OSPAR COMMISSION

Background Document on

CEMP Assessment Criteria for QSR 2010

Monitoring and Assessment Series

2009

OSPAR Convention

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.

Convention OSPAR

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.

Acknowledgement

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Executive Summary

Assessments of monitoring data for hazardous substances in the environment require relevant assessment tools. For the OSPAR Co-ordinated Environmental Monitoring Programme (CEMP), there is a need for agreement on assessment criteria for the hazardous substances analysed in marine sediments and biota. These include polycyclic aromatic hydrocarbons (PAHs), chlorobiphenyls (CBs) and the metals mercury, cadmium and lead. Assessment criteria are needed that relate to the key thematic questions set out in the OSPAR Joint Assessment and Monitoring Programme for hazardous substances, *i.e.*:

- What are the concentrations in the marine environment, and the effects, of the substances on the OSPAR List of chemicals for priority action ("priority chemicals")? Are they at, or approaching, background levels for naturally occurring substances and close to zero for man made substances?
- Are there any problems emerging related to the presence of hazardous substances in the marine environment? In particular, are any unintended/unacceptable biological responses, or unintended/unacceptable levels of such responses, being caused by exposure to hazardous substances?

For summarising and presenting assessments in a visual and meaningful way colour-based classification systems can be used based on the agreed assessment criteria. A common understanding of the meaning of any such classification scheme is needed.

This background document has been developed to support the assessment of OSPAR CEMP data underpinning the OSPAR Quality Status Report 2010. It provides the background for the agreement on CEMP Assessment Criteria for the QSR 2010 (Agreement number: 2009-2) adopted by the OSPAR Environmental Assessment and Monitoring Committee in 2009 and provides a background on their application. The results from application of these assessment criteria are provided in the 2008/2009 CEMP assessment report (publication 2009/390).

Récapitulatif

Les évaluations des données découlant de la surveillance exigent des outils d'évaluation pertinents. Il y a lieu de convenir de critères d'évaluation pour les substances dangereuses analysées dans les sédiments et le milieu vivant marins pour le Programme coordonné OSPAR de surveillance continue de l'environnement (CEMP). Il s'agit notamment des hydrocarbures aromatiques polycycliques (HAP), des chlorobiphényles (CB) et des métaux mercure, cadmium et plomb. Il est nécessaire de disposer de critères d'évaluation relatifs aux questions thématiques primordiales déterminées dans le Programme conjoint d'évaluation et de surveillance continue pour les substances dangereuses, à savoir :

- quelles sont les teneurs dans le milieu marin ainsi que les effets des substances inscrites sur la liste OSPAR des produits chimiques devant faire l'objet de mesures prioritaires (« produits chimiques prioritaires ») ? Se situent-elles aux niveaux ambiants dans le cas des substances présentes à l'état naturel ou approchent-elles ces niveaux, ou sont-elles proches de zéro dans le cas des substances de synthèse ?
- y a-t-il des problèmes émergeants dus à la présence de substances dangereuses dans le milieu marin ? En particulier, l'exposition à des substances dangereuses donne-t-elle lieu

à des réactions biologiques imprévues/intolérables, ou à des réactions d'une ampleur imprévue/intolérable ?

On pourrait utiliser des systèmes de classification à partir de couleurs, fondés sur les critères d'évaluation convenus, afin de résumer et de présenter les évaluations de manière visuelle et significative. Il est nécessaire d'avoir une perception commune de la signification de ce système de classification.

Le présent document de fond a été élaboré pour étayer l'évaluation des données CEMP OSPAR sous-jacentes au QSR 2010 OSPAR. Il fournit le contexte de l'accord sur les critères d'évaluation CEMP pour le QSR 2010 (Accord numéro 2009-2), adopté par le Comité OSPAR évaluation et surveillance de l'environnement en 2009, ainsi que pour leur application. Le rapport de l'évaluation CEMP de 2008/2009 (publication 2009/390) comporte les résultats de l'application de ces critères d'évaluation.

1. Considerations around generic definitions for blue, green and red within a 'traffic light' assessment tool

There are several cases in the QSR 2010, and the reports used to compile it, where a traffic light system has been put forward to indicate the status of different aspects of the marine environment. This is sensible from a presentational perspective, as it can give the reader a clear and immediate picture of where environmental conditions are acceptable, *i.e.* where statutory targets and policy objectives are met, and where this is not the case.

The primary objective of this document is to explain the assessment criteria and a data presentation framework used by the OSPAR Working Group on Monitoring (MON) in preparing the 2008/2009 assessment of CEMP data on contaminant concentrations in sediment and which is the basis for the material in Chapter 5 of the QSR 2010 on concentrations of contaminants in the marine environment. The aim was to support a consistent use of colours in the presentation of these assessments across matrices and contaminants.

As Contracting Parties are intending to use the QSR 2010 as part of the Initial Assessment required under the Marine Strategy Framework Directive (MSFD) in 2012 it would seem to be prudent to ensure that the use of "green" has a relationship to "Good Environmental Status" to the extent that it is currently possible to assess this. The basic principle is that the transition from red to green implies a transition from an unacceptable risk to a state which is acceptable and where there is little or no risk.

The interpretation of the proposed blue/green/red scheme in relation to hazardous substances is summarised in Table 1, which explains what this means in the context of contaminants. Table 1 further summarises the type of management activity which may be possible for each colour.

2. Use of Environmental Assessment Criteria (EACs) and Effects Range (ER) values as assessment criteria

The primary assessment threshold used in the assessment of contaminant concentrations in sediment and biota corresponds to the achievement, or failure to achieve, statutory targets or policy objectives for contaminants in these matrices. The outcomes of these assessments should be described by the transition in a traffic light scheme between green and red. Green indicates that the target/objective has been achieved; red that it has not.

In the OSPAR CEMP assessment context, OSPAR Environmental Assessment Criteria (EACs) are intended to provide the green/red transition point. EACs, which represent the contaminant concentration in the environment below which no chronic effects are expected to occur in marine species, including the most sensitive species, continue to be developed for use in data assessments. EACs for a range of contaminants were proposed in 2004 and updated EACs for PAHs and PCBs were proposed in 2008. Concentrations below the EACs are considered to present no significant risk to the environment, and to that extent may be considered as being related to the EQSs applied to concentrations of contaminants in water, for example under the Water Framework Directive (WFD). Concentrations below the EAC are unlikely to give rise to unacceptable biological effects. EACs have been developed for a range of matrices and contaminants through a combination of work by OSPAR and ICES groups. In some cases, these have been recommended or accepted for use in data assessments. ICES recommends that the EACs for all ICES7 CBs in sediment and PAHs in shellfish may be used for OSPAR assessments. EACs are therefore used as the green/red transitions for CBs in sediment and PAHs in shellfish[1] (Figure 1A; Table 6).

As implied above, some EACs have not been used in OSPAR assessments, mainly because the proposed EACs are less than the OSPAR Background Assessment Concentrations (BACs). For example, EACs for three of the parent PAHs (benz[*a*]anthracene, benzo[*ghi*]perylene and indeno[1,2,3-*cd*]pyrene) in sediment are below the BACs. For trace metals, EACs for Cd and Pb in sediment, Hg in mussels and Hg and Cd in fish are also below the corresponding BACs. It is also noted that for trace metals in sediment, Background Concentrations (BCs) and BACs are normalised to 5% aluminium whilst proposed EACs are normalised to 1% organic carbon. It has been concluded that EACs for PAHs or trace metals in sediment and for metals or CBs in biota cannot be used to describe the green/red (T_1) transition. Therefore, in cases where the EACs have not been recommended, alternative approaches to appropriate criteria for the assessment of data on contaminant concentrations in sediment and biota need to be considered.

In order to maintain consistency, wherever possible, when filling these gaps in the suite of assessment criteria, it is helpful to employ as few alternatives as possible to the EACs. The use of alternatives needs to be consistent across groups of contaminants so that the output from the assessment process is readily understandable and features in the assessment can be interpreted.

2.1 Assessment at the green/red transition in sediments

EACs are available and recommended for use for CBs in sediment. However, this is not the case for PAHs or for metals in sediment, and an alternative approach is required. The US Environmental

[1] The ICES advice refers specifically to mussels and does not comment on oysters. However the pragmatic approach is to use the figures for both mussels and oysters.

Protection Agency (EPA) have developed Effects Range (ER) values to be used to assess the quality of coastal and estuarine environments and the ecological significance of the concentrations of hazardous substances found in sediment (USEPA, 2002; Long *et al,* 1998). ER values were established as sediment quality guidelines to be used to predict adverse biological effects on organisms. In summary, the derivation of ER values involved the collation of a large amount of information on the concentrations of contaminants in sediments in which biological effects (for example on the benthic infauna) were found to be occurring. Two main assessment criteria are then calculated from this data collation. The ER-Low (ERL) value is defined as the lower tenth percentile of the data set of concentrations in sediments which were associated with biological effects, and the ER-Median (ERM) as the median of the concentrations associated with biological effects. Adverse effects on organisms are rarely observed when concentrations fall below the ERL value, and the ERL therefore has some parallels with the philosophy underlying the OSPAR EACs and WFD EQSs. The ways in which the criteria are derived are very different, and so precise equivalence should not be expected.

ERL values are available for individual PAHs and trace metals (including the 3 CEMP metals Hg, Cd and Pb) (Table 2)[2]. ERL values are also available for “total PAHs”, but it is not clear to the authors to what this total refers. Therefore, an ERL was calculated for total PAHs by summing the relevant individual ERLs, where available. The totals are shown in Table 2, based on the sum for selected parent PAHs (including the CEMP 9) and may be amended to include alkylated PAHs by adding the individual ERL values for the alkylated PAHs. The ERL values are higher than the BACs for the parent PAHs (Table 2), though the difference is small for the 6-ring PAHs. Compared to the proposed, but not used, EACs the ERL values for some PAHs are lower, and others are higher. The ERLs for Hg, Cd and Pb are greater than the BACs (Table 2).

Although BCs and BACs are normalised to 5% aluminium for trace metals and 2.5% organic carbon for organic contaminants, no normalisation is made for sediment type when deriving ER values. For the purpose of CEMP data assessment, ERLs have been used in most cases (see section 5 below) as the green/red transition for PAHs and trace metals in sediment (Figure 1A; Table 6), and normalised concentrations have been compared to the ERLs.

2.2 Assessment at the green/red transition in biota

2.2.1 CBs in fish and shellfish

There are no recommended EACs for CBs in biota, and therefore an alternative approach to assessment criteria is required. Recent work on the bioavailability of hydrophobic contaminants in sediment using silicone rubber passive samplers has generally shown that the complete burden of CBs in sediments has the potential to be mobilised into the sediment pore water, *i.e.* to be potentially bioavailable (Smedes, 2007). Therefore, partitioning theory can be reliably applied to calculate the concentrations of CBs in lipid in biota that would be in equilibrium with the CBs in the sediment.

The biota sediment accumulation factor (BSAF) can be expressed as the ratio between the contaminant concentration in sediment (expressed on the basis of organic carbon) and the concentration in biological material (expressed on a lipid basis). In cases where the total concentration of a contaminant in sediment is potentially bioavailable, the value of BSAF is close to unity.

The EACs for CBs in sediment are expressed for sediment of 2.5% organic carbon. It is possible therefore to calculate lipid-normalised concentrations of CBs in fish liver and mussel tissue in

[2] ER values are also available for total CBs (Aroclor equivalents) but not for individual CBs. Aroclor equivalents are approximately equivalent to 2 x ΣICES7 CB concentrations.

equilibrium with sediment containing CB concentrations equal to the EACs in sediment (Tables 3, 4). These calculated values (termed $EAC^{passive}$) have been used as the green/red boundary for CBs in biota (Figure 1A and Table 6).

2.2.2 Metals in fish and shellfish

There are no recommended EACs for metals in biota and equivalents to ER values are not available for fish and shellfish. Therefore an alternative approach to assessment criteria was required, which needed to be coherent across the range of species addressed in the CEMP programme. Two possible approaches were considered.

The first approach considered was the use of an added risk approach. This requires the use of the sum of the BCs and the EACs that have been proposed to derive a maximum permissible concentration (MPC). The advantages of this approach include that the derived MPC involves the use of the OSPAR BCs and EACs, and that the process is described in Moffat *et al*. (2004) and has been discussed in WFD contexts. The disadvantages include that the EACs were not recommended for use in this way, and that the EACs are in some case only a small proportion of the BC/BACs so that the derived MPCs would not differ greatly from the BACs. The absence of proposed EACs for oysters prevents the derivation of MPCs for this species.

The second approach considered was an assessment of the contaminant concentrations in fish and shellfish with respect to their human health risk. The Commission Regulation (EC) No 1881/2006 (and subsequent additions and amendments) sets maximum concentrations for contaminants in foodstuffs to protect public health, *i.e.* to ensure that contaminant concentrations are toxicologically acceptable. This regulation includes maximum levels for Pb, Hg and Cd in bivalve molluscs and fish muscle (Tables 3 and 4) on a wet weight basis. Advantages of this approach are that the dietary standards are firmly established within EC statute, and that they can be used to fill the gaps for metals in both fish and shellfish species. Disadvantages include that standards are not directly available for all the matrix/contaminant combinations required for the assessment. Standards for shellfish exist, and for application in assessments of concentrations in mussels and oysters, the standards were converted to a dry weight basis by multiplying by 5 (Table 3). Standards exist for mercury in fish muscle, but, the EC Regulation does not address Cd and Pb in fish liver (as are required in the CEMP). It is recognised that Cd and Pb concentrations in fish liver are naturally greater than in fish muscle (and this is reflected in dietary limits for bird and mammal muscle and liver tissue), and therefore that fish muscle standards cannot be used. The statutory dietary limits for Cd and Pb in bivalve mollusc tissue have therefore been used as a boundary for the assessment of Cd and Pb concentrations in fish liver.

Clearly, neither of these approaches are fully satisfactory. It was considered that the advantages of having assessment criteria that covered all three metals in both fish and shellfish greatly outweighed the consequences of not having any criteria for the green/red transition for metals in biota. Without criteria, all assessments would default to red, and this would result in very significant loss of information.

As an interim position, until a more appropriate approach to assessment criteria for metals in biota becomes available, the EC dietary limits, as described above, have been used for the purposes of the QSR 2010 assessment as a coherent suite of assessment criteria for trace metals in biota at an amber (replacing the green)/red transition (Figure 1B; Table 6). The use of amber rather than green takes account of concerns over the relevance of the EC dietary limits as criteria for environmental effects. Thus the colour scheme used to classify against these criteria should be red/amber/blue to reflect the larger risks and uncertainties. Exceeding the food standard, results in red. Concentrations below the BAC result in blue. Concentrations in between, result in amber, to indicate the uncertainty in the classification due to lack of information, as shown in Figure 1B. OSPAR looks to continue efforts in future years to derive a reliable series of EACs that address the ecological risk of metals in fish and shellfish.

3. Background Concentrations (BCs) and Background Assessment Concentrations (BACs) within OSPAR and their use as a transition point

In addition to assessment criteria corresponding to statutory limits, or to policy objectives aimed at avoiding unacceptable biological effects arising from contaminants in the environment, the OSPAR Hazardous Substances Strategy has "the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances". It is therefore appropriate, where possible, that assessment of contaminants data in an OSPAR context should take account of this additional policy aim.

In order to assess progress towards near background or zero concentrations, OSPAR has developed Background Concentrations (BCs), the definition for which is "the concentration of a contaminant at a 'pristine' or 'remote' site based on contemporary or historical data" (OSPAR Agreement 2005-6). For naturally occurring substances, such as polycyclic aromatic hydrocarbons (PAHs) and trace metals, BCs are the typical concentrations found in uncontaminated locations in the OSPAR maritime area (North-East Atlantic). For man-made synthetic substances such as chlorobiphenyls (CBs), OSPAR has adopted a BC of zero. In order to facilitate precautionary assessments of data collected under the OSPAR CEMP against BCs, OSPAR has developed Background Assessment Concentrations (BACs). Observed concentrations are said to be 'near background' if the mean concentration is statistically significantly below the corresponding BAC (see Tables).

BCs and BACs, developed using criteria as outlined above, have been recommended for use throughout the OSPAR maritime area. It is recognised that natural processes such as geological variability or upwelling of oceanic waters near the coast may lead to significant variations in background concentrations of contaminants, for example trace metals. The natural variability of background concentrations should be taken into account in the interpretation of CEMP data, and local conditions should be taken into account when assessing the significance of any exceedance. This needs to be explained where it is a relevant factor in data interpretation.

3.1 Sediment

BCs and BACs have been previously adopted (OSPAR Agreement 2005-6) for 10 parent PAHs (9 CEMP PAHs[3] plus naphthalene) in sediment (Table 2). BCs for parent PAHs were derived through determining pre-industrial concentrations of PAHs in deep sediment cores. In 2008, the ICES Working Group on Marine Sediments proposed BCs for alkylated PAHs and DBT, again using deep core data from France, Norway and Scotland (ICES, 2008a) (Table 2). BCs and BACs for PAHs are expressed in µg/kg dry weight normalised to 2.5% organic carbon (Table 2). The BC for total PAHs is the sum of the individual BCs. However, the corresponding BAC is not the sum of the individual BACs and is yet to be calculated.

As noted above, the BCs for CBs are zero. However, to calculate the BAC, a positive low concentration (LC) needs to be chosen that is both measurable and 'close to zero'. For individual CBs,

[3] The 9 CEMP parent PAHs are anthracene, benz[*a*]anthracene, benzo[*ghi*]perylene, benzo[*a*]pyrene, chrysene, fluoranthene, indeno[1,2,3-*cd*]pyrene, pyrene, phenanthrene.

2 x QUASIMEME constant error is used as a low concentration (LC) and for the ΣICES7, the value used is 8 x QUASIMEME constant error (Table 2). BACs have been calculated for the ICES7 CBs in sediment (Table 2). Concentrations are expressed in µg/kg dry weight normalised to 2.5% organic carbon.

BCs and BACs have been previously adopted for cadmium, lead and mercury in sediments. The values (Table 2), derived from deep sediment cores, are normalised to 5% aluminium.

3.2 Biota

3.2.1 PAH compounds in shellfish

In 2008, the ICES Marine Chemistry Working Group (MCWG) proposed low concentrations (LCs) for PAHs in shellfish (mussels and oysters) (ICES, 2008b). The MCWG suggested that natural background concentrations would be lower than the proposed LCs. The MCWG used the limited available dataset from areas identified as pristine (mussel data from Spain and Scotland, and mussels and oysters from France) to estimate LCs as the 10th percentile of the data (Table 3). LCs were initially derived as µg/kg wet weight, but were converted to a dry weight basis by multiplying by 5 since OSPAR MON undertakes the assessment of mussel data on a dry weight basis. LCs could not be proposed for naphthalene, anthracene, dibenzothiophene and alkylated naphthalenes due to the limited dataset and because the concentrations of some PAHs were commonly below limits of quantification.

3.2.2 Metals in shellfish

The MCWG 2008 also reviewed information on the concentrations of metals in mussels from pristine areas in Spain, Greenland, Shetland/Faroe, Norway and Ireland. Median values for each of the regions were calculated. LCs proposed by MCWG (median of regional medians) are shown in Table 3 and were similar to those proposed by MON in 2006. With respect to oysters, conversion factors proposed by France at the 2008 meeting of the Environmental Assessment and Monitoring Committee (ASMO) have been used to calculate LCs for oysters (Table 3). It is recognised that natural processes, such as run-off from mineralised areas, or upwelling of deep oceanic water, may lead to enhanced natural concentrations of some metals in coastal shellfish. It is appropriate that the consideration of the significance of these processes, as well as of other processes such as anthropogenic inputs of metals, should be part of the interpretation of temporal trends and geographical patterns in monitoring data.

3.2.3 Metals in fish

The MCWG could not recommend BCs or LCs for trace metals in fish, due to the limited dataset. MCWG 2008 suggested that for fish, OSPAR MON should use a statistical approach to derive proxy BACs as illustrated in the MON 2007 Summary Record.

3.2.4 CBs in fish and shellfish

The BC for CBs in fish liver and shellfish is zero. For individual CBs, 2 x QUASIMEME constant error is used as a LC and for the ΣICES7 CBs, 8 x QUASIMEME constant error (Tables 3 and 4) is used. This follows the protocol used for CBs in sediment.

As discussed above, it is appropriate that the assessment of contaminants data for the QSR 2010 should include comparisons against BCs/BACs. This is as a second stage of assessment, to be carried out after the comparisons related to the green/red transition (see section 2 above). Concentrations which have been assessed as below the green/red transition boundary (amber/red transition boundary for metals in biota) are compared against the relevant BAC. Concentrations determined to be significantly below the BAC (as determined by the assessment methods adopted by OSPAR MON for the assessment of CEMP data (see CEMP Assessment Manual (OSPAR Publication 379/2008) are assigned the colour blue. The authors consider that this approach takes account of the desire for a generic description of the three primary traffic light colours and of the view that OSPAR's assessment work should lead to results which are, if at all possible, consistent with assessments under the WFD and the MSFD. The BAC may be considered conceptually as a transition point between what might be termed 'high' status and 'good' status (Figure 1), although this degree of discrimination is not required in chemical status assessments for WFD purposes. BAC are therefore used in the CEMP Assessment, but provide a second transition point (T_0) between blue and green (or amber for metals in biota) (Figure 1) and allow specific reporting in the context of the OSPAR Hazardous Substances Strategy.

4. Sediment normalisation

During the development of these approaches, it became clear that both Spain and Portugal have reservations concerning aspects of the application of normalisation procedures to contaminant concentrations in sediment. The procedure that has been used to date in CEMP data assessments by MON is based upon the frequent observation that, within a localised survey area, contaminant concentrations are generally higher in muddy sediments than in sand. Furthermore, the contaminant concentrations are often linearly related to expressions of the bulk properties of the sediment, such as the particle size distribution or organic carbon content. The geochemical normalisation used by MON is based upon these linear relationships, and seeks to use the normalisation process to express contaminant concentrations in sediments of different bulk properties in terms of the equivalent concentrations in a "typical" muddy sediment, considered to contain 5% aluminium (mainly from clay minerals) and 2.5% organic carbon.

The composition selected for this "typical" sediment has been found to be generally appropriate for sediments in and around the North Sea and Celtic Seas. However, it is less applicable to muddy sediments in the Iberian area. Information from Spain and Portugal indicates that typical aluminium concentrations in muddy sediments are around 2%, and that organic carbon concentrations are generally less than 2.5%.

To take into account the specific typical bulk composition of muddy sediments in the Iberian area, sediment data from Portugal was normalised to 2% aluminium and 2.5% organic carbon prior to comparison with ERLs at the green/red transition and BACs at the blue/green transition. BACs for metals was adjusted to reflect normalisation to 2% aluminium. Concentrations of organic contaminants were normalised to 2.5% organic carbon for comparisons at both the green/red and blue/green transitions.

Concentrations of contaminants in sediment from Spain were not be normalised, and were compared directly to ERL values (including the ERL for ΣICES7 CBs in Table 2), and with non-normalised BACs to be derived from appropriate low concentrations, to be developed prior to MON 2008. Appropriate explanatory text would be included in the proposal for the values of low concentrations. The reasons for different treatment of data from Spain and Portugal are set out in the CEMP assessment report (OSPAR Commission 2009/390).

5. Summary of approach used in the QSR CEMP assessment

A three colour traffic light system has been used for assessing hazardous substances data for marine sediments and biota for the purposes of the QSR 2010. The initial assessment of data was made in relation to a green/red or amber/red transition. A green assessment for a particular contaminant means that the environmental concentrations meet relevant statutory limits or policy objectives, and are satisfactory in that they present little or no risk. A red assessment means that the relevant limit or objective had not been met. The statistical aspects of the comparisons are on a precautionary basis.

To report against the ultimate aim of the OSPAR Hazardous Substances Strategy that concentrations should be at, or close to, background concentrations, a second comparison has been made for a blue/green or blue/amber transition, against the relevant BAC. Concentrations that are significantly below the BAC, *i.e.* the OSPAR ultimate aim has been achieved, have been coloured blue. Concentrations that did not meet this precautionary statistical test remain green or amber.

5.1 Green/Red and Amber/Red Transitions (T_1)

5.1.1 Sediment:

Concentrations of contaminants in sediment were normalised to 2.5% organic carbon for organic contaminants and 5% aluminium for metals (with the exception of the situations discussed in section 4 above) before comparing to assessment criteria. The assessment criteria for the green to red transitions were the ERLs for PAHs and trace metals in sediment, and the EACs for CBs in sediment. Mean concentrations needed to be significantly below the ERL (PAHs and trace metals) or EAC (CBs) to be classed as green (Figure 1; Tables 5 and 6).

5.1.2 Biota:

The assessment criteria for PAHs in mussels at the green/red transition were the EACs. This followed the recommendation by ICES.

The assessment criteria used for CBs in shellfish (mussels and oysters) and in fish were derived from the sediment EACs on the basis that the biota sediment accumulation factor (BSAF) is close to unity for CBs (Table 5). This has been termed the ‘$EAC^{passive}$’. Mean concentrations needed to be significantly below the EAC (PAHs) or $EAC^{passive}$ (CBs) to be classed as green (Figure 1; Tables 5 and 6).

As an interim position, until a more appropriate approach to assessment criteria for metals in biota becomes available, the EC maximum acceptable dietary levels (Commission Regulation (EC) No 1881/2006) were used, as described in Section 2 above, as a coherent suite of assessment criteria for trace metals in biota at an amber/red transition (Figure 1B; Tables 5 and 6) for the purposes of the QSR 2010 assessment.

5.2 Blue/Green Transition (T_0)

The purpose of the blue/green transition is to represent assessment against the ultimate aim of the OSPAR Hazardous Substances Strategy that concentrations should be at, or close to, background concentrations. A comparison with BCs was therefore appropriate using the BACs that have been developed by MON, and calculating new BACs where they are required (for example, for metals in oysters). Some additional calculations were required, including the conversion of BACs for CBs in fish to a lipid weight basis using the appropriate conversion factor for the fish species. Furthermore, BACs for CBs and selected PAHs in shellfish were required, and the BACs for some PAHs in shellfish needed to be recalculated.

5.3 Dealing with a lack of assessment criteria

Where there are no potential green/red assessment criteria available, *e.g*. no EACs are available for chrysene or indeno[1,2,3-*cd*]pyrene, determinands were assessed for ancillary information (*e.g.* for trends, and for reference to such relevant assessment criteria that do exist).

6. References

Commission Regulation (EC) No. 1881/2007 setting maximum levels for certain contaminants in foodstuffs.

Environmental Protection Agency (US), Mid-Atlantic Integrated Assessment (MAIA) estuaries 1997-1998. Summary Report, 2002, EPA/620/R-62. 115.

E. R. Long, L. J. Field and D. D. MacDonald, *Environ. Toxicol. Chem.*, 1998, **17,** 714 - 727.

ICES, 2008a. Report of the Working Group of Marine Sediments (WGMS) ICES CM 2008/MHC:03.

ICES, 2008b. Report on the Marine Chemistry Working Group (MCWG 2008).

Moffat, C.F., Pijnenburg, J. and Trass, T. (eds), 2004. OSPAR/ICES Workshop on the evaluation and update of Background Reference Concentrations (B/RCs) and Ecotoxicological Assessment Criteria (EACs) and how these assessment tools should be used in assessing contaminants in water, sediment, and biota. Report of the joint OSPAR/ICES Workshop, The Hague, Netherlands 9 – 13 February 2004.

OSPAR Commission (2007) Report of the Meeting of the Working Group on Monitoring (MON) (4-7 December 2007).

OSPAR Commission (2008) CEMP Assessment Manual: Coordinated Environmental Monitoring Programme Assessment Manual for Contaminants in Sediment and Biota. Publication 379/2008.

OSPAR Commission (2009) Assessment of data collected under the Coordinated Environmental Monitoring Programme. Publication 2009/390 – in press.

F. Smedes, 2007. Methods using passive sampling techniques in sediment for the estimation of porewater concentrations and available concentrations for hydrophobic contaminants, ICES Annual Science Conference, Helsinki, Finland, September 17-21, 2007, ICES CM 2007/ J: 07.

1. **Figure 1** Illustration of the proposed traffic light system and the relevant transition point criteria for: A. PAHs and CBs in sediment and biota and metals in sediments, and B. metals in biota. The green/red boundary corresponds to the achievement of a statutory target (c.f. EQS in WFD terms) or a policy objective (*e.g.* EAC in OSPAR terms).

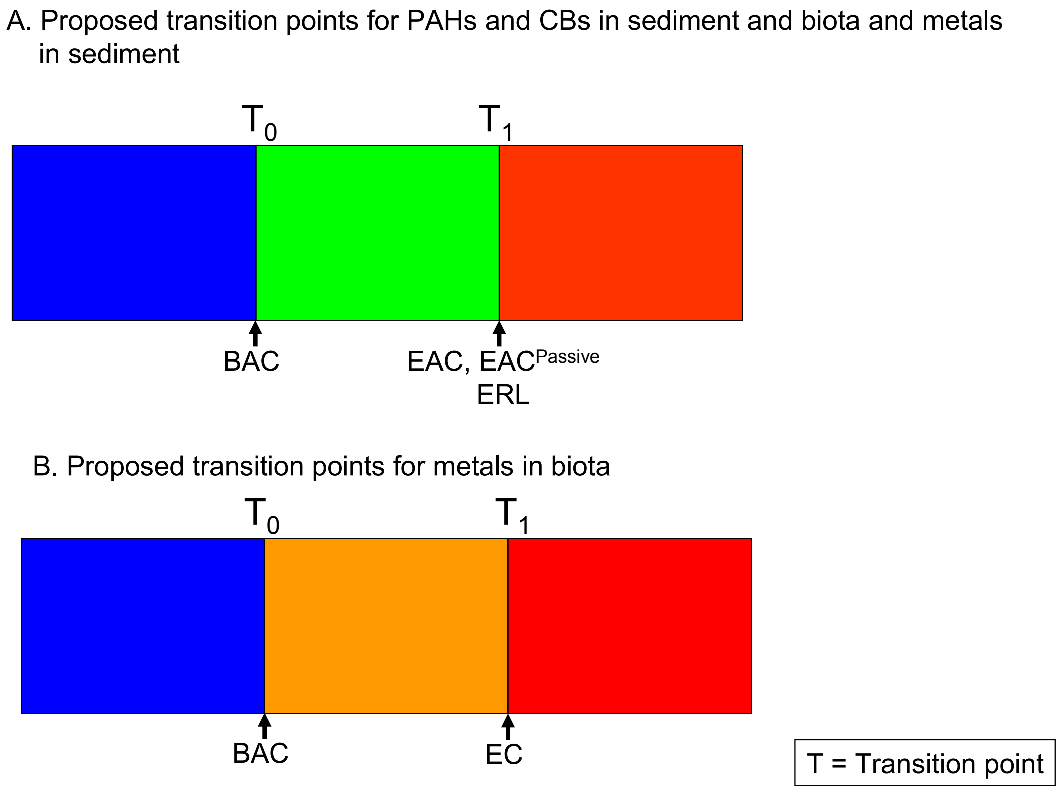

Table 1: Descriptors for a red, green, blue 'traffic light' system.

Traffic light colour	**Understanding of what the traffic light colours mean**		**Possible types of management activity**
RED	Status is unacceptable. Concentrations of contaminants are at levels where a risk to the environment and its living resources at the population or community level should be assumed. Potential for significant adverse effects to the environment, or to human health.		Measures in place or under consideration to address the cause. Regular monitoring to determine status and trends.
GREEN	Status is acceptable. Concentrations of contaminants are at levels where it can be assumed that little or no risks are posed to the environment and its living resource at the population or community level. No significant risk of adverse effects to the environment, or to human health.		Measures generally are not necessary to improve status, but may be required if there is a trend towards a deterioration in status. Appropriate monitoring regime to ensure that there is no deterioration.
BLUE	Status is acceptable. Concentrations are close to background or zero, i.e. the ultimate aim of the OSPAR Strategy for Hazardous Substances has been achieved.		Measures not required. Appropriate monitoring regime to ensure that there is no deterioration.
AMBER	Concentrations are lower than EC dietary limits for fish and shellfish and above background but the extent of risks of pollution effects is uncertain		

Table 2: Assessment Criteria for PAHs, CBs and trace metals in *sediment*. BCs and BACs are normalised to 2.5% organic carbon for PAHs and CBs, and to 5% aluminium for trace metals. Grey shaded cells show where there are no data. Purple shaded cells show where the EACs are below the BACs.

PAHs (µg/kg dry weight)				
Compound	**BC normalised to 2.5% TOC**	**BAC normalised to 2.5% TOC (T_0)**	**EAC normalised to 2.5% TOC**	**Effects Range-Low (ERL) (T_1)**
Naphthalene	5	8	43	160
Phenanthrene	17	32	1250	240
Anthracene	3	5	78	85
Dibenzothiophene	0.6[b]	[a]		190
Fluoranthene	20	39	250	600
Pyrene	13	24	350	665
Benz[*a*]anthracene	9	16	1.5	261
Chrysene/ Triphenylene	11	20		384
Benzo[*a*]pyrene	15	30	625	430
Benzo[*ghi*]perylene	45	80	2.1	85
Indeno[*1,2,3-cd*]pyrene	50	103	1.5	240
C1-Naphthalene	2.7[b]	[a]		155
C2-Naphthalene	6.7[b]	[a]		150
C3-Naphthalene	3.3[b]	[a]		
C1-Phenanthrene/ Anthracene	2.7[b]	[a]		170
C2-Phenanthrene/ Anthracene	3.7[b]	[a]		200
C3-Phenanthrene/ Anthracene	2.2[b]	[a]		
C1-DBT	1.0[b]	[a]		
C2-DBT	0.7[b]	[a]		
C3-DBT	0.4[b]	[a]		
Total PAH (11 parent PAH (CEMP 9 + naphthalene and DBT)	188.6[c]	[a]		3340[c]
Total PAH (As for parent + alkylated PAHs)	212[d]			

CBs (µg/kg dry weight)				
Compound	**LC**	**BAC normalised to 2.5% TOC (T_0)**	**EAC normalised to 2.5% TOC (T_1)**	**Effects Range-Low (ERL)**
CB28	0.05[e]	0.22	1.7	
CB52	0.05[e]	0.12	2.7	
CB101	0.05[e]	0.14	3.0	
CB118	0.05[e]	0.17	0.6	
CB138	0.05[e]	0.15	7.9	
CB153	0.05[e]	0.19	40	
CB180	0.05[e]	0.10	12	
Total CB (Aroclor Equivalents ~ = 2 x ICES7CBs)				23 (ERL)
ΣICES7CBs	0.20[f]	0.46		11.5 (ERL)[g]
Trace metals (µg/kg dry weight)				
	BC normalised to 5% Al	**BAC normalised to 5% Al (T_0)**	**EAC Normalised to 1% TOC**	**Effects Range Low (ERL) (T_1)**
Hg	50[h]	70[h]	220[i]	150
Cd	200[h]	310[h]	60[i]	1,200
Pb	25,000[h]	38,000[h]	2,200[i]	47,000

[a] to be defined in relation to adopted BC assuming sufficient data in ICES database

[b] proposed at the ICES Working Group on Marine Sediments in Relation to Pollution (WGMS) in 2008

[c] sum of individual BCs or ERLs for 11 parent PAHs

[d] sum of individual BCs for specified parent and alkylated PAHs

[e] LC = 2 x QUASIMEME constant error

[f] LC = 8 x QUASIMEME constant error

[g] ER values for total CB concentration/2

[h] normalised to 5% aluminium

[i] normalised to 1%TOC

Table 3: Assessment criteria for PAHs, CBs and trace metals in *mussels and oysters*. For CBs, EACs were estimated from sediment EACs and biota sediment accumulation factors (BSAF). Purple shaded cell are where EACs were not recommended for use by ICES (CBs) or are below the LC. EC - Commission Regulation No 1881/2006 sets maximum concentration for contaminants in foodstuffs to protect public health. $EAC^{passive}$ - calculated on the basis of BSAFs and sediment EACs.

Compound	**LC (µg/kg dry weight)**	**BAC (µg/kg dry weight) (T_0)**	**EAC (µg/kg dry weight) (T_1)**	**EC (µg/kg dry weight) (T_1)**	**$EAC^{passive}$ (µg/kg dry weight) (T_1)**
		PAHs			
Naphthalene		81.2 [b]	340		
Phenanthrene	4.0[a]	12.6 [b]	1700		
Anthracene		2.7 [b]	290		
Fluoranthene	5.5[a]	11.2 [b]	110		
Pyrene	4.0[a]	10.1[b]	100		
Benzo[*bj*]fluoranthene	3.0 [a]	[b]			
Benzo[*k*]fluoranthene	1.0 [a]	[b]	260		
Benzo[*a*]anthracene	1.0[a]	3.6 [b]	80		
Chrysene	4.0[a]	21.8 [b]			
Benzo[*e*]pyrene	2.5[a]	[b]			
Benzo[*a*]pyrene	0.5 [a]	2.1[b]	600	50 (10 ww[h] X 5)	
Benzo[*ghi*]perylene	1.5 [a]	7.2 [b]	110		
Indeno[*1,2,3*-cd]pyrene	1.0 [a]	5.5 [b]			
C1-Phenanthrene/ Anthracene	7.0 [a]	[b]			
C2-Phenanthrene/ Anthracene	7.0 [a]	[b]			
C3-Phenanthrene/ Anthracene	6.5 [a]	[b]			
C1-DBT	1.0 [a]	[b]			
C2-DBT	3.5 [a]	[b]			
C3-DBT	3.5 [a]	[b]			
Total PAH (11 Parent PAH)	28.0[c]	[b]			
Total PAH (11 Parent + alkylated PAH with LCs)	56.5[d]	[b]			

CBs					
Compound	**LC (µg/kg dry weight)**	**BAC (µg/kg dry weight) (T_0)**	**EAC (µg/kg dry weight)**	**EC (µg/kg dry weight) (T_1)**	**EAC^{passive} (µg/kg dry weight) (T_1)**
CB28	0.25[e]	[b]	13.5		3.2
CB52	0.25[e]	[b]	80		5.4
CB101	0.25[e]	[b]	5.0		6.0
CB118	0.25[e]	[b]	1.0		1.2
CB138	0.25[e]	[b]	100		15.8
CB153	0.25[e]	1.1[b]	1790		80
CB180	0.25[e]	[b]	26.5		24
ΣICES7CBs	1.0[f]	4.6[b]			
Trace metals (µg/kg dry weight) – mussels					
Determinand	**LC (µg/kg dry weight)**	**BAC (µg/kg dry weight) (T_0)**	**EAC (µg/kg dry weight)**	**EC (µg/kg dry weight) (T_1)**	**EAC^{passive} (µg/kg dry weight) (T_1)**
Hg	50[g]	140[h]	10	2,500 (500 ww[i] x 5)	
Cd	600[g]	1,940[h]	280	5000 (1,000 ww[i] x 5)	
Pb	800[g]	1,520[h]	8,500	7,500 (1,500 ww[i] x 5)	
Trace metals (µg/kg dry weight) – oysters					
Hg	100[j]	[k]		2,500	
Cd	1,800[j]	[k]		5,000	
PB	800[j]	[k]		7,500	

[a]low concentrations (LC) proposed at MCWG 2008 from the 10th percentile of datasets (Scotland, Spain and France)

[b]BACs used in the 2005/6 MON assessment to be defined/re-defined for updated BCs or LCs

[c]includes 8 of the 9 parent CEMP PAHs, benzo[*bj*]fluoranthene, benzo[*k*]fluoranthene and benzo[*e*]pyrene.

[d]includes 11 parent PAHs and selected alkylated PAHs. LCs were not proposed for anthracene or naphthalene nor for the alkylated naphthalenes due to a high proportion of samples in the datasets for which the values were below the limits of quantification for these PAHs

[e]LC = 2 x QUASIMEME constant error

[f]LC = 8 x QUASIMEME constant error

[g]low concentrations (LC) proposed at ICES MCWG 2008, median of regional medians

[h]BACs used in 2006/7 MON assessment to be redefined for new LCs

[i] ww, wet weight

[j]calculated using conversion factors proposed at ASMO 08 by France[(3)]

[k]To be calculated

Table 4: Assessment Criteria for CBs and trace metals in *fish*. For CBs EACs were estimated from sediment EACs and biota sediment accumulation factors (BSAF). Purple shaded cells are where EACs were not recommended for use by ICES (CBs) or are below the BAC. EC - Commission Regulation No 1881/2006 sets maximum concentration for contaminants in foodstuffs to protect public health. $EAC^{passive}$ - calculated on the basis of BSAFs and sediment EACs.

CBs					
Compound	**LC (µg/kg wet weight)**	**BAC (µg/kg wet weight) (T_0)**	**EAC (µg/kg wet weight)**	**EC (µg/kg wet weight) (T_1)**	**$EAC^{passive}$ (µg/kg lipid weight) (T_1)**
CB28	0.05[a]	0.6[e]	27[f]		64
CB52	0.05[a]	0.2[e]	163[f]		108
CB101	0.05[a]	1.9[e]	3.2[f]		120
CB118	0.05[a]	1.3[e]	0.65[f]		24
CB138	0.05[a]	0.2[e]	80[f]		316
CB153	0.05[a]	0.2[e]	53[f]		1600
CB180	0.05[a]	0.5[e]	126[f]		480
ΣICES7	0.2[b]	1.2[e]			
Trace Metals					
Determinand	**LC (µg/kg wet weight)**	**BAC (µg/kg wet weight) (T_0)**	**EAC (µg/kg wet weight)**	**EC (µg/kg wet weight) (T_1)**	**$EAC^{passive}$ (µg/kg lipid weight) (T_1)**
Hg (muscle)	[c]	35[d]	3.5	500 (fish muscle)	
Cd (liver)	[c]	26[d]	7	1000 (bivalve tissue)	
Pb (liver)	[c]	26[d]	300	1500 (bivalve tissue)	

[a]LC = 2 x QUASIMEME constant error
[b]LC = 8 x QUASIMEME constant error
[c]The MCWG was unable to recommend BCs for metals in fish due to the limited dataset
[d]proxy BACs derived at MON in 2007
[e]based on UK data: to be re-estimated from CEMP data and with updated LCs; to convert to lipid weight, these should be multiplied by 5 for megrim, 9 for flounder and plaice, and 7 for common dab.
[f]whole fish

Table 5: Summary of assessment criteria used in the 2008/9 CEMP Assessment for **(a)** sediment, **(b)** mussels and oysters and **(c)** fish. (Orange shaded boxes correspond to non-CEMP parent PAHs)

(a) Sediment

PAHs (µg/kg dry weight normalised to 2.5% TOC)			
Assessment	**BC**	**Blue < BAC (T_0)**	**Green < ERL (T_1)**
Naphthalene	5	8	160
Phenanthrene	17	32	240
Anthracene	3	5	85
DBT	0.6	[a]	190
Fluoranthene	20	39	600
Pyrene	13	24	665
Benz[*a*]anthracene	9	16	261
Chrysene/ Triphenylene	11	20	384
Benzo[*a*]pyrene	15	30	430
Benzo[*ghi*]perylene	45	80	85
Indeno[*1,2,3-cd*]pyrene	50	103	240
CBs (µg/kg dry weight, normalised)			
Assessment	**BC/LC**	**Blue < BAC (T_0)**	**Green < EAC (T_1)**
CB28	0.0/0.05	0.22	1.7
CB52	0.0/0.05	0.12	2.7
CB101	0.0/0.05	0.14	3.0
CB118	0.0/0.05	0.17	0.6
CB138	0.0/0.05	0.15	7.9
CB153	0.0/0.05	0.19	40
CB180	0.0/0.05	0.10	12
Trace Metals (µg/kg dry weight, normalised)			
Assessment	**BC**	**Blue < BAC (T_0)**	**Green < ERL (T_1)**
Hg	50	70	150
Cd	200	310	1,200
Pb	25,000	38,000	47,000

Table 5

(b) Mussels and oysters

PAHs (µg/kg dry weight)			
Assessment	**LC**	**Blue < BAC (T_0)**	**Green < EAC (T_1)**
Naphthalene		-	340
Phenanthrene	4.0	11.0	1700
Anthracene		-	290
Fluoranthene	5.5	12.2	110
Pyrene	4.0	9.0	100
Benzo[*bj*]fluoranthene	3.0	-	
Benzo[k]fluoranthene	1.0	-	260
Benz[*a*]anthracene	1.0	2.5	80
Chrysene/ Triphenylene	4.0	8.1	
Benzo[*a*]pyrene	0.5	1.4	600
Benzo[*ghi*]perylene	1.5	2.5	110
Indeno[*1,2,3-cd*]pyrene	1.0	2.4	
CBs (µg/kg dry weight)			
Assessment	**BC/LC**	**Blue < BAC (T_0)**	**Green < EAC (T_1)**
CB28	0.0/0.25	0.75	3.2
CB52	0.0/0.25	0.75	5.4
CB101	0.0/0.25	0.70	6.0
CB118	0.0/0.25	0.60	1.2
CB138	0.0/0.25	0.60	15.8
CB153	0.0/0.25	0.60	80
CB180	0.0/0.25	0.60	24
Trace Metals (µg/kg dry weight) - mussels			
Assessment	**LC**	**Blue < BAC (T_0)**	**Amber< EC maximum food level (T_1)**
Hg	50	90	2,500
Cd	600	960	5,000
Pb	800	1300	7,500
Trace Metals (µg/kg dry weight) - oysters			
Hg	100	180	2,500
Cd	1,800	3000	5,000
Pb	800	1300	7,500

Table 5
(c) Fish

CBs (µg/kg wet weight)			
Assessment	**BC/LC**	**Blue < BAC (T_0)**	**Green < EAC[passive] (µg/kg lipid weight) (T_1)**
CB28	0.0/0.05	0.10	64[a]
CB52	0.0/0.05	0.08	108 [a]
CB101	0.0/0.05	0.08	120 [a]
CB118	0.0/0.05	0.10	24 [a]
CB138	0.0/0.05	0.09	316 [a]
CB153	0.0/0.05	0.10	1600[a]
CB180	0.0/0.05	0.11	480 [a]
Trace Metals (µg/kg wet weight)			
Assessment	**BC**	**Blue < BAC (T_0)**	**Amber < EC maximum food level (T_1)**
Hg (muscle)	[b]	35	500
Cd (liver)	[b]	26	1000 (bivalve tissue)
Pb (liver)	[b]	26	1500 (bivalve tissue)

[a]lipid weight basis
[b]The MCWG was unable to recommend BCs for metals in fish due to the limited dataset

Table 6: Summary of transition points for assessing contaminants in sediment and biota for the OSPAR CEMP Assessment. T_0 = blue/green transition; T_1 = green/red or amber/red transition.

Contaminant	Transition Point	Sediment	Biota
PAH	T_0	BAC	BAC
	T_1	ERL	EAC
CB	T_0	BAC	BAC
	T_1	EAC	$EAC^{passive}$
Metal	T_0	BAC	BAC
	T_1	ERL	EC

Where suitable assessment criteria are not available, values will default to the lower status class.

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