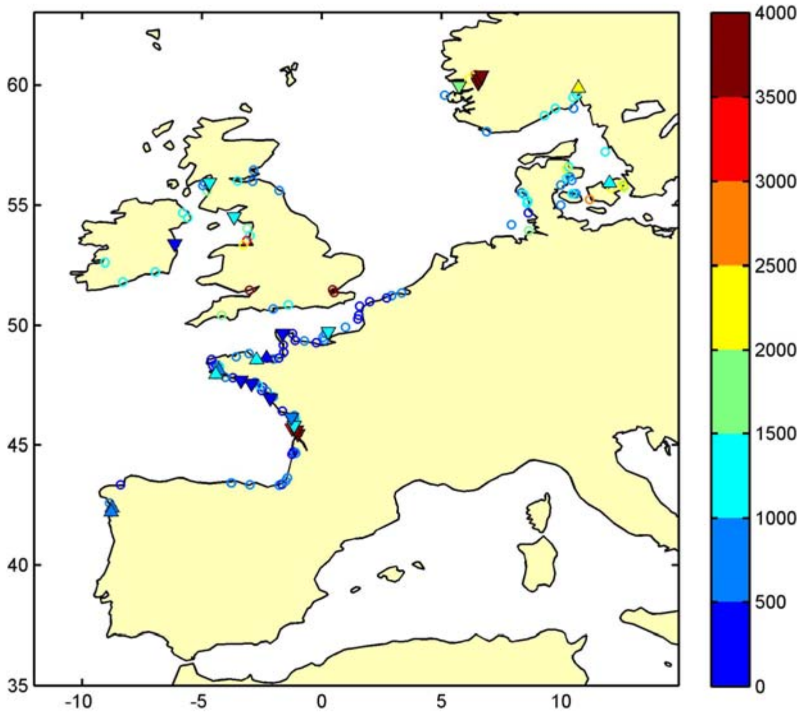

Figure 4.1. Cadmium concentration (noted by colour) and time trends in mussels (noted by triangles up/down for upward/downward trends). Concentrations in pacific oysters along the French coast of the Bay of Biscay have been adjusted by a factor of 2.5 down, in accordance with table 4.2.

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6 *OSPAR Commission (2005b) 2005 Assessment of data collected under the OSPAR Comprehensive Study on Riverine Inputs and Direct Discharges for the period 1990 – 2002, OSPAR Commission (2005/233) 39pp + appendices*

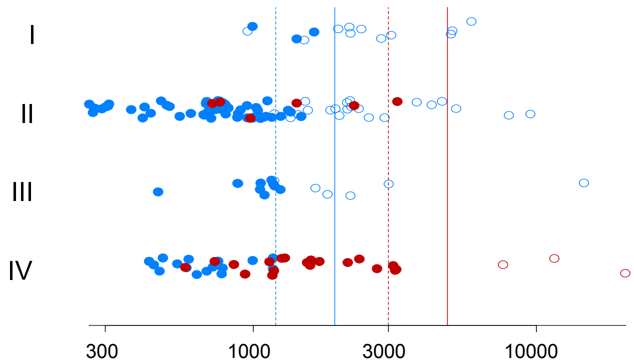
7 *OSPAR Commission (2005c) Assessment of trends in atmospheric concentration and deposition of hazardous pollutants to the OSPAR maritime area: Evaluation of the CAMP network*

25. The highest concentrations in Blue mussels are found in Region II, at Byrkjenes, Kvalnes, Eitrheimsneset and Krossanes in the Sørfjord (Norway), which is characterised by metallurgical industry point sources. High concentrations are also found in the Thames and Medway (UK). The Thames area has been subject to a mixture of historical contamination, sewage discharges and diffuse inputs of contaminants. In Region I, there are high concentrations at Grimsey, Mjófjördur and Dvergasteinn Alftafjördur (Iceland), which can be attributed to geological factors. Pacific oysters from the Gironde (France) in Region IV have high concentration due to an upstream zinc and cadmium mining activity which closed more than 15 years ago. Inner Sørfjord (Norway), an industrial area, has the highest concentrations found in both cod and flounder. High concentrations are also found in plaice offshore from the Tay/Forth estuaries and in common dab at the Dogger Bank and Inner Cardigan Bay (all UK). The UK has made considerable efforts in the past to determine the cause of the relatively high concentrations of cadmium at the Dogger Bank, including assessments of at potential inputs. Recent research has suggested that one source of cadmium to offshore banks like the Dogger can be detritus following the annual die-off of plankton populations. Cardigan Bay receives run-off from metalliferrous areas of Wales, and riverine inputs of cadmium and lead are relatively high. In flounder, concentrations from the Belgian continental shelf, Great Belt (Denmark) and Åkrefjord (Norway) are above average.

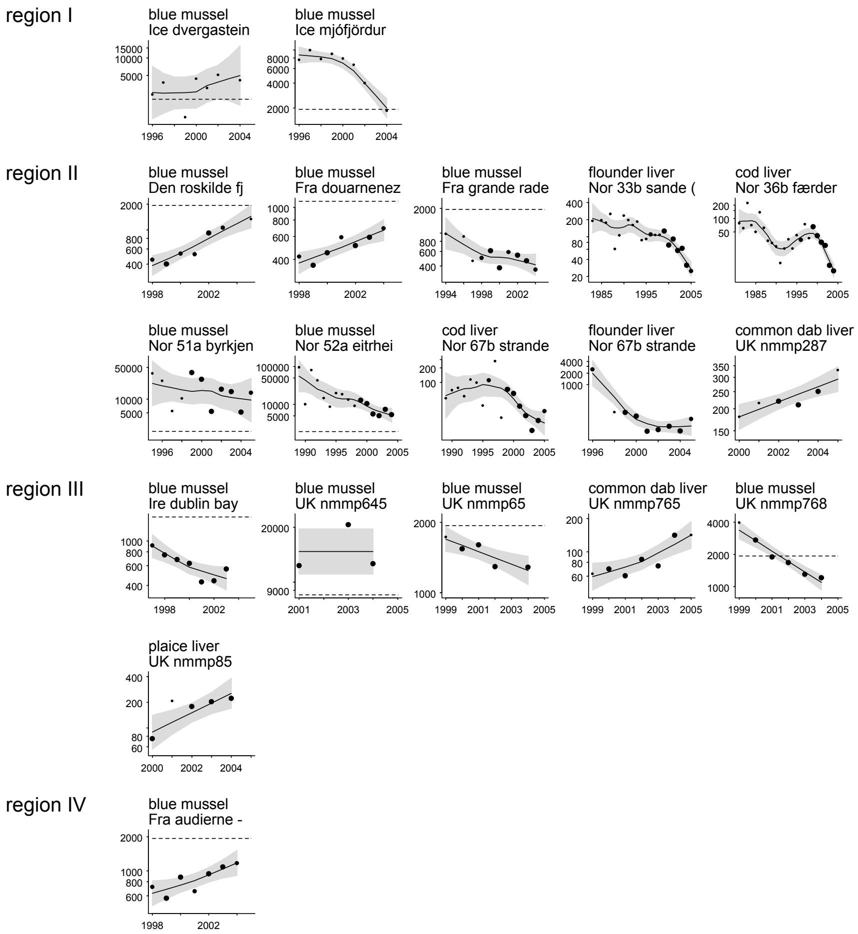
Cadmium: summary of time series. BCs and BACs have not yet been set for fish.

	region	number of time series 3-4	5-6	7+	total	trends up	down	UCL< BAC
shellfish	I	0	2	12	14	3	1	3
	II	24	4	53	81	5	6	58
	III	8	7	1	16	0	3	10
	IV	0	1	37	38	3	8	35
		32	**14**	**103**	**149**	**11**	**18**	**106**
fish	I	0	0	4	4	0	1	
	II	10	13	35	58	2	6	
	III	9	5	5	19	2	0	
		19	**18**	**44**	**81**	**4**	**7**	

Mean concentration (ug kg^{-1} dw) in mussels (blue) and oysters (red) in the final monitoring year. The vertical dotted lines are the BCs of 1200 and 3000 ug kg^{-1} dw for mussels and oysters respectively; the vertical solid lines are the corresponding BACs. The old BRC for blue mussels was 550 ug kg^{-1} dw.



Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



4.2.2 Zinc in biota

26. The purpose of looking at concentrations of zinc is to consider whether increases of cadmium in biota are linked to uptake in areas where the bioavailability of zinc is reduced.

27. A total of 284 time series, covering twelve species, were available for assessment. Mean concentrations are at background at 97% of shellfish stations. Trends were detected in 7% of time series, most of them downwards.

29. Focussing on changes in concentration in the last ten years, there were downward trends in 4 time series in Norwegian fjords (Region II), 4 in pacific oyster and 2 in blue mussels stations in France (Regions II and IV), cod and herring from Fladen in the Kattegat (Sweden), common dab from the Dogger Bank (Netherlands), flounder from Jade (Germany). The steepest downward trend was in Pacific oysters from Baie de l'aiguillion (France) at 11%/year.

30. Upward trends over the last ten years were found in blue mussels and flounder from the Elbe (Germany, 11-12 %/year), in blue mussels from the Roskilde Fjord (Denmark, 8%/year), in shrimps from the Belgian costal shelf (8%/year) and in blue mussels from Marennes (France, 2%/year).

31. The highest concentrations in blue mussel are in the Elbe Outer (Germany). This is the only station above the new BAC. The BC was recalculated based on new data *(see chapter 3.3)* resulting in an increase of that value to 275000 ug/kg and an increase of the BAC to 426000 ug/kg. As a result, virtually all concentrations in 2005 were below the BAC.

33. For fish, the herring from Fladen and Väderöarna (Sweden) and megrin from Strandebarm and Åkrefjord (Norway) have the highest concentration, thereafter flounder from the Great Belt and The Sound (Denmark), cod from the Inner Sørfjord (industrial area) (Norway), Åkrefjord (Norway). The Zn concentration in common dab liver (data from Norway and the Netherlands) vary within a range of less than 25% with highest concentrations found in Åkrefjord (Norway) and Fresian Front area 40km north west off shore of Terschelling (Netherlands).

34. For blue mussels, there was no evident correspondence between concentration of Zn and Cd concentrations or time trends, and no correlation was found between low Zn concentrations and Cd concentrations or time trends. Figures 4.1 and 4.2 indicate the concentrations of Cd and Zn, in the different bivalve species used in the OSPAR regions. Consideration of only the low Zn concentrations, which are indicative of a low bioavailability of Zn, does not change these conclusions.

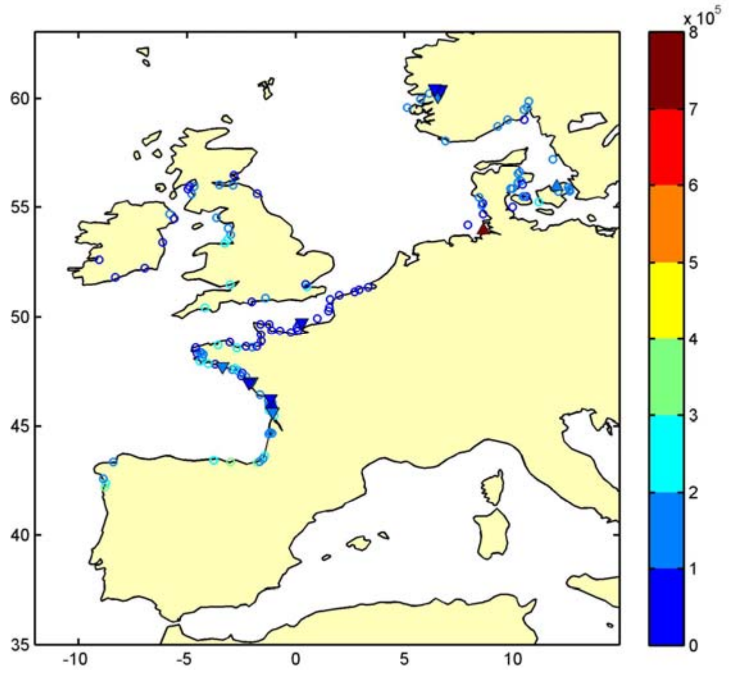
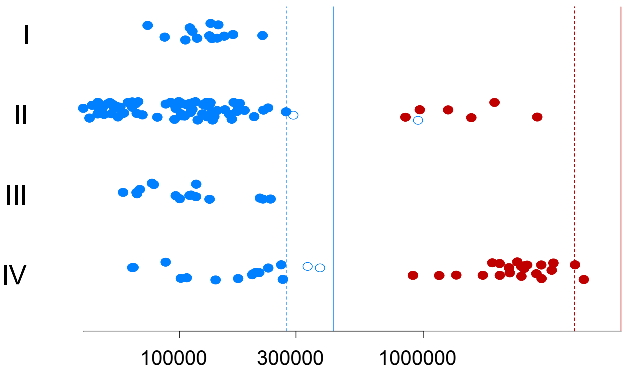


Figure 4.2. Zinc concentration (noted by colour) and time trends in mussels (noted by triangles up/down for upward/downward trends). Concentrations in pacific oysters along the French coast of the Bay of Biscay have been adjusted by a factor of 15 down, in accordance with table 4.2.

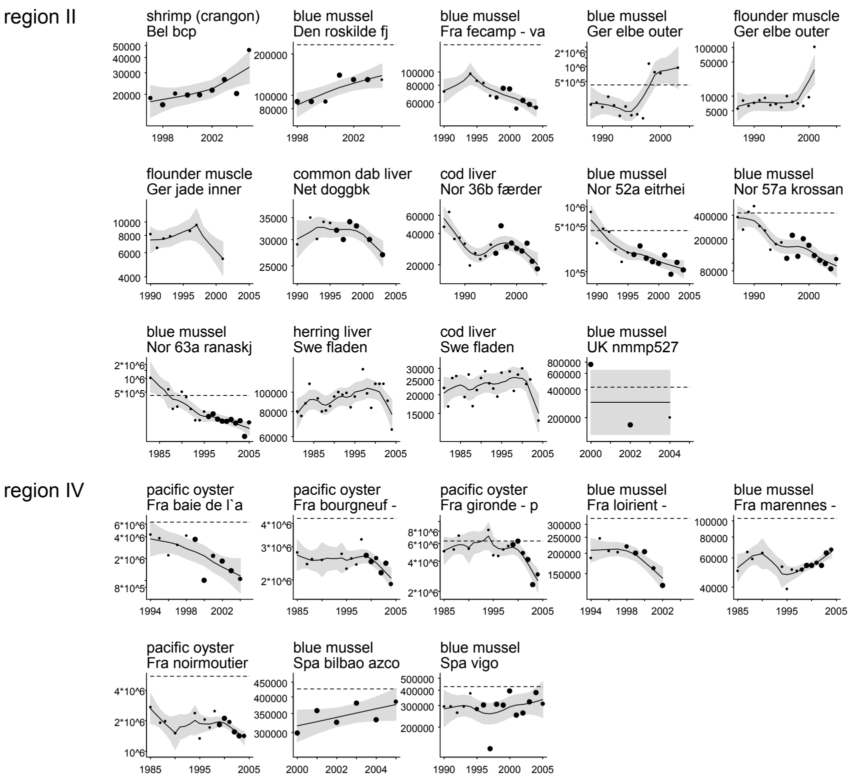
Zinc: summary of time series. BCs and BACs have not yet been set for fish.

	region	number of time series				trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
shellfish	I	0	2	12	14	0	0	14
	II	24	5	52	81	3	4	78
	III	8	7	1	16	0	0	16
	IV	0	1	37	38	1	5	36
		32	**15**	**102**	**149**	**4**	**9**	**144**
fish	I	0	0	4	4	0	0	
	II	2	2	27	31	1	5	
		2	**2**	**31**	**35**	**1**	**5**	

Mean concentration (ug kg^{-1} dw) in mussels (blue) and oysters (red) in the final monitoring year. The vertical dotted lines are the BCs of 275000 and 4125000 ug kg^{-1} dw for mussels and oysters respectively; the vertical solid lines are the corresponding BACs. The old BRC for blue mussels was 150000 ug kg^{-1} dw.



Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



4.2.3 Mercury in biota

34. A total of 234 time series, covering twelve species, were available for assessment. Of these mean concentrations are at background at only 36% of shellfish stations and at 20% of fish stations. With the new BAC (140 ug/kg), most of the Region I and II mussel concentrations are below BAC. However, the mean concentration graph indicates that concentrations in region III and IV in general are greater than those in Regions II and IV.

35. In biota, there were 17 downward trends over the past ten years: from six French stations (3 in Region IV and 3 in Region II); seven Norwegian stations (2 in Region I and 5 in Region, II) two UK stations in Region II and III (Clyde and Tyne); and three German stations in the Elbe. There were 14 upward trends in the same period, the steepest of which was 38%/year in Blue mussel from the Bay of Århus in Denmark in Region II. The other upward trends of more than 10% were Bilbao (Spain), the Wadden Sea (Denmark) and Inner Sørfjord (Norway), an industrial area contaminated by a metallurgical industrial point source. Other upward trends could be found at Esepvær, Ullerø and Gressholmen (Norway), Marennes, Lannion and Vilaine (France), the Central Sound area (Denmark) and 40km offshore from the Scheldt (Belgium). This latter trend was measured in a shrimp (*Crangon crangon*) a species not reported by other Contracting Parties.

36. The highest concentrations in blue mussel are found in the Estuary of the River Medway (UK), Byrkjenes in the Inner Sørfjord (Norway), which is characterised by metallurgical point sources, the Severn and Morecambe (UK), the Wadden Sea and the Sound (Denmark) and Pontevedra (Spain). The high concentrations found at Pontevedra (Spain) result from industrial point sources in the past. Measures taken to prevent pollution are leading to a gradual reduction in these concentrations.

37. The Inner Sørfjord and Oslo areas (Norway) have the highest concentrations in cod. Concentrations in flounder in the inner Sørfjord are three times higher than the next highest concentrations in the Mersey and Thames (UK). The Thames area has been subject to a mixture of historical contamination, sewage discharges and diffuse inputs. Morecambe Bay (UK) has the highest concentration in plaice, 50% above the concentrations found at Hvide Sande (Denmark). For common dab, Liverpool Bay, Morecambe Bay and the Mersey (UK) have higher concentrations than other areas, including Netherlands and Norwegian stations. These fish species are the most commonly used in monitoring programmes, allowing results to be compared on a larger geographic scale. The area off the UK around Morecambe, Liverpool Bay, and the Mersey are known to have inherited mercury through the legacy of 100 years of the chloralkali industry. Mercury discharges in the area are now < 1% of those 20 years ago.

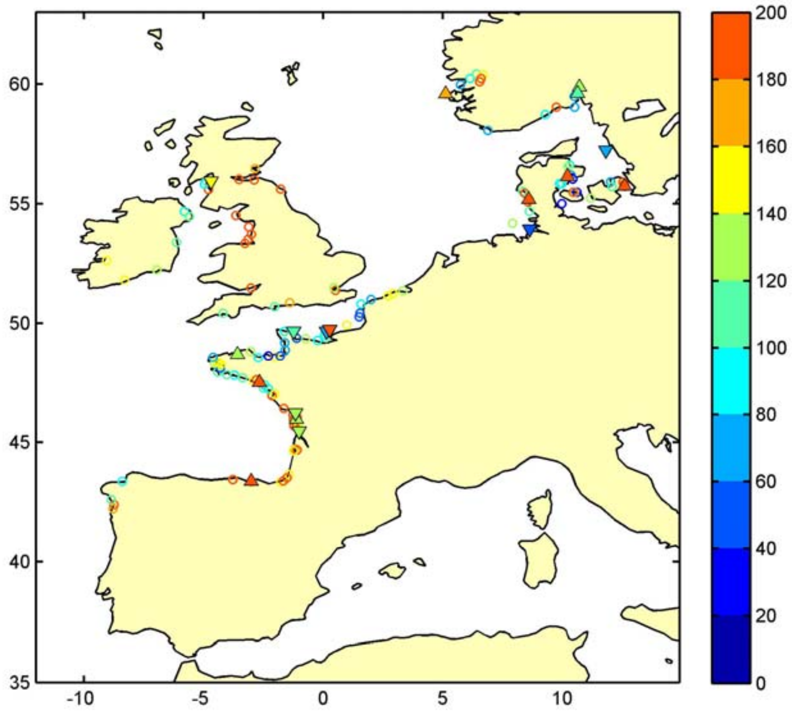
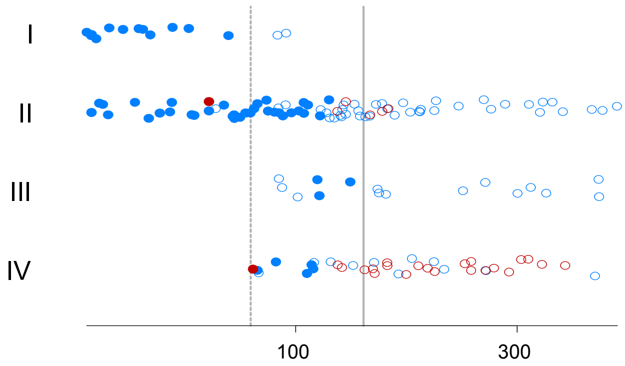


Figure 4.3. Mercury concentration (noted by colour) and time trends in mussels (noted by triangles up/down for upward/downward trends)

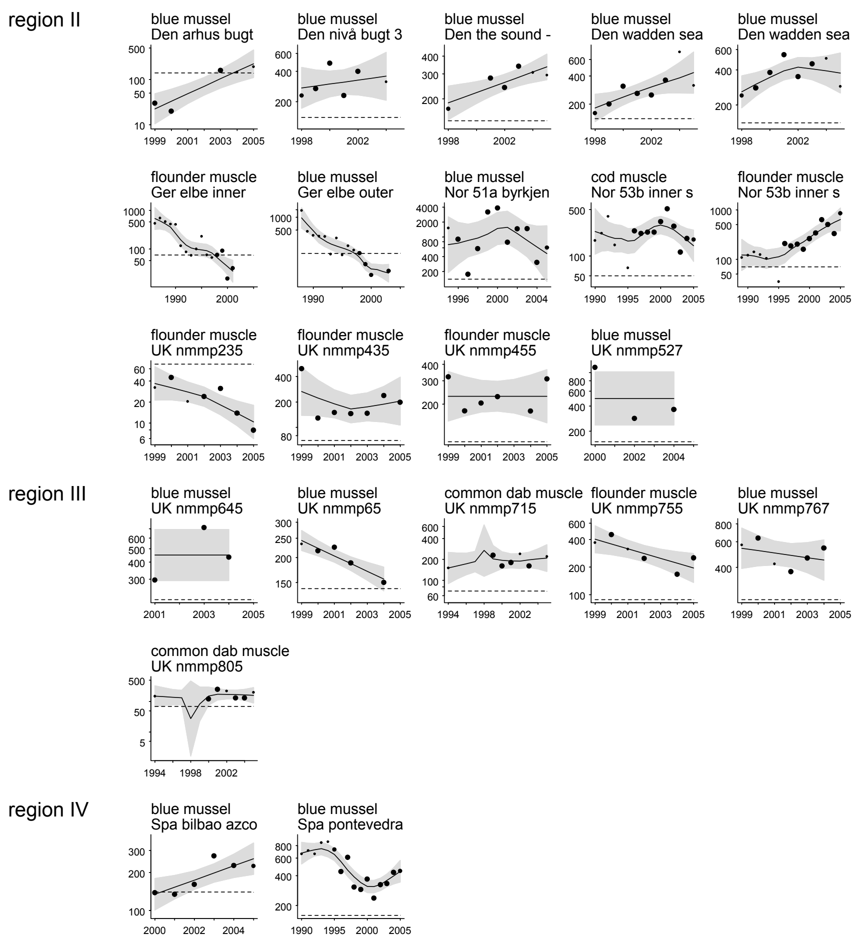
Mercury: summary of time series. For fish, the BRC has been used in place of a BAC.

	region	number of time series				trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
shellfish	I	0	2	12	14	0	1	12
	II	20	9	53	82	7	5	34
	III	8	8	0	16	0	1	2
	IV	0	1	37	38	3	2	6
		28	**20**	**102**	**150**	**10**	**9**	**54**
fish	I	0	0	4	4	0	1	2
	II	12	10	39	61	4	7	14
	III	5	6	8	19	0	0	1
		17	**16**	**51**	**84**	**4**	**8**	**17**

Mean concentration (ug kg^{-1} dw) in mussels (blue) and oysters (red) in the final monitoring year. The vertical dotted line is the BC of 80 ug kg^{-1} dw, applied to both mussels and oysters; the vertical solid line is the corresponding BAC. The old BRC for blue mussels was 50 ug kg^{-1} dw.



Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



4.2.4 Lead in biota

38. A total of 231 time series, covering twelve species, were available for assessment. Mean concentrations are at background at 39% of shellfish stations, as assessed against the new proposed BAC of 1520 ug/kg. All region I mussel concentrations are below the BAC. For the other regions, concentrations are of the same range.

39. There were trends in 19% of biota time series, mostly downwards in molluscs.

40. Focussing on changes in concentration in the last ten years, there were downward trends in 10 time series from Norwegian fjords (Regions I and II), 4 in pacific oyster and 6 in blue mussels stations from France (regions II and IV), one each in flounder from the Ribble and Thames (UK), one in herring from Fladen in the central Kattegat (Sweden), one each in blue mussels from Vigo and Santander Pedrena (Spain), and one in blue mussels from Hvassahraun (Iceland). The steepest downward trends were in flounder in the Ribble (UK, 35%/year), the Thames (UK, 21%/year), Strandebarm (Norway, 27%/year) and Århus harbour (Denmark, 18%/year). Cod concentrations at Strandebarm also decreased by 10%/year.

41. Upward trends over the last ten years were found in Blue mussels from the Wadden Sea (Denmark, 10%/year) and Roskilde Fjord (Denmark, 18%/year), in flounder from the Belgium costal shelf (24%/year), the Inner Sørfjord and Åkrefjord (Norway, 10-14%/year) and the Elbe (Germany,4%/year), in plaice offshore from the Tay and Forth estuaries (UK; 22%/year), and in common dab offshore from the Humber estuary, Inner Cardigan Fjord and Morecambe Bay (UK, 15-21%/year).

42. The highest concentrations in Blue mussel are in the inner Sørfjord at Byrkjenes, Eitrheimsneset, Kvalnes (Norway) and Cork Harbour West Channel (Ireland). These stations are influenced by metallurgical industrial point sources.

43. For fish, the Inner Sørfjord (an area affected by metallurgical industry point sources) and Oslo (harbour) (Norway) both have high concentrations in cod and flounder, only exceeded by concentrations in flounder from the Mersey (UK). The highest concentrations in plaice were at the Tay/Forth (UK) station.

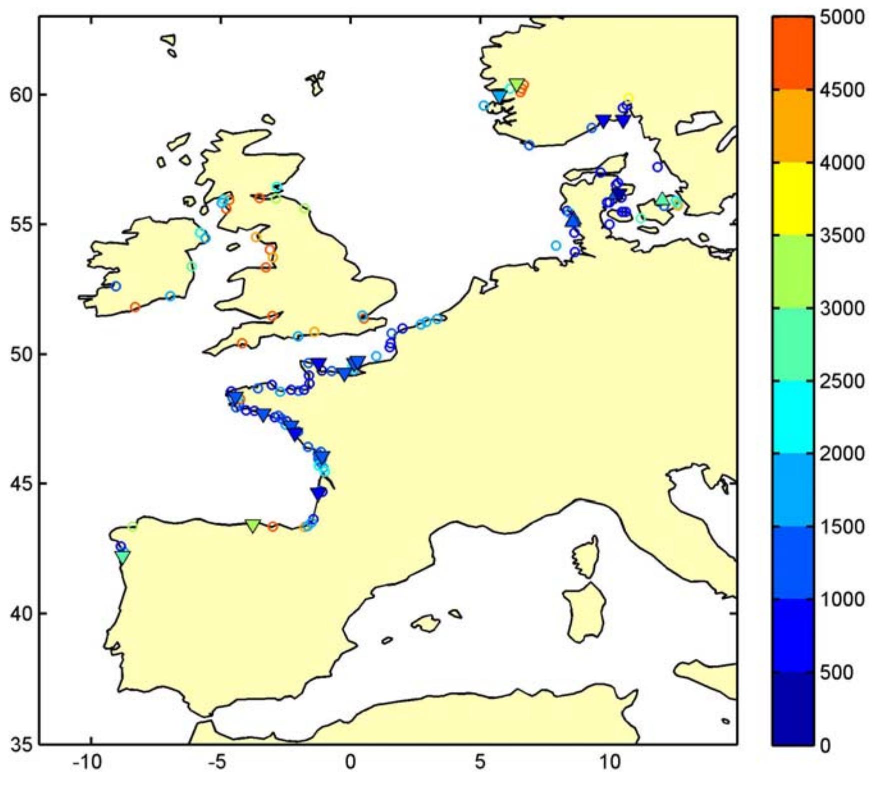
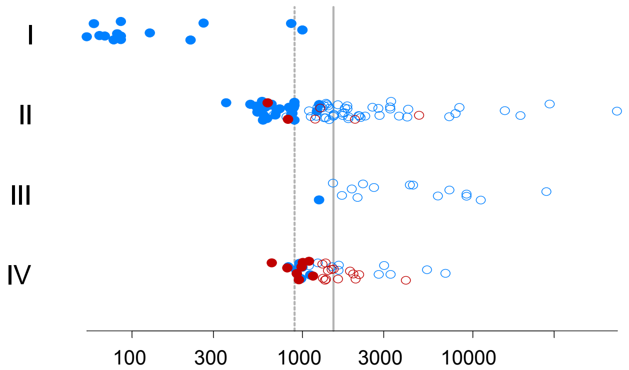


Figure 4.4: Lead concentration (noted by colour) and time trends in mussels (noted by triangles up/down for upward/downward trends)

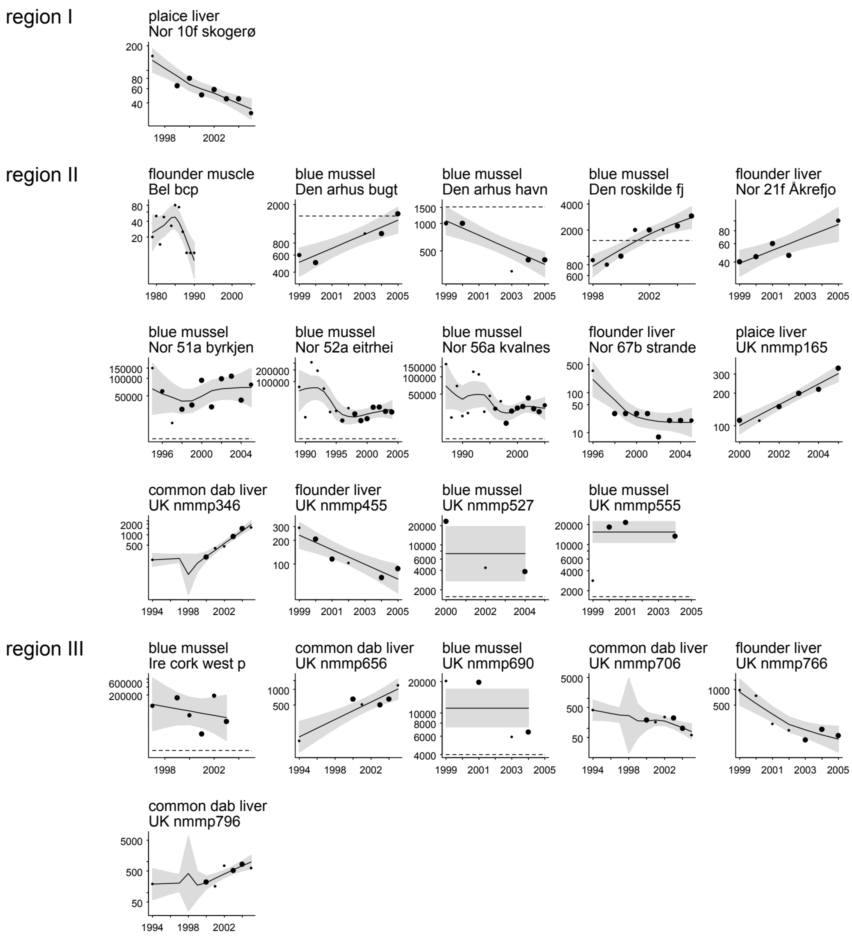
Lead: summary of time series. BCs and BACs have not yet been set for fish.

	region	number of time series				trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
shellfish	I	1	3	10	14	0	2	14
	II	22	9	54	85	4	10	31
	III	7	7	1	15	0	0	1
	IV	0	1	37	38	0	7	14
		30	**20**	**102**	**152**	**4**	**19**	**60**
fish	I	0	0	4	4	0	3	
	II	12	11	33	56	6	7	
	III	9	5	5	19	2	3	
		21	**16**	**42**	**79**	**8**	**13**	

Mean concentration (ug kg^{-1} dw) in mussels (blue) and oysters (red) in the final monitoring year. The vertical dotted line is the BC of 900 ug kg^{-1} dw, applied to both mussels and oysters; the vertical solid line is the corresponding BAC. The old BRC for blue mussels was 950 ug kg^{-1} dw.



Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



4.2.5 TBT in biota

44. Tributyltin has been used widely as an antifouling agent in bottom paints for boats. Use on pleasure craft and small boats was forbidden in the early 1990s due to unwanted biological effects on bivalve molluscs and marine snails. More recently, marketing and use restrictions were introduced within the EU aiming to cease use within all anti-fouling systems.

45. The prohibition of use of TBT by the International Convention on the Control of Harmful Anti-fouling Systems on Ships, adopted by the International Maritime Organisation (IMO) in October 2001, has not yet entered into force.

46. There are 30 time series for TBT in Blue mussels and 1 in Sand gaper. Downward trends are found at Færder, Björköja and Gressholmen (Norway, 25-57%/year, Region II) and Århus harbour, Little Belt, Wadden Sea Roskilde fjord and Ringkjobing fjord (Denmark, 10-34%/year, Region II) .

47. Concentrations range between 3.3 and 956 (median 63) µg/kg TBT with the BAC of 3 ug/kg non of the concentrations were below BAC. The highest concentration was found close to a shipyard in Odense fjord with concentrations decreasing with the distance from the shipyard.

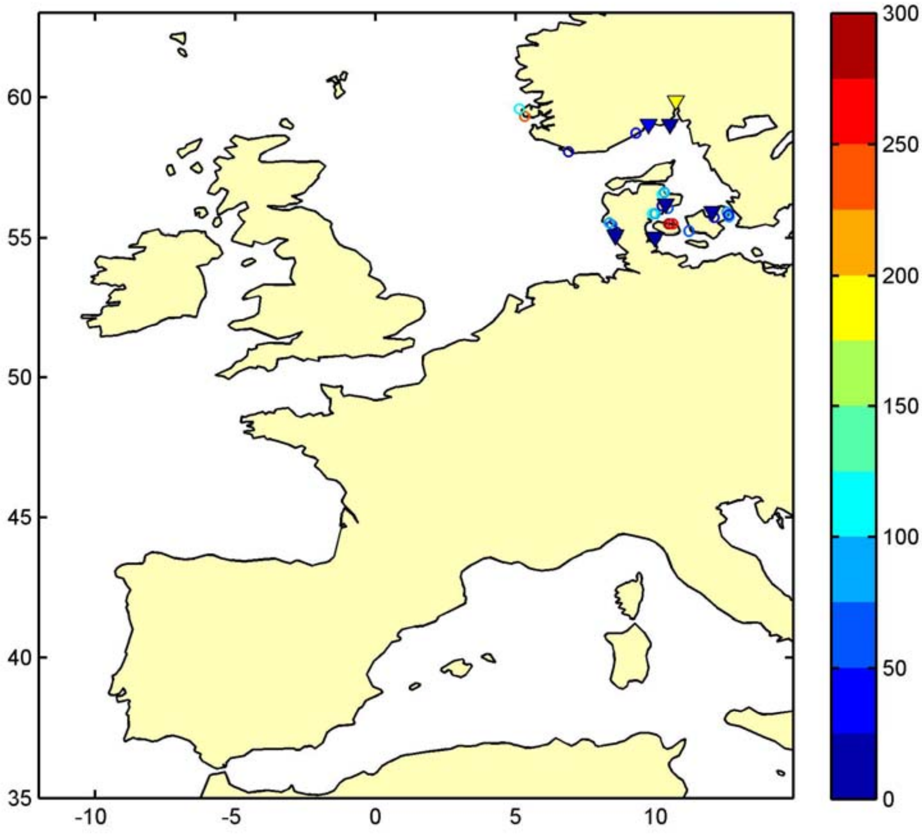
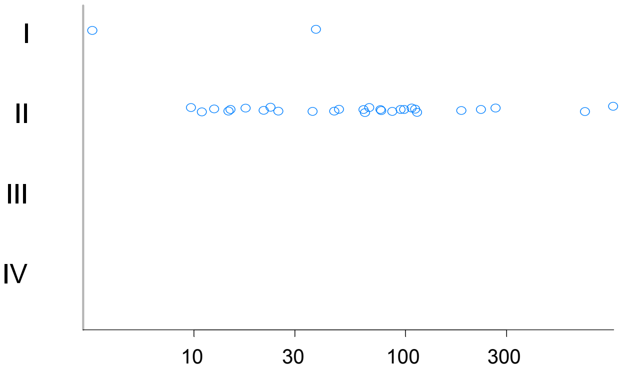


Figure 4.5: TBT concentration (noted by colour) and time trends in mussels (noted by triangles up/down for upward/downward trends). Only data from Norway and Denmark was available for assessment.

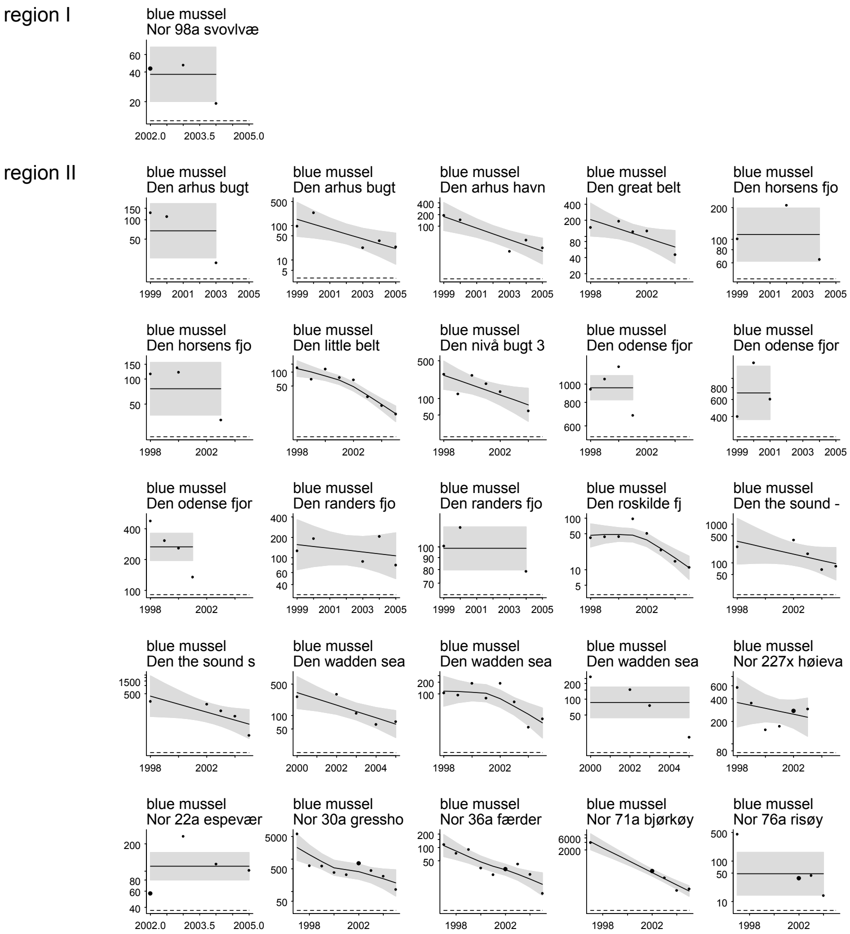
TBT: summary of time series.

	region	number of time series				trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
shellfish	I	2	0	0	2	0	0	0
	II	11	12	6	29	0	8	0
		13	**12**	**6**	**31**	**0**	**8**	**0**

Mean concentration (ug kg[-1] dw) in mussels in the final monitoring year. The BC is 0 ug kg[-1] dw; the vertical solid line is the BAC of 3.0 ug kg[-1] dw.



Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



4.2.6 Copper in biota

48. Copper has been included in the assessment to indicate whether the use in anti-fouling treatments is leading to increases in copper in the marine environment.

49. A total of 185 time series, covering twelve species, were available from all regions. Mean concentrations are at background at 23% of shellfish stations. The same BC seems adequate for all regions.

50. There were trends in 15% of biota time series with upward trends steeper than downward trends.

51. Over the last ten years, there were downward trends in 3 time series from the Norwegian fjords (Strandebarm and Faerder aera) (Regions II), 1 in pacific oyster and 2 in blue mussels stations from France (Regions II and IV), one in herring from Väderöarna in the Skagerrak (Sweden), and in blue mussels from 4 stations between Vigo and Santander (Spain), and one in blue mussels from Hvalstöd Hvalfjördur (Iceland). The steepest downward trends were in blue mussels from Iceland at 7%/year. Common dab concentrations at Dogger Bank (Netherlands) decreased with 6%/year.

52. Upward trends over the last ten years were found in blue mussels from the Great Belt (Denmark, 19 %/year), in flounder and cod from the Belgian costal shelf (9-15%/year), flounder from the Elbe (Germany, 10%/year) and in blue mussels from the Wadden Sea and Little Belt (Denmark, 7-8 %/year) and in blue mussels and cod from Svovlvær and the industrial area Inner Sørfjord (Norway, 4-5 %/year) and in pacific oyster from Brest to Marennes (France, 2-5 %/year). This clearly perceptible increase recorded since 1982, may be attributable to the growing use of copper paints subsequent to the antifouling paint regulations adopted in 1982 (Claisse *et al*., 1993)[8]

53. The highest concentrations in Blue mussels are in the Southampton water (UK), Great Belt (Denmark), Mjofjördur (Iceland), Medway and Tamar (UK), Randers fjord and the Sound area of Denmark.

54. Pacific oysters tend to have ten times higher concentrations than blue mussels, but at Gironde the concentrations are twenty times higher then the highest concentration in blue mussels. There is a clear gradient in concentrations going downwards to the North of the Bay of Biscay.

55. For fish, the inner Sørfjord (industrial area), Karihavet (shipyard) (Norway) both have high concentrations in cod, Hvide Sande (Denmark) has the highest concentration in flounder liver nearly twice that found in flounder liver from Sande (Norway).

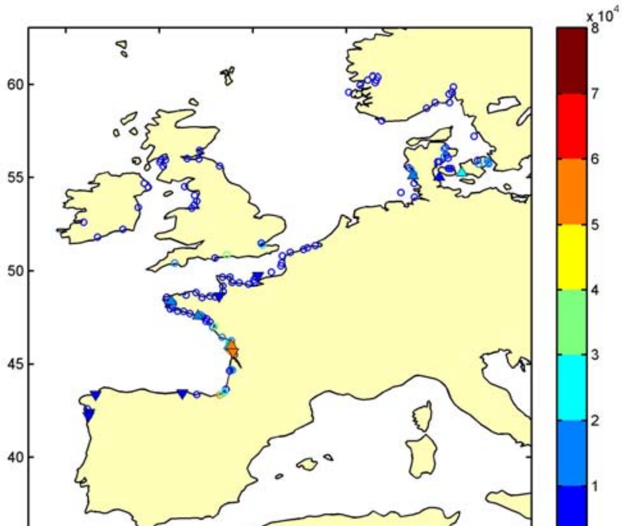


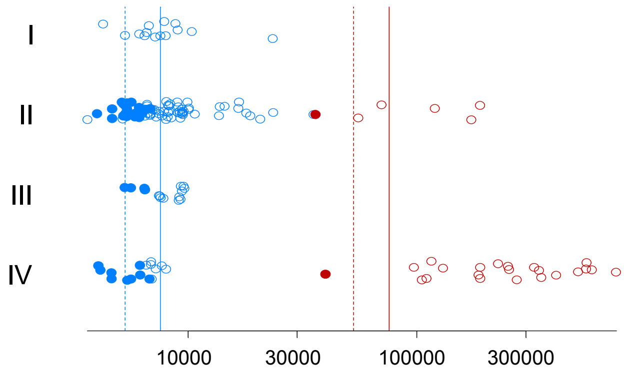
Figure 4.6. Copper concentration (noted by colour) and time trends (noted by triangles up/down for upward/downward trends). Concentrations in pacific oysters along the French coast of the Bay of Biscay have been adjusted by a factor of 10 down, in accordance with table 4.2.

8 D. Claisse & Cl. Alzieu, 1993. Copper contamination as a result of antifouling paint regulation? *Marine Pollution Bulletin*, Volume 26, No 7, pp 395-397.

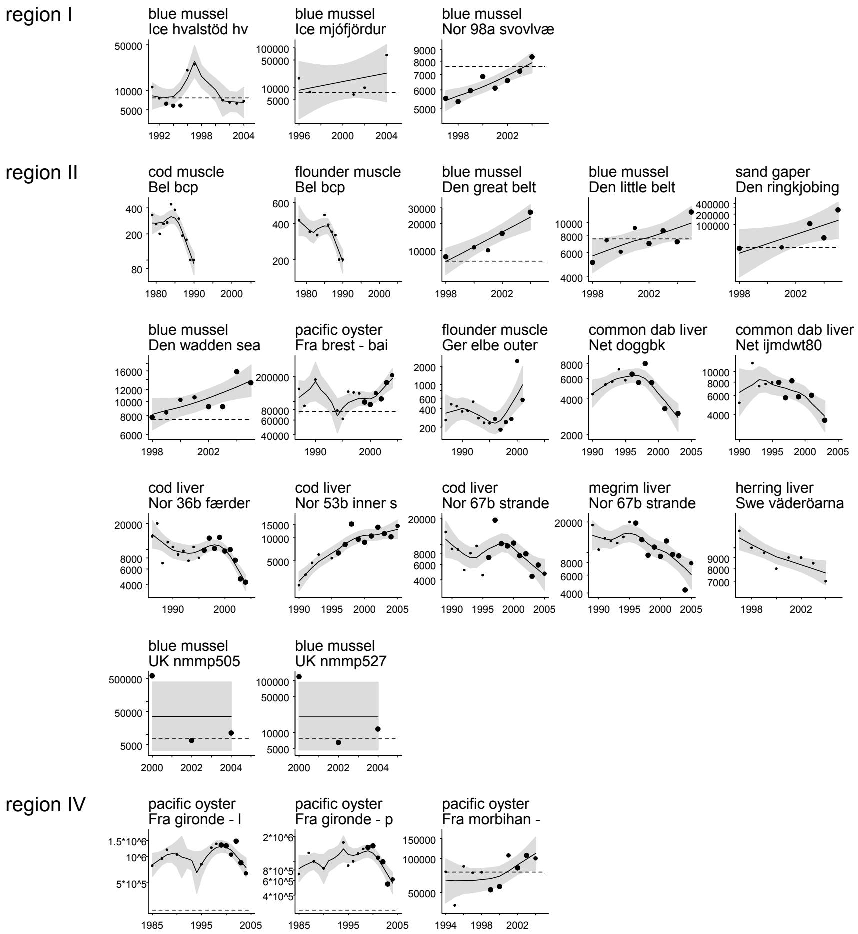
Copper: summary of time series. BCs and BACs have not yet been set for fish.

	region	number of time series 3-4	5-6	7+	total	trends up	down	UCL< BAC
shellfish	I	2	3	9	14	1	1	0
	II	21	10	51	82	4	2	22
	III	7	7	1	15	0	0	3
	IV	0	1	37	38	4	5	10
		30	**21**	**98**	**149**	**9**	**8**	**35**
fish	I	0	0	4	4	0	0	
	II	2	2	27	31	4	6	
	III	1	0	0	1	0	0	
		3	**2**	**31**	**36**	**4**	**6**	

Mean concentration (ug kg^{-1} dw) in mussels (blue) and oysters (red) in the final monitoring year. The vertical dotted lines are the BCs of 5300 and 53000 ug kg^{-1} dw for mussels and oysters respectively; the vertical solid lines are the corresponding BACs. The old BRC for blue mussels was 5500 ug kg^{-1} dw.



Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



4.2.7 TBT and copper in molluscs

56. A comparison of trends between TBT and copper in Blue mussel shows that two stations in the Little Belt and Wadden Sea both have a significant time trend where TBT is decreasing and copper is increasing. In general there is no connection between TBT and copper trend e.g. in Århus harbour, which has a large shipping intensity of both container ships, ferries and recreational boating, a significant downward trend of 34%/year for TBT does not show any trend in copper (p=0.96).

57. For Odense fjord the decreasing concentration for TBT with the distance from the shipyard is also found in copper concentrations, as shown in figure 4.7 below. Apart from this, no apparent correlation between TBT and copper concentrations can be discerned.

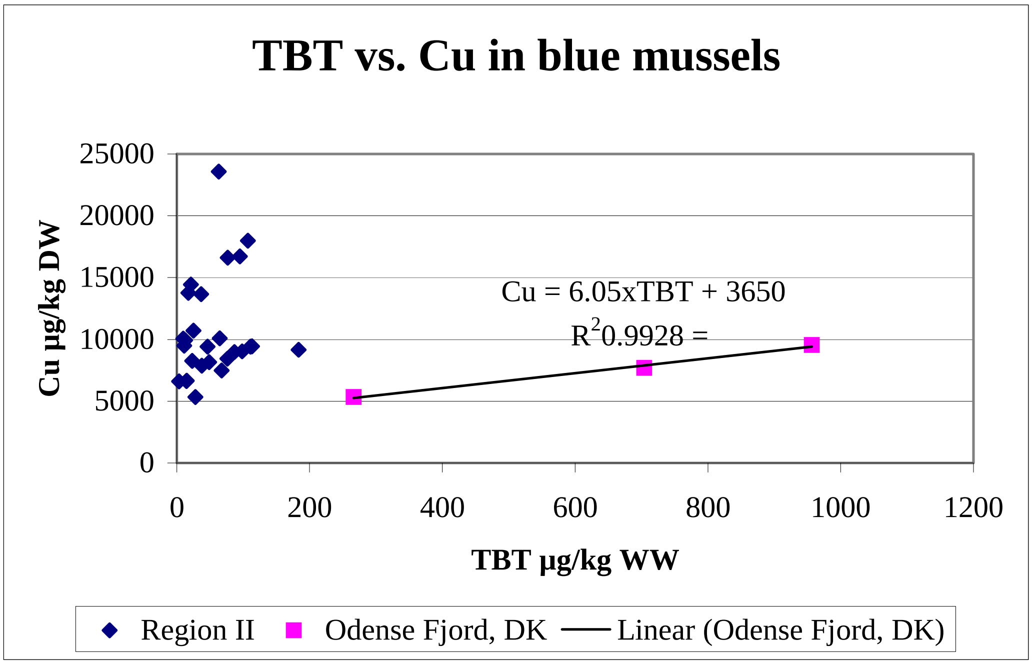


Figure 4.7. TBT vs. copper data for all Blue mussels, with Odense Fjord, DK in square dots, indicating the linear relationship of Cu and TBT. Odense Fjord is home to a large ship yard for ocean going ships

4.3 Trends of PAHs in biota

4.3.1 Fluoranthene in biota

58. Fluoranthene was selected from the PAHs because it is present in the highest concentrations and it is relatively easy to quantify.

59. PAH monitoring sites are still unevenly distributed throughout the OSPAR regions, with biota monitoring sites mainly in Belgium, Denmark, France, the UK and Spain, *as illustrated in the map below*. Time series are therefore mainly related to OSPAR regions II and IV, and to a much smaller extent to region III.

60. Only a few fluoranthene time series show trends and these are generally downwards. Downward trends are found in the Denmark, France, Norway and Spain. Particularly for the Spanish stations the earlier observed downward trends are sustained. During this assessment no upward trends were found in Region II and III. Only 1 upward trend was found for pacific oyster in Region IV for a French monitoring station (Gulf of Biscay South of the Gironde river). In France the analytical method used to determine PAHs was changed in 2001. This may lead to the detection of significant trends which are in fact artificial. For example, a decrease in the limits of detection could lead to an apparent increasing trend.

61. The BC was recalculated based on new data *(see chapter 3.3)* resulting in an increase of that value and a proportional increase of the BAC. As a result more concentrations in 2005 were below the BAC. For Region II approx. 20% (all French stations) and for Region IV approx. 16% (French and 1 Spanish station) of the time series have a value in the final year that is below the BAC. However, those Spanish stations with a sustained downward trend have an upper concentration limit in the last year that is well above the BAC.

62. The highest concentrations in biota are found in Region III for UK stations from Morecambe Bay and the Cumbrian coast near Whitehaven, both off the north-west coast of England. However, it may be that the the reported trends are a consequence of one year of anomalous data, and this should be resolved as data accumulate for later years. High concentrations are also found in Region II for French stations from the Bay of the Seine. The Bay of Seine is located under the direct influence of the Seine river basin, which is a highly industrialized and urbanized zone characterized by high levels of contaminants. Other locations with high concentrations were found for the Danish Wadden Sea, in the harbour of Santander (Spain), Roskilde fjord (Denmark), confluence of the Tamar and Tavy river near Plymouth (UK) and the Ribble near Blackpool (UK).

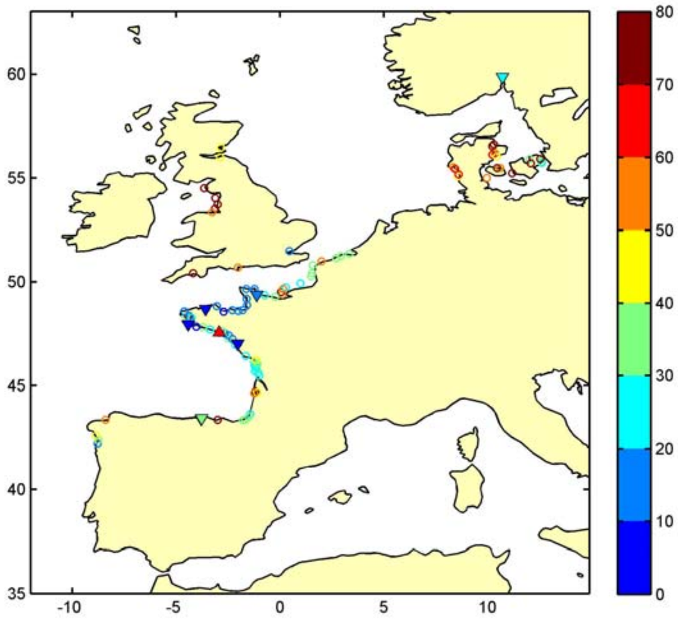
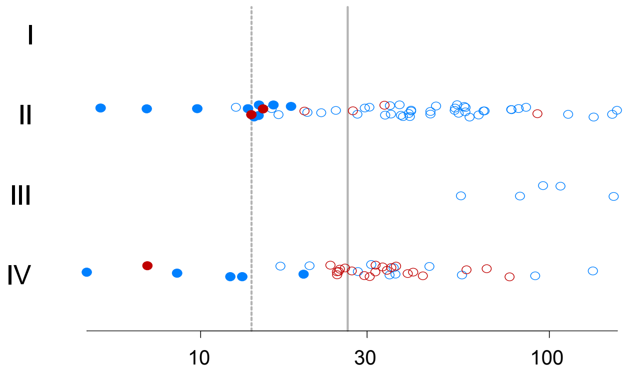


Figure 4.8: Fluoranthene in mussels. Concentrations are noted by colour and time trends by triangles pointing up/down for upward/downward trends respectively.

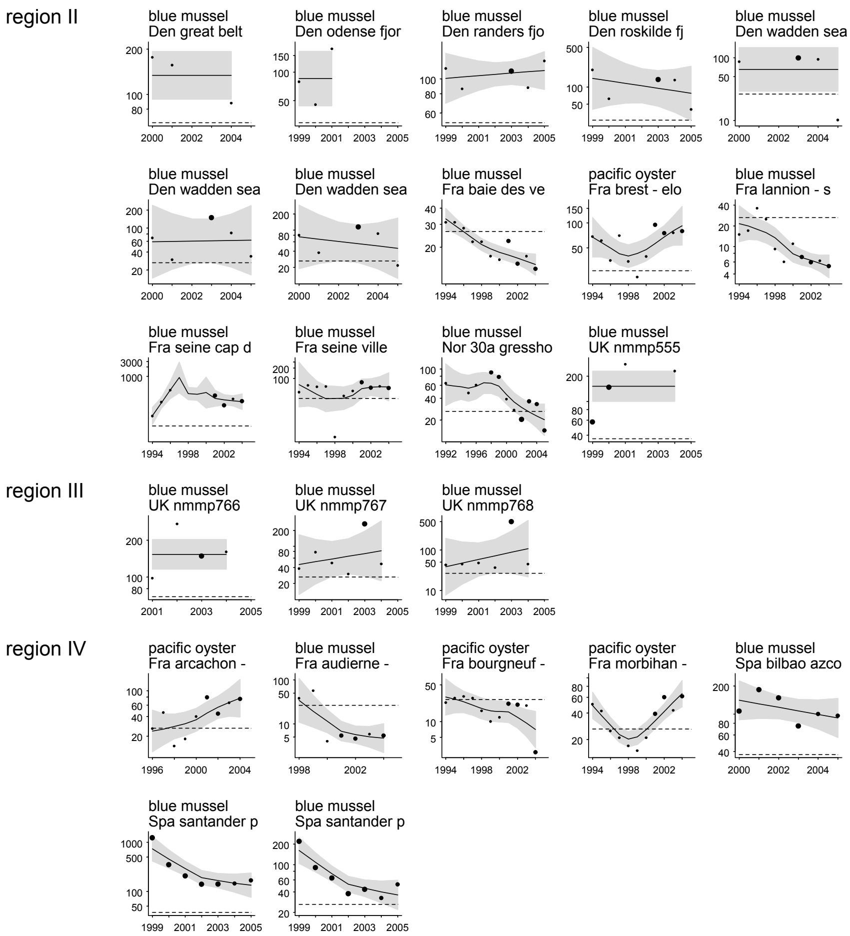
Fluoranthene: summary of time series.

	region	number of time series				trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
shellfish	II	20	6	31	57	0	3	11
	III	3	2	0	5	0	0	0
	IV	0	1	37	38	1	4	6
		23	**9**	**68**	**100**	**1**	**7**	**17**

Mean concentration (ug kg^{-1} dw) in mussels (blue) and oysters (red) in the final monitoring year. The vertical dotted line is the BC of 14 ug kg^{-1} dw, applied to both mussels and oysters; the vertical solid line is the BAC of 26.4 ug kg^{-1} dw. In the previous assessment, a BAC of 11.2 ug kg^{-1} dw was used for blue mussels.



Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



4.3.2 Benzo[a]pyrene in biota

63. Benzo[a]pyrene was selected for assessment because it is the most toxic of the more abundant PAHs, although perhaps not generally as accurately determined as fluoranthene.

64. Again, only a limited number of trends were detected. In contrast to fluoranthene most of the significant trends were upwards (10 out of 16). The upward trends were found almost exclusively in Region IV (9). In Region II the only upward trend was observed for a French monitoring station north of Le Havre in the beginning of the English Channel. All other upward trends were observed in the Gulf of Biscay, mostly North of the Gironde river, particularly in the region of Morbihan north of St.-Nazaire (on the Loire river). although an upward trend was also observed at a French monitoring station near the Spanish border (St Jean de Luz/Ciboure). These upward trends were almost exclusively for Pacific oysters and in one of the stations (Marennes), both mussels and oysters showed the same trend. Pacific oysters were only analysed in France. As described for Fluoranthrene these trends may be the artefact of a change of analytical method for PAH in 2001.

65. Six downward trends were mostly for Region II (4) and all from the North coast of Brittany. The other two were in Region III (UK, near Whitehaven) and IV (France, Bay of Biscay). The downward trend for benzo[a]pyrene in Whitehaven is in stark contrast to the upward trend for fluoranthene at the same location.

66. As for fluoranthene, the proposed new values for BCs and BACs caused a big change in the number of stations where concentrations appear to be close to background. For Regions II, III and IV respectively approx. 45, 50 and 70% of mean concentrations in the final year are significantly below the BAC for blue mussel. Nearly 90% of mean concentrations in the final year are significantly below the BAC for pacific oyster. During the previous assessment, concentrations were, in general, above the BAC (where available) in both sediment and biota.

67. Biota stations with mean concentrations in 2005 well above the BAC are in Denmark, near large cities and shipping routes (the Sound), in France (bay of the Seine), UK (Liverpool bay) and Spain (Santander) near industrialised and/or harbour areas. The Bay of Seine is located under the direct influence of the Seine river basin, which is a highly industrialized and urbanized zone characterized by high levels of contaminants.

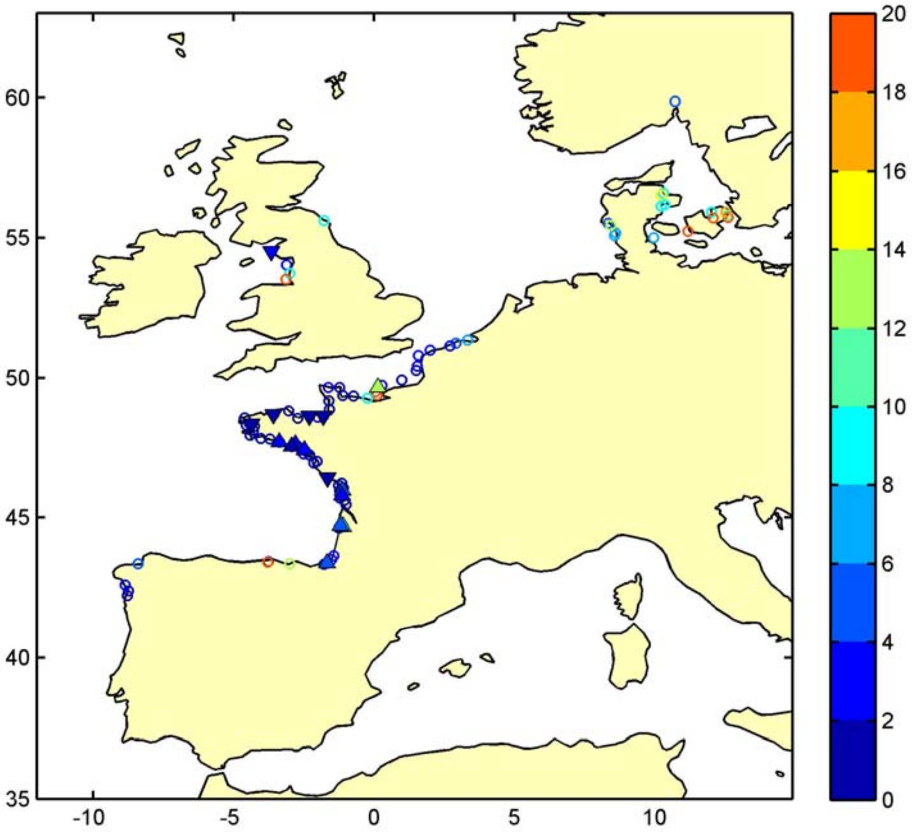
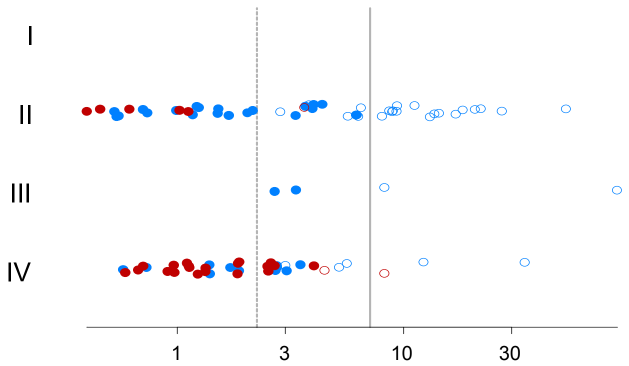


Figure 4.9: Benzo [a] pyrene in mussels. Concentrations are noted by colour and time trends by triangles pointing up/down for upward/downward trends respectively.

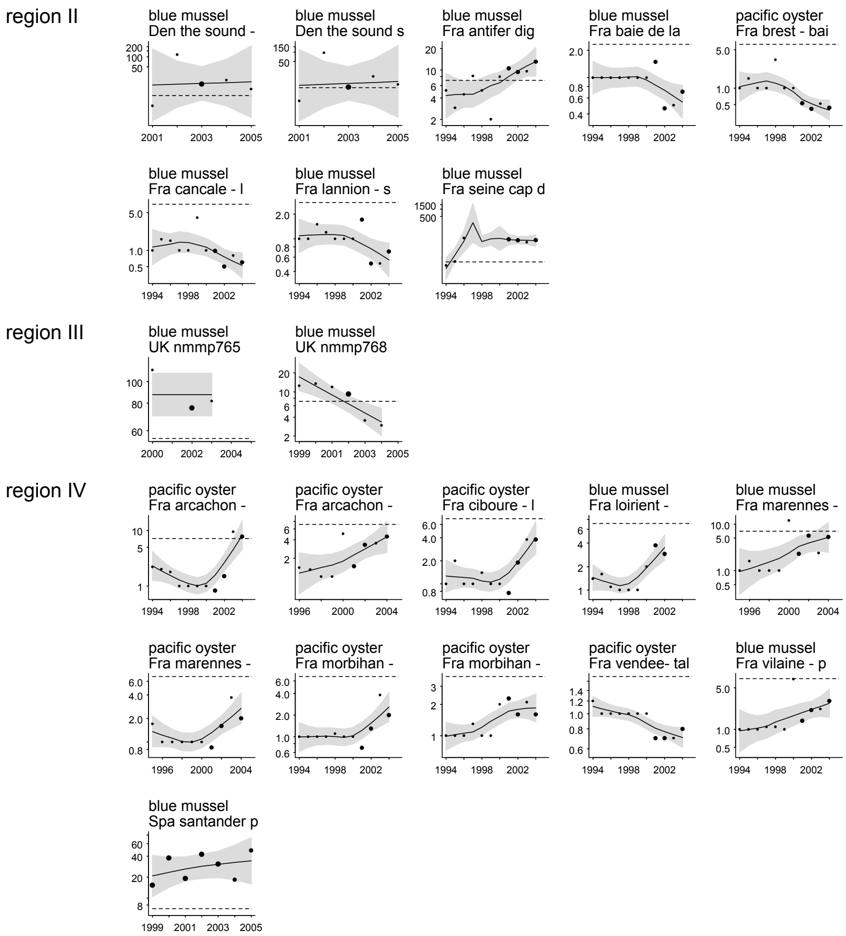
Benzo[a]pyrene: summary of time series.

	region	number of time series 3-4	5-6	7+	total	trends up	down	UCL< BAC
shellfish	II	13	7	29	49	1	4	25
	III	2	2	0	4	0	1	2
	IV	0	1	37	38	9	1	31
		15	**10**	**66**	**91**	**10**	**6**	**58**

Mean concentration (ug kg^{-1} dw) in mussels (blue) and oysters (red) in the final monitoring year. The vertical dotted line is the BC of 2.25 ug kg^{-1} dw, applied to both mussels and oysters; the vertical solid line is the BAC of 7.1 ug kg^{-1} dw. In the previous assessment, a BAC of 2.1 ug kg^{-1} dw was used for blue mussels.



Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



4.3.3 Benzo[ghi]perylene in biota

68. Benzo[ghi]perylene was selected for assessment as representative of PAHS with a higher boiling point.

69. Only a very limited number of trends were detected (5), all of which were increasing. The upward trends were found in Regions II (2) and IV (3). In region II both upward trends were observed for French monitoring stations in the bay of the Seine and Pas de Calais near Boulogne (Dover Strait). For Region IV, the upward concentrations are in the same region as those for benzo[a]pyrene in the region of Morbihan north of St.-Nazaire (on the Loire river). Both blue mussel and pacific oyster show the same trend. As described for Fluoranthrene these trends may be the artefact of a change of analytical method for PAH in 2001.

70. As for both other PAHs, the new BC and therefore BAC resulted in many stations appearing to have mean concentrations at background in the last monitoring year. For Regions II and IV approx. 70% of mean concentrations are significantly below the BAC for blue mussel and up to 85% of mean concentrations are significantly below the BAC for pacific oyster.

71. Biota stations with concentrations well above the BAC are found, as for benzo[a]pyrene, in the Sound (Denmark), near large cities and shipping routes (), in Bay of the Seine (France) (, a highly industrialized and urbanized zone under the influence of the Seine river basin), and Santander (Spain) near industrialised and/or harbour areas. However, these Spanish stations have a sustained downward trend. In the UK concentrations well above the BAC are found at the confluence of the Tamar and Tavy river, near Plymouth (see also fluoranthene), in Liverpool Bay and near Whitehaven (Cumbrian coast). The reasons for these features of UK data are not clear.

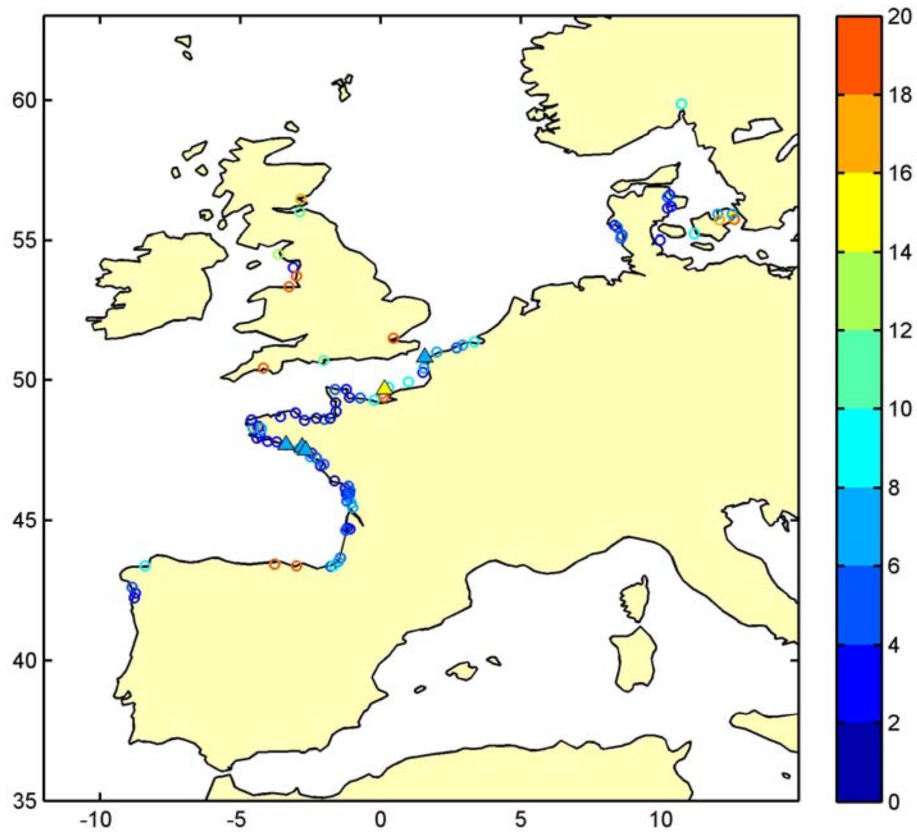
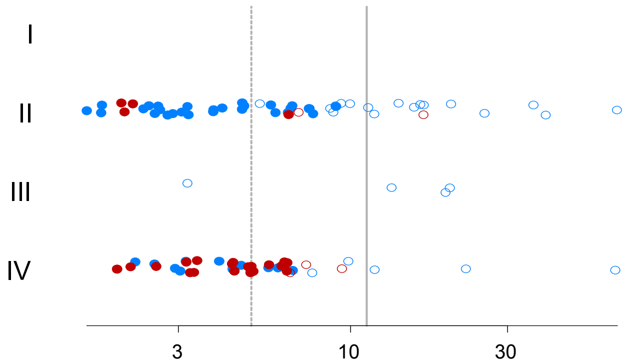


Figure 4.10: Benzo [ghi]perylene in mussels. Concentrations are noted by colour and time trends by triangles pointing up/down for upward/downward trends respectively.

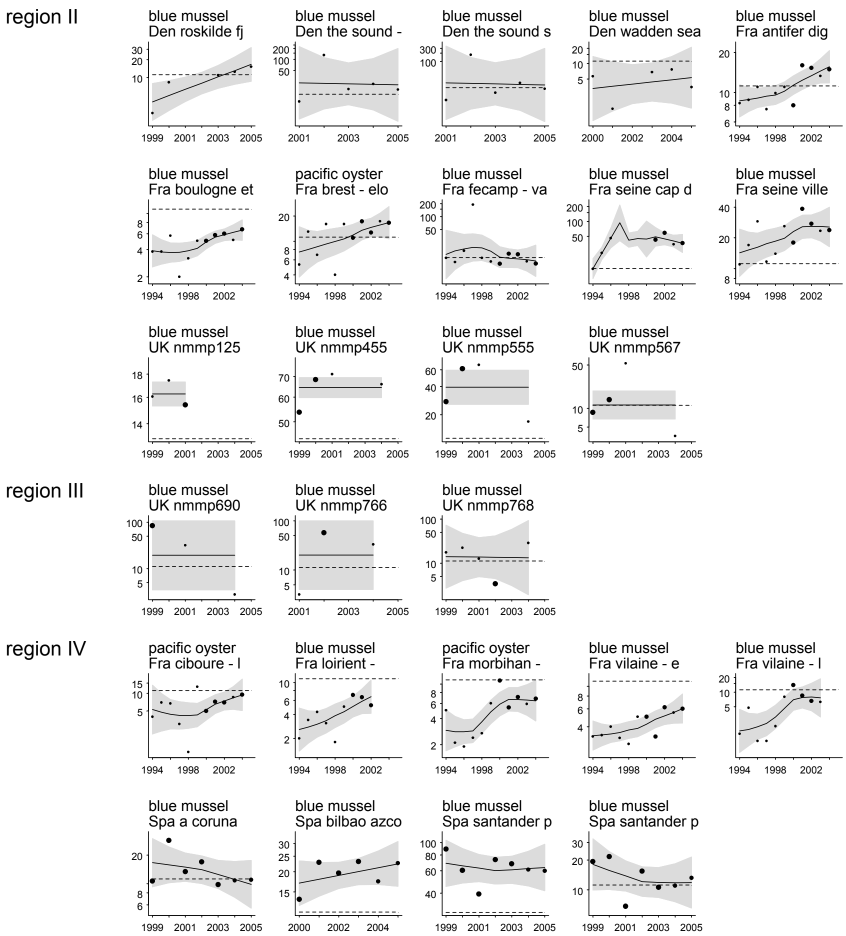
Benzo[ghi]perylene: summary of time series.

	region	number of time series 3-4	5-6	7+	total	trends up	down	UCL< BAC
shellfish	II	16	8	29	53	2	0	33
	III	2	2	0	4	0	0	0
	IV	0	1	37	38	3	0	30
		18	**11**	**66**	**95**	**5**	**0**	**63**

Mean concentration (ug kg^{-1} dw) in mussels (blue) and oysters (red) in the final monitoring year. The vertical dotted line is the BC of 5 ug kg^{-1} dw, applied to both mussels and oysters; the vertical solid line is the BAC of 11.2 ug kg^{-1} dw. In the previous assessment, a BAC of 7.2 ug kg^{-1} dw was used for blue mussels.



Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



4.3.4 Ratio of phenanthrene and anthracene

72. For this assessment an initial evaluation was made of the use of the ratio of phenanthrene and anthracene. A number of PAH concentration ratios have been used to distinguish between pyrolytic and petrogenic sources. A summary of the ratios commonly used was presented recently by Webster et al. (2000)[9] and Readman et al. (2002)[10]. The most frequently examined PAH ratios are phenanthrene to anthracene (P/A), fluoranthene to pyrene (Fl/Py), methylphenanthrenes to phenanthrene (MP/P), Fl plus Py to methylfluoranthene plus methylpyrene and Benzo[a]anthracene to chrysene (BaA/Chr). A P/A ratio of less than 10 and a MP/P ratio of less than 1 are generally accepted to indicate a pyrolytic origin.

73. The means of the ratios for the last monitoring year were compared and everything above an arbitrary ratio of 20 was considered to be of petrogenic origin. This clearly showed that most of the sampling stations situated at, or in, harbour areas or in the vicinity of busy shipping lanes have ratios of above 20, suggesting petrogenic origin. It is also remarkable that the upward trends for the French monitoring stations in the Gulf of Biscay seems to be associated with a petrogenic source or sources. However, the trend for the ratio in that region is generally downward, which would indicate that the source is shifting from petrogenic to pyrogenic. This merits further investigation and certainly shows that the use of ratios should be further developed. It is possible that the conclusions may be an artefact resulting from a change in the analytical methodology for Fluoranthrene determination.

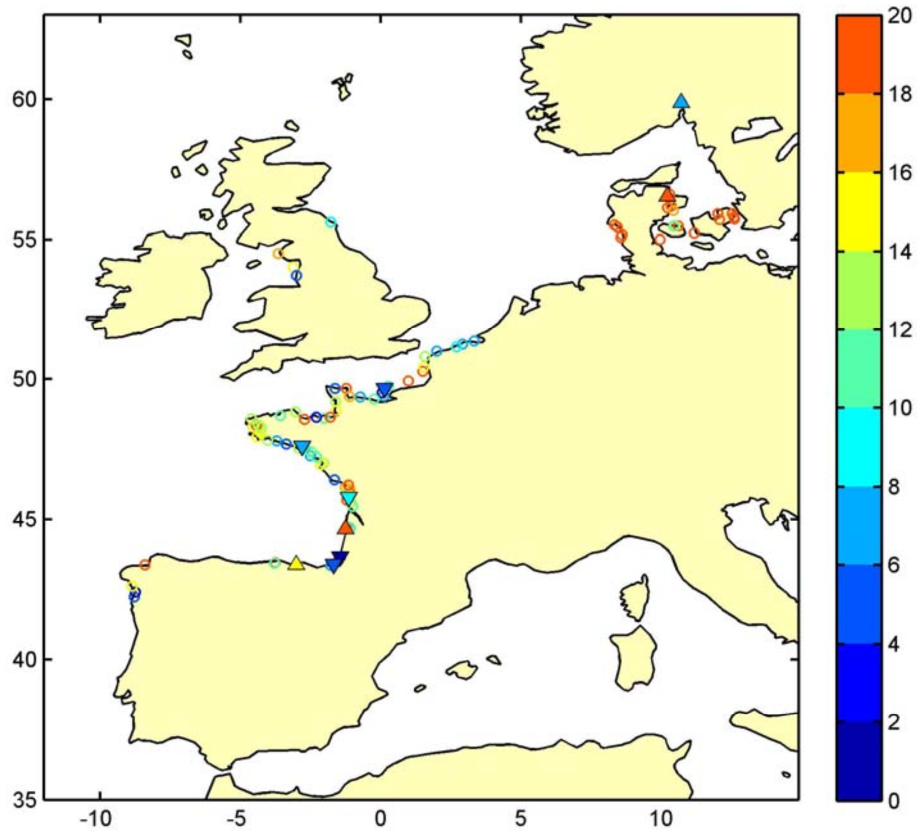


Figure 4.11: Ratios of Phenanthrene/anthracene concentrations in mussels. Values are noted by colour and time trends by triangles pointing up/down for upward/downward trends respectively.

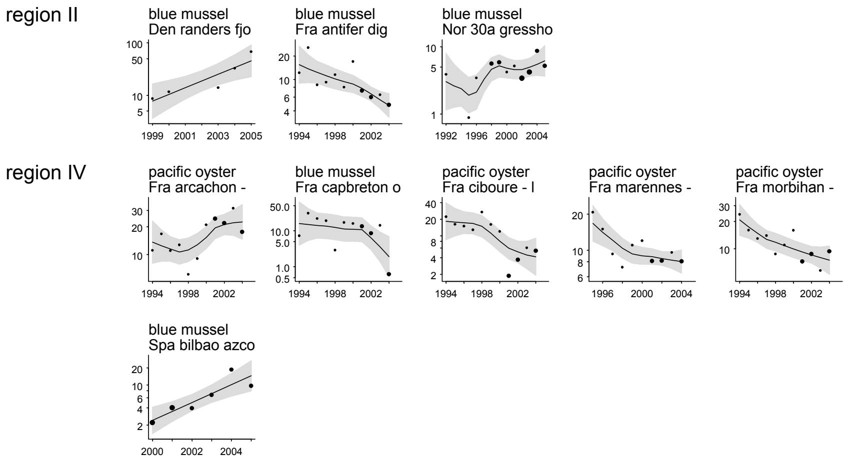
9 Webster L., McIntosh A.D., Moffat C.F., Dalgarno E.J., Brown N.A. and Fryer R.J. J. Environ. Monit., 2, 29-38, 2000.

10 Readman J.W.; Mantoura R.F.C., Rhead M.M. and Brown L. Est. Coast. Shelf. Sc. 14, 369-389, 1982.

Phenanthrene / anthracene: summary of time series. BACs or some other assessment criterion have not yet been considered for this ratio.

	region	number of time series				trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
shellfish	II	17	6	30	53	2	1	
	III	1	2	0	3	0	0	
	IV	0	1	37	38	2	4	
		18	**9**	**67**	**94**	**4**	**5**	

Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



4.4 Trends of pesticides in biota

4.4.1 p,p'-DDE in biota

74. From the available database, p,p'-DDE was selected as being representative of the overall DDT contaminant burden. DDE is generally the primary metabolite found in biota and it is usually possible to quantify DDE more accurately than the parent DDT compound.

75. In total, 185 time series were available for all regions and species, of which 119 were of 7 years or greater in duration. For blue mussels, a total of 100 time series were available for all OSPAR regions, with most of the longer time series (>7 years) available for Region II. 34 other shellfish time series were available from Regions II and IV with the majority of longer time series found in Region IV. 51 time series for fish species were available from Regions I and II with longer time series predominant in Region II.

76. Trends in the last ten years are generally in a downward direction with 90% of significant trends showing a decrease in p,p'-DDE levels. This pattern may however be expected as a result of the ban on the use of DDT. For shellfish, 13 downward trends were found, with the majority in blue mussels from Region II. For fish, 13 significant downward trends were found, mostly in region II.

77. Upward trends are found only for molluscs in Region I (2 in blue mussel from Mjófjördur in Iceland) and Region IV (1 trend at Baie de l'Aiguillon in France for pacific oyster).

78. Highest concentrations are primarily found in fish (cod, megrim, flounder, common dab) from region II, mainly in Norwegian waters. High concentrations are also found in blue mussel at Kvalnes in the industrialised Sørfjord (Norway) as well as in molluscs from the UK and France. The UK site is at Tayport, and is close to a relatively large soft fruit growing industry that used DDT in the past.

The lowest concentrations are found in fish from Belgium and Norway, and in mussels originating mainly in region I and from the French coast.

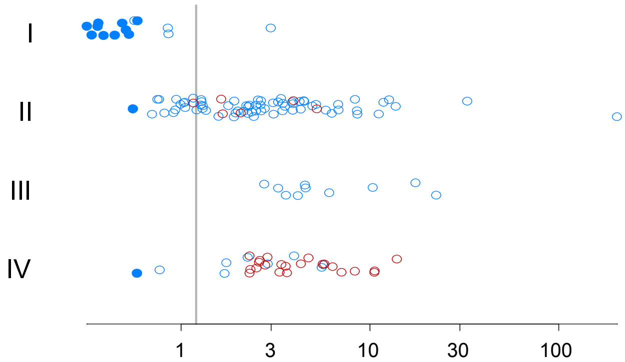
79. Mean concentrations are primarily close to zero in blue mussels from region I (10 among 14 in total). In regions II, III and IV, most of the concentrations well are above zero in both molluscs and fish. While most trends are in a downward direction, zero levels are not likely to be reached in the near future, as most of the concentrations are still relatively elevated with respect to the BAC, especially for a number of time series from regions II, III and IV.

80. While the measurement of p,p'-DDE in biota provides a mechanism by which the overall DDT contaminant burden in marine species may be assessed, the inclusion of information on other DDT metabolites and of the parent DDT compound may provide a mechanism by which point source inputs may be further identified.

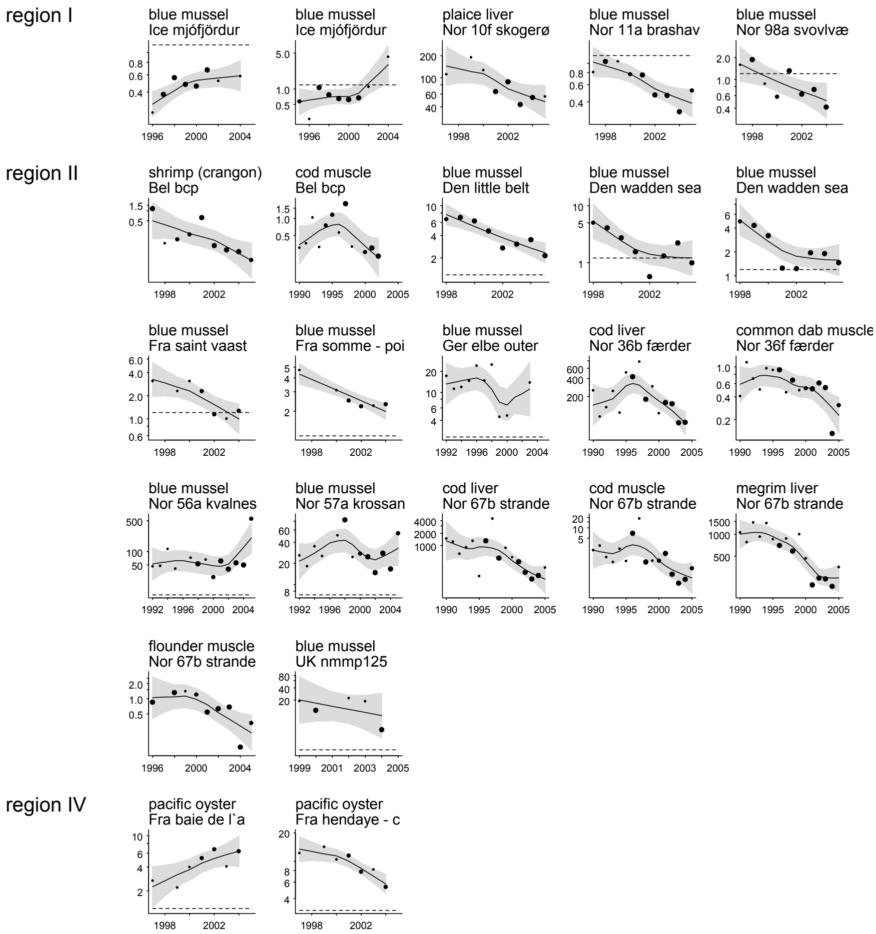
p,p'-DDE: summary of time series. BACs have not yet been set for fish.

	region	number of time series				trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
shellfish	I	0	1	13	14	2	3	10
	II	18	19	42	79	0	10	1
	III	6	4	0	10	0	0	0
	IV	0	10	21	31	1	1	1
		24	**34**	**76**	**134**	**3**	**14**	**12**
fish	I	0	0	8	8	0	1	
	II	4	4	35	43	0	12	
		4	**4**	**43**	**51**	**0**	**13**	

Mean concentration (ug kg^{-1} dw) in mussels (blue) and oysters (red) in the final monitoring year. The BC is 0 ug kg^{-1} dw; the vertical solid line is the BAC of 1.2 ug kg^{-1} dw, applied to both mussels and oysters.



Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



4.4.2 HCB in biota

81. There were 75 shellfish time series, all but one of blue mussel, available for OSPAR regions I, II and III, with a majority from region II. Of these, 38 time series were 7 years or longer. For fish, 56 time series were available, however these were limited to both regions I and II with the majority of long time series available for region II.

82. Eighteen significant trends over the last ten years were identified, all of them being in the downward direction. From region I 3 downward trends were found in blue mussels (Hvalstöd, Hvitanes and Eyri hvalfjördur) and region II only one downward time series was detected (Bjørkoya (Risøyodd). For fish, 13 significant downward trends were found in region II, and 1 in region I. No significant upward trends in HCB levels have been determined among any of the indicator species.

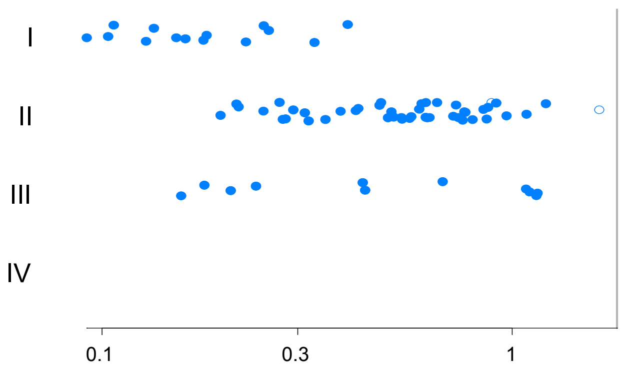
83. The highest concentrations are found in fish liver from Germany, Norway and the Netherlands. Highest levels in mussels are found in molluscs originating in Germany and the UK. The lowest concentrations are found in fish muscle tissue originating mainly from Norway. Less elevated contaminant levels in mussels are found in the more Northerly latitudes (Norway, Iceland) in addition to some locations in Ireland.

84. There are only two time series where the mean concentration in the final year is not significantly below the BAC; the outer Elbe and Budle Bay, Northumberland, UK.

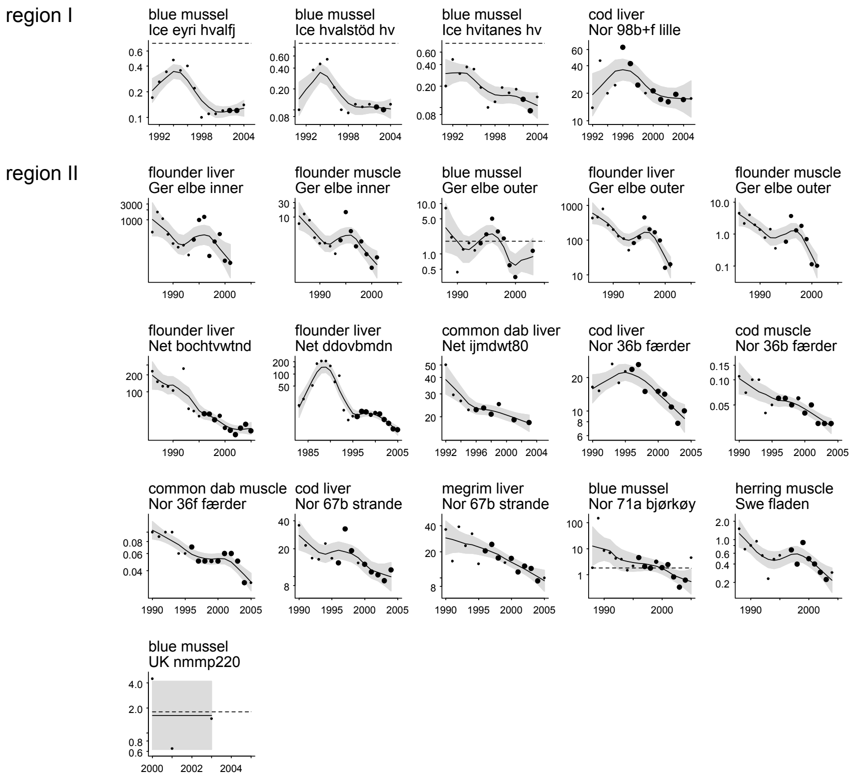
HCB: summary of time series. BACs have not yet been set for fish.

	region	number of time series				trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
shellfish	I	0	1	13	14	0	3	14
	II	17	9	24	50	0	1	44
	III	7	3	1	11	0	0	11
	IV	0	0	0	0			
		24	**13**	**38**	**75**	**0**	**4**	**69**
fish	I	0	0	8	8	0	1	
	II	3	2	43	48	0	13	
		3	**2**	**51**	**56**	**0**	**14**	

Mean concentration (ug kg^{-1} dw) in mussels (blue) and oysters (red) in the final monitoring year. The BC is 0 ug kg^{-1} dw; the vertical solid line is the BAC of 1.8 ug kg^{-1} dw.



Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



4.4.3 γ-HCH (lindane) in biota

85. A total of 174 time series were available for γ-HCH in biota, most of which (79%) are greater than 7 years duration. The majority of available blue mussel data originate in region II (62 time series), which has the greatest coverage of data for blue mussel and fish (a total of 105 time series), while a number of datasets for other shellfish originate primarily from region IV.

86. A total of 76 downward trends are evident, most being found in mussel and fish samples from region II (78%). Only one significant increasing trend was determined in flounder from Weser outer (Germany).

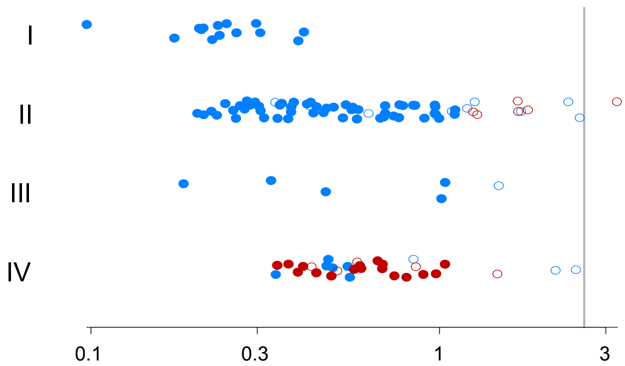
87. The highest concentrations are found in fish liver samples originating mainly from Germany, and the highest concentrations in molluscs were identified in time series originating in France. The lowest levels were found in fish muscle from regions I and II (Norway).

88. Concentrations in 87% of blue mussel time series in region II are close to zero. Concentrations in 77% of pacific oyster time series from region IV are also close to zero.

γ-HCH: summary of time series. BACs have not yet been set for fish.

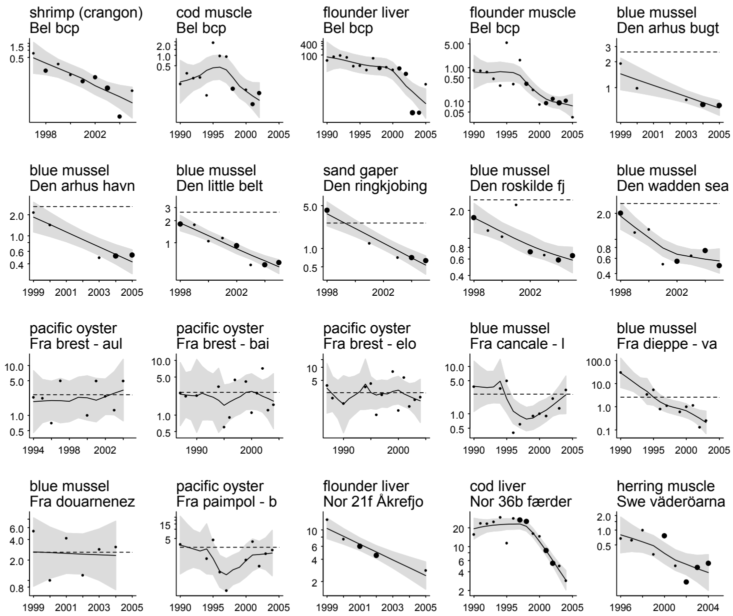
	region	number of time series				trends		UCL<BAC
		3-4	5-6	7+	total	up	down	
shellfish	I	0	1	13	14	0	3	14
	II	12	11	49	72	0	34	55
	III	4	1	1	6	0	2	5
	IV	0	2	29	31	0	8	23
		16	**15**	**92**	**123**	**0**	**47**	**97**
fish	I	0	0	8	8	0	3	
	II	4	2	37	43	1	26	
		4	**2**	**45**	**51**	**1**	**29**	

Mean concentration (ug kg^{-1} dw) in mussels (blue) and oysters (red) in the final monitoring year. The BC is 0 ug kg^{-1} dw; the vertical solid line is the BAC of 2.6 ug kg^{-1} dw, applied to both mussels and oysters.

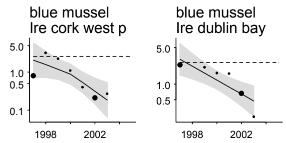


Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.

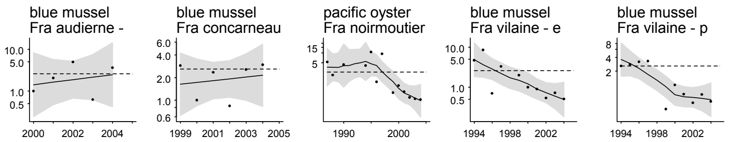
region II



region III



region IV



4.4.4 α-HCH in biota

89. In response to requests to explore the potential use of contaminant rations in data assessments, MON addressed the use of the ratio between α-HCH and γ-HCH. This ratio has the potential to investigate potential differences in point or other source inputs at individual locations. Technical HCH can contain varying amounts of alpha, beta, delta and epsilon HCH isomers. In preparation for that task, data for α-HCH were assessed independently. A total of 169 datasets were available for α-HCH in biota with the majority (89%) being in excess of five years duration. The majority of these time series (51%) were available for blue mussels.

90. The majority of time series were from region II (66%) while the remaining datasets were from Region IV (19%), Region I (13%) and Region III (2%).

91. A total of 33 downward trends were evident for α-HCH, a majority being derived from fish species. 41% of the datasets from Region I show decreasing trends in α-HCH levels, while decreasing trends of 17% and 16% were evident in the datasets from regions II and IV respectively.

92. In Region II downward trends were observed in 40% of fish time series but only in 2% of blue mussel time series. No significant upward trends in the levels of α-HCH in biota were evident from the available data.

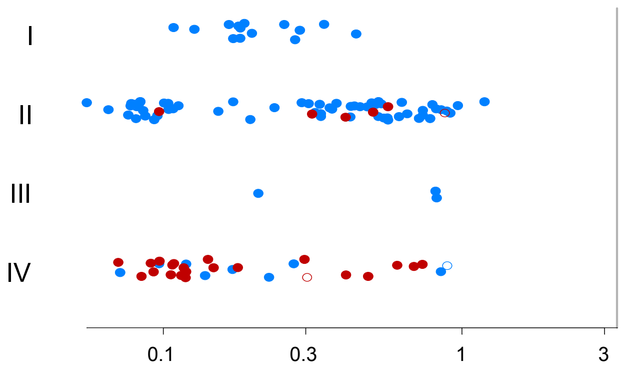
93. The most elevated α-HCH levels were found the Elbe, Jade and Weser rivers in Germany in founder liver tissue. Lowest levels were observed in fish muscle tissue originating in Belgian and Norwegian time series.

94. Mean concentration were close to zero in the last year of monitoring in 113 of the 118 shellfish time series. Two pacific oyster time series (France-Martennes and Brest) and one blue mussel time series (France- Audierne/Penhors) had last year mean concentrations not significantly below the BAC.

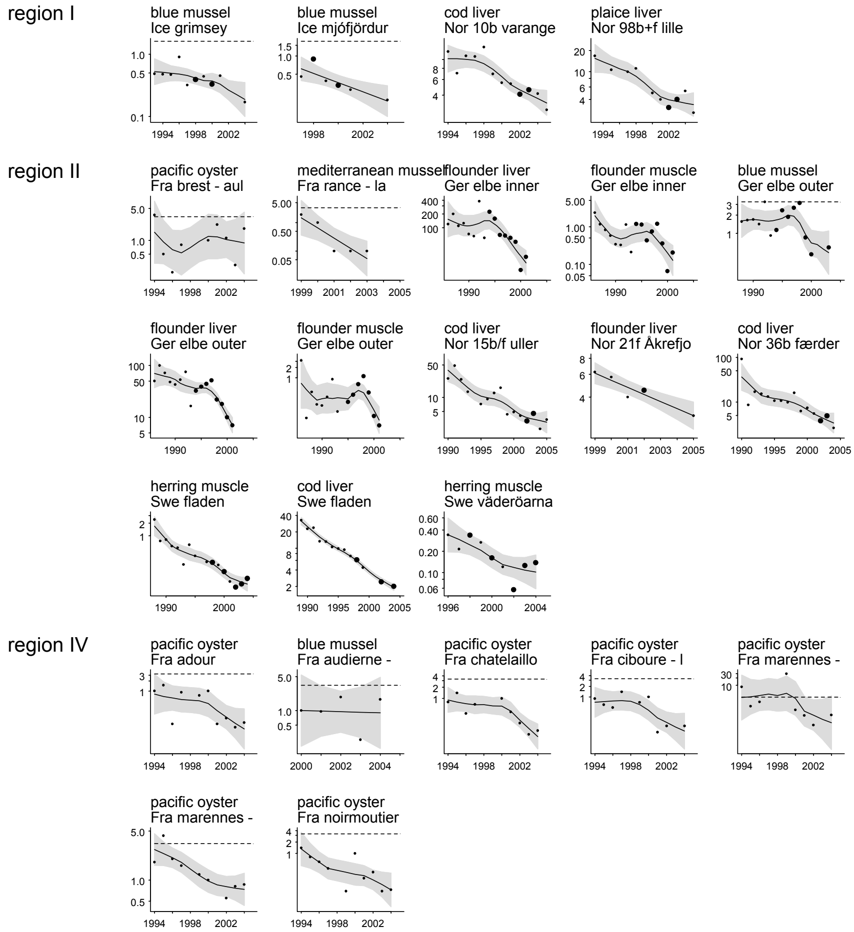
α-HCH: summary of time series. BACs have not yet been set for fish.

	region	number of time series				trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
shellfish	I	0	1	13	14	0	5	14
	II	12	11	47	70	0	2	67
	III	3	0	0	3	0	0	3
	IV	0	2	29	31	0	5	29
		15	**14**	**89**	**118**	**0**	**12**	**113**
fish	I	0	0	8	8	0	4	
	II	4	3	36	43	0	17	
		4	**3**	**44**	**51**	**0**	**21**	

Mean concentration (ug kg^{-1} dw) in mussels (blue) and oysters (red) in the final monitoring year. The BC is 0 ug kg^{-1} dw; the vertical solid line is the BAC of 3.3 ug kg^{-1} dw, applied to both mussels and oysters.



Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



4.4.5. Ratio of α-HCH to γ-HCH in biota

95. The ratio of α-HCH to γ-HCH ratio in all biota samples was examined to assess whether this ratio provides a useful mechanism to further investigate potential differences in point or other source inputs at individual locations. Time series from 2001 onwards where both α-HCH and γ-HCH isomer concentrations were reported were selected from the dataset. The median ratio was then determined for each dataset and was illustrated on a map.

96. In general γ-HCH will be more prevalent than the α-HCH isomer in marine biota, thereby generation of a statistic < 1 will result.

97. A number of limitations/considerations need to be noted where contaminant ratios are employed. The use of this ratio will primarily be applicable in regions where concentrations are found to be above the limit of quantification of analytical methodologies. In pristine areas where concentrations of the isomers will be expected to be low or in samples where high limits of quantification are reported, the use of α-HCH to γ-HCH ratios should be avoided, as they will primarily reflect quantification limits rather than "true" environmental levels of the HCH isomers. The current analysis of the data covers all the relevant times series,, and therefore includes data reported as less than limits of quantification, This is clearly a weakness in the analysis, and the results should be interpreted with caution. Intersessional work is planned to modify the data analysis routine prior to MON 2007.

98. In mussels a wide range of ratios were observed throughout the OSPAR convention area. The majority of data indicated a greater influence of γ -HCH at time series locations. The majority of the data for fish livers came from the UK information. Insufficient data were available for both mussels and fish liver from similar stations to determine whether point source inputs and/or potential metabolic activity was responsible for the observed ratios.

99. It should be noted that species from higher trophic level, such as fish, may preferentially metabolise individual isomers of HCH. α -HCH isomer exhibits properties of chirality and preferential metabolism of enantiomers of α -HCH have been reported in marine species.

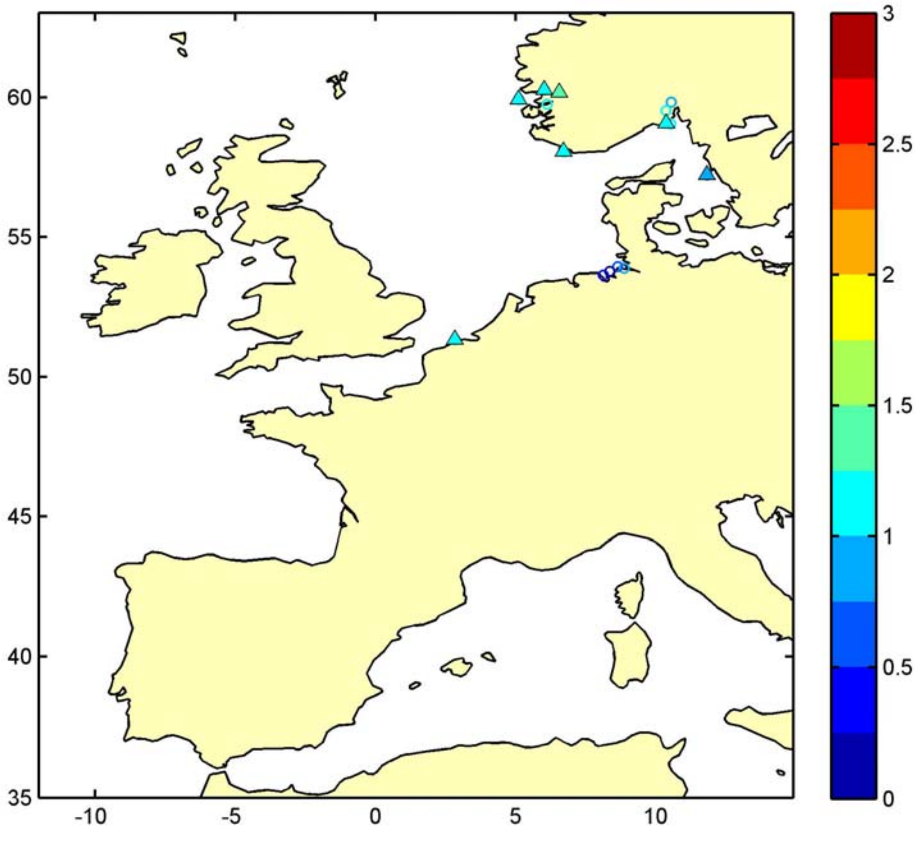


Figure 4.12: Ratio of α-HCH and γ-HCH in fish liver in the North Sea. Values are noted by colour and time trends by triangles pointing up/down for upward/downward trends respectively.

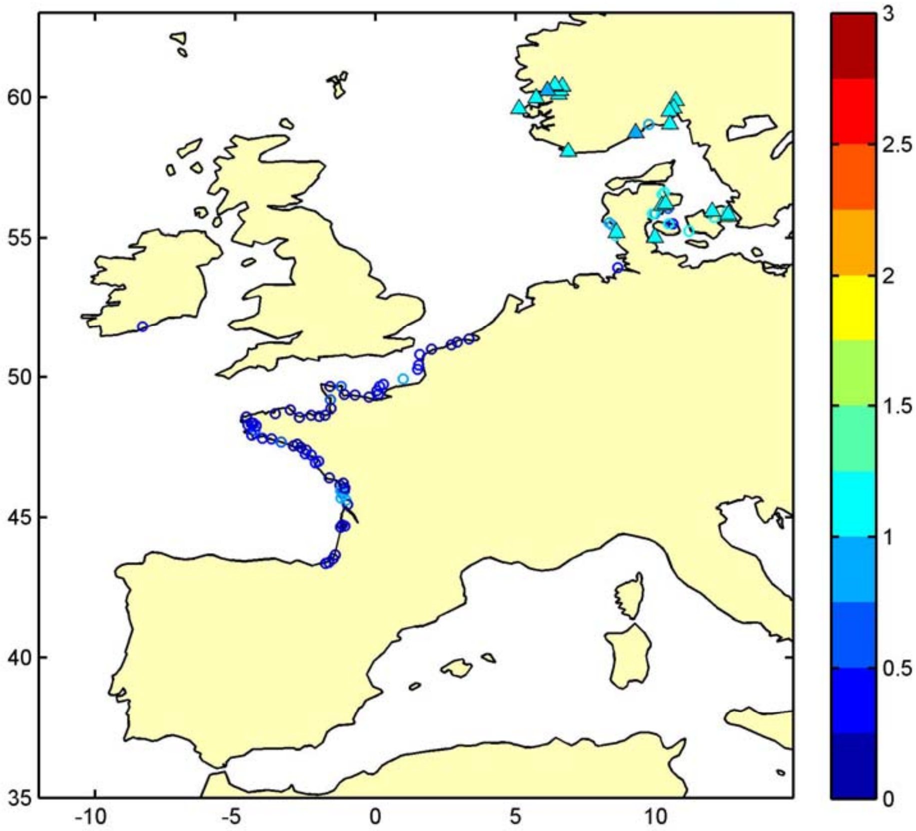


Figure 4.13: Ratio of α-HCH and γ-HCH in mussels. Values are noted by colour and time trends by triangles pointing up/down for upward/downward trends respectively.

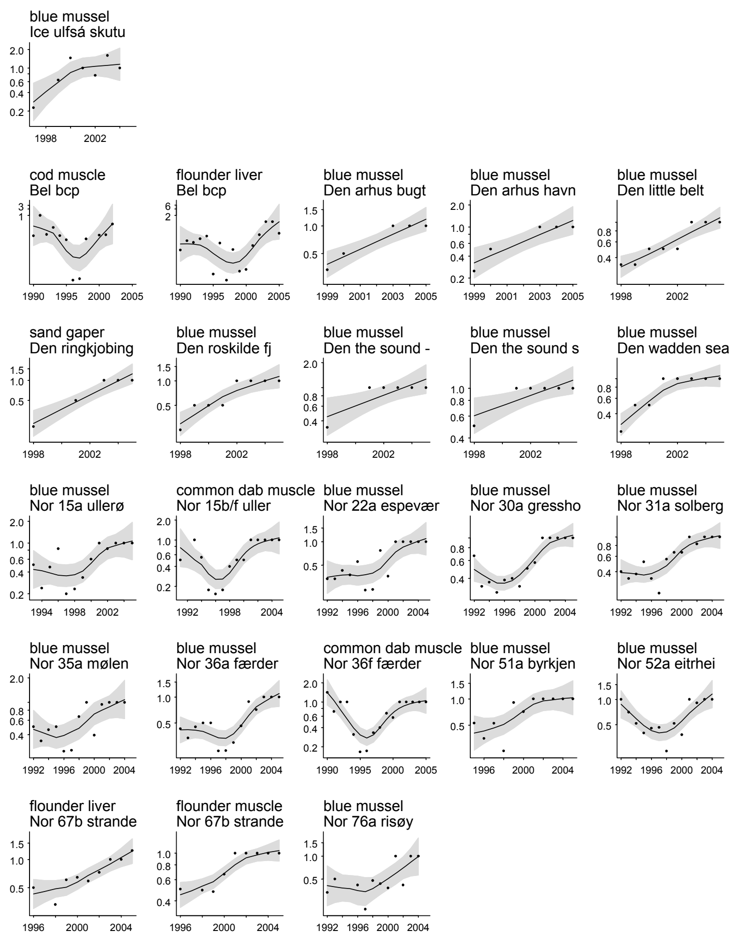
α-HCH / γ-HCH: summary of time series. BACs are not meaningful for this ratio.

	region	number of time series 3-4	5-6	7+	total	trends up	down	UCL< BAC
shellfish	I	0	1	13	14	2	0	
	II	12	12	46	70	22	0	
	III	1	0	0	1	0	0	
	IV	0	2	29	31	0	0	
		13	**15**	**88**	**116**	**24**	**0**	
fish	I	0	0	8	8	0	0	
	II	4	2	37	43	17	0	
		4	**2**	**45**	**51**	**17**	**0**	

Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.

region I

region II



4.5 PCBs in Biota

100. The congener CB153 was selected to represent the group of PCBs as it is generally present in the highest concentration in marine biota and correlates well with the concentrations of other CBs. CB118 has primarily been selected on the basis that it is representative of the more toxicologically relevant mono-ortho/planar PCBs. Both CB118 and CB153 were assessed together to enable direct comparison of potential trends. Additionally the usefulness of the ratio of CB118/CB153 as a potential tool to identify differences in source inputs of the different CB types was further investigated. A further potential use of such a ratio can be as a quality control screening mechanism to identify potential errors in submitted data.

101. Data for CBs in both fish and molluscs were available from all four OSPAR regions. More than half of the biota time series cover seven or more years, with the exception of those from Ireland, where the monitoring programme has been expanded in recent years. In total, approximately 20 % of CB153 time series greater than more than five years and 16 % of CB118 time series show downward trends. Most of these are found in region II primarily as a consequence of the presence of a greater number of time series stations in that region.

103. Significant upward trends were indicated in 6 time series for PCB 153 (2.6% of datasets) and in 3 for CB118 (1.2% of total datasets). Upward trends in blue mussels were found in Mjöfördur(Iceland - Region I) and Vigo (Spain- Region IV), where an unidentified spillage was detected in 2004 and monitoring set in place. High values were found again in 2005. Upward trends in pacific oyster at Gironde la fosse (France - Region IV), in plaice liver in the outer Moray Firth (UK), in flounder liver from the inner Sørfjord (Norway) and in cod liver in the Oslo city area(Norway). The Moray Firth (UK) site is relatively remote, and there is no clear reason for an increase. The trend is only marginally significant ($p = 0.0499$) and further data should clarify the status of the trend.

104. Variations in the percentage of significant trends for the individual CB 153 and 118 congeners are likely to be a consequence of analytical variability within time series datasets.

105. In all time CB153 time series for shellfish, the upper confidence limit on the mean concentrations in the last year of monitoring was greater than the BAC, so none of these time series can be considered close to zero. For CB118, 40% of shellfish mean concentrations in the final year of monitoring were significantly below the BAC and hence close to zero.

106. Overall the most elevated concentrations were found in fish liver at coastal stations influenced by industrial processes, such as the Western Scheldt, Mersey, Inner Sørfjord and Oslo City in Norway, the Inner Elbe, Outer Weser. In blue mussels, the highest concentrations were found at several locations in the Seine river basin and at the north-western Spanish coast (Vigo, Bilbao and A Coruna).

107. To further investigate the use of CB118 to CB153 ratios, a selection was made of time series from 2001 onwards where both CB118 to CB153 congener concentrations were available above quantification limits. For each dataset the median ratio was then determined and was illustrated on a map.

108. The ratios of CB118 to CB153 in mussels reflect the greater influence of CB 153 in the species. A number of mussel time series from the German Bight and from Belgian samples do however show a much greater influence of CB118 compared to the main body of data.

109 It should be noted that at a number of areas where both mussel and fish liver ratio data are available from adjacent sampling sites, the ratios between CBs are rather different, although data allowing the comparison to be made are only available from a few locations. It is not clear whether any observed differences are the result of analytical artefacts, reporting errors and/or are reflective of metabolic or other processes within different species.

110. Examination of the CB118 to CB153 ratio indicated potential errors exist in reporting/analysis of 13 time series, primarily from Germany and Belgium, which are being examined by Contracting Parties.

111. Ratio plots have potential to provide valuable information related to potential source inputs at locations throughout the convention area. Additionally they provide a further measure of quality assurance on submitted data. The use of ratio plots should be restricted however, to time series where concentrations are above the limit of concentration for respective contaminants. As such data from “pristine” locations may not be suitable.

112. Ratio plots should be interpreted in conjunction with information on the magnitudes and chemical characteristics of likely sources of CB inputs and knowledge of the potential metabolic capabilities within the indicator species.

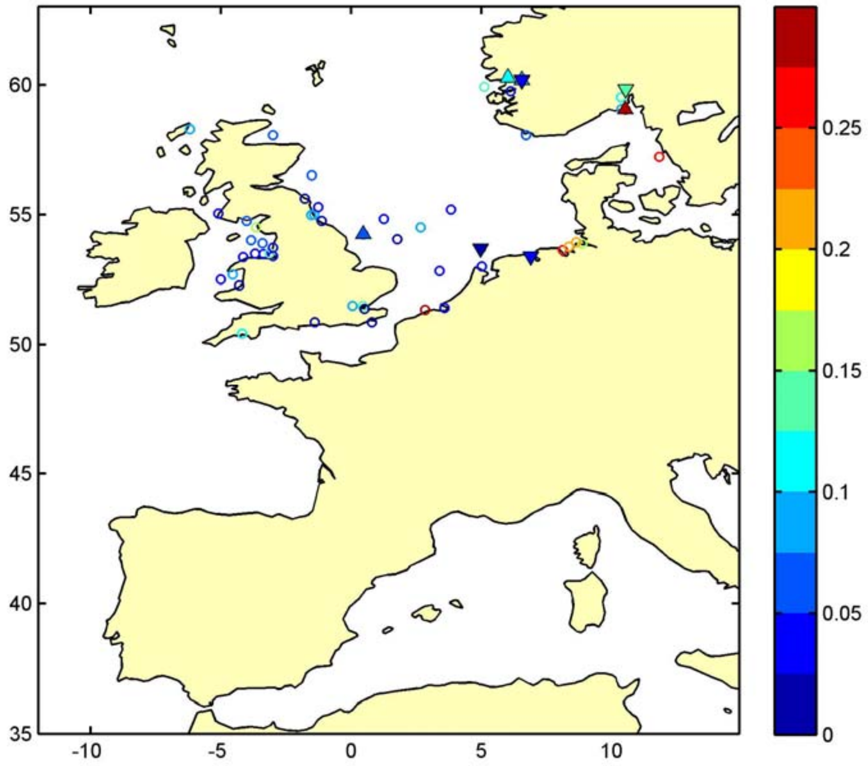


Figure 4.14. Ratio of CB118 to CB153 in fish liver in North Sea. Values are noted by colour and time trends by triangles pointing up/down for upward/downward trends respectively.

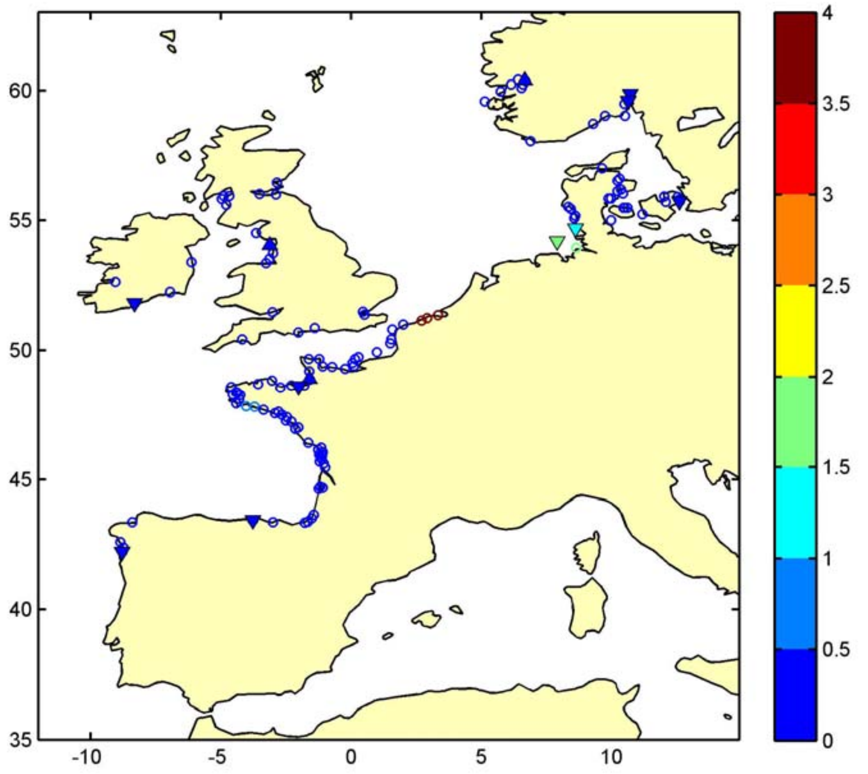
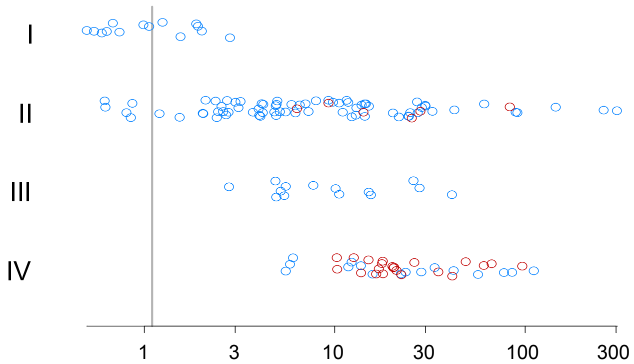


Figure 4.15: CB118 to CB153 in mussels in North Sea. Values are noted by colour and time trends by triangles pointing up/down for upward/downward trends respectively.

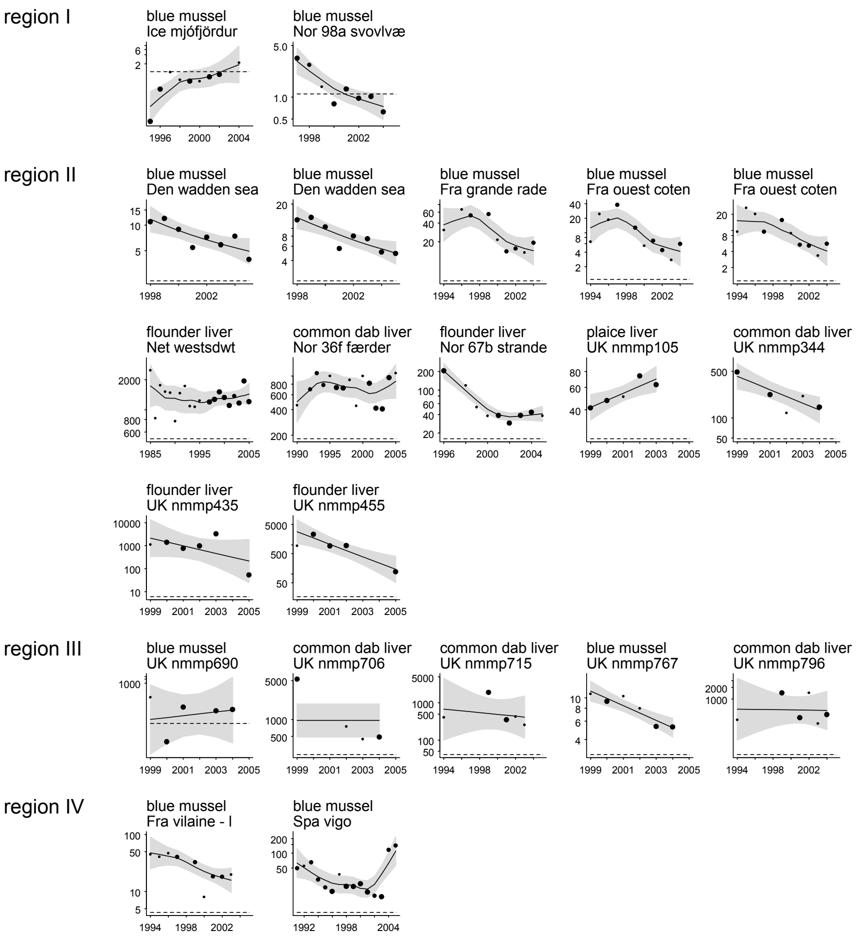
CB153: summary of time series.

	region	number of time series				trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
shellfish	I	0	1	13	14	1	4	0
	II	19	13	51	83	0	13	0
	III	5	8	1	14	0	1	0
	IV	0	3	35	38	2	8	0
		24	**25**	**100**	**149**	**3**	**26**	**0**
fish	I	0	0	8	8	0	0	0
	II	12	10	43	65	3	11	0
	III	9	6	0	15	0	0	0
		21	**16**	**51**	**88**	**3**	**11**	**0**

Mean concentration (ug kg-1 dw) in mussels (blue) and oysters (red) in the final monitoring year. The BC is 0 ug kg-1 dw; the vertical solid line is the BAC of 1.1 ug kg-1 dw, applied to both mussels and oysters. The same BAC was applied to blue mussels in the previous assessment.



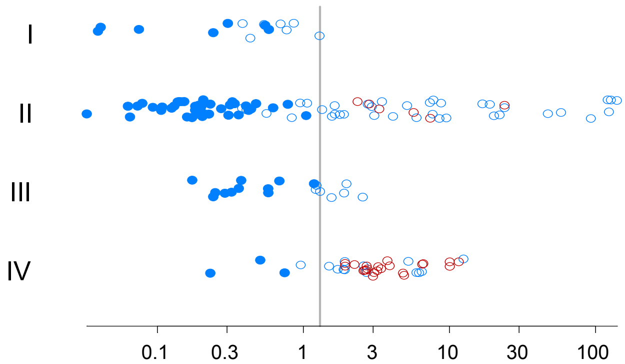
Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



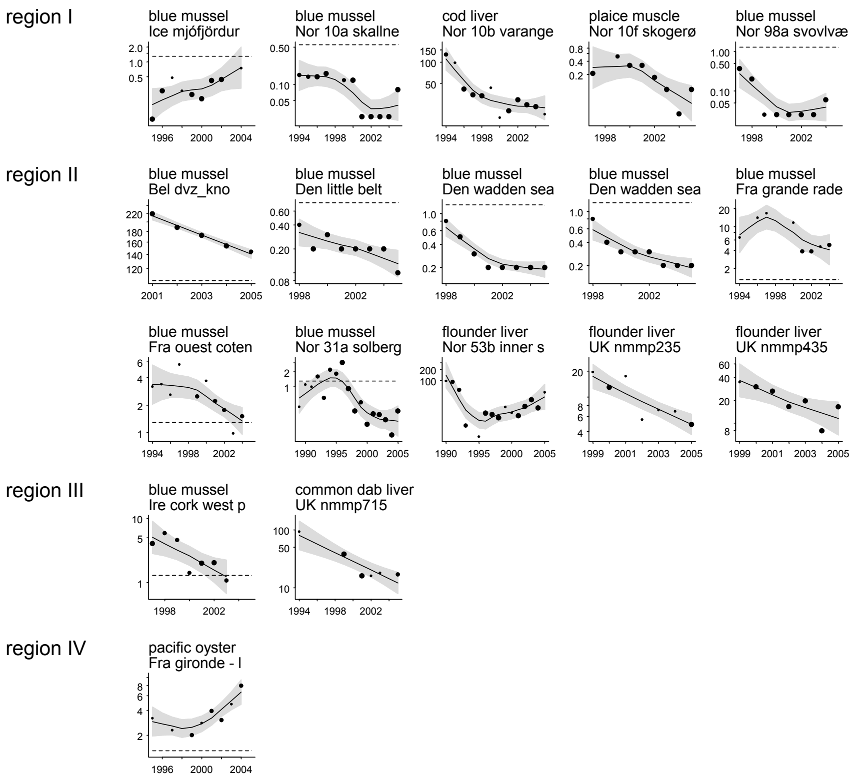
CB118: summary of time series. BACs have not yet been set for fish.

	region	number of time series				trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
shellfish	I	0	1	13	14	1	2	7
	II	16	21	53	90	0	16	43
	III	9	6	3	18	0	1	11
	IV	0	3	35	38	1	2	3
		25	**31**	**104**	**160**	**2**	**21**	**64**
fish	I	0	0	8	8	0	3	
	II	12	7	51	70	1	9	
	III	7	7	4	18	0	1	
		19	**14**	**63**	**96**	**1**	**13**	

Mean concentration (ug kg^{-1} dw) in mussels (blue) and oysters (red) in the final monitoring year. The BC is 0 ug kg^{-1} dw; the vertical solid line is the BAC of 1.3 ug kg^{-1} dw, applied to both mussels and oysters.



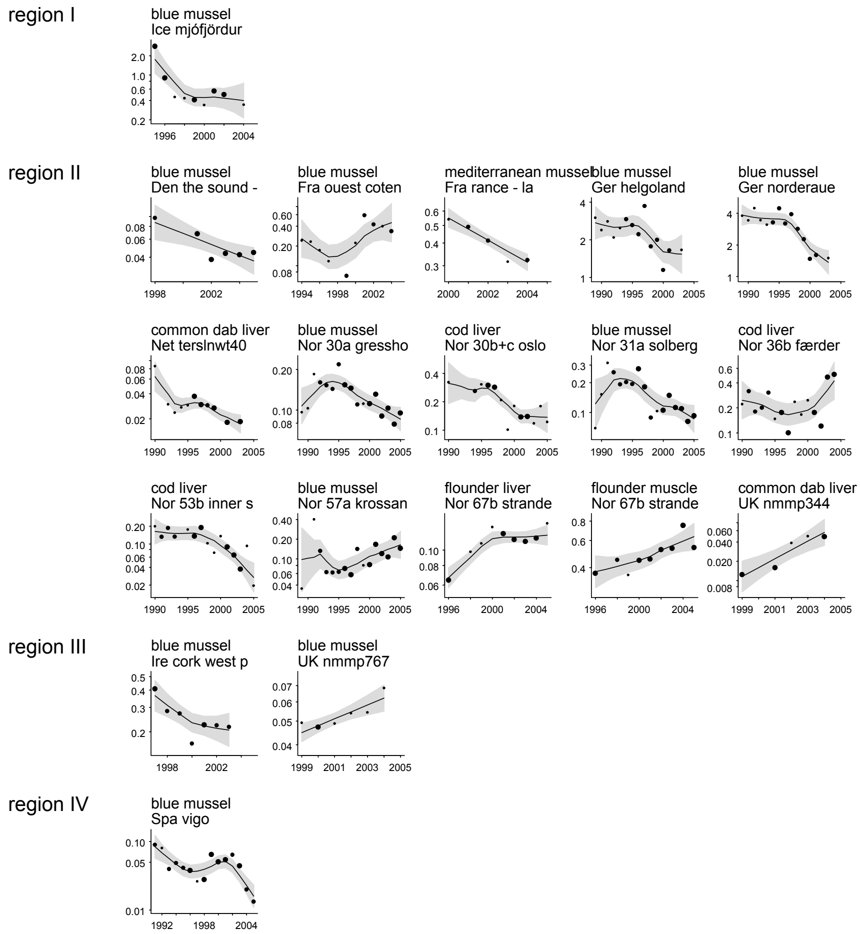
Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



CB118 / CB153: summary of time series. BACs are not meaningful for this ratio.

	region	number of time series				trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
shellfish	I	0	1	13	14	0	1	
	II	20	12	51	83	2	6	
	III	5	8	1	14	1	1	
	IV	0	3	35	38	0	2	
		25	**24**	**100**	**149**	**3**	**10**	
fish	I	0	0	8	8	0	0	
	II	13	10	43	66	5	6	
	III	9	6	0	15	0	0	
		22	**16**	**51**	**89**	**5**	**6**	

Selected time series with significant trends or where the upper confidence limit in the final year exceeds the BAC.



5. Summary and Conclusions

5.1 Summary of the results

113. Temporal trends in the concentrations in biota of a selection of contaminants monitored in the CEMP in OSPAR regions I-IV were investigated as a step to streamlining the assessment process. Cadmium, mercury, lead, copper, zinc, the PAHs fluoranthrene, benzo[a]pyrene, benzo[ghi]perylene, anthracene and phenanthrene, and the CB congeners CB118 and CB153 were assessed in biota. TBT and the pesticides p,p'-DDE (a metabolite of DDT), α-HCH and γ-HCH (lindane) and HCB in biota. These contaminants were chosen either because of their relevance as part of the mandatory CEMP or their toxicity and/or as being representative of a group of contaminants (e.g. PAHs or CBs). Other contaminants can, and should, be considered in future assessments. The distribution of sampling sites (Figures 1 and 2) indicates a need for better coverage.

114. The selection of data for the assessment meant that 2968 time series were assessed including those of the ratios mentioned above. Approximately 16% (498) of these time series showed trends; of which over 72% were downwards. The highest proportion (21%) of trends were detected for lindane, and all were downwards. High concentrations of contaminants were generally found near known point-sources such as industry (e.g. Sørfjord (Norway), Roskilde (Denmark), Ponteverdra (Spain)), harbours (e.g. Oslo) or river outflows (e.g. Seine, Rhine, Elbe, Thames). But many downward trends were also found in such areas. Although downward trends are positive signs and underline the effectiveness of measures taken, the latest measurements in most time series are still well above background concentrations. Notable upwards trends were in the German Bight (lead) and the Sørfjord (mercury and cadmium).

115. An important difference between this assessment and previous assessments has been the trial use of revised/updated Background Concentrations and Background Assessment Concentrations for contaminants in shellfish. The report of previous data assessments carried out by MON in 2004/5 and 2005/6 had noted that there was a need to revise some of the assessment criteria required for the assessments, notably EACs and BC/BACs for contaminants in biota. The review of EACs is being undertaken through SIME, and that of the BCs and BACs by ICES through WGs on Marine Chemistry and Statistical Aspects of Environmental Monitoring. Although WGMC had discussed the problem at length, they had been unable so far to propose revised values. As an interim measure, pending advice from ICES, data on contaminant concentrations in biota from near-pristine monitoring locations were submitted intersessionally by Contracting Parties to MON MIG. The BCs and BACs for shellfish derived by MON from these data were generally higher than those that had been applied in previous assessments. As a consequence, an increased proportion of the final values in time series were assessed as being significantly below the BAC, i.e. as having attained the OSPAR long-term target. Clearly, such a conclusion is of significance for the QSR2010, and for strategy development in OSPAR. It is therefore important that Contracting Parties provide OSPAR with comments on the methods used to develop the new BCs and on the values obtained. Additional data to improve the values would also be very valuable.

116. The continuing lack of revised EACs greatly limits the ability of MON to assess the environmental significance of the concentrations observed.

117. It was very clear during the assessment meeting that the continuing refinement and increasing sophistication of the data handling process by ICES and members of MON is bringing additional benefits to the assessment process. It is now easier to identify anomalies in the monitoring data, and it has been recognised that some time series may be strongly influenced by methodological factors, and by reporting errors. The procedures now in place allow these factors to be identified and for remedial action to be taken. In turn, this will increase the reliability of the assessments, and Groups undertaking future assessments should maintain vigilance to identify such cases and ensure that they do not give rise to misleading assessments.

Table 5.1 Overview of time series considered and results from those selected

	region	number of time series				trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
blue mussel	I	5	20	159	184	10	26	102
	II	298	165	615	1078	48	117	452
	III	86	74	11	171	1	10	64
	IV	0	30	198	228	14	22	95
		389	**289**	**983**	**1661**	**73**	**175**	**713**
other molluscs	II	0	10	118	128	2	4	38
	IV	0	4	348	352	16	40	97
		0	**14**	**466**	**480**	**18**	**44**	**135**
fish	I	0	0	84	84	0	17	2
	II	94	78	486	658	44	125	14
	III	51	37	53	141	5	9	1
		141	**113**	**573**	**827**	**47**	**141**	**31**
GRAND TOTAL		**530**	**416**	**2022**	**2968**	**138**	**360**	**879**

5.2 Future development of annual assessments

118. An important target for assessment work over the next two meeting cycles will be the development and application of procedures leading to data products for the QSR 2010 project. With that in mind, for future annual assessments of CEMP data, it is proposed to develop the following aspects of the work:

a. **Application of spatial distribution tools**. A valuable development for the QSR 2010 would be the capacity to assess whether current monitoring is representative of the spatial variation in concentrations of substances. This would allow CEMP assessments to consider those additional substances of interest for which monitoring have not been sufficiently long term to support temporal trend assessment.

b. **Extending the range of hazardous substances**. Provided the tools are available to enable spatial assessment it is planned to cover in future assessments the following additional substances:

   a. brominated flame retardants

   b. dioxins and

   c. co-planar PCBs.

c. **Application of Environmental Assessment Criteria.** If available, EACs will be considered in future for application in assessments to provide additional information on the potential risk posed by the concentrations contaminants observed in the marine environment.

d. **Assessment of regional trends**. A quantitative approach for assessing regional trends has been presented and trialled as part of the 2006-7 assessment and will be developed further with application in QSR 2010 in mind. .

e. **Further development of a visual tool for assessing spatial trends**: The integration of spatial information with trend characteristics is one of the main technical problems in the process of illustrating and assessing regionally distributed trend information. Ideally, the spatial distribution of contaminant concentrations, the location of sampling stations, the temporal trends and their significance should be combined in one presentation.

f. **Dealing with "Less than" values.** On rare occasions, the current assessment procedures do not handle "less than" values reliably, and these can lead to the detection of spurious trends in data if, for example, detection limits change. Additionally, the current methodology is not appropriate for comparing data sets in which there are large proportions of "less than" values with BACs, particularly if the detection limit is close to background concentrations. Procedures to handle these situations are required.

g. Currently, there are differences between the assessment methods applied to sediment and biota. Harmonisation of these would be desirable, but is currently not essential as the two procedures are both generally reliable.

h. **Identifying anomalies in CEMP data.** Some time series may be strongly influenced by methodological factors and future assessments should maintain vigilance to identify such cases and ensure that they do not give rise to misleading assessments.

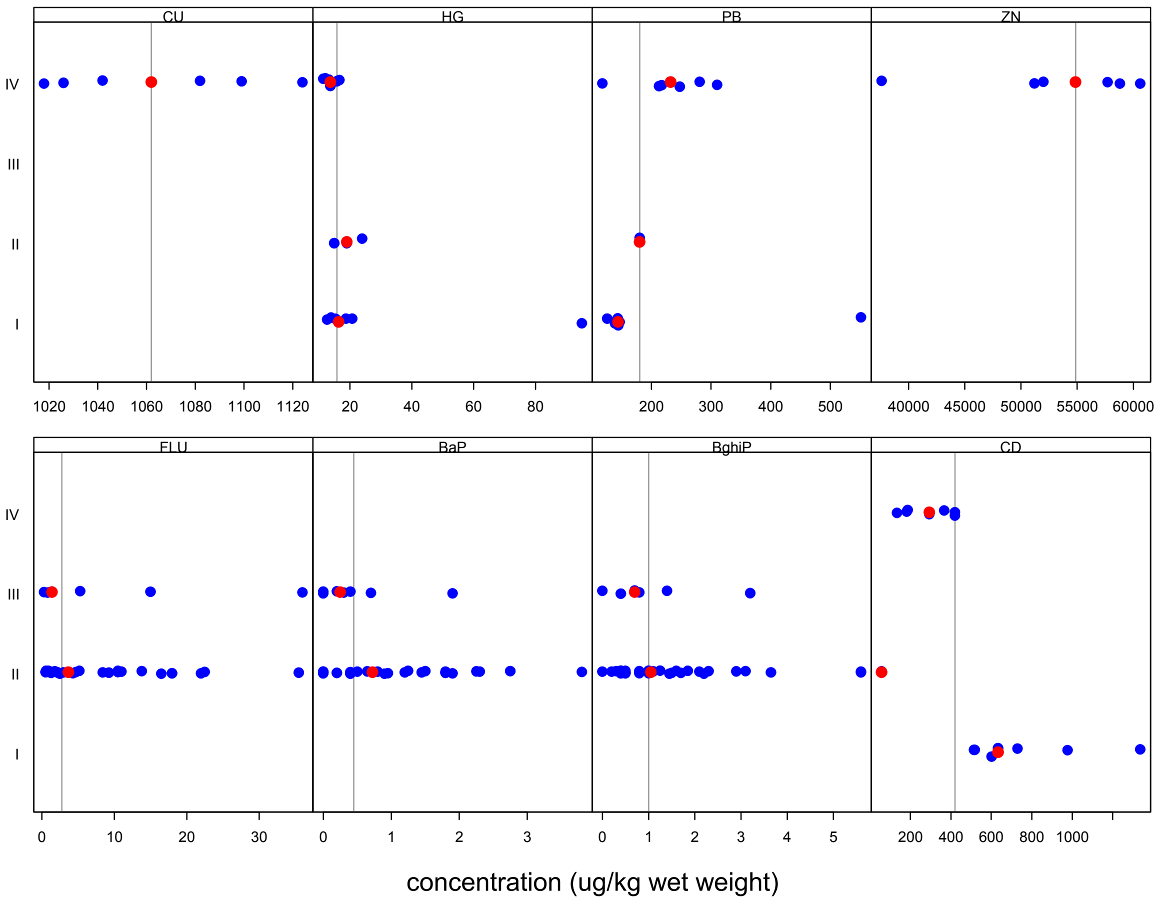
Annex 1

Updated values for Background Concentrations (BCs) and Background Assessment Concentrations (BACs)[11]

The report of previous data assessments carried out by MON in 2004/5 and 2005/6 had noted that there was a need to revise some of the assessment criteria required for the assessments, notably EACs and BC/BACs for contaminants in biota. The review of EACs is being undertaken through SIME, and that of the BCs and BACs by ICES through WGs on Marine Chemistry and Statistical Aspects of Environmental Monitoring. Although WGMC had discussed the problem at length, they had been unable so far to propose revised values. As an interim measure, pending advice from ICES, data on contaminant concentrations in biota from near-pristine monitoring locations were submitted intersessionally by Contracting Parties to MON MIG. The data were used to estimate values for updated BCs in bivalves for those metals and PAHs included in the 2006/7 assessments. There were insufficient data to estimate updated BCs for contaminants in fish.

The figure below shows, for each contaminant,

- the median concentration in mussels (exact species unspecified) at each near-pristine monitoring location in each OSPAR region (blue dots)
- the median of the median concentrations by region (red dot)
- the median of the median concentrations across regions (grey vertical line)



11 The updated BCs (i.e. 2006/7 BCs) presented here have not been formally adopted by OSPAR

The updated BC was estimated to be the median of the median concentrations across regions, except for cadmium, which was based on the data from regions II and IV only (on the basis that region I has higher natural levels of cadmium).

There was no attempt to review the submission of data sets to establish if Contracting Parties had similar criteria for choosing near-pristine locations.

The BCs were assumed to apply to all regions, despite the patchy distribution of near-pristine locations.

The BCs were established using mussel data, but were also applied to Pacific oysters in the 2006/7 assessment. The BAC plots (later) suggest that this decision should be reviewed.

BACs were estimated using the methodology described in Section 6.1 of the 2004 report of the ICES Advisory Committee on the Marine Environment, with the following slight modifications:

	BC □g kg^{-1} wet weight
Fluroranthene	2.8
Benzo[a]pyrene	0.45
Benzo[ghi]perylene	1.0
Cadmium	240
Copper	1060
Mercury	16
Lead	180
Zinc	55000

- time series were excluded when more than 25% of concentration measurements were ‘less-thans’
- blue mussel, Mediterranean mussel and Pacific oyster time series were used to establish a common BAC for bivalves

The following tables give the updated values for BCs and associated BACs for bivalves (usual font), with 95% confidence intervals on the BACs shown in grey. All units are □g kg^{-1} dry weight. The BCs have been converted from a wet weight basis by multiplying them by 5. Historic values are tabulated for comparison.

BACs have also been calculated for man-made substances covered in 2006/2007 CEMP Assessment. For these the BC is 0 and a Low Concentration (LC) is required to establish a BAC; these were taken to be twice the old Quasimeme constant error.

Metals	pre-2006	2006/7			
	BRC	BC		BAC	
Cadmium	550	1200	1850	1940	2020
Copper	5500	5300	7240	7570	7910
Mercury	50	80	133	140	147
Lead	950	900	1430	1520	1610
Zinc	150000	275000	406000	426000	447000
Tributyltin		1.0[12]	1.9	3.0	4.8

12 Low Concentration

PAHs		2004/5[13]		2006/7			
		BC[14]	BAC	BC	BAC		
Naphthalene	nap	1	81.2				
Phenanthrene	pa	4.5	12.6				
Anthracene	ant	1	2.7				
Fluoranthene	flu	7	11.2	14	22.8	26.4	30.6
Pyrene	pyr	5.5	10.1				
Benzo[a]anthracene	baa	1.5	3.6				
Chrysene	chrtr	6.5	21.8				
Benzo[a]pyrene	bap	1	2.1	2.25	5.6	7.1	9.1
Benzo[ghi]perylene	bghip	2.5	7.2	5	10.4	11.2	12.0
Indeno[123-cd]pyrene	icdp	2	5.5				

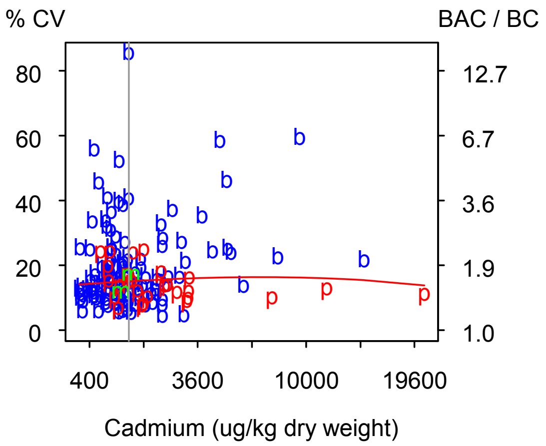
Organochlorines	2004/5[2]		2006/7			
	LC	BAC	LC	BAC		
CB118			0.5	1.2	1.3	1.5
CB153	0.5	1.1	0.5	1.0	1.1	1.2
□$_7$CB	2.0	4.6				
α HCH			0.5	1.8	3.3	5.9
γ HCH			0.5	2.2	2.6	3.0
Hexachlorobenzene			0.5	1.2	1.8	2.5
DDE (p,p´)			0.5	1.0	1.2	1.3

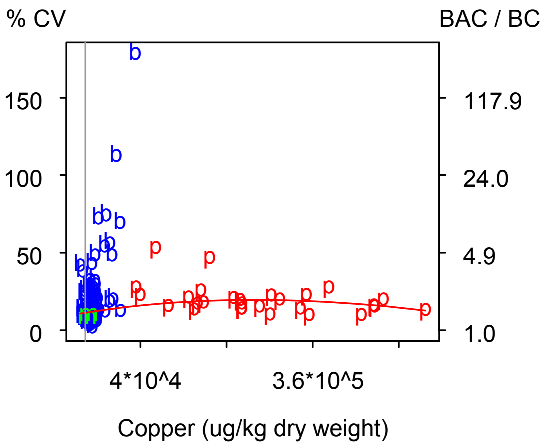
The following graphs show the % coefficient of variation (%CV) in each time series plotted against the estimated mean concentration in the final year, with a smooth curve fitted to the data. Data from blue mussel, Pacific oyster and Mediterranean mussel are plotted with a blue 'b', a red 'p' and a green 'm' respectively. 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.

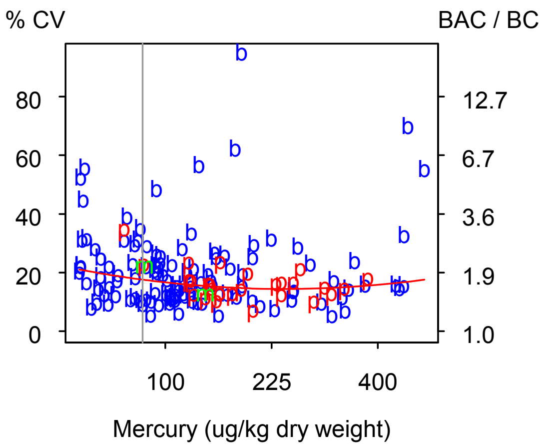
13 See Appendix 6 of the 2005 Assessment of CEMP data

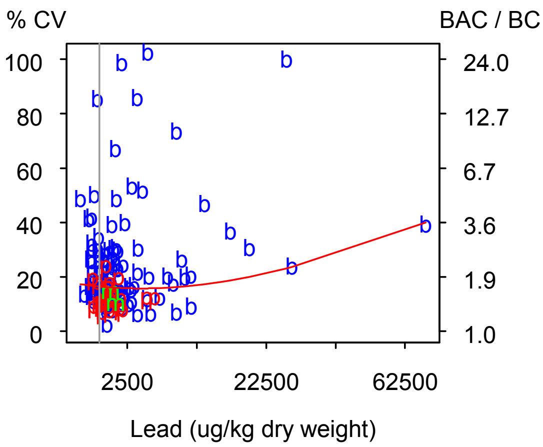
14 based on a more limited selection of near-pristine locations

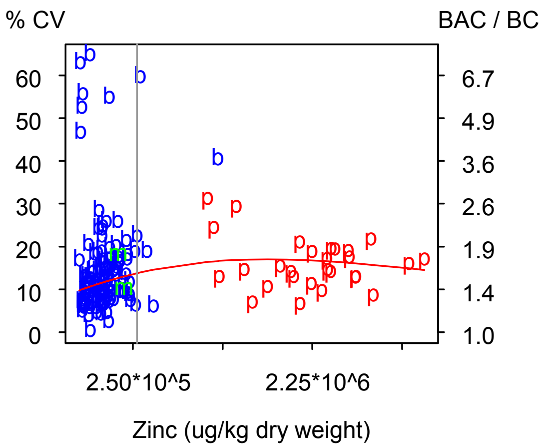
Metals

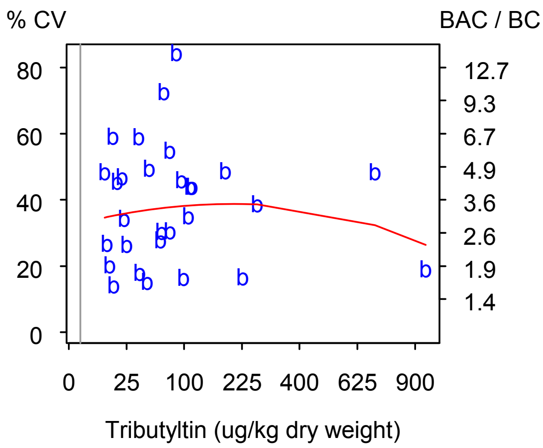

% CV
BAC / BC
0
20
40
60
80
1.0
1.9
3.6
6.7
12.7
400
3600
10000
19600
Cadmium (ug/kg dry weight)


% CV
BAC / BC
0
50
100
150
1.0
4.9
24.0
117.9
4*10^4
3.6*10^5
Copper (ug/kg dry weight)

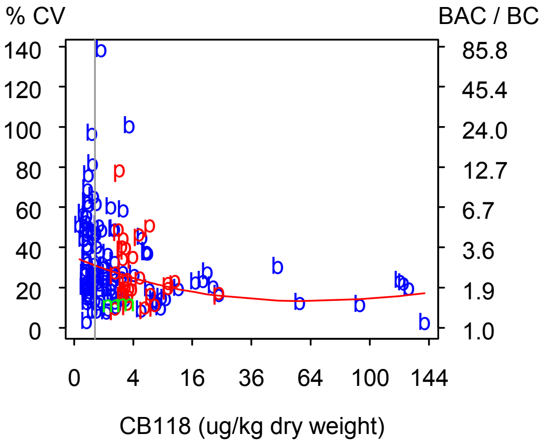

% CV
BAC / BC
0
20
40
60
80
1.0
1.9
3.6
6.7
12.7
100
225
400
Mercury (ug/kg dry weight)

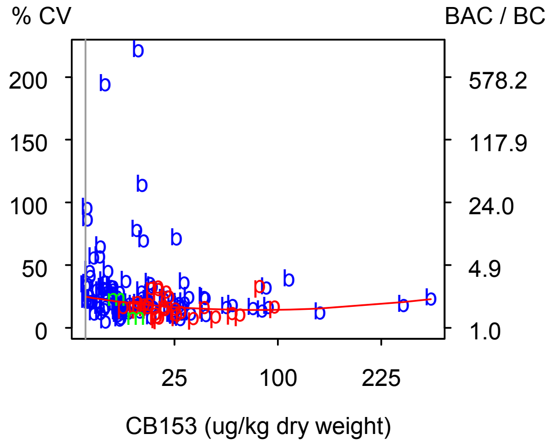

% CV
BAC / BC
0
20
40
60
80
100
1.0
1.9
3.6
6.7
12.7
24.0
2500
22500
62500
Lead (ug/kg dry weight)

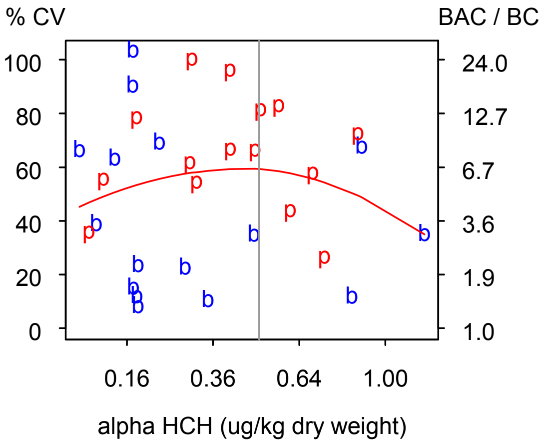

% CV
BAC / BC
0
10
20
30
40
50
60
1.0
1.4
1.9
2.6
3.6
4.9
6.7
2.50*10^5
2.25*10^6
Zinc (ug/kg dry weight)

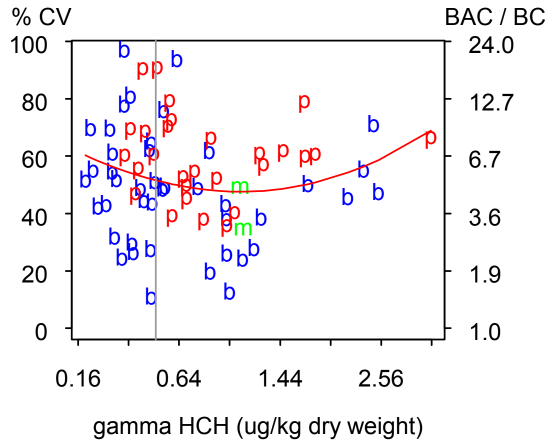

% CV
BAC / BC
0
20
40
60
80
1.4
1.9
2.6
3.6
4.9
6.7
9.3
12.7
0
25
100
225
400
625
900
Tributyltin (ug/kg dry weight)

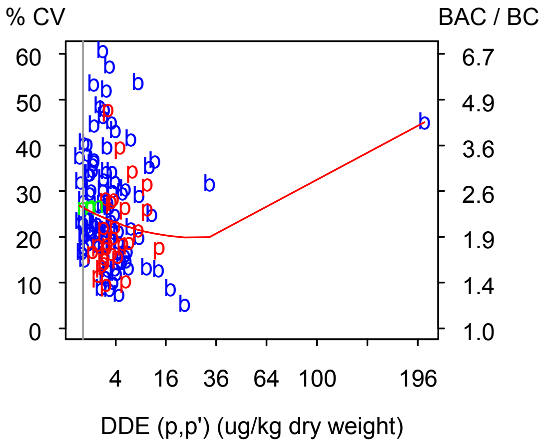
Organochlorines

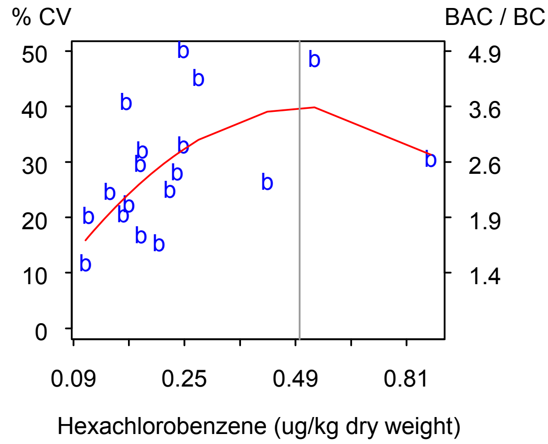


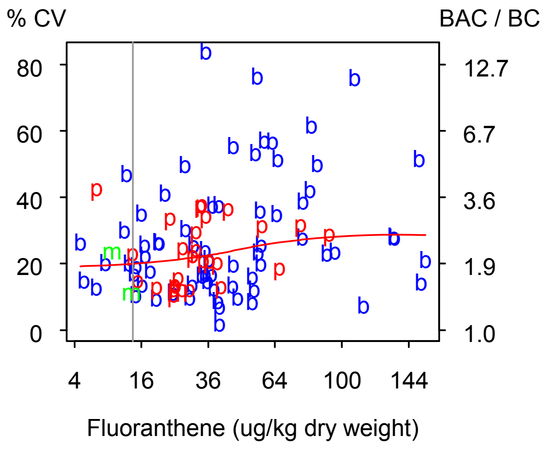


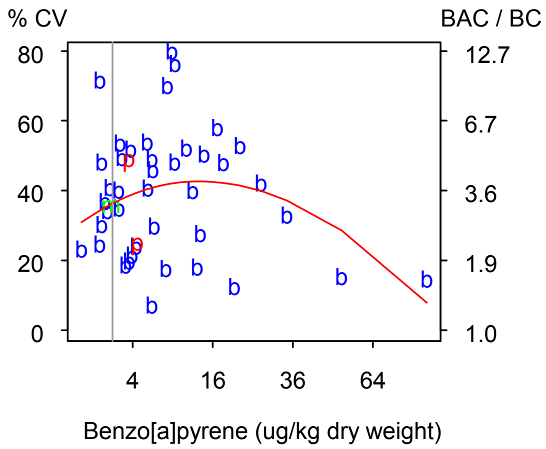


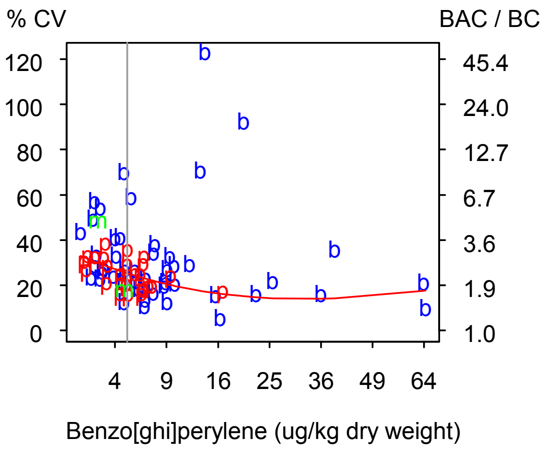







% CV
BAC / BC
80
60
40
20
0
12.7
6.7
3.6
1.9
1.0
4
16
36
64
100
144
Fluoranthene (ug/kg dry weight)


% CV
BAC / BC
80
60
40
20
0
12.7
6.7
3.6
1.9
1.0
4
16
36
64
Benzo[a]pyrene (ug/kg dry weight)


% CV
BAC / BC
120
100
80
60
40
20
0
45.4
24.0
12.7
6.7
3.6
1.9
1.0
4
9
16
25
36
49
64
Benzo[ghi]perylene (ug/kg dry weight)