Report of the Third OSPAR Workshop on Ecotoxicological Assessment Criteria

The Hague: 25-29 November 1996

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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 Union 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 l'Espagne et l'Union européenne.

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Executive Summary

Ecotoxicological assessment criteria are considered to be an essential component of the success of implementation of the new monitoring programme, as has been pointed out in the strategy document of the Joint Monitoring Group (JMG) concerning the future monitoring programme (Annex 5 to the summary record of the JMG meeting 1993; JMG 18/13/1). This document presents the Report of the Third OSPAR Workshop on Ecotoxicological Assessment Criteria held to establish ecotoxicological assessment criteria for chemical monitoring data from the North-East Atlantic Ocean, i.e. concentration levels below which no harm to the marine environment is expected.

The terms of reference for the workshop were (ASMO 96/16/1, Annex 17):

[1] to fill in gaps in assessment criteria for those substances and matrices for which the former two workshops had not yet provided data;

[2] to upgrade the ‘provisional’ and/or ‘firm’ ecotoxicological assessment criteria;

[3] to provide clear guidance on the applicability of this approach, its benefits and its limitations, the use of the ecotoxicological assessment criteria with regard to the assessment of JAMP monitoring data, and the relative use of ecotoxicological assessment criteria and background/reference concentrations;

[4] to prepare an overview of the results of the three workshops.

The workshop evaluated and reached agreement on the procedure for derivation of ecotoxicological assessment criteria. The principle of the procedure is the derivation of an extrapolated concentration based on ecotoxicological information. Subsequently, an ecotoxicological assessment criterium is generated by setting an interval around the extrapolated concentration. The extrapolated concentration is calculated by selecting the lowest NOEC or L(E)C50 from the toxicological data available and applying extrapolation factors which depend on the extent of the data set. Taking into consideration the uncertainties involved in the derivation, a distinction was made between firm and provisional assessment criteria. Ecotoxicological assessment criteria were derived when ecotoxicological data were available for at least 3 different species, being either marine or freshwater species.

Criteria for the specific contaminants were derived using all ecotoxicological data passing predefined quality criteria. The data applied included toxicity data for water and sediment, estimates from the Canadian BEDS database, calculated and measured estimates for partitioning coefficients, calculated and measured coefficients for bioconcentration factors as well as toxicity data for birds and mammals concerning contaminants evaluated for biomagnification.

The workshop reached agreement on the ecotoxicological assessment criteria for metals, organochlorine compounds, PAHs and TBT as best estimates, based on current knowledge. The Ecotoxicological assessment criteria derived by the workshop are listed in table 1.

Compared to the previous workshops significant progress was made: [a] the methods to derive Ecotoxicological Assessment Criteria were better defined; [b] the assessment of available toxicological data was done in a more systematic way, due to the fact that for each compound an overview of relevant toxicological data was available; [c] the relevant toxicological data were more reliable as a quality check has been introduced; [d] the derivation of ecotoxicological assessment criteria has been documented extensively in the Annexes to this report, together with an overview of the available literature.

Several gaps in the assessment criteria for which the former two workshops had not yet provided criteria, were filled in (e.g. nickel in sediment, lindane in fish, organochlorines in mussel). The ecotoxicological assessment criteria for several compounds (e.g. naphthalene and lindane in water, naphthalene and phenanthrene in sediment; DDE in fish) were upgraded from provisional to firm on the basis of more extensive data sets. As a result of careful evaluation of the available data the status of the ecotoxicological assessment criteria for nickel in water was changed to provisional, whereas previously it was considered firm.

Despite the large data sets available, the workshop decided after careful evaluation to reject the ecotoxicological assessment criteria for metals in biota that were set previously, and not to derive new criteria. The reasons for this were the high variation in certain parameters and problems in the extrapolation of laboratory studies to the field situation, which to the opinion of the workshop resulted in the overestimation of the toxicity of these metals. A comparison of the laboratory effect concentrations with background concentrations confirmed this decision. This problem was considered to be specific for metals.

The ecotoxicological assessment criteria derived were considered to be reasonable estimates based on the current state of knowledge and were evaluated for their applicability by comparison with JMP monitoring data kindly provided by ICES and background concentrations from the 1996 ICES/OSPAR workshop on background concentrations in Hamburg. Though ecotoxicological assessment criteria for some of the compounds showed some overlap with background concentrations, the criteria together with background concentrations are considered useful for preliminary assessments of JMP/JAMP monitoring data and should be considered as guidance for further work.

In this document an extensive overview is presented of the benefits and limitations of the derivation and use of ecotoxicological assessment criteria for the assessment of the pollution status of the marine environment.

It was concluded that:

a. The ecotoxicological assessment criteria should be used to assess JMP/JAMP chemical monitoring data, e.g. for the QSR 2000, taking into account whether an EAC is provisional or firm.

b. Ecotoxicological assessment criteria should be used to identify possible areas of concern and indicate which substances could be considered a priority, and should not be used as firm standards or as triggers for remedial action.

c. Caution should be exercised in using generic, particularly provisional, assessment criteria in specific situations. Their use does not preclude the use of common sense and expert judgement with regard to the natural concentrations of e.g. trace metals in assessing the (potential for) environmental effects Furthermore, the ecotoxicological assessment criteria do not take into account specific long term biological effects such as carcinogenicity, genotoxicity and reproductive disruption due to hormone balance disturbances and do not include combination toxicity.

d. The effects of environmental contamination will ultimately have to be assessed in biological terms and SIME is recommended to implement an integrated chemical and biological effects monitoring programme as soon as possible.

e. If effects are found in an integrated chemical and biological effects programme, ecotoxicological assessment criteria can be used to diagnose which compounds may be responsible.

f. Ecotoxicological assessment criteria need to be further refined and updated at intervals of e.g. 5-10 years in order to take account of: a) changes in the parameter list of the JAMP; and b) the availability of new marine toxicity data. Biological effect monitoring data should be taken into account in further deriving such criteria.

Table 1 *Overview of ecotoxicological assessment criteria for trace metals, PCBs, PAHs, TBT and some organochlorine pesticides for various matrices*

Cautionary note: These assessment criteria have no legal significance and should only be used for the preliminary assessment of JMP/JAMP chemical monitoring data with the aim of identifying potential areas of concern. When applied, the fact whether an EAC is firm or provisional should be taken into account.

Substance	**Water** (µg/l)	**Sediment** (mg/kg dw)	**Fish** (mg/kg fw)	**Mussel** (mg/kg dw)
Trace metals				
As	1-10 (f)	1-10 (p)	n.r.	n.r.
Cd	0.01-0.1 (f)	0.1-1 (p)	f.c.	f.c.
Cr	1-10 (f)	10-100 (p)	n.r.	n.r.
Cu	0.005-0.05 (f)[1]	5-50 (p)	f.c.	f.c.
Hg	0.005-0.05 (f)	0.05-0.5 (p)	f.c.	f.c.
Ni	0.1-1 (p)	5-50 (p)	n.r.	n.r.
Pb	0.5-5 (f)	5-50 (p)	f.c.	f.c.
Zn	0.5-5 (f)	50-500 (p)	n.r.	n.r.
Organochlorine pesticides				
DDE	n.r.	0.0005-0.005 (p)	0.005-0.05 (f)	0.005-0.05 (f)
Dieldrin	n.r.	0.0005-0.005 (p)	0.005-0.05 (f)	0.005-0.05 (f)
Lindane	0.0005-0.005 (f)	n.r.	0.0005-0.005 (f)	n.r.
PAHs				
Naphthalene	5-50 (f)	0.05-0.5 (f)	n.r.	0.5-5 (p)
Phenanthrene	0.5-5 (p)	0.1-1 (f)	n.r.	5-50 (p)
Anthracene	0.001-0.01 (p)	0.05-0.5 (f)	n.r.	0.005-0.05 (p)
Fluoranthene	0.01-0.1 (p)	0.5-5 (p)	n.r.	1-10 (p)
Pyrene	0.05-0.5 (p)	0.05-0.5 (p)	n.r.	1-10 (p)
Benzo[*a*]anthracene	n.d.	0.1-1 (p)	n.r.	n.d.
Chrysene	n.d.	0.1-1 (p)	n.r.	n.d.
Benzo[*k*]fluoranthene	n.d.	n.d.	n.r.	n.d.
Benzo[*a*]pyrene	0.01-0.1 (p)	0.1-1 (p)	n.r.	5-50 (p)
Benzo[*ghi*]perylene	n.d.	n.d.	n.d.	n.d.
Indeno[*123-c,d*]pyrene	n.d.	n.d.	n.r.	n.d.
ΣPCB_7	n.r.	0.001-0.01 (p)	0.001-0.01 (f)	0.005-0.05 (f)
TBT	0.00001-0.0001(f)	0.000005-0.00005 (p)	n.r.	0.001-0.01 (f)

f = firm
p = provisional
f.c. = for future consideration
n.r. = not relevant in relation to the current monitoring programme
n.d. = no data available or no sufficient data available
1 = this range is within the background range for natural water. This value should be compared to the bioavailable fraction of Cu in seawater.

CONTENTS

ANNEXES

Chapter 1 - Preface

This document presents the Report of the Third OSPAR Workshop on Ecotoxicological Assessment Criteria held in The Hague (The Netherlands), 25-29 November 1996.

In the past, the Joint Monitoring Group (JMG) and the Assessment and Monitoring Committee (ASMO) have recognised the need to establish assessment criteria in order to improve the assessment of its chemical monitoring results. The aim of the workshop was to establish ecotoxicological assessment criteria for chemical monitoring data from the North-East Atlantic Ocean, i.e. concentration levels below which no harm to the marine environment is expected. To provide ecotoxicological assessment criteria three workshops have been held. At the two previous workshops, the first held in Scheveningen (15-17 November 1993, EAC 1/2) and the second in Berlin (27-29 November 1995, EAC 1/3), methods were developed and some of the ecotoxicological assessment criteria were derived. This document reports on the outcome of the third workshop and provides an overview of the results from all three workshops. The terms of reference for the workshop were (Annex 4 and ASMO 96/16/1, Annex 17):

a. to fill in gaps in assessment criteria for those substances and matrices for which the former two workshops had not yet provided data;

b. to upgrade the ‘provisional’ and/or ‘firm’ ecotoxicological assessment criteria;

c. to provide clear guidance on:

   i) the applicability of this approach, its benefits and its limitations;

   ii) the use of the ecotoxicological assessment criteria agreed upon to date, with regard to the assessment of marine chemical monitoring data generated within the framework of the JAMP;

   iii) the relative use of ecotoxicological assessment criteria and background/reference concentrations; and

d. to prepare an overview of the results of the three workshops.

Chapter 2 - Introduction

Under the auspices of the Oslo and Paris Commissions a Joint Monitoring Programme (JMP) has been conducted by the Contracting Parties to the Oslo and Paris Conventions since 1979 to continuously review the pollution of the marine environment of the North-East Atlantic Ocean and to study the effectiveness of the measures taken to improve the quality of the seas. To facilitate the evaluation of data on toxic substances in the marine environment, there is a clear need for ecotoxicological assessment criteria.

The JMP has the objectives of assessing:

a. possible hazards to human health, i.e. estimating the levels of pollutants in edible (shell)fish;

b. harm to living resources and marine life i.e. biological and biological-effect monitoring;

c. existing levels of marine pollution, i.e. determining the spatial distribution of pollution;

d. the effectiveness of measures taken for the reduction of marine pollution in the framework of the Oslo and Paris Conventions, i.e. temporal trend monitoring.

Over the years several assessments of the data on concentrations of contaminants in water, sediment or biota have been carried out to assess temporal trends or spatial distributions. For the purpose of reviewing the data from baseline studies, arbitrary ‘divisions’ were established often based on the numerical distribution of the data (e.g. quartiles or so called lower and upper levels). These ‘divisions’ were established purely for descriptive purposes, and were not intended to imply which levels should or should not be considered acceptable with respect to potential toxicity or bioaccumulation of a contaminant.

In September 1992 a new Convention for the Protection of the Marine Environment of the North-East Atlantic was signed at a Ministerial meeting in Paris. The Ministerial meeting stated that, as a matter of principle, for the whole maritime area, ‘discharges and emissions of substances, and which could reach the marine environment should, regardless of their anthropogenic source, be reduced by the year 2000 to levels that are not harmful to man or nature, with the aim of their elimination’.

The new Convention has consequences for the JMP. Ecotoxicological assessment criteria are considered to be an essential component of the success of implementation of the new monitoring programme, as has been pointed out in the strategy document of the Joint Monitoring Group (JMG) concerning the future monitoring programme (Annex 5 to the summary record of the JMG meeting 1993; JMG 18/13/1).

In line with the aims of the new Convention, the purpose of all three workshops were to establish ecotoxicological assessment criteria for selected microcontaminants within the North-East Atlantic Ocean that represent ranges in concentration that are not harmful to the marine environment. The elements and compounds considered include: arsenic, cadmium, copper, chromium, lead, nickel, mercury, zinc, PAHs, PCBs, lindane, DDE, dieldrin and TBT. Limits concerning human consumption of marine fish and shellfish were not considered during the workshops.

The ecotoxicological assessment criteria established during this third workshop were evaluated for their practicality based on comparison with background concentrations (EAC 4/Info.1) and various sets of monitoring data, either JMP data sets provided by ICES or national monitoring data.

This third workshop was chaired by Ketil Hylland, Norway, and attended by representatives from Denmark, France, Germany, the Netherlands, Portugal, Sweden and the United Kingdom. A list of participants can be found in Annex 1.

Chapter 3 - Derivation procedures for ecotoxicological assessment criteria (EACs)

3.1 Discussion at the third workshop

The procedure used for the derivation of EACs was presented by Mr Douwe Jonkers of the Netherlands. This procedure was based on the one followed in the first (EAC 1/2) and second (EAC 1/3) workshops.

The preparatory work for the present workshop performed by the Centre for Substances and Risk Assessment (CSR) of the National Institute of Public Health and the Environment (RIVM) in the Netherlands was presented by Mr Erik van de Plassche.

Several discussion papers on critical steps in the derivation procedure were presented:

- EAC 2/2: Quality criteria for the evaluation of ecotoxicological studies underlying the derivation of Ecotoxicological Assessment Criteria (EAC);
- EAC 2/3: Criteria setting: compilation of procedures and effect-based criteria used in various countries;
- EAC 2/4: A method to derive Ecotoxicological Assessment Criteria (EAC) taking secondary poisoning into account;
- EAC 2/5: Can Critical Body Residues be used for the derivation of Ecotoxicological Assessment Criteria for biota?;
- EAC 2/6: Derivation of Ecotoxicological Criteria for sediment.

The following decisions were taken at the present workshop with respect to several aspects of the procedure to derive EACs:

a. it was agreed that there is a need for a uniform and clearly defined evaluation procedure for ecotoxicological studies prior to the derivation of EACs. The evaluation procedure as described in document EAC 2/2 was accepted. This document is at Annex 5;

b. In the former workshops the lower end of the L(E)C50 or NOEC data was used, to reduce the chance of setting an EAC on the basis of an outlier which might originate from a poor quality study. Here it was agreed to use the lowest L(E)C50 or NOEC as all ecotoxicological data were evaluated and checked against predefined quality criteria;

c. the evaluation of national guidelines served as a first step in the derivation procedure at the previous workshops. Considering the fact that relevant national guidelines are scarce and the variation often is large, this step in the derivation of EACs was considered to be a rather arbitrary one. Therefore it was decided to remove the evaluation of national guidelines from the procedure for the derivation of EACs;

d. the method described in EAC 2/4 to derive EACs for fish and mussels taking secondary poisoning into account was considered a valid approach and it was agreed that the method can be used in the procedure. This document is presented at Annex 6;

e. the concept of Critical Body Residues (CBR) was considered a promising approach for deriving EACs in biota. It was however realised that its use would be very limited due to the lack of CBR data and the fact that the monitoring programme only covers a limited number of substances. It was agreed to leave the concept in the procedure to derive EACs, to allow future development and use of this method;

f. It was decided that EACs will only be derived when toxicity data are available for at least three species, either marine or fresh water;

g. For all matrices, i.e. water, sediment and biota, a firm criterion may be changed into a provisional one due to: [1] the chronic mode of action not being reflected in the data set, so relevant parameters are not included, e.g. carcinogenicity; [2] the range being unrealistic or not applicable for some other reason, e.g. if the resulting EAC is lower than the natural background concentration.

3.2 General derivation procedure

It was agreed at the present workshop that the procedure for deriving EACs, including the criteria for setting provisional or firm EACs, and taking into account the documents EAC 2/4 and 2/6, is as follows:

The principle of the procedure is the derivation of an extrapolated concentration based on ecotoxicological information. Subsequently, the extrapolated concentration is rounded to the nearest order of magnitude interval to generate the EAC. Based on the method applied and the data available, the EAC is considered either firm or provisional. For all matrices, i.e. water, sediment and biota, a firm criterion may be changed into a provisional one due to:

a. the chronic mode of action not being reflected in the data set, so relevant parameters are not included, e.g. carcinogenicity;
b. the range being unrealistic or not applicable for some other reason, e.g. if the resulting EAC is lower than the natural background concentration.

EACs will only be derived when ecotoxicological data are available for at least 3 different species, being either marine or freshwater species (minimum data requirement). The lowest NOEC or L(E)C50 is selected from the toxicological data available. Depending on the extent of the data set, the following extrapolation factors are to be applied to calculate the extrapolated concentration:

extrapolation factor	information
1000	applied to the lowest acute L(E)C50 when the data available are few, or the range of organisms is narrow
100	applied to the lowest acute L(E)C50 when there is an extensive data base covering a phylogenetically wide range of species, or to the lowest chronic EC50 or NOEC when few chronic data are available
10	applied to the lowest chronic NOEC for a sufficient and representative number of species

Expert judgement can always be used to deviate from the procedure. However, this deviation should always be substantiated and documented.

3.2.1 Water

The EAC is considered firm if ecotoxicological information is available on the chronic toxicity of the relevant compound for 3 marine species, including one fish, one invertebrate and one algal species.

3.2.2 Sediment

Three approaches are available to derive EACs for sediment:

a. Spiked sediment assays
This is considered the preferred approach for organic contaminants, but is not appropriate for metals primarily due to differences in bioavailability between laboratory and field conditions. Appropriate extrapolation factors should be applied to the lowest acute L(E)C50 or chronic EC50 or NOEC to derive the extrapolated concentration. If data are available for 2 marine sediment-dwelling organisms from different taxonomic groups the EAC is considered firm.

b. Equilibrium Partitioning
Here the extrapolated concentration is derived by multiplying the extrapolated concentration in water with the appropriate partition coefficient (Kp) for sediments assuming 1% organic carbon. This value is considered representative for the majority of sediments in the Convention Area. Experimental Kp are preferred, either from field measurements or determined in the laboratory using e.g. shake flask method. If no experimental Kp is available, the Kp can be calculated using the following equation:

$Kp = 0.5 * K_{ow} * f_{oc}$

where:
K_{ow}: octanol-water partition coefficient;
f_{oc}: organic carbon content in sediment, being 1%.

For metals the equilibrium partitioning method is not applied to derive EACs because of the large uncertainties in Kp values for metals. For organics the EAC is considered to be firm when a measured Kp value has been used and sufficient ecotoxicological information was available for aquatic organisms, i.e. a firm EAC for water.

c. Co-occurence
This approach is based on data compiled by the "North American Biological Effects Database for Sediment" (BEDS). In the previous workshops the ERL values from Long et al., 1995 and the No Observed Effect Levels as reported by MacDonald et al., 1993 have been used. At the previous workshops an extrapolation factor of 5 was applied to the ERL to derive an EAC for sediments.

For the present workshop a document of Environment Canada, Soil and Sediment Quality Section Guidelines Division entitled "Interim Sediment Quality Guidelines" was available (EAC 2/Info.1 and EAC 2/Info.2). In this document so-called TEL and PEL values are given. The Threshold Effect Level (TEL) is the geometric mean of the lower 15^{th} percentile of the effects data set and the

50^{th} percentile of the no-effects data set. The Probable Effect Level (PEL) is the geometric mean of the 50^{th} percentile of the effect data set and the 85^{th} percentile of the no-effect data set. The TEL can be regarded as a value below which adverse effects are expected to occur rarely, whereas above the PEL effects are predicted to occur frequently. Because different statistics are used to derive the TEL compared to the ERL value and as for the derivation of the TEL also the no-effect data are taken into account, it was agreed that an extrapolation factor of 5 was not needed to derive an EAC from a TEL.

Specifically for PAHs, it was agreed that the range between the TEL and the PEL should be compared with results from equilibrium partitioning, because all PAHs are likely to contribute to the observed effect. For all other contaminants the TEL value is considered comparable to the extrapolated concentration derived with the EqP approach. As no causal relationship was established between the occurrence of the substance considered and the effects observed in the BEDS data base, it was decided that an EAC based on the TEL should always be regarded as provisional.

Summarising, three methods can be used to derive an extrapolated concentration for sediment. Based on their outcome and on the uncertainties involved in their derivation, one or more of the extrapolated concentrations can be selected as a basis for setting the EAC. It was agreed that if it is possible to apply two or more methods and if the outcome of these methods does not differ by more than one order of magnitude, the resulting EAC should be set around these extrapolated concentrations and should be considered as firm, although each individual extrapolated concentration is classified as a provisional value.

It should be noted that in the case of metals it will not be possible to set firm values at the present workshop because neither spiked sediment nor partitioning methods can be used.

3.2.3 Biota

Three different methods are available to derive an EAC for biota:

a. Critical Body Residues
It was agreed that this method can be used and the results can be regarded as firm. However, it was envisaged that this method could not be used for any of the substances considered for the workshop due to lack of data.

b. Based on direct effects on aquatic organisms
An extrapolated concentration can be derived by multiplying the extrapolated concentration in water with the appropriate BCF for fish or mussels. If no measured BCF is available the BCF can be calculated for organic substances with a log K_{ow} of less than 6-7 using the equations:

fish: $BCF = 0.05 * K_{ow}$
where the BCF is expressed in L/kg fw

mussels: $BCF = 0.085 * K_{ow}$
where the BCF is expressed in L/kg dw.

It was agreed that if sufficient ecotoxicological information for aquatic organisms and a measured BCF for fish or mussels is available the resulting EAC can be considered firm.

c. Based on indirect effects: secondary poisoning

It was agreed that for organic substances with a log K_{ow} of > 5 and for certain metals like cadmium and mercury the potential adverse effects due to secondary poisoning should be taken into account. The method to be used is given in Annex 6. It was agreed that if toxicity data are available for one bird and mammal species exposed via the food the resulting EAC can be considered firm.

Chapter 4 - Compound Specific Derivation Methodology

4.1 Subgroup on PAHs

The group reviewed the PAHs to be included in the evaluation and established that adequate data existed for the following PAHs:

Naphthalene (Annex 7)
Phenanthrene (Annex 8)
Anthracene (Annex 9)
Fluoranthene (Annex 10)
Pyrene (Annex 11)
Benzo(a)pyrene (Annex 12)

For Chrysene (Annex 13) and Benzo(a)anthracene (Annex 14) there were TEL/PEL values available but no toxicity data. For Benzo(ghi)perylene, Ideno(123-c,d)pyrene and Benzo(k)fluoranthene (Annex 15) there was none or not sufficient data available with which to derive EACs.

4.1.1 Water

The general procedure as described in Chapter 3 was used for the derivation of EACs in water.
Results are given in Table 4.1.

4.1.2 Sediment

a. Sediment partition coefficients
Generally four methods were identified:

a. calculation from octanol water partition coefficients;
b. laboratory determined values using the “shake-flask” method;
c. laboratory determined values using the co-solvent extraction method; and
d. field determined values.

Generally the calculated sediment equilibrium coefficients were similar to those determined in the laboratory by the shake flask method and both were lower than the field determined values. Coefficients determined by the co-solvent methods were always higher than those determined by the shake flask method and were sometimes higher than those determined from field data, especially for the higher molecular weight PAH. The differences in values between the shake flask method and the field values were attributed to an increase in the partition coefficients with contact time in the sediment. It was therefore decided to use laboratory determined shake flask values for the low molecular weight PAH which are more water soluble and volatile and to use field determined values for the more recalcitrant higher molecular weight PAH. The methods used are:

Naphthalene and Phenanthrene	Shake flask laboratory determined values
Pyrene	No field or laboratory data were available and therefore a value calculated from the K_{ow}
All other PAHs	Field determined values were used

b. Determination of EACs in sediment

To derive an extrapolated concentration for sediment three different methods are available. The first method is based on applying extrapolation factors in experimental studies using spiked sediment. The second method is based on the equilibrium partitioning approach (see EAC 2/1) and the third utilises threshold effects levels (TELS) and probable effects levels (PELS) derived from a statistical analysis of the BEDS data base by Environment Canada (EAC 2/Info.2). For PAHs no reliable or sensitive data was available based on sediments spiked with PAHs and so this approach could not be used. For each of the PAHs where there was an adequate data set on aquatic toxicity then a extrapolated concentration was derived by the sediment partitioning approach. Specifically for PAHs, it was agreed that the range between the TEL and the PEL should be compared with results from equilibrium partitioning, because all PAHs are likely to contribute to the observed effect. Where there was good agreement between the two approaches a range was constructed around the concentration value predicted from partitioning. Where it was not possible to use the sediment partitioning approach or, where the TEL/PEL range was appreciably lower than that obtaining from partitioning, a range was constructed around the TEL and PEL range. Results are given in Table 4.1.

4.1.3 Biota

The general procedure as described in Chapter 3 was used for the derivation of EACs in biota. Results are given in Table 4.1.

Table 4.1 *Ecotoxicological assessment criteria for polycyclic aromatic hydrocarbons together with the TEL and PEL data for sediment obtained from the BEDS data base by Environment Canada (EAC 2/Info.2)*

Substance	Water (µg/l)	Sediment (mg/kg dw)				Biota Mussel (mg/kg dw)
	EAC	EqP Extrapolated concentration	Beds TEL	Beds PEL	EAC	EAC
Naphthalene	5-50 (f)	0.106[1]	0.035	0.39	0.05-0.5 (f)	0.5-5.0 (p)
Phenanthrene	0.5-5.0 (p)	0.39[1]	0.087	0.54	0.1-1.0 (f)	5-50 (p)
Anthracene	0.001-0.01 (p)	0.107[2]	0.047	0.25	0.05-0.5 (f)	0.005-0.05 (p)
Fluoranthene	0.01-0.1 (p)	1.9[2]	0.11	1.5	0.5-5.0 (p)	1-10 (p)
Pyrene	0.05-0.5 (p)	0.1[3]	0.15	1.4	0.05-0.5 (p)	1-10 (p)
Benzo(a)anthracene	n.d.	n.d.	0.075	0.69	0.1-1.0 (p)	n.d.
Chrysene	n.d.	n.d..	0.11	0.85	0.1-1.0 (p)	n.d.
Benzo(k)fluoranthene	n.d.	n.d.	n.d.	n.d.	n.d..	n.d..
Benzo(a)pyrene	0.01-0.1 (p)	4.26[2]	0.089	0.76	0.1-1.0 (p)	5-50 (p)

f = firm
p = provisional

n.d. = not data or insufficient data available
Sediment partitioning determined by: 1 the shake flask method 2 field measurements 3 from the Kow and the organic carbon content

4.2 Subgroup on Pesticides and PCBs

The general procedures for the derivation of ecotoxicological assessment criteria (EACs) as described in Chapter 3 for water, sediment and biota were considered applicable and were used in case the data were available.

4.2.1 Water

For water EACs were only derived for lindane (Annex 16) and tributyltin (Annex 17) since EACs for dieldrin (Annex 18), DDE (Annex 19) and ΣPCB_7 (Annex 20) were not considered relevant for the monitoring programme. Although in both cases an extrapolation factor of 100 was used on an EC50-value, the EACs for lindane and TBT were considered firm. The reasons for this was that the data set on lindane and TBT toxicity was extensive and included chronic data on the expected most sensitive group of species. Results are given in Table 4.2.

4.2.2 Sediment

For sediment provisional EACs were derived for DDE and dieldrin based on the BEDS approach. A provisional EAC was set for ΣPCB_7 based on both a spiked sediment test and the BEDS approach. For TBT a provisional EAC was derived using EqP. Results are given in Table 4.2.

4.2.4 Biota

EACs were derived for biota by multiplying the extrapolated concentration in water with the geometric mean of measured BCFs (dieldrin, lindane, TBT) or secondary poisoning (DDE, dieldrin, ΣPCB_7). All EACs were classified as firm. Results are given in Table 4.2.

Table 4.2 *Ecotoxicological assessment criteria for pesticides and PCBs*

Substance	**EAC Water [µg/l]**	**EAC Sediment [mg/kg dw]**	**EAC Fish [mg/kg fw]**	**EAC Mussel [mg/kg dw]**
DDE	n.r.	0.0005-0.005 (p)	0.005-0.05 (f)	0.005-0.05 (f)
Dieldrin	n.r.	0.0005-0.005 (p)	0.005-0.05 (f)	0.005-0.05 (f)
Lindane	0.0005-0.005 (f)	n.r.	0.0005-0.005 (f)	n.r
ΣPCB_7	n.r.	0.001-0.01 (p)	0.001-0.01 (f)	0.005-0.05 (f)
TBT	0.00001-0.0001 (f)	0.000005-0.00005 (p)	n.r.	0.001-0.01 (f)

n.r. = not relevant

4.3 Subgroup on Metals

4.3.1 Water

For two metals (As, Annex 21 and Cr, Annex 23) there were chronic toxicity data available for marine algae and invertebrates, but such data were missing for marine fish. In both cases, a substantial database on chronic toxicity for freshwater organisms from many taxonomic groups was available. Based on these fresh water data, the lacking taxonomic group (fish) was considered less sensitive for both metals than other groups. An extrapolation factor of 10 was therefore applied to the lowest NOEC and the criteria was set as firm. For the other metals (Cd (Annex 22), Cu (Annex 24), Hg (Annex 25), Pb (Annex 26), Ni (Annex 27), Zn (Annex 28)) the general procedure (Section 3.2) was applied. Results are given in Table 4.3.

4.3.2 Sediment

Of the three alternative methods presented to derive EAC for metals in sediment (equilibrium partitioning, spiked sediment assays, TELs from BEDS) the workshop decided to use only TEL-values to derive EACs. Although new data were available on partition coefficients for all relevant metals (EAC 2/6), the workshop decided against using the EqP-approach to derive EACs for metals because of the large uncertainties in Kp values for metals. Although spiked sediment assays (SSA) is the set of methods most similar to toxicity tests such as those used for water, the workshop decided against the use of SSAs to derive EACs for metals in sediments. This decision was primarily founded on the lack of information on the actual bioavailability of the relevant metal in SSAs and the difference in approaches regarding the determination of sediment metal content (total digestion vs extraction vs metal added). EACs for metals in sediments were constructed from TEL-values from BEDS without the use of an extrapolation factor. All EACs for metals in sediment were classified as provisional. Results are given in Table 4.3.

Table 4.3 *Ecotoxicological Assessment Criteria for metals.*

Metal	Water (µg/l)	Sediment (mg/kg dw)	Fish (mg/kg fw)	Mussel (mg/kg dw)
As	1-10 (f)	1-10 (p)	n.r.	n.r.
Cd	0.01-0.1 (f)	0.1-1 (p)	f.c.	f.c.
Cr	1-10 (f)	10-100 (p)	n.r.	n.r.
Cu	0.005-0.05 (f)	5-50 (p)	f.c.	f.c.
Hg	0.005-0.05 (f)	0.05-0.5 (p)	f.c.	f.c.
Ni	0.01-0.1 (p)	5-50 (p)	n.r.	n.r.
Pb	0.5-5 (f)	5-50 (p)	f.c.	f.c..
Zn	0.5-5 (f)	50-500 (p)	n.r.	n.r.

f = firm
p = provisional
f.c. = for future consideration
n.r. = not relevant
n.d. = no data or insufficient data available
n.a. = not available

4.3.3 Biota

Both approaches available to derive EACs for metals (Cd, Cu, Hg, Pb) in biota had weaknesses. One method to derive EACs for metals in biota (the BCF-method) uses toxicity data from a different compartment (water) to calculate the EAC. In addition, it depends on a BCF which may vary over orders of magnitude depending on the length of exposure, exposure concentration and other factors. Thus, the group decided to calculate extrapolated values for toxicity using best estimates of BCF (geometric means of relevant values), but that the resulting estimates were regarded as being too uncertain to be used to derive EACs.
The second approach attempts to include possible toxicity for organisms at higher trophic levels in the ecosystem, so-called secondary poisoning. Secondary poisoning was assessed for Cd and Hg using the general procedures outlined above (Section 3.4 and Annex 6). In this approach, the toxicity of the metal (either Cd or Hg) to mammals or birds was identified and used to derive a value. The latter approach yielded very low extrapolated concentrations for both Cd and Hg in fish and mussels, presumably overestimating the toxicity. Because of this, the subgroup regarded the resulting estimates as being too uncertain to be used to derive EACs. The extrapolated concentrations have been documented for all the metals in the relevant Annexes. In Table 4.3 the EACs for metals in biota have been marked 'for future consideration'.

Chapter 5 - Comparison with the First and Second Workshops

5.1 General comparison

Compared to the previous workshops, at the present workshop:

a. the methods to derive EACs were better defined;

b. the assessment of available toxicological data was done in a more systematic way, due to the fact that for each compound an overview of relevant toxicological data was available;

c. the relevant toxicological data were more reliable as a quality check had been introduced;

d. the derivation of EACs has been documented extensively in the Annexes, together with an overview of the available literature.

5.2 Subgroup on PAHs

5.2.1 Water

Additional toxicity data enabled EACs to be determined for phenanthrene and pyrene and resulted in lower EACs for anthracene and fluoranthene. For naphthalene the EAC is higher due to rejection of the lowest NOEC (Caldwell, 1977) as detailed in Annex 7. This rejected study was used to derive the EAC in the last workshop. The EAC for naphthalene has been reclassified as firm as sufficient toxicity data were available.

Table 5.1 *Ecotoxicological assessment criteria for PAHs in water derived by the different workshops (µg/l)*

Substance	EAC from First workshop (µg/l)	EAC from Third workshop (µg/l)
naphthalene	1-10 (p)	5-50 (f)
phenanthrene	n.d.	0.5-5 (p)
anthracene	0.005-0.05 (p)	0.001-0.01 (p)
fluoranthene	0.05-0.5 (p)	0.01-0.1 (p)
pyrene	n.d.	0.05-0.5 (p)
benzo(a)anthracene	n.d.	n.d.
chrysene	n.d.	n.d.
benzo(k)fluoranthene	n.d.	n.d.
benzo(a)pyrene	0.01-0.1 (p)	0.01-0.1 (p)

n.d. = no data or insufficient data available
f = firm
p = provisional

5.2.2 Sediment

During the first workshop on ecotoxicological assessment criteria, provisional values for 4 PAHs (naphthalene, anthracene, fluoranthene, benzo(a)pyrene) have been defined on the basis of the equilibrium partitioning approach. The second workshop had to identify assessment criteria for 9 PAHs in sediments. Among these, 3 PAHs had already been dealt with at the first workshop. Assessment criteria have been determined at the second workshop by two different approaches. In addition to the equilibrium partitioning approach (EqP) a Canadian method (ERL - effects range low) was applied at the former workshop as described in the report (EAC 1/3).

The third workshop had the task to derive assessment criteria for 9 PAHs which are included into the Joint Assessment and Monitoring Programme. One new PAH was added (benzo(k)fluoranthene) and 2 substances from the previous workshop were not considered.

The comparison is presented in Table 5.2 and shows that there is a tendency for higher EACs in the current workshop except for pyrene which has the same range. This is due to a more critical assessment of the toxicity data and quality control restraints on the data, to the use of laboratory-derived or field-derived partition coefficients and to the adoption of the TEL/PEL range rather than a range to the ERL data. The requirement that there should be at least toxicity data for three different species has reduced the numbers of PAH for which sediment EACs could be derived. For naphthalene, phenanthrene and anthracene the EACs have been reclassified as firm as the equilibrium partitioning approach and co-occurrence approach resulted in the same range.

Table 5.2 *Ecotoxicological assessment criteria for PAHs in sediments derived by the different workshops (mg/kg dw., 1% OC).*

Substance	Workshops				
	first	second		third	
	EqP - EAC	EqP - EAC	ERL - EAC	EAC	TEL/PEL range
naphthalene	0.01-1 (p)	-	-	0.05-0.5 (f)	0.035-0.39
phenanthrene	-	0.5-5 (p)	0.01-0.1 (p)	0.1-1 (f)	0.087-0.54
anthracene	0.001-0.01 (p)	0.001-0.01 (p)	0.005-0.05 (p)	0.05-0.5 (f)	0.047-0.25
fluoranthene	0.01-0.1 (p)	0.01-0.1 (p)	0.05-0.5 (p)	0.5-5 (p)	0.11-1.5
pyrene	-	n.d.	0.05-0.5 (p)	0.05-0.5 (p)	0.15-1.4
benzo(a)anthracene	-	5-50 (p)	0.01-0.1 (p)	0.1-1 (p)	0.075-0.69
chrysene	-	n.d.	0.01-0.1 (p)	0.1-1 (p)	0.11-0.85
benzo(k)fluoranthene	-	-	-	n.d.	n.d.
benzo(a)pyrene	0.05-0.5 (p)	0.05-0.5 (p)	0.01-0.1 (p)	1-10 (p)	0.089-0.76

EqP = equilibrium partitioning approach
ERL = effects range low approach
EAC = ecotoxicological assessment criteria
TEL/PEL = threshold effect level/probable effect level
n.d. = no data or insufficient data available

5.2.3 Biota

In all cases the EACs are higher than in the previous workshops except for anthracene for which the EAC has remained the same. In some cases (e.g. naphthalene) this is partly explained by re-assessed toxicity data, but it is mainly due to higher BCFs resulting from the use of measured values. A comparison of the two workshops is given in Table 5.3.

Table 5.3 *Ecotoxicological assessment criteria for PAHs in Mytilus derived by the different workshops (mg/kg dw)*

Substance	EAC Second workshop (mg/kg dw)	EAC Third workshop (mg/kg dw)
naphthalene	0.005-0.05 (p)	0.5-5 (p)
phenanthrene	1-10 (p)	5.0-50 (p)
anthracene	0.005-0.05 (p)	0.005-0.05 (p)
fluoranthene	0.5-5 (p)	1-10 (p)
pyrene	n.d.	1-10 (p)
benzo(a)anthracene	0.5-5 (p)	n.d.
chrysene	0.1-1 (p)	n.d.
benzo(k)fluoranthene	n.d.	n.d.
benzo(a)pyrene	0.005-0.05 (p)	5.0-50 (p)

n.d. = no data or insufficient data available
f = firm
p = provisional

5.3 Subgroup on Pesticides and PCBs

Ecotoxicological Assessment Criteria could be derived for all relevant matrices of the five organic substances. Of these only 4 EACs are still provisional and 10 EACs are firm.

Among the five organic substances considered, the derivation of EACs was not relevant for six matrices.

Gaps due to lacking data could be filled in with EACs in all four cases (lindane in fish, DDE in mussel, dieldrin in mussel, PCBs in mussel) where EACs were still missing (Table 5.4).

In three cases (DDE in sediment, PCBs in sediment and fish) the EACs remained unchanged. All other EACs were changed to lower values, due to the more extensive dataset on sensitive species available. The EAC became a factor of 10 lower in 5 cases (lindane in water, DDE in fish, dieldrin in sediment and fish, TBT in water), a factor of 20 lower in one case (TBT in sediment) and a factor of 50 lower in one case (TBT in mussels).

Among the existing EACs from the two former workshops, two became firm (lindane in water, DDE in fish). The status of the other EACs remained unchanged.

Table 5.4 *Overview of derived EACs for Pesticides and PCBs. EACs obtained at this workshop are presented in bold whereas previously obtained EACs are presented in plain text.*

Substance	**EAC Water [µg/l]**	**EAC Sediment [mg/kg dw]**	**EAC Fish [mg/kg fw]**	**EAC Mussel [mg/kg dw]**
DDE	n.r.	**0.0005-0.005 (p)** 0.0005-0.005 (p)	**0.005-0.05 (f)** 0.05-0.5 (p)	**0.005-0.05 (f)** n.d.
Dieldrin	n.r.	**0.0005-0.005 (p)** 0.005-0.05 (p)	**0.005-0.05 (f)** 0.05-0.5 (f)	**0.005-0.05 (f)** n.d.
Lindane	**0.0005-0.005 (f)** 0.005-0.05 (f)	n.r.	**0.0005-0.005 (f)** n.d.	n.r.
ΣPCB_7	n.r.	**0.001-0.01 (p)** 0.001-0.01 (p)	**0.001-0.01 (f)** 0.001-0.01 (f)	**0.005-0.05 (f)** n.d.
TBT	**0.00001-0.0001 (f)** 0.0001-0.001 (f)	**0.000005-0.00005 (p)** 0.0001-0.001 (p)	n.r.	**0.001-0.01 (f)** 0.05-0.5 (f)

n.r. = not relevant
n.d. = not derived

5.3.1 DDE

water not relevant
sediment the present provisional EAC remained the same as at the first workshop, although new data were used during the present workshop
fish the present EAC is a factor of 10 lower than the previous provisional one and became firm. During the first workshop a NEC predator for DDE of 1 mg/kg fw in food has been applied, whereas now a NEC predator of 0.015 mg/kg food and a conversion factor of 0.32 were applied
mussel the present, firm EAC has been determined for the first time, as data were not available to the previous workshops.
A detailed subgroup report can be found at Annex 19

5.3.2 Dieldrin

water not relevant
sediment the present, provisional EAC is a factor of 10 lower than the previous one and still provisional. During the first workshop the EqP-method was used, whereas now the lower TEL-value has been taken
fish the present, EAC is still firm, but a factor of 10 lower than the previous one. During the first workshop, secondary poisoning was used to derive the EAC, but now the BCF-method was preferred because it gave lower values
mussel the present, firm EAC has been determined for the first time, as data were not available to the previous workshops.

A detailed subgroup report can be found at Annex 18

5.3.3 Lindane

water the present EAC is a factor of 10 lower than the previous one and became firm. During the first workshop, a fresh water NOEC of 2.2 µg/l had been used, whereas during the present workshop a salt water LC50 of 0.17 µg/l was applied.

sediment not relevant

fish the present firm EAC has been determined for the first time, as data were not available to the previous workshops

mussel not relevant.

A detailed subgroup report can be found at Annex 16

5.3.4 ΣPCB_7

water not relevant

sediment the present, provisional EAC is the same as the EAC of the previous workshop since the same value has been used for the calculation

fish the present, firm EAC is the same as the previous, firm one

mussel the present, firm EAC has been determined for the first time. The same secondary poisoning data as for fish have been used and were corrected for mussels.

A detailed subgroup report can be found at Annex 20

5.3.5 TBT

water the present, firm EAC is a factor of 10 lower than the previous, firm EAC. Additional data on growth appeared to be more sensitive than imposex and have been used

sediment the present, provisional EAC is a factor of 20 lower than the previous, provisional EAC. The previous EAC was based on the mean value of a field experiment and an EqP-value. The present EAC is based on the EqP-method only using the low aquatic toxicity value

fish not relevant

mussel the present, firm EAC is a factor of 50 lower than the previous one. Presently the BCF-approach was applied on the low aquatic value, whereas before less sensitive field data on *Nucella* were used.

A detailed subgroup report can be found at Annex 17

5.4 Subgroup on Metals

The present workshop has set new EACs for the metals As, Cd, Cr, Cu, Hg, Ni, Pb and Zn in water, and sediment. The EACs are presented in Table 5.5 together with the previously obtained EACs (from EAC 1/2). The changes in EACs relative to earlier workshops reflect the increased size and quality of data sets available to the present workshop.

Table 5.5 *Overview of derived values. EACs obtained at this workshop are presented in bold whereas previously obtained EACs are presented in plain text.*

Metal	Water (µg/l)	Sediment (mg/kg dw)	Fish (mg/kg fw)	Mussel (mg/kg dw)
As	**1-10 (f)** 1-10 (f)	**1-10 (p)** 1-10 (p)	n.r.	n.r.
Cd	**0.01-0.1 (f)** 0.1-1 (f)	**0.1-1 (p)** 0.5-5 (p)	**f.c.** 0.01-0.1 (p)	**f.c.** 0.1-1.0 (p)
Cr	**1-10 (f)** 1-10 (f)	**10-100 (p)** 5-50 (p)	n.r.	n.r.
Cu	**0.005-0.05 (f)** 0.01-1 (f)	**5-50 (p)** 5-50 (p)	**f.c.** 0.05-0.5 (p)	**f.c.** 0.05-0.5 (p)
Hg	**0.005-0.05 (f)** 0.001-0.01 (f)	**0.05-0.5 (p)** 0.05-0.5 (p)	**f.c.** 0.05-0.5 (f)	**f.c.** n.d.
Ni	**0.01-0.1 (p)** 0.1-1 (f)	**5-50 (p)** n.a.	n.r.	n.r.
Pb	**0.5-5 (f)** 0.1-1 (f)	**5-50 (p)** 5-50 (p)	**f.c.** n.d.	**f.c.** n.d.
Zn	**0.5-5 (f)** 0.5-5 (f)	**50-500 (p)** 10-100 (p)	n.r.	n.r.

f = firm
p = provisional
f.c. = for future consideration
n.r. = not relevant
n.d. = no data or insufficient data available
n.a. = not available

5.4.1 Water

All EACs set for metals in water were set as firm except Ni, which was set as provisional. The EAC for Ni was set as provisional due to a limited set of toxicity data for marine species. A very low EAC was derived for Cu in water, presumably due to the large bioavailability that can be attained in experimental systems. The EAC was supported by a substantial database on both chronic and acute toxicity. However, this EAC should be used to assess the bioavailable fraction of Cu in seawater and not total Cu. The remainder of the EACs were based on substantial data sets and represent reasonable estimates at the current state of knowledge. A comparison of the EACs (Table 5.5) derived with previous values shows the following:

As the EAC for As in water (1-10 µg/l, firm value) is identical to the previously obtained EAC

Cd the EAC set for Cd in water (0.01-0.1 µg/l) remains firm but is a factor of 10 lower than the range set previously

Cr the firm EAC for Cr in water (1-10 µg/l) is identical to the criterium derived previously

Cu the firm EAC obtained for Cu in water (0.005-0.05 µg/l) is 20 times lower than the EAC set previously. The lower EAC appears to be the result of a larger data set for chronic effects of copper made available for the present workshop.

Hg the EAC obtained for Hg in water (0.005-0.05 µg/l) is a factor of 5 higher than the one previously derived

Ni because only one chronic toxicity study was available for Ni, the EAC for water was set as a provisional range from 0.01-0.1 µg/l. This is a factor of 10 lower than the previously set firm EAC for Ni of 0.1-1 µg/l.

Pb the EAC obtained for Pb in the water compartment of 0.5-5 µg/l is a factor of 5 higher than the one previously obtained (0.1-1 µg/l) and is considered firm, identical to the original EAC.

Zn the firm EAC for Zn in water of 0.5-5 µg/l is equivalent to the criterion obtained at the previous workshops.

5.4.2 Sediment

All EACs for metals in sediment were set using the TEL-value from the Canadian BEDS database and were classified as provisional. As argued above, neither equilibrium partitioning nor spiked sediment assays were found to be satisfactory methods for the setting of EACs.

A comparison of the present EACs with those derived previously (Table 5.5), shows the following:

As the provisional EAC derived for sediment is identical to the EAC derived previously

Cd a provisional EAC for Cd in sediment of 0.1-1 mg/kg dw was obtained which was a factor of 5 lower than that the EAC derived previously. The difference may be ascribed to the methods used for deriving the sediment criteria. The criterion obtained at the workshop in Scheveningen (1993) was based on the NOEL (BEDS) of 1 mg/kg dw whereas the EAC obtained during the present workshop was derived by using the TEL-value of 0.676 mg/kg dw

Cr the provisional EAC derived for sediment is a factor 2 higher than was derived previously

Cu the provisional EAC derived for sediment is identical to the EAC derived previously

Hg the provisional EAC derived for sediment is identical to the EAC derived previously

Ni the provisional EAC for Ni in sediment of 5-50 mg/kg dw can not be compared to a previous value as the previous workshops did not derive an EAC

Pb the provisional EAC derived for sediment is identical to the EAC derived previously

Zn a provisional EAC for Zn in sediment of 50-500 mg/kg dw was determined. This value lies a factor of 5 above the previously set EAC. The previous EAC was based on the NOEL (BEDS) of 68 mg/kg dw whereas the present EAC was based on the TEL-value of 124 mg/kg dw which may explain the difference.

5.4.3 Biota

As no EACs were derived for metals in biota, a comparison with values derived previously was not made

Chapter 6 - Comparison with Background Concentrations and Monitoring Data

6.1 General

The Terms of Reference for the present workshop state that one of its tasks is to: 'provide clear guidance on [1] the use of Ecotoxicological Assessment Criteria (EACs) agreed upon, with regard to the assessment of marine monitoring data generated within the framework of JAMP (by means of examples) and on [2] the relative use of ecotoxicological assessment criteria and background/reference concentrations'

For this purpose, ICES kindly made available JMP data sets. The data sets have been selected according to the following criteria:

a. it should provide general information on the possible application of EACs;

b. it should provide information on the results that could be expected from such an exercise; and

c. it should provide the possibility to elaborate on 'technical' guidance for the application of EACs. For example, two aspects that should be dealt with are the application of EACs in relation to background concentrations and the possible ways of converting EACs if they are not expressed on the same basis as the monitoring data (e.g. whole body EACs vs fish liver monitoring data).

It was considered essential to use monitoring data with appropriate QA. The data sets supplied by ICES on sediment and biota were used in former JMP Ad Hoc Mon assessments, respectively the assessments of 1992 and 1993, and have therefore been checked on QA. For data sets on concentrations in seawater, the QA was checked before data were included in the QSR 1993. In order to allow the workshop to give technical guidance for the application of EACs, monitoring data for all matrices, (water, sediment and biota (fish and mussel)) were selected. To get a realistic idea of the possible results of an assessment using EACs, the chosen data sets covered as far as possible the whole Convention area. However, one should bear in mind that, especially for organic substances, some data sets were quite limited.

For a comparison with background concentrations, the draft report of the 1996 OSPAR/ICES Workshop on Background Concentrations in Hamburg (EAC 4/Info.1) was used. As a simple way of applying the assessment criteria each data set has been presented in a Box and Whisker plot (Annex 29), and compared to the EAC range as well as to relevant background concentrations. These ranges have been compared and this gives an indication of the possible outcome of the application of the proposed EAC. The results of these comparisons give an indication how 'realistic' the derived ranges are.

6.2 Subgroup on PAHs

6.2.1 Comparison with Background Values

The background values used in this comparison were the highest values reported for the Convention Area (EAC 4/Info.1).

a. Water

The data was compared to background values from the draft report of the 1996 OSPAR/ICES Background Concentrations Workshop (Table 6.1 and EAC 4/Info.1) and the data clearly shows that the EAC values derived exceed background values by several orders of magnitude.

Table 6.1 *Ecotoxicological assessment criteria for polyaromatic hydrocarbons compared to background concentrations for water (µg/l)*

Substance	EAC	Background concentration
naphthalene	5-50	< 0.0027
phenanthrene	0.5-5	< 0.0064
anthracene	0.001-0.01	< 0.000041
fluoranthene	0.01-0.1	< 0.00029
pyrene	0.05-0.5	< 0.000053
benzo(a)anthracene	n.d.	< 0.0000058
chrysene	n.d.	< 0.000057
benzo(k)fluoranthene	n.d.	< 0.0000031
benzo(a)pyrene	0.01-0.1	< 0.0000052

n.d. = no data or insufficient data available

b. Sediments

The data are compared in Table 6.2 and show that the lowest end of the EAC range is greater than the background concentration except in the case of pyrene. It is worth noting that pyrene was the only PAH in which the EAC for sediment was derived by partitioning and in which the K_{oc} was calculated from the K_{ow}. The EAC range for pyrene is also a factor of 3 lower than the TEL/PEL values from Environment Canada of 0.15/1.40

c. Biota

No background data on biota were available

The subgroup concluded that the comparison with background values indicated that the EACs ranges for PAHs were sufficiently distinct from the background range to allow their use in making assessments of chemical monitoring data.

Table 6.2 *Ecotoxicological assessment criteria for polyaromatic hydrocarbons compared to background concentrations for sediment (mg/kg dw, 1% OC)*

Substance	**EAC**	**Background concentration**	**Ratio[1] EAC:BKGRD**
naphthalene	0.05-0.5	< 0.026	1.9
phenanthrene	0.1-1	< 0.046	2.2
anthracene	0.05-0.5	< 0.015	3.3
fluoranthene	0.5-5	< 0.048	10.4
pyrene	0.05-0.5	< 0.054	0.9
benzo(a)anthracene	0.1-1	< 0.018	5.6
chrysene	0.1-1	< 0.016	6.2
benzo(k)fluoranthene	n.d.	< 0.095	-
benzo(a)pyrene	0.1-1	< 0.036	2.8

1 = Ratio derived using the lower end of the EAC range
n.d. = no data or insufficient data available

6.2.2 Comparison with Monitoring Data

Because PAHs are voluntary parameters in the JMP programme, only very limited data sets were available for comparison. These data sets were benzo[a]pyrene in sediments and *Mytilus* and fluoranthene in *Mytilus*. The data, expressed as a Box and Whisker plots, are shown in Annex 29 together with information on the range of background values and the EAC. It is clear that the EAC for benzo[a]pyrene in sediment is well above the background value and encompasses the lower percentile of the monitoring data. For *Mytilus* there are no agreed background values and the benzo[a]pyrene levels are completely encompassed by the EAC range whereas for fluoranthene the EAC is an order of magnitude below the range of data presented.

The subgroup concluded that the range of monitoring data available was insufficient to enable a proper evaluation of the EACs for PAH to be made.

6.3 Subgroup on Pesticides and PCBs

6.3.1 General remarks

Because TBT and the organochlorine compounds under consideration are manmade substances, no comparison with natural background concentrations can be made. However, at the Hamburg background concentration workshop a value for ΣPCB_7 in biota was derived for relatively uncontaminated areas, and this value was compared with the corresponding EAC.

To evaluate the practical applicability of the EACs, it was checked whether the EAC range was above the detection limit and whether there was a need to use conversion factors before the derived

EACs could be applied because of differences in the way they are expressed (e.g. whole body vs. liver). Furthermore, for all substances a comparison was made between the EACs and monitoring data to give an indication of the order of magnitude of the EACs in relation to the concentrations in the field. For those substances for which no JMP data were available, national monitoring data were used for this comparison.

6.3.2 DDE

Mussel All monitoring data fell within the EAC range for DDE in mussel. The data set was too small to allow a conclusion based on this comparison.

Fish **fish muscle** The EAC for DDE in fish muscle fell within the range of JMP monitoring data. It was concluded that there were no practical problems in the application of the derived EAC but that the data set was too small to allow a conclusion based on this comparison.
fish liver For fish liver, the EAC was not considered directly applicable because the EAC is derived for whole body concentrations and the concentrations in liver may be significantly higher. Application of the " Fish EAC" on fish liver data will overestimate the risk for marine organisms. It is recommended to derive fish liver/muscle ratio's for DDE in fish and correct fish liver data before assessing the data with the "Fish EAC".

6.3.3 Dieldrin

Sediment The EAC range is above the detection limit, the JMP monitoring data were within the EAC range. It was concluded that there were no practical problems in the application of the derived EAC and that the results of the comparison did not seem unrealistic.

Mussel All monitoring data fell within the EAC range for dieldrin in mussel. The data set was too small to allow a conclusion based on this comparison.

Fish **fish muscle** The EAC for dieldrin in fish muscle fell below and within the range of JMP monitoring data. It was concluded that there were no practical problems in the application of the derived EAC but that the data set was too small to allow a conclusion based on this comparison.
fish liver For fish liver, the EAC was not considered directly applicable because the EAC is derived for whole body concentrations and the concentrations in liver may be significantly higher. Application of the " Fish EAC" on fish liver data will overestimate the risk for marine organisms. It is recommended to derive fish liver/muscle ratio's for dieldrin in fish and correct fish liver data before assessing the data with the "Fish EAC".

6.3.4 Lindane

Water The JMP monitoring data concern total (unfiltered) concentrations, the EAC for lindane in water are based on dissolved concentrations. Because the amount of lindane adsorbed on suspended solids is considered to be negligible compared to the dissolved concentration, it was concluded that the EAC for lindane can be used to assess unfiltered concentrations in water. The EAC range fell within the measured concentrations, with the highest value approximately 5 times the upper level of the EAC range. The detection limit for lindane in water is below the EAC range. It was concluded that there were no practical problems in the application of the derived EAC and that the results of the comparison did not seem unrealistic.

Sediment Although for lindane sediment is not a preferred matrix in the JMP programme, JMP monitoring data were available (110 records) and an EAC was derived and compared with the field data. For lindane in sediment, it was recommended that the EAC should be applied on the carbon-normalised data. Detection limits in sediment might fall within the lower range of the EAC. The EAC for lindane in sediment fell within the range of the JMP monitoring data. It was concluded that, apart from possible problems with the detection limit at lower concentrations, there were no practical problems in the application of the derived EAC and that the results of the comparison did not seem unrealistic.

Mussel Although for lindane mussel is not the preferred matrix in the JMP programme, JMP monitoring data were available (49 records) and an EAC was derived and compared with the field data. The EAC for lindane in mussel fell within the range of monitoring data with the highest value reported approximately 3 times the upper level of the EAC range. The results of this comparison did not seem unrealistic, although the data set was too small to allow a firm conclusion.

Fish **fish muscle** .The EAC for lindane in fish muscle fell within the range of monitoring data (24 records) with no value exceeding the EAC range. The data set was too small to allow a conclusion based on this comparison.

fish liver For fish liver, the EAC was not considered directly applicable because the EAC is derived for whole body concentrations and the concentrations in liver may be significantly higher. Application of the “ Fish EAC” on fish liver data will overestimate the risk for marine organisms. It is recommended to derive fish liver/muscle ratio’s for lindane in fish and correct fish liver data before assessing the data with the” Fish EAC”.

6.3.5 ΣPCB_7

Sediment For PCB in sediment, it was recommended that the EAC should be applied on the carbon-normalised data. The EAC range lies above the detection limit in sediment. The JMP monitoring data (128 records) were above or within the EAC range, the highest value approximately 12 times the EAC upper level. It was concluded that there were no practical problems in the application of the derived EAC and that the results of the comparison did not seem unrealistic.

Mussel The EAC for mussel was in all cases lower than the monitoring data. The data set was too small to allow a conclusion based on this comparison.

Fish **fish muscle** At the Hamburg background concentration workshop a value for ΣPCB_7 in biota was derived for relatively uncontaminated areas, and this value was compared with the corresponding EAC. The upper level of the (anthropogenic) background concentration corresponds with the lower level of the EAC. The EAC range is above the detection limit in fish. The EAC for PCB in fish muscle is below the range of monitoring data (37 records), the highest value being approximately 10 times the upper level of the EAC range. It was concluded that there were no practical problems in the application of the derived EAC but that the data set was too small to allow a conclusion based on this comparison.

fish liver For fish liver, the EAC was not considered directly applicable because the EAC is derived for whole body concentrations and the concentrations in liver may be significantly higher. Application of the “ Fish EAC” on fish liver data will overestimate the risk for marine organisms. It is recommended to derive fish liver/muscle ratio's for PCB in fish and correct fish liver data before assessing the data with the "Fish EAC".

6.3.6 TBT

Sediment For TBT in sediment, no JMP data sets were available. Instead, national monitoring data from the Netherlands and France have been have been evaluated. The provisional EAC is much lower than both the monitoring data and the detection limit. Taking into account the uncertainties with respect to sediment-partitioning (whether behaviour can simply be described on the basis of a relation with de octanol-water partition coefficient - as was assumed) the EAC for TBT in sediment should be applied with caution.

Mussel For TBT in biota, no JMP data sets were available. Instead, national data from the Netherlands have been used. The EAC is mainly lower than the monitoring data. The detection limit was within the range of the EAC. Taking into account the regional origin of the monitoring data the EAC for TBT in biota is considered realistic and applicable.

6.4 Subgroup on Metals

6.4.1 General remarks

The EACs derived for metals in water, sediment and biota were compared to background concentrations (EAC 4/Info.1), JMP monitoring data and national monitoring data (Annex 29).

6.4.2 Metals in water

As no background concentrations were available for As in water (see Table 6.3).

Cd the lower end of the EAC for Cd in water lies close to the upper end of mean background concentrations (0.002-0.012 µg/l, see Table 6.3).

Cr the EAC for Cr in water lies well above mean background concentrations (0.05 µg/l, see Table 6.3).

Cu mean background concentrations of Cu lies, according to EAC 4/Info.1, in the range of 0.03-0.36 µg/l, which is well above the EAC. The EAC for Cu in water should be compared to the bioavailable fraction and not to total Cu in seawater

Hg comparison with the mean background concentrations for Hg in water (0.00005-0.0001 µg/l) reveals that the EAC set for Hg in water (0.005-0.05 µg/l) is above background levels.

Ni comparison with mean background concentrations of Ni of 0.1-0.24 µg/l reveals that the EAC lies below the background level of Ni with the exception of the upper limit. The EAC for Ni in water may be too low and should therefore be used with caution.

Pb the mean background concentration of Pb in water lies in the range 0.005-0.02 µg/l. The EAC for Pb lies well above this range.

Zn comparison with background values for Zn in seawater of 0.1-0.28 µg/l reveals that the set criterion for Zn in seawater is above background concentrations.

Table 6.3 *Overview of background concentrations for metals in different matrices (from EAC 4/Info.1)*.

Metal	Water (µg/l)[1]	Sediment (mg/kg dw)[2]	Fish (mg/kg fw)	Mussel (mg/kg dw)[3]
As	n.a.	9	n.r.	n.r.
Cd	0.002-0.012	0.05	n.a.	0.525-0.818
Cr	0.05	25	n.r.	n.r.
Cu	0.03-0.36	15	n.a.	5.7-8.25
Hg	0.00005-0.0001	0.03	0.01-0.03 (cod) 0.03-0.07 (flatfish)	0.038-0.075
Ni	0.1-0.24	4	n.r.	n.r.
Pb	0.005-0.02	12	n.a.	0.075-1.425
Zn	0.1-0.28	32	n.r.	n.r.

n.a. = not available
n.r. = not relevant
1 = range of median values (EAC 4/Info.1)
2 = lowest median value (EAC 4/Info.1)
3 = dry weight values for mussel was calculated from wet weight using a conversion factor of 0.134

6.4.3 Metals in sediment

Except for As, the EACs for metals in sediment were either above background concentrations of the relevant metal (Cd, Cr, Hg, Ni, Zn) or the background concentrations overlapped with the lower end of the EAC range (Cu, Pb). The sediment EACs represent good indications of ranges above which biological effects may appear. It should be noted that various non-contaminant sediment factors such as particle size distribution, organic content (although standardised to 1%), redox-conditions and biological activity will affect the bioavailability of metals in natural sediments, which are not accounted for in the derivation of EACs.

6.4.4 Metals in biota

The workshop decided not to derive EACs for metals in biota, because of methodological problems which resulted in large uncertainties and overestimation of metal toxicity. Thus no EACs were derived for Cd, Cu, Hg or Pb in biota. Extrapolated concentrations for these metals, documented in the Annexes, were generally lower than background concentrations.

6.5 Conclusions

PAHs

1. the EACs ranges for PAHs were sufficiently distinct from the background range to allow their use in making assessments of chemical monitoring data.
2. the range of monitoring data available was insufficient to enable a proper evaluation of the EACs for PAH to be made.

Pesticides and PCBs

3. Because TBT and the organochlorine compounds under consideration are manmade substances, no comparison with natural background concentrations could be made, with the exception of PCB in fish for which an anthropogenic background concentration was derived at the 1996 OSPAR/ICES Workshop. The upper level of the (anthropogenic) background concentration for ΣPCB_7 corresponds with the lower level of the EAC.
4. It was concluded that there were no practical problems in the application of the derived EAC, except for the assessment of concentrations in fish liver. It is therefore recommended to derive fish liver/muscle ratio's and correct fish liver data before assessing the data with the "Fish EAC".
5. The comparison with available monitoring data showed that most EACs fell within the range of monitoring data, and some below. This was concluded to be not unrealistic. However, for a number of substances and matrices the available data sets were too limited to allow any firm conclusions based on this comparison.

Metals

6. The EACs for As, Cd, Cr, Hg, Pb and Zn in water are all based on substantial data sets and represent reasonable estimates at the current state of knowledge. These EACs were all above the background concentrations (for As no background concentration in water was available).
7. The toxicity data set for Ni in water was limited and the EAC was therefore classified as provisional. The EAC derived is below the background concentration. The EAC for Ni in water may be too low and should therefore be used with caution.
8. The firm EAC for Cu in water was based on a substantial data set but the background concentrations were well above the EAC. The EAC for Cu in water should be compared to the bioavailable fraction and not to total Cu in seawater.
9. The sediment EACs for metals are all classified as provisional but represent good indications of ranges above which biological effects may appear. The EACs were either above background concentrations (Cd, Cr, Hg, Ni, Zn) or overlapped with the background concentrations (Cu and Pb). It should be noted that various non-contaminant sediment factors will affect the bioavailability of compounds in natural sediments, which are not accounted for in the derivation of EACs.
10. The workshop decided not to derive EACs for metals in biota, because of methodological problems which resulted in large uncertainties and overestimation of metal toxicity. Thus no EACs were derived for Cd, Cu, Hg or Pb in biota.

Chapter 7 - Benefits and Limitations of EACs

7.1 Introduction

Ecotoxicological assessment criteria (EACs) have been developed to evaluate the chemical monitoring data that have been collected over the years in the OSPAR convention area. In general assessment criteria can be used to evaluate monitoring data by comparing them with other relevant data. Objectives for this assessment can be, *inter alia*, to determine whether concentrations are exceeding their background levels, whether effects on biota are likely to occur, and to identify the geographical area involved (areas of concern). Alternatively this information can be used to optimise the monitoring programme, because it provides guidance on the selection of areas where the monitoring should focus on. In this Chapter, an overview is given of the benefits and limitations based on discussion of the workshops 1 to 3 (EAC 1/2, 1/3) the comments of ICES ACME report (included in EAC 1/3) and the comments of WWF (EAC 5/Info.1).

7.2 Benefits

The benefits of using assessment criteria based on ecotoxicological data , such as EACs, are:

a. the assessment gives a better idea of the quality of the marine environment than an assessment of the chemical monitoring data alone, as information on potential effects of the contaminants is provided;

b. these criteria provide an absolute yardstick to compare the data with in contrast to the statistical approach which has been used so far (upper quartiles);

c. EACs can be diagnostic. When effects are observed in a general biological effects program, the EACs can be used to diagnose which compounds may be responsible.

Concerning the assessment of the JMP/JAMP data sets up to 1996, one should realise that there is a very limited amount of biological effects data which could be used for the interpretation of the monitoring data in terms of effects on biota. The identification of potential effects on the basis of ecotoxicological data (EACs) is therefore the only instrument available to retrospectively assess the quality of the marine environment for the bulk of the data collected under the JMP/JAMP.

7.3 Limitations of the EAC approach

Limitations of the EAC approach can be classified into three areas: [1] general limitations of the approach; [2] problems in the derivation of EACs; [3] problems in the application of EACs.

7.3.1 General limitations of the approach

a. The assessment criteria presented in this document were derived for individual substances separately, without specifically addressing the possible interactions with other substances. In the field, especially in estuaries and in coastal areas, organisms are exposed to numerous substances at the same time. Interactions between different (groups of) substances may lead to antagonistic, synergistic or additive effects. For chemicals with a specific toxicity mechanism (such as PCBs, dioxins and dibenzofurans) or a non-specific (narcotic) mode of action the effects of mixtures of chemicals can often be adequately described by concentration addition. The combined toxicity of a mixture of substances with different toxic mechanisms, however, is extremely difficult to estimate. Besides the fact that the mixture of chemicals in the field changes from place to place, present scientific knowledge is too limited to even establish a scientifically based (additional) safety factor for combination toxicity. Therefore, in deriving ecotoxicological assessment criteria, the first workshop in Scheveningen decided, for the time being, not to take into account possible effects of combination toxicity. An exception to this may be the use of BEDS which does indirectly account for mixtures and bioavailability.

b. The EAC approach does not account for reductions in biological availability of contaminants as a result of geochemical processes (e.g. ageing). Such processes however do occur in the field.

c. As the EACs are used within the context of the OSPAR monitoring program, an assessment using EACs can only distinguish possible effects of the compounds which are being monitored and therefore will not detect effects of the wide variety of other chemicals that are present in the marine environment.

d. This approach may not relate to specific routes of exposure such as exposure via the microsurface layer, which is not being monitored and where high concentrations of organic chemicals might accumulate.

e. In the EAC approach toxicity data are evaluated and the lowest NOEC, or an estimate thereof is selected to derive the EAC. For essential elements however, concentrations may result from this, which indeed are not toxic to the most sensitive organisms but will result in deficiencies for other organisms: what is toxic for some organism may be essential for other organisms.

f. The EAC approach does not allow the evaluation of secondary ecological effects of toxicants such as the reduction in predator numbers following the pollution induced decline of the prey population.

g. The EAC approach does not account for effects which result from pollution related stress in combination with other environmental stresses e.g. infectious diseases, salinity gradients, exposure to air, oxygen deficiencies etc. It is known however that sometimes such effects occur in the field e.g. the viral epidemic which killed half the Dutch common seals population has been related to immunosuppression due to PCB contamination.

7.3.2 Problems in the derivation of EACs

The data sets available to the workshop probably form a state of the art overview of the knowledge on the ecotoxicity of the compounds studied. In addition the individual studies have undergone a quality assessment by the CSR and the critical studies have been reviewed by the workshop members. Despite this, both the quality of the data sets and the quantity of the data may cause problems in the derivation of EACs:

a. the data sets used generally have a bias towards acute and chronic studies which may insufficiently represent long term exposure to contaminants in long-lived species or modes of action such as carcinogenicity and secondary poisoning. During the workshops these shortcomings have been recognised and a procedure for the secondary poisoning approach as described at Annex 6, has been implemented. This approach however does not take into account the difference in assimilation efficiency for the food given to the animals in the experiment (grain) and marine birds or mammals (fish), which may have a small effect on the ultimate value derived. Using expert judgement, the deficiencies in some databases have been taken into account in selecting toxicity studies and extrapolation factors. More chronic data however are urgently needed to be able to take into account e.g. carcinogenic effects when deriving EACs;

b. the data set are not always representative of the wide variety of organisms present in the marine environment. Sometimes data sets are limited to fresh water data only. At the workshops preference was given to the use of marine data, although not all participants were convinced about differences in sensitivity for certain compounds between fresh water and marine organisms. The problem of limited data has been recognised by the workshops and the derivation procedure tries to account for this by the combined use of extrapolation factors and the distinction in firm and provisional EACs. All EACs that have been derived from fresh water toxicity data have been qualified provisional by the workshop. Using expert judgement, the deficiencies in some databases have been taken into account in selecting toxicity studies and extrapolation factors;

c. the data set is not likely to include the most sensitive species. This has been recognised by the workshops and the derivation procedure tries to account for this aspect by the combined use of extrapolation factors and the distinction in firm and provisional EACs;

d. the data set hardly contain any sediment toxicity studies. This has been recognised by the workshops and the derivation procedure tries to account for this aspect by applying the equilibrium partitioning approach and the co-occurence approach. Both approaches are however subject to discussion.

e. the derivation of EACs for sediment or biota can be done by applying a conversion factor to aquatic toxicological data. This was considered to be a very critical step in the procedure which could introduce a lot of uncertainty, especially for metals. Because of this the workshop decided not to extrapolate water concentrations for metals to biota or sediment.

f. the toxicity of the compound may be overestimated by the presence of “false NOECs” in the data set. A false NOEC is based on a toxicity experiment in which the response of an organism upon exposure to a contaminant is interpreted as a toxic effect, which however is not the case as the observed response pattern results from pure chance. The view was expressed that it would be preferable to use either the lower end of the NOEC range, or data that have been derived via statistical methods that take this into account, e.g. BEDS. This was considered an important issue, which could influence the EAC range considerably. Although the quality check on the data includes a close study of the dose response relationship, a NOEC resulting from chance can not be excluded. A close study of the data sets is required to identify such outliers.

g. the derivation procedure of EACs includes the application of factors to account for species variation, differences between LC50 values and concentration at which effects due to chronic exposure might occur, and the extrapolation from a lab situation to a field situation. Depending on the data available, a factor of 10, 100 or 1000 is applied. Although at the Berlin workshop, the applicability of these factors were questioned in relation to the marine environment (they are mostly applied to freshwater data), the participants of the present workshop considered the factors to be appropriate. One should bear in mind that the application of these factors mean that lack of toxicological data will result in a lower range for the EACs.

7.3.3 Problems in the application of EACs

It would be undesirable if the assessment using EACs would either over- or underestimate the potential for pollution related effects in the field.

In the case of an underestimation or a false negative, the concentrations of chemicals are lower than the EACs and consequently no effects on biota are considered likely, yet effects on biota do occur. False negatives can be the result of a number of factors:

- the extrapolation factors applied when deriving an EAC are too small
- other compounds then the ones monitored cause effects
- the compounds monitored contribute to the overall effect by additive or synergistic mixture toxicity
- the risk of secondary poisoning is underestimated. It should be noted that the risk of secondary poisoning is only accounted for in EACs set for biota (Annex 6). As the EACs for water and sediment do not account for this risk an evaluation of the chemical environmental quality of the marine environment for substances liable to accumulate should include an assessment of the monitoring data for biota.

In the case of an overestimation or a false positive, the concentrations of chemicals are higher than the EACs and consequently effects on biota are considered likely, however effects on biota do not occur. False positives can be the result of a number of factors:

- the extrapolation factors applied when deriving an EAC are too high
- the bioavailability of the compounds is reduced
- adaptation of the biota to high levels of pollution

7.4 Conclusions

Compared to the previous workshops significant progress was made: [a] the methods to derive Ecotoxicological assessment criteria were better defined; [b] the assessment of available toxicological data was done in a more systematic way, due to the fact that for each compound an overview of relevant toxicological data was available; [c] the relevant toxicological data were more reliable as a quality check has been introduced; [d] the derivation of ecotoxicological assessment criteria has been documented extensively in the Annexes to this report, together with an overview of the available literature.

The ecotoxicological assessment criteria derived were considered to be reasonable estimates based on the current state of knowledge and were evaluated for their applicability by comparison with monitoring data and background concentrations. Though ecotoxicological assessment criteria for some of the compounds showed some overlap with background concentrations, the criteria together with background concentrations appear useful for preliminary assessments of JMP/JAMP monitoring data and should be considered as guidance for further work.

In this chapter an extensive overview is presented of the benefits and limitations of the derivation and use of ecotoxicological assessment criteria for the assessment of the pollution status of the marine environment. It was concluded that:

[1] The ecotoxicological assessment criteria as given in Table 7.1 should be used to assess JMP/JAMP chemical monitoring data, e.g. for the QSR 2000, taking into account whether an EAC is provisional or firm.

[2] Caution should be exercised in using generic, particularly provisional, assessment criteria in specific situations. Their use does not preclude the use of common sense and expert judgement with regard to the natural concentrations of e.g. trace metals in assessing the (potential for) environmental effects Furthermore, the ecotoxicological assessment criteria do not take into account specific long term biological effects such as carcinogenicity, genotoxicity and reproductive disruption due to hormone balance disturbances and do not include combination toxicity.

[3] The effects of environmental contamination will ultimately have to be assessed in biological terms and SIME is recommended to implement an integrated chemical and biological effects monitoring programme as soon as possible.

Table 7.1 *Overview of ecotoxicological assessment criteria for trace metals, PCBs, PAHs, TBT and some organochlorine pesticides for various matrices*

Cautionary note: These assessment criteria have no legal significance and should only be used for the preliminary assessment of JMP/JAMP chemical monitoring data with the aim of identifying potential areas of concern. When applied, the fact whether an EAC is firm or provisional should be taken into account.

Substance	**Water (µg/l)**	**Sediment (mg/kg dw)**	**Fish (mg/kg fw)**	**Mussel (mg/kg dw)**
Trace metals				
As	1-10 (f)	1-10 (p)	n.r.	n.r.
Cd	0.01-0.1 (f)	0.1-1 (p)	f.c.	f.c.
Cr	1-10 (f)	10-100 (p)	n.r.	n.r.
Cu	0.005-0.05 (f)[1]	5-50 (p)	f.c.	f.c.
Hg	0.005-0.05 (f)	0.05-0.5 (p)	f.c.	f.c.
Ni	0.1-1 (p)	5-50 (p)	n.r.	n.r.
Pb	0.5-5 (f)	5-50 (p)	f.c.	f.c.
Zn	0.5-5 (f)	50-500 (p)	n.r.	n.r.
Organochlorine pesticides				
DDE	n.r.	0.0005-0.005 (p)	0.005-0.05 (f)	0.005-0.05 (f)
Dieldrin	n.r.	0.0005-0.005 (p)	0.005-0.05 (f)	0.005-0.05 (f)
Lindane	0.0005-0.005 (f)	n.r.	0.0005-0.005 (f)	n.r.
PAHs				
Naphthalene	5-50 (f)	0.05-0.5 (f)	n.r.	0.5-5 (p)
Phenanthrene	0.5-5 (p)	0.1-1 (f)	n.r.	5-50 (p)
Anthracene	0.001-0.01 (p)	0.05-0.5 (f)	n.r.	0.005-0.05 (p)
Fluoranthene	0.01-0.1 (p)	0.5-5 (p)	n.r.	1-10 (p)
Pyrene	0.05-0.5 (p)	0.05-0.5 (p)	n.r.	1-10 (p)
Benzo[*a*]anthracene	n.d.	0.1-1 (p)	n.r.	n.d.
Chrysene	n.d.	0.1-1 (p)	n.r.	n.d.
Benzo[*k*]fluoranthene	n.d.	n.d.	n.r.	n.d.
Benzo[*a*]pyrene	0.01-0.1 (p)	0.1-1 (p)	n.r.	5-50 (p)
Benzo[*ghi*]perylene	n.d.	n.d.	n.d.	n.d.
Indeno[*123-c,d*]pyrene	n.d.	n.d.	n.r.	n.d.
ΣPCB_7	n.r.	0.001-0.01 (p)	0.001-0.01 (f)	0.005-0.05 (f)
TBT	0.00001-0.0001(f)	0.000005-0.00005 (p)	n.r.	0.001-0.01 (f)

f = firm
p = provisional
f.c. = for future consideration
n.r. = not relevant in relation to the current monitoring programme
n.d. = no data available or no sufficient data available
1 = this range is within the background range for natural water. This value should be compared to the bioavailable fraction of Cu in seawater

Chapter 8 - Recommendations

8.1 Recommendations with respect to the JMP/ JAMP monitoring programme

a. The ecotoxicological assessment criteria should be used to assess JMP/JAMP chemical monitoring data, e.g. for the QSR 2000, taking into account whether an EAC is provisional or firm.

b. EACs should be used to identify possible areas of concern and indicate which substances could be considered a priority, and should not be used as firm standards or as triggers for remedial action.

c. Caution should be exercised in using generic, particularly provisional, assessment criteria in specific situations. Their use does not preclude the use of common sense and expert judgement with regard to the natural concentrations of e.g. trace metals in assessing the (potential for) environmental effects Furthermore, the ecotoxicological assessment criteria do not take into account specific long term biological effects such as carcinogenicity, genotoxicity and reproductive disruption due to hormone balance disturbances and do not include combination toxicity.

d. The effects of environmental contamination will ultimately have to be assessed in biological terms and SIME is recommended to implement an integrated chemical and biological effects monitoring programme as soon as possible.

e. If effects are found in an integrated chemical and biological effects programme, ecotoxicological assessment criteria can be used to diagnose which compounds may be responsible.

f. Ecotoxicological assessment criteria need to be further refined and updated at intervals of e.g. 5-10 years in order to take account of: a) changes in the parameter list of the JAMP; and b) the availability of new marine toxicity data. Biological effect monitoring data should be taken into account in further deriving such criteria.

8.2 Recommendations with respect to further data requirements

a. There is a need for more long-term toxicity information for those chemicals which are persistent and bioaccumulative. The result of integrated chemical and biological effects programmes also strongly support the further development of EACs.

b. There is an urgent need for the development of sensitive whole sediment experimental models to evaluate the effects of contaminants in sediments.

c. The algorithm for the risk assessment of secondary poisoning was agreed upon by the workshop as an important approach to derive assessment criteria for biota which aim to protect top predators such as fish-eating birds and mammals. More research of this type should be carried out especially for persistent lipophilic contaminants.

d. The EACs for DDE, dieldrin, lindane and PCBs in fish were derived for whole body concentrations, while the monitoring data concern concentrations in liver. As the latter may be significantly higher, correction factors should be developed (e.g. fish liver/muscle ratio's) which allow the comparison of fish liver data with whole body EACs.

OSLO AND PARIS CONVENTIONS FOR THE PREVENTION OF MARINE POLLUTION
THIRD WORKSHOP ON ECOTOXICOLOGICAL ASSESSMENT CRITERIA
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OSLO AND PARIS CONVENTIONS FOR THE PREVENTION OF MARINE POLLUTION
THIRD WORKSHOP ON ECOTOXICOLOGICAL ASSESSMENT CRITERIA
THE HAGUE: 25-29 NOVEMBER 1996

Agenda

1. Adoption of the Draft Agenda
2. Procedure for the Derivation of Ecotoxicological Assessment Criteria
3. Derivation of Ecotoxicological Assessment Criteria
4. Practical use of Ecotoxicological Assessment Criteria
5. Benefits and limitations of Ecotoxicological Assessment Criteria
6. Any other business
7. Adoption of the Summary Record

ANNEX 3

OSLO AND PARIS CONVENTIONS FOR THE PREVENTION OF MARINE POLLUTION

THIRD WORKSHOP ON ECOTOXICOLOGICAL ASSESSMENT CRITERIA

THE HAGUE: 25-29 NOVEMBER 1996

List of Documents

Agenda Item 1

EAC 1/1	Draft Agenda	Secretariat
EAC 1/2	Report Workshop 1	Secretariat
EAC 1/3	Report Workshop 2	Secretariat

Agenda Item 2

EAC 2/1	Review of first and second workshops: Procedure for the derivation of Ecotoxicological Assessment Criteria	Netherlands
EAC 2/2	Quality Criteria for the evaluation of ecotoxicological studies, underlying the derivation of Ecotoxicological Assessment Criteria (EAC)	Netherlands
EAC 2/3	Criteria Setting: compilation of procedures and effect-based criteria used in various countries	Netherlands
EAC 2/4	A method to derive Ecotoxicological Assessment Criteria (EAC) taking possible secondary poisoning into account	Netherlands
EAC 2/5	Can Critical Body Residues be used for the derivation of Ecotoxicological Assessment Criteria for biota?	Netherlands
EAC 2/6	Derivation of Ecotoxicological Assessment Criteria for sediment	Netherlands
EAC 2/Info.1	Fax from Environment Canada re Canadian Sediment Quality Guidelines	Netherlands
EAC 2/Info.2	Draft - Interim Sediment Quality Guidelines: Soil and Sediment Quality Section Guidelines Division	Netherlands

Agenda Item 3

EAC 3/1	Annotated Factsheet	Netherlands
	Factsheets for Trace Metals:	Netherlands
EAC3/2/1	Arsenic	
EAC3/2/2	Cadmium	
EAC3/2/3	Chromium III and Chromium VI	
EAC3/2/4	Copper	
EAC3/2/5	Mercury	
EAC3/2/6	Nickel	
EAC3/2/7	Lead	
EAC3/2/1	Zinc	

	Factsheets for Organochlorine Pesticides:	Netherlands
EAC 3/3/1	DDE	
EAC 3/3/2	Dieldrin	
EAC 3/3/3	Lindane	
	Factsheets for Polycyclic Aromatic Hydrocarbons:	Netherlands
EAC 3/4/1	Naphthalene	
EAC 3/4/2	Phenanthrene	
EAC 3/4/3	Anthracene	
EAC 3/4/4	Fluoranthene	
EAC 3/4/5	Pyrene	
EAC 3/4/6	Benz[a]anthracene	
EAC 3/4/7	Chrysene	
EAC 3/4/8	Benzo[k]fluoranthene	
EAC 3/4/9	Benzo[a]pyrene	
EAC 3/5	Factsheet for the sum of 7 polychlorinated biphenyls (Σ PCBs)	Netherlands
EAC 3/6	Factsheet for tributyltin (TBT)	Netherlands

Agenda Item 4

EAC 4/1	Proposal for a Procedure for a Trial Assessment	Netherlands
EAC4/Info.1	Draft - Report of the Subgroup on Background Concentrations of Organic Contaminants Report of the Subgroup on Background Concentrations of Nutrients Report of the Subgroup on Background Values of Metals in Seawater and Sediments Report of the Subgroup on Background Concentrations in Biota	Germany

Agenda Item 5

EAC 5/Info.1	Limitations of Ecotoxicological Assessment Criteria for Contaminants within the Marine Environment and Suggestions for Improving the Monitoring Undertaken	World Wide Fund for Nature (WWF)

OSLO AND PARIS CONVENTIONS FOR THE PREVENTION OF MARINE POLLUTION
THIRD WORKSHOP ON ECOTOXICOLOGICAL ASSESSMENT CRITERIA
THE HAGUE: 25-29 NOVEMBER 1996

Terms of Reference

The terms of reference for the workshop are as follows:

1. To fill in gaps in assessment criteria for those substances and matrices (water, sediment, and/or biota) for which the former two workshops have not yet provided data (see Table 1).

2. To upgrade the 'provisional' and/or 'firm' ecotoxicological assessment criteria (see Table 1).

3. To provide clear guidance on:
   a. the applicability of this approach, its benefits and its limitations;
   b. the use of the ecotoxicological assessment criteria agreed upon to date, with regard to the assessment of marine chemical monitoring data generated within the framework of the JAMP (by means of examples);
   c. the relative use of ecotoxicological assessment criteria and background/ reference concentrations.

4. To prepare an overview of the results of the three workshops on ecotoxicological assessment criteria, i.e.:
   a. the workshop held in Scheveningen (The Netherlands) November 1993;
   b. the workshop held in Berlin (Germany) November 1995;
   c. the present workshop.

Table 1: Overview of ecotoxicological assessment criteria for trace metals, PCBs, PAHs, TBT and some organochlorine pesticides for various matrices

	Water	**Sediment**	**Fish**	**Mussel**
Trace metals				
As	f (S)	p (S)	nr	nr
Cd	f (S)	p (S)	p (B)	p (B)
Cr	f (S)	p (S)	nr	nr
Cu	f (S)	p (S)	p (B)	p (B)
Hg	f (S)	p (S)	f (S)	fc
Ni	f (S)	fc	nr	nr
Pb	f (S)	p (S)	fc	fc
Zn	f (S)	p (S)	nr	nr
Organochlorine pesticides				
DDE	nr	p (S)	p (S)	fc
Dieldrin	nr	p (S)	f (S)	fc
Lindane	p (S)	nr	fc	nr
PAHs				
Naphthalene	p (S)	p (S)	nr	p (B)
Antracene	p (S)	p (S, B)	nr	p (B)
Fluoranthene	p (S)	p (S, B)	nr	p (B)
Benzo[*a*]Pyrene	p (S)	p (S,B)	nr	p (B)
Chrysene	nr	p (B)	nr	p (B)
Benzo[*a*]anthracene	nr	p)B)	nr	p (B)
Phenanthrene	nr	p (B)	nr	p (B)
Benzo[*a*]perylene	nr	no data available	nr	no data available
Pyrene	nr	p (B)	nr	no data available
Indeno[123-*c,d*]pyrene	nr	no data available	nr	no data available
ΣPCB	nr	p (S)	f (S, B)	fc
TBT	f (S)	p (S)	nr	f (S)

Results of the workshops in Scheveningen (S) and Berlin (B)
f = firm
p = provisional
fc = for future consideration
nr = not relevant in relation to the current monitoring programme
An explanation of 'f', 'p', 'fc' and 'nr' in the reports of the workshops in Scheveningen and Berlin

ANNEX 5

OSLO AND PARIS CONVENTIONS FOR THE PREVENTION OF MARINE POLLUTION

THIRD WORKSHOP ON ECOTOXICOLOGICAL ASSESSMENT CRITERIA

THE HAGUE: 25-29 NOVEMBER 1996

Quality Criteria for the Evaluation of Ecotoxicological Studies, Underlying the Derivation of Ecotoxicological Assessment Criteria (EAC)

CONTENTS

1. SUMMARY

In this document the quality criteria applied for evaluation of the ecotoxicological data, underlying the derivation of Ecotoxicological Assessment Criteria (EAC) are presented. An overview of the used literature sources and the applied search strategies are given, as well as the quality criteria applied for evaluation of the ecotoxicological data and data on sediment partition coefficients.

2. INTRODUCTION

In this document the quality criteria applied for evaluation of the ecotoxicological data, underlying the derivation of Ecotoxicological Assessment Criteria (EAC) are presented.

The evaluation of the data used for derivation of the EACs for the workshop is carried out by the Centre for Substances and Risk Assessemnt (CSR[1]) of the National Institute of Public Health and the Environment (RIVM[2]) in the Netherlands. The CSR has experience in the evaluation of data: e.g. notification procedures for new substances and pesticides and derivation of environmental quality objectives. A Quality Assurance (QA) System has been developed recently. Subsequently, the main part of the present document stems from Standard Operating Procedures written in the context of this QA-system.

A comparison with quality criteria by (inter)national organisations like the European Union or the International Commission for the Protection of the Rhine is not possible at the moment as these criteria do not exist or have not been published.

The steps necessary to derive ecotoxicological data for fresh- and saltwater organisms, birds and mammals and sediment water partition coefficients from literature are presented in this document in sequence: starting with the collection of literature (chapter 2) followed by the preparations necessary for evaluation (chapter 3). Finally, in chapter 4 the evaluation procedures of the individual literature are outlined.

3. COLLECTING LITERATURE

For the derivation of EACs it is essential to consult <u>all</u> relevant literature sources available: this means public as well as 'grey' literature from sources within and outside the CSR. In this chapter all consulted literature sources are outlined. These sources are separated in internal- (paragraph 2.1) and external (paragraph 2.2) CSR literature sources.

A request to send grey literature to the organisors of the workshop was published in the SETAC Europe Newsletter from July (1996), vol. 7, issue 4 and was send to a large number of scientists (Annex 2). A list of the studies that were submitted in response to these requests is at Annex 3.

[1] Abbreviation in Dutch for 'Centre for Substances and Risk Assessment'.
[2] Abbreviation in Dutch for 'National Institute of Public Health and the Environment'.

3.1. Internal CSR literature sources

The internal sources are:

- The CSR documentation with 'grey' literature.
- The CSR library containing reviews and handbooks (see annex 1). These sources are being screened for the original public literature references.
- The 'Ecotox literature' database. This CSR database is checked for relevant articles from public literature that already have been collected and evaluated in previous projects.

3.2. External CSR literature sources

The external literature sources are:

- The library of the National Institute of Public Health and the Environment. In this library a large quantity of national and international literature is available.
- On-line/CD-ROM search. An on-line search action is carried out, based on the year of publication of the most recent reliable review of the compound of concern. The on-line search starts 2 years before the publication year of this review. If no reviews are available, the on-line search starts from 1970 or from the beginning of the database in question. The on-line sources often consulted are the bibliographic databases BIOSIS and TOXLINE.

The reference lists of all studies and articles collected from all mentioned sources, are critically screened for relevant literature which is not yet retrieved.

4. START OF THE EVALUATION PROCEDURE

It is essential to obtain information about physical-chemical properties (paragraph 3.1) and properties concerning degradation (paragraph 3.2).

4.1. Physical-chemical properties

Water solubility

The water solubility has to be determined at a temperature (nearly) equal to the temperature of the toxicity test. If the result of a toxicity test is above the water solubility, this is referred to in the footnotes of the toxicity tables as follows: "above water solubility, which is .... mg/l, temp. ...°C". Studies in which results up to 10 times above the water solubility are given, are considered to be acceptable for reporting in the toxicity tables. Results more than 10 times above the water solubility are not included.

To increase the bioavailability and/or water solubility often carrier solvents are used, the following criteria are applied. Deviating from the OECD guidelines (OECD, 1987), a maximum of 1 ml/l organic solvent is accepted when tests include both solvent and water controls and no adverse effects occur in both controls. When more than 0.1 ml/l was applied the amount of solvent is mentioned in a footnote. When the amount of solvent is not reported this is mentioned in a footnote as "amount of solvent not reported".

Henry law constant

To assess the volatilisation of a compound from water the Henry law constant (H) is used. Henry law constants derived indirectly from laboratory test are preferred. The Henry law constant is calculated as follows:

Formula 1: Henry law constant dimensionless

$$H = P * M / S * R * T$$

Legend:
P = vapour pressure in Pa,
M = molecular weight in $g*mol^{-1}$,
S = water solubility in $g*m^{-3}$,
R = 8.317 $Pa*m^3*mol^{-1}*K^{-1}$,
T = temperature in K.

Table 1. Classification according to Lyman, (1981)

highly volatile from water	$H > 3E-2$
moderately volatile from water,	$1E-5 < H < 3E-2$
slightly volatile from water	$H < 1E-5$

In (semi)static tests with highly volatile substances it is difficult to maintain stable concentrations. Special attention is paid to the test conditions if H>3E-2 for the dimensionless Henry law constant (Lyman, 1981). If the mentioned limit is exceeded the test vessels must preferably be closed. This is noted in the toxicity tables. It is also reported whether the test vessels are aerated. If the test vessels in (semi)static tests are closed, special attention is paid to the oxygen concentration (for minimal permissible oxygen concentration: see OECD guidelines).

Octanol/water partition coefficient (log K_{ow})

The log K_{ow} can be used for:
- calculation of QSAR's
- calculation of BCF values
- cut-off-value to assess the risk for secondary poisoning (see document EAC 2/4)
- estimation of log K_{oc}, when experimental data are lacking

How is the log K_{ow} derived:

Experimental values obtained by the slow-stirring method are preferred (De Bruijn *et al*., 1989). If not available, so called 'star values' selected from the MEDCHEM database are used. The MEDCHEM database is considered the most extensive and reliable source for K_{ow}s available. The value that is considered most reliable in the data-base is indicated with a star. Besides a large number of K_{ow} values from the literature, the MEDCHEM database contains a routine for estimation of K_{ow}s based on structural properties of the compound (ClogP method). K_{ow}s calculated with the ClogP method are less reliable than experimental values. However, Verhaar and Hermens (1990) conclude that this estimation method normally leads to reasonable values.

Organic carbon normalised partition coefficient (Log K_{oc})

Experimental log K_{oc}-values from public literature are preferred. When experimental data are lacking log K_{oc}-values are collected from the MEDCHEM or ASTER database or from handbooks (MacKay *et al*., 1992).

How is the log K_{oc} derived:
Batch experiments are preferred above column experiments. Batch experiments involve the shaking of soil, sediment or particulate matter with an aqueous solution containing the adsorbing chemical. After a certain equilibrium period the suspension is either centrifuged or filtered and the aqueous concentration of the chemical is determined. In most of the studies the adsorbed fraction is calculated from the decrease of the aqueous concentration.

For chemicals with a large affinity to the "third phase" (colloids and organic macromolecules that cannot be separated from the water phase) this method will lead to overestimation of the aqueous concentration and an underestimation of the K_p. In this case studies with calculation of a mass balance are preferred.

4.2. Properties concerning degradation

A broad survey of hydrolysis, photolysis and biodegradation of the test substance is made. When these processes will occur rapidly (see table 2), the toxicity of the main metabolite(s)has (have) to be examined. According to Whitehouse and Mallet (1993) the following criteria concerning photolytic and/or hydrolytic breakdown are used.

Table 2. Breakdown criteria according to Whitehouse and Mallet (1993)

DT50 =	≥12 h toxicity based on parent substance
DT50 =	between 4-12 h case by case judgement
DT50 =	<4 h toxicity based on metabolites

5. EVALUATION OF INDIVIDUAL LITERATURE

In this chapter the evaluation procedures of individual literature for all toxicity studies are presented. The starting point in judging the reliability of all studies are the criteria established by the OECD (OECD, 1987). Tests for which no OECD guidelines are available, are judged case by case, keeping the criteria established by the OECD as a key source. In chapter 4.1 the evaluation criteria are outlined. The criteria are outlined in the same sequence as placed in the toxicity tables. In paragraph 4.2 the handling of test results and the derivation of NOECs and L(E)C50s is described.

5.1. Evaluation criteria

5.1.1. *Test species*

In order to create conveniently arranged tables taxonomic classifications are applied. The proposed taxonomic classification groups of aquatic organisms are listed in table 3.

Age, size, weight or lifestage is mentioned behind the name of the organism. The toxicity data of animals with different age, size or weight are presented individually in the tables. When the tested organisms are collected from field populations, this fact is mentioned in a footnote with the duration of the acclimation period. When the authors report that the organisms are originating from a contaminated area the test is not included.

According to the OECD guidelines the maximum fish loading is 1 g fish/l. Higher fish loadings are accepted, but only if data on the O_2 concentration are available in the test. For minimum oxygen concentrations see OECD guidelines (OECD, 1987).
When the number of algae per ml test solution becomes too high the availability of toxicant to each cell can be questioned. A value of 10^5 cells/ml is used as cutt-off value. The algae used should always be in their exponential growth phase. For *Daphnia magna* the OECD guidelines are followed (at least 2 ml of test solution for each animal and the oxygen concentration should be ≥ 60% of the air saturation level). For other organisms no criteria have been established yet.

Table 3. taxonomic classification

1 Bacteria			8 Rotatoria
2 Cyanophyta			9 Nematoda
3 Protozoa			10 Mollusca
4 Algae	- Chrysophyta,	- Euglenophyta,	11 Annelida
	- Cryptophyta,	- Chlorophyta,	12 Crustacea
	- Dinophyta,	- Phaeophyta.	13 Insecta
5 Macrophyta			14 Pisces
6 Coelenterata			15 Amphibia
7 Patyhelminthes			

5.1.2. *Analysis of testcompound*

If the concentration of the testcompound is measured during the test a **Y (yes)** is placed in the toxicity table. If the concentration of the testcompound is not measured or mentioned during the test a **N (no)** is placed in the toxicity table. When concentrations have been analysed during the test and the results are expressed as the measured values an α is placed in the table behind the result. If in static or renewal tests, samples are analysed at different points of time, the geometric mean of the measured values is reported. When the initial concentration is not measured and one or more samples during the test are, the geometric mean of the initial nominal and the measured concentration(s) is reported. In continuous flow experiments the concentrations are usually reported as mean measured values, no further calculations are necessary.

5.1.3. *Test type*

The following test types are being distinguished:

- R renewal system (semi-static)
- S static system
- CF continuous flow system
- IF intermittent flow

5.1.4. *Test substance purity/test compound metals*

<u>Substance purity</u>

The purity of the tested substance has to be at least 80%. For pesticides with a purity of 80-95% data on impurities are reported in a footnote.

<u>Metals</u>

Toxicity data of metal compounds are always expressed as the element and not as the salt, e.g. mg Co^{2+}/l. In case of metals no purity is mentioned. In the tables the metal species will be mentioned in the column compound, e.g. $CoSO_4$.

5.1.5. *Test water*

The following test waters are distinguished:

- am artificial media
- nw natural water
- rw reconstituted water
- tw tap water

5.1.6. *pH*

Data from a study in which a range of pH values is tested, will be handled as follows: select all data obtained in experiments performed under conditions that fit in the ranges recommended by the OECD guidelines for several species.

When the tested species is not included in the OECD guidelines, select all data with circumstances in accordance with the natural habitat of the tested species. The geometric mean of these values will be reported in the table. The same procedure is followed for temperature ranges.

5.1.7. *Hardness/salinity*

Hardness (mg $CaCO_3$ per litre).
If not reported the hardness is calculated from other Ca- and Mg-compounds present in the testwater following formula 2.

Formula 2: German degree

$$(2x \text{ mmol } Ca^{2+} + 2y \text{ mmol } Mg^{2+}) * 2.8 = \ldots DH$$

Legend: 1 DH = 17 mg $CaCO_3$/l

Salinity (°/₀₀ (ppt)).
Water with a salinity of at least 20 promille is qualified as marine water. Freshwater has a salinity of 5 promille or less, brackish water between 5 and 20 promille. The category "brackish" is not represented in separate tables animals belonging to this category are included in the saltwater tables.

5.1.8. *Exposure time*

Exposure time is expressed as:

- months (m)	(>19 w in months, 1 month = 4.3 weeks)
- weeks (w)	(5-19 w)
- days (d)	(5-31 d)
- hours (h)	(1-96 h)
- minutes (min)	(0-60 min)

Acute: in view of the life span of the species this will always represent a relative short period of time. The exact length of the time period depends on the physiological nature of the species in question.
Chronic: this represents a complete or partial life cycle including sensitive young stages or one or more reproduction cycles, the exact length of the time period again depending on the physiological nature of the species in question.

For a number of species from several taxonomic groups the OECD proposes a fixed test duration. In addition to these guidelines the following distinctions are drawn:

- Algae, Bacteriophyta, Protozoa: a test duration of maximal 4 days; EC50 data for a time period of maximal 4 days are defined as acute; NOEC data over a test period of 3-4 days are defined as chronic.

Tests in which longer exposure duration are used, will only be taken into account if the control population is still in the exponential growth phase.

- Crustacea and Insecta: test duration of 48 or 96 hours are considered to be acute.
- Pisces, Mollusca and Amphibia: for these species 96 hours is the time span of the standard acute toxicity test. Early life stage tests (OECD 210) egg and sac-fry stage tests and 28 day growth tests (both subject of discussion at OECD) are considered chronic tests. The prolonged toxicity test (OECD 204) is considered an acute test.

5.1.9. *Test criterion*

Expressed as acute L(E)C50 or chronic NOEC.

Only those effect parameters are taken into account that exclusively affect the species on the population level (Slooff, 1992): mortality, growth, reproduction and photosynthesis. Whether other effect parameters e.g. behaviour, are included is decided in each individual case. In a footnote is mentioned which parameter is tested. The parameters for growth and reproduction are specified, e.g. growth measured as chlorophyll content and reproduction measured as number of eggs.

5.1.10. *References*

All studies that are mentioned in the tables, are placed in the reference list. If a study was examined but found not valid according to the outlined quality criteria, no data are reported and the reference is listed under studies evaluated but rejected.

5.2. **Specific quality criteria for groups of compounds**

In some cases it is neccesary to establish specific quality criteria for groups of compounds. In this pargraph the specific quality criteria and the need for these criteria are explained.

5.2.1. *Polycyclic Aromatic Hydrocarbons (PAH)*

Many PAHs are known to absorb high quantities of UV-radiation (Oris *et al*., 1984). They can be activated by various wavelengths in the UV-radiation spectra and by visible light (UV-A, 345-400 nm; UV-B, 285-345 nm; visible light, >400 nm) in aqueous, sediment and soil media. This activation only takes place if the energy associated with the wavelength is equivalent to the difference between the energetic states of electrons in the organic molecule. In general photodynamic processes will only occur when light (visible or non visible) is absorbed. The photo activation of PAH may lead to phototoxic reactions in organisms.

5.2.1.1. *The proces phototoxicity*

One of the main processes which may cause phototoxicity of PAHs is as follows: PAHs absorb UV-radiation, electrons will be elevated to higher energy states and form the so called excited single state molecules. These excited single state molecules might react direct with other (bio)molecules. A second possibility is that the single state molecules can undergo a process called intersystem crossing. In this process single state molecules turn into triple state molecules, the latter being more persistent. A third possible mechanism was proposed by Landrum *et al*. (1987). They suggested that the formation of singlet oxygen was the most important mechanism. Phototoxicity can occur by one or a combination of the former mentioned processes; which of these proposed processes is the most important/likely cannot be judged at the moment.

Photoactivated PAH molecules may damage tissues directly or may induce redox cycling through formation of free oxygen radicals resulting in much greater toxicity under UV light. Bowling *et al*. (1983) and Newsted & Giesy (1987) stated that the photodynamic response is due to PAHs that have been assimilated by organisms rather than to phototoxic metabolites formed in the external environment.

5.2.1.2. *Quality criteria for light sources used in PAH toxicity tests*

Most toxicity studies found in the literature are performed under standard laboratory conditions. In these studies animals are exposed to light regimes of 12h:12h or 16h:8h light/dark and light sources like bulbs or fluorescent lamps. It was found that PAHs showed light-induced photo oxidation (phototoxicity) when exposed to different sources of light. It is therefore likely that phototoxicity of PAHs will occur in natural ecosystems also. This idea is supported by Landrum *et al*. (1987), who measured UV-B intensities in eutrophic surface water. In this study they found that 50% of the initial UV-B radiation was still present at a depth of 1.2 meters. Contradicting results are found in Dutch eutrophic surface water, where algae and humic substances absorb most of the UV radiation (Van Liere, *pers. comm.*; RIVM). Although it remains unclear to what extent UV radiation might penetrate into the water surface, it is very important that the light sources used in toxicity tests are comparable to natural situations, with respect to wavelength and intensity.

Light sources as bulbs, halogen- and fluorescent lamps produce mainly UV-A and visible light and almost no UV-B. None of the mentioned commonly used artificial light sources will produce as much UV-A+B radiation as sunlight (Eggink, *pers. comm.*; RIVM). Therefore, light comparable with sunlight is only expected in studies where researchers have been paying extra attention to the light conditions in their toxicity test.

In a number of publications tests are performed in which field illumination is simulated (Hall & Oris, 1991; Holst & Giesy, 1989; Huang *et al*., 1993). However, in most tests the specific illumination/spectrum is not specified. Therefore the following selection criteria have been established:

- Light regime used in the test should be comparable with natural situation as much as possible (see also 3.2.2). (12h:12h or 16h:8h light/dark, and clear-, half clouded and full clouded sky in short term tests).
- Light source used in the test should produce visible light, UV-A and/or UV-B radiation as close as possible to natural situation (wavelength and intensity).
- Accumulation of PAHs during a pre-incubation period in the dark is allowed, the incubation time is mentioned in the footnotes of the toxicity tables.

The studies in agreement with the criteria mentioned above are presented in the toxicity tables. If a test is not performed in agreement with these criteria, the reliability of the data is judged case by case.

5.3. **Derivation of NOECs and L(E)C50s**

5.3.1. ***Deriving NOEC values***

The following procedures are used for deriving NOEC (No Observed Effect Concentration) values.

- If the NOEC value is based on a statistical method these results are used: the highest concentration tested not differing from the control at $P < 0.05$ is regarded as the NOEC,
- If no statistical method is applied or could be used in principle the concentration showing less than 10% effect is considered as the NOEC. There must be a distinct concentration-effects relationship, however.

LOEC-values (Lowest Observed Effect Concentration)

LOECs are transformed in NOECs as follows:

a) LOEC > 10 to 20% effect: the NOEC = LOEC/2,

b) LOEC ≥ 20% effect and a distinct concentration-effect relationship: the EC10 is calculated or extrapolated and regarded as the NOEC (Haanstra *et al*., 1985; Van Beelen *et al*., 1991),

c) LOEC ≥ 20% with no distinct concentration-effects relationship:
- LOEC 20 to 50% effect: NOEC = LOEC/3,
- LOEC 50 to 80%: effect: NOEC = LOEC/10.

MATC-values

In aquatic ecotoxicology often the Maximum Acceptable Toxicant Concentration (MATC) is calculated instead of the NOEC. In order to derive a NOEC from a MATC, the latter is divided by 2 if the MATC is presented as a single value, while the lowest value is used as NOEC if the MATC is presented as a range of 2 values.

TGK/TT

"Toxische Grenzkonzentration" (TGK) or Toxic Threshold of Bringmann and Kühn (Bringmann and Kühn, 1977) is defined by Bringmann and Kühn as the concentration at which 3-5% inhibition occurs (the limit of 3 or 5% depends on the organism tested) and is calculated by a graphic method. A NOEC is derived as TGK = NOEC.

5.3.2. ***Deriving L(E)C50 values***

If only raw data are available the L(E)C50 is calculated according to the method of Spearman and Karber (Hamilton *et al*., 1977/1978). This method is used only when the test parameter is mortality and immobility. When the method of Spearman and Karber is used this is mentioned in the footnote. When data for calculation are lacking, values cannot be reported, despite the fact that many of these studies are considered reliable. Acute studies are carried out for a long time and have been standardized to a great extent.

5.4. Partition coefficients

In this paragraph a number of quality criteria on partition coefficients are outlined.

5.4.1. *Solid/water mass distribution*

Solid/water concentrations should be chosen in such a way that adsorption will lie between 20 to 80%. Studies with experimental conditions resulting in nearly complete or no adsorption are not included in the table. This is derived from information on determination in the water phase, solid phase or on the mass balance of the chemical.

5.4.2. *Mass balance*

If the concentration of the chemical after equilibrium is determined in both the water and soil, allowing calculation of a mass balance: Y (yes) is added. If the concentration of the chemical is determined in the water phase only: N (no) is added.

5.4.3. *Equilibrium time*

To determine the period required for equilibration of the adsorption process the progress of the adsorption should be determined in a preliminary experiment. If possible it is checked whether equilibrium is reached.

5.5. Toxicity studies with Birds and Mammals

In order to assess possible effects due to secondary poisoning (a comprehensive explenation on secondary poisoning can be found in document EAC 2/4) toxicity studies for birds and mammals are evaluated: subacute and (semi)chronic studies with mammals and acute and (semi)chronic studies for birds, all exposed via food. LC50 values for birds and NOEC values for birds and mammals are derived. Relevant OECD guidelines are 205, 206, 407/409, 414/416, 451/453.

Quality criteria for birds and mammal studies:

- Especially in acute dietary studies with birds repellency may occur: the outcome of the LC50 test is not only the reflection of the intrinsic toxicity of the tested chemical but also of a decreasing food consumption leading to starvation. Therefore special attention is paid to, if available: food consumption pattern, the shape of the dose-mortality curve in time and the No Repellent Concentration. More guidance can be found in Luttik (1993).
- Most relevant effects with respect to secondary poisoning are mortality, reproduction (fertility, pregnancy rate, number of live foetuses, pup mortality, eggshell thinning, egg production, egg fertility, hatchability, and chick survival) and growth (Romijn *et al*., 1993). Eggshell thinning is taken into account only if the effect is more than 20%. Especially in (semi)chronic studies with mammals also other effects are considered and often no NOEC is derived for mortality and growth. Therefore, NOECs have to be extracted from the original literature source. According to Romijn *et al*. (1993) an uncertainty factor of 10 is applied to NOEC values from studies on short-term exposure, i.e. < 1 month.

The duration of reproduction studies is often less than 1 month. Still, these studies are considered as chronic ones, as the sensitive life stage of an organism is studied.

- From chronic tests with mammals in general no NOEC values for mortality can be derived because more than 20% mortality occurs in many tests in the second year, mortality which cannot be ascribed to the test substance,
- If NOECs are reported in mg/kg bw these values are converted to mg/kg food using the following BW/DFI (BW: body weight; DFI: daily food intake) factors: *Canis domesticus* (dog): 40; *Macaca spec.* (rhesus monkey): 20; *Microtus spec.* (hamster): 8.3; *Mus musculus* (mouse): 8.3; *Oryctolagus cuniculis* (rabbit): 33; *Rattus norvegicus* (rat): 20; *Gallus domesticus* (chick): 2; and *Mustela vison* (mink): 10 (Romijn *et al*., 1991a,b).

5.6. **BCF studies**

- Experimentally derived BCFs have to be reported for whole body of fish or worm. For mussels BCFs for whole body are based on the soft parts.
- The experimental duration has to be sufficiently long in order to establish or approach a steady state between concentrations in water and the test species. However, in many studies it is often not clear whether steady state is reached. Therefore, an estimate is made of the duration of the uptake phase to reach 80% of the steady state (T80) based on the log K_{ow} according to OECD guidelines. Only studies with an exposure time longer than the estimated T80 are included.
- No signs of overt toxicity should have been observed. According to the OECD guidelines the highest concentration should be less than 0.1 of the incipient LC50 for the test species and at least 10 times higher than the detection limit in water. Based on an evaluation of the literature for several compounds Van de Plassche (1994) concluded that these criteria are too stringent . Therefore deviating from OECD guidelines tests are evaluated in the following way: if mortality occurs the test concentration is excluded, while if nothing is reported on mortality by the author(s) all test concentrations higher than 0.20 times the 96 h LC50 of the test species are excluded.
- Experimental BCFs for fish and mussel are calculated as concentration in fish on the basis of wet weight divided by the concentration in water.

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ANNEX 6

OSLO AND PARIS CONVENTIONS FOR THE PREVENTION OF MARINE POLLUTION

THIRD WORKSHOP ON ECOTOXICOLOGICAL ASSESSMENT CRITERIA

THE HAGUE: 25-29 NOVEMBER 1996

A Method to Derive Ecotoxicological Assessment Critera (EAC) Taking Possible Secondary Poisoning into Account

CONTENTS

SUMMARY

In this document a method is described which incorporates secondary poisoning in the derivation of Ecotoxicological Assessment Criteria (EAC). The method is based on the food chain water → fish or mussel → fish- or mussel-eating predator. The method is based on a No Effect Concentration (NEC) for predators which is derived from laboratory studies with mammals or birds using assessment factors. A caloric conversion factor is used to compensate for differences in caloric content of laboratory food versus mussels or fish, serving as food under field conditions. Based on the NEC for predators a concentration in mussel and fish is derived which (given the available data) will not result in adverse effects on predators. These concentrations can be compared with the extrapolated concentration based on direct effects on aquatic organisms. If the latter is higher it can be concluded that secondary poisoning can be a critical pathway and the EAC can be adjusted to the concentration which is presumed to be safe for predators. Such a decision however depends on aspects such as data availability and field information.

INTRODUCTION

Bioconcentration and bioaccumulation may be of concern for lipophilic organic chemicals and some metals as both direct and indirect effects may be observed upon long term exposure. Bioconcentration is the net result of uptake, distribution and elimination of a substance in an organisms due to water-borne exposure, whereas bioaccumulation includes all routes, i.e. air, water, soil and food. Biomagnification is the accumulation and transfer of chemicals via the food chain, resulting in an increase of the internal concentration in organisms at the higher levels in the trophic chain. Secondary poisoning is concerned with toxic effects in the higher members of the food chain which result from ingestion of organisms at the different trophic levels that contain accumulated substances.

METHOD

In order to develop a method on incorporating secondary poisoning in effect assessment Romijn et al. (1993) analyzed the food chain water → fish → fish-eating predators (birds and mammals). They proposed the following algorithm to calculate environmental quality objectives (EQO) for secondary poisoning:

$$EQO = NEC_{predators} \;/\; BCF_{fish} \qquad (1)$$

NEC: No Effect Concentration for predators in mg/kg food. The NEC has to be considered as a maximum concentration in food which will not lead to adverse effects after ingestion of this food. The NEC is based on toxicity data for predators like birds and mammals. Preferably, this should be data for fish-eating birds and mammals. However, these data are seldom available. Therefore, data on other bird and mammalian species, exposed via the food, have to be used.

Toxicity data for birds and mammals result in LC50 (e.g. 5 days dietary study with birds) or NO(A)EL values (e.g. 28 days oral study with rats). If results are expressed in mg/kg body weight they should be converted to mg/kg food using conversion factors (see Appendix 1).

Extrapolation from these LC50 and NO(A)EL values gives the NEC. Assessment factors have to be used which take into account interspecies variation, subchronic to chronic toxicity extrapolation and laboratory to field impact extrapolation. In the EU Technical Guidance Document (1996) the following assessment factors are used:

- on results from 5 days avian dietary LC50: a factor 1,000 is applied to derive the NEC;
- on results from 28 days test: a factor 100 is applied to derive the NEC;
- on results from 90 days test: a factor 30 is applied to derive the NEC;
- on results from a chronic study: a factor 10 is applied to derive the NEC.

BCF: Bioconcentration Factor. The BCF can be measured or calculated. The static BCF is the ratio between the concentration in the organism and the concentration in a steady-state (sometimes also called equilibrium) situation. When uptake and depuration kinetics are measured, the dynamic BCF can be calculated from the quotient of the upake and depuration rate constants.

The algorithm can also be used to derive 'critical concentrations in biota' to protect higher organisms in the food-chain from possible adverse effects due to the consumption of fish and mussels. The NECpredators can be used as the 'critical concentration in biota' or, for this workshop, as the Ecotoxicological Assessment Criteria (EAC) in mussel or fish.

Based on the work of Romijn et al. (1993), Everts et al. (1993) discussed whether so called correction factors should be applied for several aspects which influence secondary poisoning:

- laboratory - field conversion: differences in metabolic rate between animals in laboratory (toxicity tests) and the field;
- caloric conversion: differences in caloric content of the different types of food: cereals versus fish or mussels;
- normal versus extreme conditions: differences in metabolic rate under normal field conditions and more extreme ones like breeding period, migration and winter;
- food assimilation efficiency: differences in use of different types of food;
- pollutant assimilation effiency: differences in bioavailability of test compounds (surface application of a test compound) and compound incorporated in food in the field;
- relative sensitivity: differences in biotransformation of certain compounds between taxonomic groups of birds or mammals.

Values for several correction factors are proposed by Traas et al. (in press). Of these factors the one for caloric conversion has a firmer scientific basis than the other ones (Dutch Health Council, 1993). This factor is based on an extensive literature search on differences in caloric content between laboratory food versus fish and mussels. Subsequently, this leads to the following formula for deriving an EAC in fish and mussels:

$$EAC_{fish} = NEC_{predator} \times 0.32 \qquad (2)$$

$$EAC_{mussel} = NEC_{preadator} \times 0.20 \qquad (3)$$

Because mussels have a lower caloric value than fish the correction factor is higher. Predators must consume more mussels compared to fish to obtain the same amount of energy.

EXPERIENCE

Experience with this scheme for secondary poisoning is scarce. Romijn et al. (1993) applied formula 1 to derive EQOs for lindane, dieldrin, cadmium, mercury and PCB153. Van de Plassche (1994) applied formulas 2 and 3 to derive EQOs for several compounds with a potential for secondary poisoning, mainly organochlor pesticides. Jongbloed et al. (1995) extended the aquatic food chain and derived EQOs for the common tern and harbor seal.

A validation of the scheme has never been carried out. The Dutch Health Council (1993) states: “The committee regards the method as a pragmatic approach for obtaining a rough initial indication of the potential for secondary poisoning on the basis of existing (limited) data. In view of the major uncertainties and the limited number of (simple) food chains considered, the recommended values derived by means of the method do not guarantee higher species of animals sufficient protection. To clarify this matter, extensive follow-up research is required in which local and species-specific information is gathered.” In the EU Technical Guidance Document the scheme is considered provisional due to lack of experience.

Summarizing:
[1] with this method a concentration in fish and mussel tissue can be derived which will not result in adverse effects to predators;
[2] these concentrations can be compared with the extrapolated concentration based on direct effects on aquatic organisms. If the latter are higher it can be concluded that secondary poisoning can be a critical pathway;
[3] the EAC can be adjusted to the concentration which is safe for predators. Such a decision should however depend on aspects like data availability on e.g. toxicity data for birds and mammals and field information.

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APPENDIX 1. CONVERSION OF TOXICITY DATA

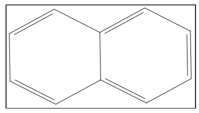
The endpoints of toxicity tests should be expressed as a concentration in food. Often, however, test results are expressed in mg/kg body weight. These results should be transformed by mulitplying them with the a conversion factor (BW/DFI = body weight / daily food intake). In the EU Technical Guidance Document the following factors are proposed:

Canis domesticus (dog):	40;
Macaca spec. (monkey):	20;
Microtus spec. (guinea pig):	8.3;
Mus musculus (mouse):	8.3;
Oryctolagus cuniculus (rabbit):	33.3;
Rattus norvegicus > 6 weeks old (rat):	20;
Rattus norvegicus < 6 weeks old (rat):	10.

ANNEX 7 : Subgroup report - Derivation of naphthalene EAC

EAC 3/4/1	naphthalene
	CAS number: 91-20-3 **Molecular formula:** $C_{10}H_8$

Structural formula:



Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	3.30	l/kg	Meador *et al.* , 1995	
Sediment water partition coefficient (log Kp)	1.15	l/kg		shake flask (n=4)
BCF fish	-	l/kg fw		not relevant
BCF mussel	170	l/kg sp dw		calculated from Kow

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	340	µg/l	Moles & Rice, 1983	saltwater *1
Lowest L(E)C50	750	µg/l	Falk-Petersen *et al.* , 1982	saltwater
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	-	mg/kg food		not relevant
Lowest NOEC for birds	-	mg/kg food		not relevant

Extrapolated Concentrations	result	unit	assessment factor	note
Water	7.5	µg/l	100	
Sediment (Equilibrium partitioning)	0.106	mg/kg dw		
Sediment TEL/PEL	0.04/0.39	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	5-50	µg/l	f	
Sediment	0.05-0.5	mg/kg dw	f	TEL/PEL and EP
Fish	-	mg/kg fw		not relevant
Mussel	0.5-5.0	mg/kg dw	p	calculated from BCF

Remarks	result			
Secondary poisoning taken into account	N			Y/N

*1 Geometric mean of two NOECs being: 120 and 560 µg/l for the fish Oncorhynchus gorbuscha

ANNEX 7 : Subgroup report - Derivation of naphthalene EAC

1. DERIVATION OF THE EACS FOR NAPHTHALENE

1.1 DERIVATION OF THE EAC FOR WATER

The lowest NOEC available was 21 µg/l (Caldwell, 1977) for the crustacean *Cancer magister*. However, the end point in these experiments was the time taken to complete larval development and examination of the data revealed that the differences measured were rather small and within the range of normal variation (judged from the two sets of control data presented in the paper). The statistical procedures used were also innappropriate. The next lowest NOEC was 340 µg/l (geometric mean of two NOECs see coverpage) for a juvenile fish growth test (Moles & Rice, 1983) although there was only NOEC data available for two taxonomic groups. Examination of the LC50 data (Table 3.1.2 and 3.2.2) showed a wide range of taxonomic groups but more importantly that algae were rather insensitive to napthalene (freshwater data only) and that the most sensitive stage appeared to be the developing fish embryo. For this reason the group decided to use the fish embryo LC50 data (Falk-Petersen et al., 1982) and to apply a safety factor of 100 despite the fact that marine algal data was not available. This results in an extrapolated concentration of 7.5 µg/l. Thereupon, the extrapolated concentration to 7.5 µg/l is rounded to the EAC of 5-50 µg/l. The value was set as firm.

1.2 DERIVATION OF THE EAC FOR SEDIMENT

The Log Kp value used (assuming 1% organic carbon) was 1.15 derived from the mean of four shake-flask determinations specified in Table 4.1 The extrapolated concentration for water of 7.5 µg/l is multiplied with the Kp value of 14 l/kg (log Kp=1.15). This results in an extrapolated concentration of 0.106 mg/kg dw and an EAC of 0.05-0.5 mg/kg dw. The EAC was set as firm.

The results compare favourably with the TEL/PEL value from Environment Canada of 0.035/0.39 mg/kgand the lower limit of the band is twice the highest background value (0.026 mg/kg) reported for the Convention area.

No spiked sediment data was available for napthalene.

1.3 DERIVATION OF THE EAC FOR BIOTA

<u>Fish</u>
Not relevant.

<u>Mytilus</u>
No bioconcentration data was available and therefore a BCF value of 170 l/kg was calculated from Log $K_{ow.}$ data. The EAC for mussels is derived by multiplying the extrapolated concentration in water of 7.5 µg/l, with the BCF value of 170 l/kg. This results in a concentration in mussel of 1.275 mg/kg dw giving an EAC of 0.5-5.0 mg/kg dw. The value was set as provisional

ANNEX 7 : Subgroup report - Derivation of naphthalene EAC

2. BCF DATA

BCF values for mussels for naphthalene are not available. BCF values for fish are considered not relevant in connection with the current monitoring programme. The BCF for mussels on the coverpage is calculated using the following formula (see EAC 2/1).

BCF = Kow * 0.085 (soft parts dry weight) ***(1)***

The calculated BCF for mussels is calculated as follows: BCF = 1995 l/kg*0.085 <=> 170 l/kg dw.

3. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
result	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. Saltwater toxicity data

For naphthalene a relatively large saltwater dataset is available. The data are presented as follows:

- table 3.1.1: chronic toxicity for naphthalene to salt water organisms: NOECs
- table 3.1.2: acute toxicity for naphthalene to salt water organisms: L(E)C50s,

The lowest NOEC and L(E)C50 are presented in shading.

3.1.1. *Table : Chronic toxicity of naphthalene to saltwater organisms: NOECs*

Organism	A	Test type	Test sub. purity	Test water	pH	Salinity °/oo	Exp. time	Crite-rion	Result µg/l		Reference
Crustacea											
Cancer magister, zoeae	Y	R	anal.	nw	-	29-34	9 w	NOEC	21[a]		Caldwell, 1977
Pisces											
Oncorhynchus gorbuscha, juvenile, 0.33 g, 3.2 cm	Y	CF	-	nw	-	28	5 w	NOEC	120[b]	α	Moles & Rice, 1983
Oncorhynchus kisutch, fry, 1.0 g	Y	CF	-	nw	-	-	5 w	NOEC	370[d]	α	Moles *et al*., 1981
Oncorhynchus gorbuscha, juvenile, 0.33 g, 3.2 cm	Y	CF	-	nw	-	28	5 w	NOEC	560[c]	α	Moles & Rice, 1983

a duration of larval development, significant reduction in the first three larval instars; light regime is 13 h light and 11 h dark; larvae obtained from an alaskan female crab, no effects on the same crab species obtained from Oregon
b growth measured as body wet weight
c growth measured as body length
d same as in note a and b, and body dry weight

ANNEX 7 : Subgroup report - Derivation of naphthalene EAC

3.1.2. *Table : Acute toxicity of naphthalene to saltwater organisms: L(E)C50s*

Organism	A	Test type	Test sub. purity	Test water	pH	Salinity $^o/_{oo}$	Exp. time	Crite-rion	Result µg/l		Reference
Mollusca											
Callinectes sapidus, adult, 50-227 g	Y	CF	anal.	nw	-	30	48 h	LC50	2,000[a]	α	Sabourin, 1982
Callinectes sapidus, adult, 50-227 g	Y	CF	anal.	nw	-	20	48 h	LC50	2,200[a]	α	Sabourin, 1982
Callinectes sapidus, adult, 50-227 g	Y	CF	anal.	nw	-	10	48 h	LC50	2,900[a]	α	Sabourin, 1982
Annelida											
Neanthes arenaceodentata	Y	S	≥98%	am	-	32	96 h	LC50	3,800[b]		Rossi & Neff, 1978
Crustacea											
Neomysis americana	Y	CF	-	am	-	-	96 h	LC50	850[h]	α	Smith & Hargreaves, 1983
Hemigrapsus nudus	N	CF	-	nw	-	28-29	8 d	LC50	1,100[f]		Gharrett & Rice, 1987
Neomysis americana	Y	CF	-	am	-	-	96 h	LC50	1,300[g]	α	Smith & Hargreaves, 1983
Calanus finmarchicus, adult	Y	S_c	>97%	nw	-	33	96 h	LC50	1,400[d]	α	Falk-Petersen *et al*., 1982
Hemigrapsus nudus	N	CF	-	nw	-	28-29	8 d	LC50	2,100[f]		Gharrett & Rice, 1987
Elasmopus pectenicrus, adult	N	R	-	nw	-	30	96 h	LC50	2,700		Lee & Nicol, 1978
Hemigrapsus nudus	N	CF	-	nw	-	28-29	8 d	LC50	2,800[f]		Gharrett & Rice, 1987
Artemia salina, nauplii	Y	S	≥98%	am	8.5-8.7	32	24 h	EC50	3,200[c]	α	Foster & Tullis, 1984
Eurytemora affinis	Y	S_c	≥99%	nw	-	20	24 h	LC50	3,800[e]		Ott *et al*., 1978
Pisces											
Gadus morhua, eggs	Y	S	>97%	nw	-	33	96 h	LC50	750[d]	α	Falk-Petersen *et al*., 1982
Metapenaeus monocerus, juvenile	N	R	-	nw	7.5	18	96 h	LC50	4,200[j]		Deshmukh *et al*., 1985
Fundulus heteroclitus, 8.2 cm	Y	R	-	nw	7.6	15	96 h	LC50	5,300[i]		DiMichele & Taylor, 1978
Metapenaeus monocerus, juvenile	N	R	-	nw	7.5	18	96 h	LC50	5,500[j]		Deshmukh *et al*., 1985
Metapenaeus monocerus, juvenile	N	R	-	nw	7.5	18	96 h	LC50	5,700[j]		Deshmukh *et al*., 1985

a constant illumination

b strong decrease in test conc. LC50 as the initial actual conc.; solvent is acetone, 1 ml/l
c immobility; constant illumination; EC50 is the geom. mean between the nominal and the 24 h measured conc.; actual conc. 67% of initial conc.
d actual conc. circa 33% of initial conc.
e solvent is methanol, max. 0.4 ml/l
f different tidal schedules, with different % exposure to air; 0% (1,100 μg/l), 33% (2,100 μg/l) and 66% (2,800 μg/l); animals from field population acclimated for 1 month
g solvent is ethanol, amount unknown; temperature 15 °C; actual conc. ca. 55% of initial conc.
h solvent is ethanol, amount unknown; temperature 25 °C; actual conc. ca. 55% of initial conc.
i light regime 14 h light and 10 h dark; estimated with Spearman and Karber
j temperature 30°C, which is the summer temperature for this species; LC50s at 20°C(winter) and 25°C(monsoon) are 5,700 μg/l and 5,500 μg/l

3.2. Freshwater toxicity data

For naphthalene a relatively large freshwater dataset is available. The data are presented as follows:

- table 3.2.1: chronic toxicity of naphthalene to freshwater organisms: NOECs
- table 3.2.2: acute toxicity of naphthalene to freshwater organisms: L(E)C50s,

The lowest NOEC and L(E)C50 are presented in shading.

3.2.1. *Table : Chronic toxicity of naphthalene to freshwater organisms: NOECs*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Pisces										
Pimephales promelas, embryo/larvae	Y	CF	-	rw	7.9-8.0	535-596	30 d	NOEC	450[a]	DeGraeve *et al*., 1982
Pimephales promelas, embryo/larvae	Y	CF	-	rw	7.9-8.0	535-596	30 d	NOEC	450[c]	DeGraeve *et al*., 1982
Pimephales promelas, embryo/larvae	Y	CF	-	rw	7.9-8.0	535-596	30 d	NOEC	1,800[b]	DeGraeve *et al*., 1982
Sarotherodon mossambicus, 18 g	N	R	-	tw	7.6	235	12 w	NOEC	2,300[d]	Dange & Masurekar, 1982

a hatchability; unclear dose response curve, 14% effect at 450 µg/l; solvent is methanol, <0.4 ml/l; lowest oxygen conc. in test 4.9 mg/l
b mortality; solvent is methanol, <0.4 ml/l; lowest oxygen conc. in test 4.9 mg/l
c length and weight growth; solvent is methanol, <0.4 ml/l; lowest oxygen conc. in test 4.9 mg/l
d growth measured as wet weight

ANNEX 7 : Subgroup report - Derivation of naphthalene EAC

3.2.2. *Table : Acute toxicity of naphthalene to freshwater organisms: L(E)C50s*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Algae/Chlorophyta										
Chlorella vulgaris	N	S	-	-	-	-	48 h	EC50	33,000[1a]	Kauss & Hutchinson, 1975/ Basis-Document RIVM for PAHs, 1989
Mollusca										
Physa gyrina, 7.5 mm, 0.057 g	Y	S_c	-	nw	7.8	140	48 h	LC50	5,000	Milleman *et al*., 1984
Crustacea										
Daphnia pulex, 1.9-2.1 mm	N	S_c	-	nw	7.5	-	96 h	LC50	1,000[g]	Trucco *et al*., 1983
Daphnia magna, 24 h	Y	S_c	-	nw	7.8	140	48 h	EC50	2,200[e]	Milleman *et al*., 1984
Daphnia magna, <24 h	N	S_c	≥97%	rw	-	-	48 h	EC50	2,200[c]	Munoz & Tarazona, 1993
Daphnia magna	Y	S	-	tw	8.0-8.6	-	48 h	LC50	3,400[b]	Crider *et al*., 1982
Daphnia pulex, young	Y	S	-	tw	6.8-7.5	43-48	48 h	LC50	3,400[h] α	Geiger & Buikema, 1981
Daphnia pulex, neonates	Y	S	-	tw	7.2	43	48 h	LC50	3,400[h] α	Geiger & Buikema, 1982
Daphnia pulex, <24 h	N	S	≥96%	rw	-	170	48 h	EC50	4,700[f]	Smith *et al*., 1988
Daphnia magna, 1.5 mm, 4-6 d	N	S_c	≥97%	am	6.0-7.0	-	48 h	LC50	16,600	Bobra *et al*., 1983
Daphnia magna, adult, mixed age	N	S	-	nw	7.6	134	48 h	LC50	22,600[d]	Eastmond *et al*., 1984
Insecta										
Chironomus tentans, 4 th. instar	Y	S_c	-	nw	7.8	140	48 h	EC50	2,800[e]	Milleman *et al*., 1984
Tanytarsus dissimilis, 4 th. instar	N	S	-	tw	7.9-8.3	-	48 h	LC50	12,600	Darville & Wilhm, 1984
Chironomus attenuattus, 4 th. instar	N	S	-	tw	7.9-8.3	-	24 h	LC50	13,000	Darville & Wilhm, 1984
Pisces										
Oncorhynchus mykiss, eggs 20 min. post fertilization	Y	CF	-	am	7.4-8.1	86-116	96 h	LC50	120	Milleman *et al*., 1984
Micropterus salmoides, eggs 2-4 h post spawning	Y	CF	-	am	7.4-8.1	86-116	96 h	LC50	680	Milleman *et al*., 1984

Pimephales promelas, 1-2 months, 0.27 g, 28 mm	Y	S_c	-	nw	7.8	140	96 h	LC50	2,000[e]	Milleman *et al*., 1984
Pimephales promelas, 34 d	N	S	98%	-	7.4	44	96 h	LC50	6,100	Geiger *et al*., 1985

1 above water solubility, which is 31,000 µg/l, at 25°C

a growth; original data not available
b test performed in the dark
c immobility; solvent is methanol, max. 2 ml/l; minimal oxygen conc. 2 mg/l
d solvent is acetone + surfactant triton X-100, 0.5 ml/l and 0.5 mg/l respec.; oxygen conc. ca. 3.9 mg/l
e immobility; solvent methanol , 1ml/l
f immobility; solvent is acetone, 0.5 ml/l
g light regime is 12 h light and 12 h dark, with mixed fluorescent and natural light
h solvent is methanol, <0.4 ml/l; lowest oxygen conc. in test 4.9 mg/l

4. DATA ON PARTITION COEFFICIENTS

In this paragraph the data on sediment-pore water partiton coefficients are presented.

Legend:

solid/water	solid water ratio used in the experiment
mass balance	Y: checked whether total amount of substance analysed in different compartments equals the total amount added at start of experiment, N: no check
equilibrium time	time after the substance is added, before concentrations are analysed in different compartments

ANNEX 7 : Subgroup report - Derivation of naphthalene EAC

4.1. Table : data on equilibrium partition coefficients

testsubstance	soil type	% oc	pH	CEC mmol/kg	solid/water g/l	mass bal.	equil. time	log K_{oc}	reference
naphthalene									
	sediment	2.70	-	-	-	-	-	3.08	De Maagd & Sijm, 1995
	sediment	3.38	7.8	-	200	N	3 h	5.00[a]	Kayal & Connell, 1990
	sediment	2.9	-	-	0.4	Y	24 h	3.24	Voice *et al*., 1983
	sediment	3.8	-	-	0.4	Y	24 h	3.34	Voice *et al*., 1983
	sediment	4.02	-	-	4.55-180	N	2 h	2.93	Vowles & Mantoura, 1987
	sediment	5.55[a]	-	-	-	Y	-	4.8[a]	Van Hattum, 1995

a no batch experiment, mean value of different field contaminated sediments

5. REFERENCES

In the paragraphs 5.3 and 5.5 the references on ecotoxicologica and partition data which were evaluated but rejected based on the quality criteria presented in EAC 2/2 are given for all PAHs.

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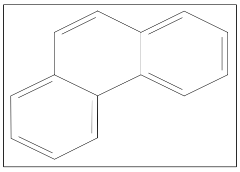
ANNEX 8 : Subgroup report - Derivation of phenanthrene EAC

EAC 3/4/2	phenanthrene

3rd OSPAR Workshop on Ecotoxicological Assessment Criteria
NOVEMBER 25-29, 1996

CAS number:	Molecular formula:
85-01-8	C14H10

Structural formula:



Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	4.50	l/kg	Meador *et al.* , 1995	
Sediment water partition coefficient (log Kp)	2.34	l/kg		Shake flask (n=3)
BCF fish	-	l/kg fw		not relevant
BCF mussel	9,300	l/kg sp dw	McLeese & Burridge	field data

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	18	µg/l	Hooftman & Evers de ruiter, 92	freshwater
Lowest L(E)C50	30	µg/l	Milleman et al., 1984	freshwater
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOAEL for mammals	-	mg/kg food		not relevant
Lowest NOAEL for birds	-	mg/kg food		not relevant

Extrapolated Concentrations	result	unit	assessment factor	note
Water	1.8	µg/l	10	
Sediment (Equilibrium partitioning)	0.39	mg/kg dw		
Sediment (TEL/PEL)	0.09/0.54	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	0.5-5.0	µg/l	p	
Sediment	0.1-1.0	mg/kg dw	f	TEL/PEL and EP
Fish	-	mg/kg fw		not relevant
Mussel	5-50	mg/kg dw	p	calculated from BCF

Remarks	result			
Secondary poisoning taken into account	N			Y/N

ANNEX 8 : Subgroup report - Derivation of phenanthrene EAC

1. DERIVATION OF THE EACS FOR PHENANTHRENE

1.1. derivation of the EAC for water

Chronic and acute data are available for a fish, crustacean, annelid and macrophyte taxonomic groups and therefore the lowest freshwater NOEC was used with an application factor of 10. The NOEC value was 18 µg/l (Hooftman & Evers de Ruiter, 1992) for the crustacean *Daphnia magna* and results in an extrapolated concentration of 1.8 µg/l. Thereupon, the extrapolated concentration of 1.8 µg/l is rounded to the EAC of 0.5-5.0 µg/l. The classification was set as provisional because of the absence of algal data and the lowest NOEC was a freshwater organism.

1.2. derivation of the EAC for sediment

The Log Kp value used (assuming 1% organic carbon) was 2.34 derived from the mean of three shake-flask determinations specified in Table 4.1. The extrapolated concentration for water of 1.8 µg/l is multiplied with the Kp value of 218.7 l/kg (log Kp=2.34). This results in an extrapolated concentration of 0.39 mg/kg dw and an EAC of 0.1-1.0 mg/kg dw.

The results compare favourably with the TEL/PEL value from Environment Canada of 0.087/0.54 and were twice the highest background value of <0.046 mg/kg when normalised to 1% organic carbon.

Spiked sediment data was limited and indicated no effect levels at much higher concentrations (10-30 mg/kg).

1.3. derivation of the EAC for biota

<u>Fish</u>

Not relevant, see chapter 2 on BCF values.

<u>Mussels</u>

The theoretical BCF value based on the Log K_{ow} was 2690 l/kg sp dw. However, experimental data exist for Mytilus (9300 l/kg sp dw) and clams (9600 l/kg sp dw; McLeese & Burridge). The EAC for mussels is derived by multiplying the extrapolated concentration in water of 1.8 µg/l, with the BCF value of 9300 for Mussels giving an extrapolated concentration in Mussels of 16.74 and an EAC in the range 5-50 mg/kg dw.

2. BCF DATA

BCF values for mussels for phenanthrene are not available. BCF values for fish are considered not relevant in connection with the current monitoring programme. The BCF for mussels on the coverpage is calculated using the following formula (EAC 2/1).

ANNEX 8 : Subgroup report - Derivation of phenanthrene EAC

BCF = Kow * 0.085 (soft parts dry weight) **(1)**

The calculated BCF for mussels is calculated as follows: BCF = 31,620 l/kg*0.085 <=> 2,690 l/kg dw.

3. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. Saltwater toxicity data

Only a small saltwater dataset is available. The data are presented as follows:

- table 3.1.1: chronic toxicity data: NOEC-values.
- table 3.1.2: acute toxicity data: L(E)C50-values

3.1.1. *Table : Chronic toxicity of phenanthrene to saltwater organisms: NOECs*

Organism	A	Test type	Test sub. purity	Test water	pH	Salinity °/oo	Exp. time	Crite-rion	Result µg/l	Reference
Crustacea										
Rhithropanopeus harrissi, zoeae	N	R	-	am	-	25	1 w	NOEC	150[a]	Laughlin & Neff, 1979

a mortality; same NOEC with a salinity 15 ppm; light regime 12 h light and 12 h dark; temperature 20°C

3.1.2. *Table : Acute toxicity of phenanthrene to saltwater organisms: L(E)C50s*

Organism	A	Test type	Test sub. purity	Test water	pH	Salinity $^o/_{oo}$	Exp. time	Crite-rion	Result µg/l		Reference
Annelida											
Neanthes arenaceodentata	Y	S	98%	am	-	32	96 h	LC50	600[a]		Rossi & Neff, 1978
Crustacea											
Artemia salina, nauplii	Y	S	98%	am	8.5-8.7	32	24 h	EC50	520[c]	α	Foster & Tullis, 1984
Artemia salina, nauplii	N	CF_c	97%	-	-	30	24 h	LC50	680[b]		Abernethy *et al*., 1986

a solvent is acetone, 1 ml/l
b test conducted in the dark
c immobility; constant illumination; EC50 is the geom. mean between the nominal and the 24 h measured conc.

ANNEX 8 : Subgroup report - Derivation of phenanthrene EAC

3.2. **Freshwater toxicity data**

A relatively large freshwater dataset is available for phenanthrene. The data are presented as follows:

- table 3.2.1: chronic toxicity data: NOECs,
- table 3.2.2: acute toxicity data: L(E)C50s,

3.2.1. *Table : Chronic toxicity of phenanthrene to freshwater organisms: NOECs*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Macrophyta										
Lemna gibba	Y	S	-	am	-	-	8 d	NOEC	600[a]	Huang *et al*., 1993
Crustacea										
Daphnia magna	N	IF	-	-	-	-	21 d	NOEC	18[b]	Hooftman & Evers-de Ruiter, 1992c
Daphnia magna	N	IF	-	-	-	-	21 d	NOEC	32[d]	Hooftman & Evers-de Ruiter, 1992c
Daphnia magna	N	IF	-	-	-	-	21 d	NOEC	56[c]	Hooftman & Evers-de Ruiter, 1992c
Daphnia pulex, <24 h	Y	R	-	tw	6.9-7.5	41-50	7-11 w	NOEC	60[f] α	Geiger & Buikema, 1982
Daphnia pulex, <24 h	Y	R	-	tw	6.9-7.5	41-50	7-11 w	NOEC	110[e] α	Geiger & Buikema, 1982
Daphnia magna	N	R	-	-	-	-	21 d	NOEC	180[b]	Hooftman & Evers-de Ruiter, 1992c
Pisces										
Brachydanio rerio	N	R	-	-	-	-	21 d	NOEC	32[g]	Hooftman & Evers-de Ruiter, 1992c
Brachydanio rerio	N	R	-	-	-	-	21 d	NOEC	56[h]	Hooftman & Evers-de Ruiter, 1992c
Brachydanio rerio	N	R	-	-	-	-	21 d	NOEC	³56[i]	Hooftman & Evers-de Ruiter, 1992c

a growth; NOEC=EC10; light regime: (constant light 'cool white fluorescent lamps', producing UV-A + UV-B); ratio visible:UV-A:UV-B is100:10:1 based on the number of photons, total intensity 40 mmol*$m^{-2}sec^{-1}$, this is comparable with natural sunlight (spectrum + intensity)

b reproduction

c mortality

d growth

e reproduction as number of broods per animal, and number of death young per brood per animal; exposure time is total life-time; light regime 16 h light and 8 h dark, by 'cool white fluorescent bulbs'

continued on the next page

f	growth measured as the length of the first brood animals; exposure time is total life-time; light regime 16 h light and 8 h dark, by 'cool white fluorescent bulbs'
g	length growth
h	growth measured as wet weight
i	mortality/hatching

3.2.2. *Table : Acute toxicity of phenanthrene to freshwater organisms: L(E)C50s*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Crustacea										
Daphnia pulex, 1.9-2.1 mm	N	S_c	-	nw	7.5	-	96 h	LC50	100[e]	Trucco *et al*., 1983
Daphnia pulex, <24 h	N	S	³96%	rw	-	170	48 h	EC50	350[d]	Smith *et al*., 1988
Daphnia magna, <24 h	N	S_c	³97%	rw	-	-	48 h	EC50	380[a]	Munoz & Tarazona, 1993
Daphnia magna, 24 h	Y	S_c	-	nw	7.8	140	48 h	EC50	700[c]	Milleman *et al*., 1984
Daphnia pulex, <24 h	N	S	³96%	rw	-	hard	48 h	EC50	730[d]	Passino & Smith, 1987
Daphnia magna, adult, mixed age	N	S	-	nw	7.6	134	48 h	LC50	840[b]	Eastmond *et al*., 1984
Daphnia pulex, young	Y	S	-	tw	6.8-7.5	43-48	48 h	LC50	1,140[1α]	Geiger & Buikema, 1981
Daphnia magna, 1.5 mm, 4-6 d	N	S_c	³97%	am	6.0-7.0	-	48 h	LC50	1,200[1]	Bobra *et al*., 1983
Pisces										
Oncorhynchus mykiss, eggs 20 min. post fertilization	Y	CF	-	am	7.4-8.1	86-116	96 h	LC50	30	Milleman *et al*., 1984
Micropterus salmoides, eggs 2-4 h post spawning	Y	CF	-	am	7.4-8.1	86-116	96 h	LC50	250	Milleman *et al*., 1984

1 above water solubility, which is 1,100 mg/l, at 25°C
a immobility; solvent is methanol, max. 2 ml/l; oxygen conc. min. 2 mg/l
b solvent is acetone + surfactant triton X-100, 0.5 ml/l and 0.5 mg/l respec., lightregime 16 h light and 8 h dark; oxygen conc. ca. 3.9 mg/l
c immobility
d immobility; solvent is acetone, 0.5 ml/l
e light regime is 12 h light and 12 h dark, with mixed fluorescent and natural light; animals also exposed during the 24 h period

4. RAW DATA ON PARTITION COEFFICIENTS

In this paragraph the data on sediment-pore water partiton coefficients are presented.

Legend:

solid/water	solid water ratio used in experiment
mass balance	Y: checked whether total amount of substance analysed in different compartments equals total amount added at start of experiment, N: no check
equilibrium time	time after substance added before concentrations are analysed in different compartments

ANNEX 8 : Subgroup report - Derivation of phenanthrene EAC

4.1. **Table : data on equilibrium partition coefficients of selected polycyclic aromatic hydrocarbons**

testsubstance	soil type	% oc	pH	CEC mmol/kg	solid/water g/l	mass bal.	equil. time	log K_{oc}	reference
phenanthrene									
	sediment (25-29 cm)	5.23	-	-	0.5	N	30 h	4.30	Chin & Gschwend, 1992
	sediment	4.02	-	-	4.55-180	N	2 h	4.26	Vowles & Mantoura, 1987
	sediment	3.38	7.8	-	200	N	3 h	6.12[a]	Kayal & Connell, 1990
	sediment	-	-	-	10	Y	72 h	5.69[b]	Evers & Smedes, 1993
	sediment	5.55[a]	-	-	-	N	-	5.9[a]	Van Hattum, 1995
	sediment	2.7	-	-	-	-	-	4.45	De Maagd & Sijm, 1995

a no batch experiment, mean value of different field contaminated sediments
b co-solvent method; 'true K_{oc}" extrapolated to 100% water; without influence of "third phase" material

5. REFERENCES

5.1. References from coversheet and chapter 1

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5.3. References evaluated but rejected 'ecotoxicological data'

See factsheet for naphthalene

5.4. References 'log K_{oc} data'

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5.5. References evaluated but rejected 'log K_{oc} data' for all PAHs

See factsheet for naphthalene.

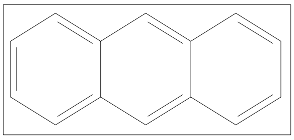
ANNEX 9 : Subgroup report - Derivation of anthracene EAC

EAC 3/4/3	anthracene

3rd OSPAR Workshop on Ecotoxicological Assessment Criteria
NOVEMBER 25-29, 1996

CAS number:	Molecular formula:
120-12-7	C14H10

Structural formula:



Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	4.50	l/kg	Meador *et al.* , 1995	
Sediment water partition coefficient (log Kp)	4.23	l/kg		field exp. (n=2)
BCF fish	-	l/kg fw		not relevant
BCF mussel	2,690	l/kg sp dw		calculated from Kow

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	0.63	µg/l	Holst & Giesy, 1989	freshwater
Lowest L(E)C50	1.3	µg/l	McCloskey & Oris, 1991	freshwater
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	-	mg/kd food		not relevant
Lowest NOEC for birds	-	mg/kd food		not relevant

Extrapolated Concentrations	result	unit	assessment factor	note
Water	0.0063	µg/l	100	
Sediment (Equilibrium partitioning)	0.107	mg/kg dw		
Sediment (TEL/PEL)	0.047/0.25	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	0.001-0.01	µg/l	p	
Sediment	0.05-0.5	mg/kg dw	f	TEL/PEL and EP
Fish	-	mg/kg bw		not relevant
Mussel	0.005-0.05	mg/kg bw	p	calculated from BCF

Remarks	result			
Secondary poisoning taken into account	N			Y/N

ANNEX 9 : Subgroup report - Derivation of anthracene EAC

1. DERIVATION OF THE EACS FOR ANTHRACENE

1.1. Derivation of the EAC for water

NOEC data was only available for freshwater species and only for three taxonomic groups (Macrophytes, Algae and Crustacea). LC50 data was only available for fish and insects in freshwater. However, the NOEC value used (0.63 µg/l for the crustacean *Daphnia magna*) was from a study (Holst & Giesy, 1989) which took account of photo-toxicity as an additional mode of action. Because of the small amount of data and the absence of data on any marine species an assessment factor of 100 was used. This leads to an extrapolated concentration of 0.0063 µg/l which results in an EAC of 0.001-0.01 µg/l, which is classified as provisional.

1.2. Derivation of the EAC for sediment

The Log Kp value used (assuming 1% organic carbon) was 4.23 derived from an average Log K_{oc} of 6.23 from 2 field studies detailed in Table 4.1. The extrapolated concentration for water of 0.0063 µg/l is multiplied with the Kp value of 16,982 l/kg (log Kp=4.23). This results in an extrapolated concentration of 0.107 mg/kg dw and an EAC of 0.05-0.5 mg/kg dw.

The results compare favourably with the TEL/PEL value from Environment Canada of 0.047/0.25 and is above the highest background values of < 0.015 mg/kg (when normalised to 1% organic carbon) for the Convention area.

No spiked sediment data was available for anthracene.

1.3. Derivation of the EAC for biota

<u>Fish</u>
Not relevant, see chapter 2 on BCF values.

<u>Mussels</u>
The theoretical BCF value based on the Log K_{ow} was 2690 l/kg sp dw. The EAC for Mussels is derived by multiplying the extrapolated concentration in water of 0.0063 µg/l, with the BCF value of 2,690 l/kg. This results in an concentration in mussels of 0.017 mg/kg dw. Applying an order of magnitude on this concentration results in an EAC of 0.005-0.05 mg/kg dw, which is classified as provisional.

2. BCF DATA

BCF values for mussels for anthracene are not available. BCF values for fish are considered not relevant in connection to the current monitoring program. The BCF for mussels for anthracene on the cover page is calculated using the following formula (EAC2/1).

BCF = Kow * 0.085 (soft parts dry weight) **(1)**

The calculated BCF for mussels is calculated as follows: BCF = 31,620 l/kg*0.085 <=> 2,690 l/kg dw.

3. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. Saltwater toxicity data

No saltwater toxicity data are available for anthracene.

3.2. Freshwater toxicity data

For anthracene a relatively large freshwater dataset is available.

- table 3.2.1: chronic toxicity data: NOECs,
- table 3.2.2: acute toxicity data: L(E)C50s,

3.2.1. ***Table : Chronic toxicity of anthracene to freshwater organisms: NOECs***

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Macrophyta										
Lemna gibba	Y	S	-	am	-	-	8 d	NOEC	300[1a]	Huang *et al*., 1993
Algae/Chlorophyta										
Selenastrum capricornutum	Y	S	99.9%	am	7.5	-	22 h	NOEC	1.5[b] α	Gala & Giesy, 1992
Selenastrum capricornutum	Y	S	99.9%	am	7.5	-	24 h	NOEC	1.7[c] α	Gala & Giesy, 1992
Selenastrum capricornutum	Y	S	99.9%	am	7.5	-	24 h	NOEC	2.2[c] α	Gala & Giesy, 1992
Selenastrum capricornutum	Y	S	99.9%	am	7.5	-	22 h	NOEC	2.3[b] α	Gala & Giesy, 1992
Selenastrum capricornutum	Y	S	99.9%	am	7.5	-	22 h	NOEC	2.5[b] α	Gala & Giesy, 1992
Selenastrum capricornutum	Y	S	99.9%	am	7.5	-	24 h	NOEC	2.5[c] α	Gala & Giesy, 1992
Selenastrum capricornutum	Y	S	99.9%	am	7.5	-	24 h	NOEC	2.7[c] α	Gala & Giesy, 1992
Selenastrum capricornutum	Y	S	99.9%	am	7.5	-	24 h	NOEC	3.9[c] α	Gala & Giesy, 1992
Selenastrum capricornutum	Y	S	99.9%	am	7.5	-	22 h	NOEC	7.8[b] α	Gala & Giesy, 1992
Selenastrum capricornutum	Y	S	99.9%	am	7.5	-	22 h	NOEC	8.7[b] α	Gala & Giesy, 1992
Crustacea										
Daphnia magna	Y	R	anal.	am	8.1	230	21 d	NOEC	0.63[l] α	Holst & Giesy, 1989
Daphnia magna	Y	R	anal.	am	8.1	230	21 d	NOEC	1.1[k] α	Holst & Giesy, 1989
Daphnia magna	Y	R	anal.	am	8.1	230	21 d	NOEC	1.9[j] α	Foran *et al*., 1991
Daphnia magna	Y	R	anal.	am	8.1	230	21 d	NOEC	1.9[g] α	Foran *et al*., 1991
Daphnia magna	Y	R	anal.	am	8.1	230	21 d	NOEC	2.2[d] α	Foran *et al*., 1991
Daphnia magna	Y	R	anal.	am	8.1	230	21 d	NOEC	2.2[e] α	Foran *et al*., 1991
Daphnia magna	Y	R	anal.	am	8.1	230	21 d	NOEC	2.2[f] α	Foran *et al*., 1991
Daphnia magna	Y	R	anal.	am	8.1	230	21 d	NOEC	2.2[i] α	Foran *et al*., 1991
Daphnia magna	Y	R	anal.	am	8.1	230	21 d	NOEC	4.1[d] α	Foran *et al*., 1991
Daphnia magna	Y	R	anal.	am	8.1	230	21 d	NOEC	4.5[h] α	Foran *et al*., 1991

to be continued on the next page

1 above water solubility, which is 45 µg/l, at 25°C

a growth; NOEC=EC10; light regime: (constant light 'cool white fluorescent lamps', producing UV-A + UV-B); ratio visible:UV-A:UV-B is 100:10:1 based on the number of photons, total intensity 40µmol*$m^{-2}sec^{-1}$, this is comparable with natural sunlight (spectrum + intensity)
b growth rate; light regime: (constant light with 'white fluorescent bulbs', used with a filter to eliminate UV-A+B (<390nm)), (UV-A with increasing intensity from the first to the fifth downwards produced by blacklights, the intensity of the UV-A in the tests was 765, 410, 406, 218 and 125 µW/cm^2, UV-B radiation was filtered from the blacklight spectrum; actual conc. 70% of nominal conc. at t=0, and 50% after the renewal period of 8 h, the results are presented as the calculated values between t=0 and t=8 h; during each renewal the conc. new substance is added to derive the initial nominal conc.
c primary production; light regime: (constant light with 'white fluorescent bulbs', used with a filter to eliminate of UV-A+B (<390nm)), (UV-A with increasing intensity from the first to the fifth downwards produced by 'blacklights', the intensity of the UV-A in the tests was 765, 410, 406, 218 and 125 µW/cm^2, UV-B radiation was filtered from the blachlight spectrum; actual conc. 70% of nominal conc. at t=0, and 50% after the renewal period of 8 h, the results are presented as the calculated average between t=0-8 h according to a first order kinetics loss model; NOEC=EC10
d growth measured as intrinsic rate of increase; no UV-radiation; visible light by 'white fluorescent lamps'; light regime: 16 h light and 8 h dark
e growth measured as intrinsic rate of increase; UV-radiation at 31 µW/cm^{-2}; ratio UV-A:UV-B is 8:1; visible light by 'white fluorescent lamps'; light regime: 16 h light and 8 h dark
f growth measured as intrinsic rate of increase; UV-radiation at 60 µW/cm^{-2}; ratio UV-A:UV-B is 8:1; visible light by 'white fluorescent lamps'; light regime: 16 h light and 8 h dark
g growth measured as intrinsic rate of increase; UV-radiation at 117 µW/cm^{-2}; ratio UV-A:UV-B is 8:1; visible light by 'white fluorescent lamps'; light regime: 16 h light and 8 h dark
h reproduction; UV-radiation at 31 µW/cm^{-2}; ratio UV-A:UV-B is 8:1; visible light by white fluorescent lamps; light regime: 16 h light and 8 h dark
i reproduction; UV-radiation at 60 µW/cm^{-2}; ratio UV-A:UV-B is 8:1; visible light by white fluorescent lamps; light regime: 16 h light and 8 h dark
j reproduction; UV-radiation at 117 µW/cm^{-2}; ratio UV-A:UV-B is 8:1; visible light by white fluorescent lamps; light regime: 16 h light and 8 h dark
k reproduction measured as total number neonates afther 6 broods; no UV-radiation; visible light by 'white fluorescent lamps'; light regime: 16 h light and 8 h dark; NOEC=LOEC/2, 6% effect at 2.1 µg/l; the 6% is significant when compared with the control
l reproduction measured as total number neonates afther 6 broods; UV-radiation at 117 µW/cm^{-2}; ratio UV-A:UV-B is 8:1; visible light by 'white fluorescent lamps'; light regime: 16 h light and 8 h dark; NOEC=LOEC/3, 23% effect at 1.9 µg/l

3.2.2. ***Table : Acute toxicity of anthracene to freshwater organisms: L(E)C50s***

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l		Reference
Pisces											
Lepomis macrochirus, juvenile, 0.8 g, 3.1 cm	Y	CF	tech.	tw	7.7	326	5 d	LC50	1.3[a]	α	McCloskey & Oris, 1991
Lepomis macrochirus, juvenile, 0.5-1 g, 2-3 cm	Y	CF	tech.	tw	8.2	328	6 d	LC50	2.8[e]		Oris & Giesy, 1985
Lepomis macrochirus, juvenile, 0.8 g, 3.1 cm	Y	CF	tech.	tw	7.7	326	5 d	LC50	3.8[c]	α	McCloskey & Oris, 1991
Lepomis macrochirus, juvenile, 0.8 g, 3.1 cm	Y	CF	tech.	tw	7.7	326	5 d	LC50	8.0[b]	α	McCloskey & Oris, 1991
Lepomis macrochirus, juvenile, 0.8 g, 3.1 cm	Y	CF	tech.	tw	7.7	326	5 d	LC50	8.3[d]	α	McCloskey & Oris, 1991
Lepomis spec., juvenile, 0.5-1 g, 2-3 cm	Y	CF	tech.	tw	8.2	328	6 d	LC50	12[f]		Oris & Giesy, 1985
Lepomis spec., juvenile, 0.5-1 g, 2-3 cm	Y	CF	tech.	tw	8.2	328	6 d	LC50	18[g]		Oris & Giesy, 1985
Lepomis spec., juvenile, 0.5-1 g, 2-3 cm	Y	CF	tech.	tw	8.2	328	6 d	LC50	26[e]		Oris & Giesy, 1985
Insecta											
Aedes aegypti, third instar	Y	R	-	am	-	-	48 h	LC50	27[h]		Oris *et al.*, 1984

a constant illumination;, UV A+B and visible light, spectrum 91 % equal to natural sunlight; UV-A and -B intensities are 108 and 6.7 µW/cm^2; total intensity approximately equal to 0.5 and 1.0 meter depth in an eutrophic lake; 24 h pre-exposure to anthracene; 20 °C temperature

b as a, except the temperature is 20°C, and oxygen conc. is 8.1 mg/l

c as a, except the temperature is 30°C, and oxygen conc. is 6.9 mg/l

d as a, except the temperature is 30°C, and oxygen conc. is 8.1 mg/l

e 48 h pre-exposure to anthracene in the dark, followed by 96 h anthrancene + UV exposure; light regime is 24 h light during 96 h exposure; simulated sunlight produced by white and ultraviolet fluorescent bulbs; UV-B intensity is 15 µW/cm^2

f as e, except UV-B intensity is 170 µW/cm^2

g as e, except UV-B intensity is 70 µW/cm^2

h 24 h pre-exposure to anthracene in the dark, followed by 24 h anthrancene + UV exposure; light regime is 24 h light during 24 h UV + anthracene exposure; simulated sunlight (half clouded sky) bulbs; UV-B intensity is 15 µW/cm^2

4. RAW DATA ON PARTITION COEFFICIENTS

In this paragraph the data on sediment-pore water partiton coefficients are presented.

Legend:

solid/water	solid water ratio used in experiment
mass balance	Y: checked whether total amount of substance analysed in different compartments equals total amount added at start of experiment, N: no check
equilibrium time	time after substance added before concentrations are analysed in different compartments

4.1. **Table: raw data on equilibrium partition coefficients of selected polycyclic aromatic hydrocarbons**

testsubstance	soil type	% oc	pH	CEC mmol/kg	solid/water g/l	mass bal.	equil. time	log K_{oc}	reference
anthracene									
	sediment	2.7	-	-	-	-	-	4.57	De Maagd & Sijm, 1995
	sediment	-	-	-	10	Y	72 h	5.93[b]	Evers & Smedes, 1993
	sediment	3.38	7.8	-	200	N	3 h	5.76[a]	Kayal & Connell, 1990
	sediment	5.5[a]	-	-	-	N	-	6.7[a]	Van Hattum, 1995

a no batch experiment, mean value of different field contaminated sediments
b co-solvent method; 'true K_{oc}" extrapolated to 100% water; without influence of "third phase" material

ANNEX 9 : Subgroup report - Derivation of anthracene EAC

5. REFERENCES

5.1. References from coversheet and chapter 1

Long *et al*. (1995) Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management, 19, (1), 81-97.

Meador et al. (1995) Bioaccumulation of polycyclic aromatic hydrocarbons by marine organisms. In: G.W. Ware, Reviews of Environmental Contamination and Toxicology, Vol. 143 p. 79-166.

5.2. References 'ecotoxicological data'

Abernethy, S., A.M. Bobra, W.Y. Shiu, P.G. Wells and D. Mackay (1986) Acute lethal toxicity of hydrocarbons and chlorinated hydrocarbons to two planktonic crustaceans: The key role of organism-water partitioning. Aquat. Toxicol., 8, 163-174.

Arfsten, D.P., R. Davenport and D.J. Schaeffer (1994) UV-A coexposure enhances the toxicity of aromatic hydrocarbons, munitions, and metals to *Photobacterium phosphoreum*. Biomedical and environmental Sciences, 7, 101-108.

Foran, J.A., L.L. Holst and J.P. Giesy (1991) Effects of photoenhanced toxicity of anthracene on ecological and genetic fitness of *Daphnia magna*: a reappraisal. Environ. Toxicol. Chem., 10, 425-427.

Gala, W.R. and J.P. Giesy (1992) Photo-induced toxicity of anthracene to the Green Algae, *Selenastrum capricornutum*. Arch. Environ. Contam. Toxicol., 23, 316-323.

Hall, A.T. and J.T. Oris (1991) Anthracene reduces reproductive potential and is maternally transfered during long-term exposure in fathead minnows. Aquatic Toxicology, 19, 249-264.

Holst, L.L. and J.P. Giesy (1989) Chronic effects of the photoenhanced toxicity of anthracene on *Daphnia magna* reproduction. Environ. Toxicol. Chem., 8, 933-942.

Huang, X.D., D.G. Dixon and B.M. Greenberg (1993) Impacts of UV radiation and photomodification on the toxicity of PAHs to the higher plant *Lemna gibba* (duckweed). Environ. Toxicol. Chem., 12, 1067-1077.

Kagan, J., E.D. Kagan, I.A. Kagan, P.A. Kagan and S. Quigley (1985) The phototoxicity of non-carcinogenic polycyclic aromatic hydrocarbons in aquatic organisms. Chemosphere, 14, (11/12), 1829-1834.

McCloskey, J.T. and J.T. Oris (1991) Effect of water temperature and dissolved oxygen concentrations on the photo-induced toxicity of anthracene to juvenile sunfish (*Lepomis macrochirus*). Aquatic Toxicology, 21, 145-156.

Munoz, M.J. and J.V. Tarazona (1993) Synergistic effect of two- and four-component combinations of the polycyclic aromatic hydrocarbons: phenanthrene, anthracene, naphthalene and acenaphthene on *Daphnia magna*. Bull. Environ. Contam. Toxicol., 50, 363-368.

Oris, J.T. and J.P. Giesy (1985) The photoenhanced toxicity of anthracene to juvenile sunfish (*Lepomis* spp.). Aquatic Toxicology, 6, 133-146.

Oris, J.T., J.P. Giesy, P.M. Allred (1984) Photoinduced toxicity of anthracene in aquatic organisms, an environmental perspective. The Biosphere: Problems and solutions, ed. Veziroglu; Elsevier Science Publ. B.V., Amsterdam, Netherlands.

5.3. References evaluated but rejected 'ecotoxicological data'

See factsheet for naphthalene

5.4. References 'log K_{oc} data'

De Maagd, G.J. and D.T.H.M. Sijm (1995) PAKs: Milieuchemische en milieu-toxicologische eigenschappen in het aquatische milieu. Ritox, Utrecht University; project RI-900

Evers, E.H.G., and F. Smedes (1993) Adsorptiegedrag van extreem hydrofobe verbindingen: PCBs, PAK's en dioxines. Bepalingsmethoden vertroebelen sorptiecoëfficiënten. In: symposiumverslag Kontaminanten in bodems en sediment, sorptie en biologische beschikbaarheid. 29 april, 1993, De Reehorst, Ede.

Kayal, S.I., and D.W. Connell (1990) Partitioning of unsubstituted polycyclic aromatic hydrocarbons between surface sediments and the water column in the Brisbane river estuary. Aust. J. Mar. Freshwater Res., 41, 443-456.

Van Hattum, B. (1995) Bioaccumulation of sediment-bound contaminants by the freshwater isopod *Asellus aquaticus* (L.). Thesis Vrije Universiteit Amsterdam.

5.5. **References evaluated but rejected 'log K_{oc} data'**

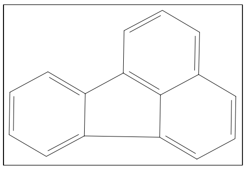
See factsheet for naphthalene.

ANNEX 10 : Subgroup report - Derivation of fluoranthene EAC

EAC 3/4/4	fluoranthene

NOVEMBER 25-29, 1996
3rd OSPAR Workshop on Ecotoxicological Assessment Criteria

CAS number: 206-44-0
Molecular formula: C16H10
Structural formula:



Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	5.10	l/kg	Meador *et al.* , 1995	
Sediment water partition coefficient (log Kp)	4.44	l/kg		field data (n=2)
BCF fish	-	l/kg fw		not relevant
BCF mussel	44,200	l/kg sp dw	McLeese & Burridge	

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	6.9	µg/l	Hooftman & Evers de Ruiter, 199?	freshwater
Lowest L(E)C50	300	µg/l	Rossi & Neff, 1978	saltwater
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOAEL for mammals	-	mg/kg food		not relevant
Lowest NOAEL for birds	-	mg/kg food		not relevant

Extrapolated Concentrations	result	unit	assessment factor	note
Water	0.069	µg/l	100	
Sediment (Equilibrium partitioning)	1.9	mg/kg dw		
Sediment (TEL/PEL)	0.11/1.5	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	0.01-0.1	µg/l	p	
Sediment	0.5-5.0	mg/kg dw	p	EP
Fish	-	mg/kg fw		not relevant
Mussel	1-10	mg/kg dw	p	calculated from BCF

Remarks	result			
Secondary poisoning taken into account	N			Y/N

ANNEX 10 : Subgroup report - Derivation of fluoranthene EAC

1. DERIVATION OF THE EACS FOR FLUORANTHENE

1.1. Derivation of the EAC for water

Acute toxicity data was confined to one Annelid study in seawater and chronic data existed only in freshwater species but was confined to two taxonomic groups (Macrophytes and fish). This study measured growth rate in the fish embryo *Brachydanio rerio* (Hooftman Evers-de Ruiter, 1992) and gave a NOEC of 6.9 µg/l which was derived from the geometric mean of the concentration which caused an effect (10 µg/l) and that which did not (4.3 µg/l). Applying a factor 100 to this NOEC leads to an extrapolated concentration of 0.069 µg/l which gives an EAC of 0.01-0.1 µg/l, which is classified as provisional.

1.2. Derivation of the EAC for sediment

The Log Kp value used (assuming 1% organic carbon) was 4.44 derived from an average Log K_{oc} of 6.44 from 2 field studies detailed in Table 4.1. The extrapolated concentration for water of 0.069 µg/l is multiplied with the Kp value of 27,543 l/kg (log Kp=4.44). This results in an extrapolated concentration of 1.9 mg/kg dw and an EAC of 0.5-5.0 mg/kg dw.

This range is a factor of 5 higher than the the TEL/PEL values from Environment Canada of 0.11/1.50 and is 10 fold higher than the highest background value (0.048 mg/kg dw normalised to 1%carbon) for the Convention area.

Spiked sediment LC50 data (from the BEDS data base) was limited to a number of amphipod species (*Corophium* and *Rhepoxinium*) and indicated no effect levels at higher concentrations (<3 mg/kg at 0.2 % organic carbon which is equivalent to 15 mg/kg at 1% organic carbon).

1.3. Derivation of the EAC for biota

<u>Fish</u>
Not relevant, see chapter 2 on BCF values.

<u>Mussels</u>
Experimental BCF data for Mussels (McLeese and Burridge) indicates a k1/k2 of 44,200 l/kg sp dw. The EAC is derived by multiplying the extrapolated concentration in water of 0.069 µg/l, with the BCF value of 44,200 l/kg. This results in a concentration in mussel of 3.05 mg/kg dw. Applying an order of magnitude on this concentration results in an EAC of 1-10 mg/kg dw, which is classified as provisional.

2. BCF DATA

BCF values for mussels for phenanthrene are not available. BCF values for fish are considered not relevant in connection with the current monitoring programme. The

BCF for mussels on the coverpage is calculated using the following formula (see EAC 2/1).

BCF = Kow * 0.085 (soft parts dry weight) ***(1)***

The calculated BCF for mussels is calculated as follows: BCF = 125,900 l/kg*0.085 <=> 10,700 l/kg dw.

3. **ECOTOXICOLOGICAL DATA**

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. **Saltwater toxicity data**

Only 1 saltwater L(E)C50 is available for phenathrene. The data are presented as follows:

- table 3.1.1: acute toxicity data: L(E)C50-values

ANNEX 10 : Subgroup report - Derivation of fluoranthene EAC

3.1.1. *Table : Acute toxicity of fluoranthene to saltwater organisms: L(E)C50s*

Organism	A	Test type	Test sub. purity	Test water	pH	Salinity $^o/_{oo}$	Exp. time	Crite-rion	Result µg/l	Reference
Annelida										
Neanthes arenaceodentata	Y	S	≥98%	am	-	32	96 h	LC50	300[a] α	Rossi & Neff, 1978

a decrease in test conc., actual conc. ca. 40% of initial conc.; solvent is acetone, 1 ml/l

ANNEX 10 : Subgroup report - Derivation of fluoranthene EAC

3.2. **Freshwater toxicity data**

Only chronic freshwater toxicity data are available for phenanthrene. The data are presented as folllows:

- table 3.2.1: chronic toxicity data: NOECs,

ANNEX 10 : Subgroup report - Derivation of fluoranthene EAC

3.2.1. *Table : Chronic toxicity of fluoranthene to freshwater organisms: NOECs*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l		Reference
Macrophyta											
Lemna gibba	Y	R	-	am	-	-	8 d	NOEC	200[a]		Ren *et al*., 1994
Pisces											
Brachydanio rerio, eggs	Y	IF	96%	rw	7.3-7.8	210	41 d	NOEC	6.9[c]	a	Hooftman & Evers-de Ruiter, 1992a
Brachydanio rerio, eggs	Y	IF	96%	rw	7.3-7.8	210	41 d	NOEC	22[d]	a	Hooftman & Evers-de Ruiter, 1992a
Brachydanio rerio, eggs	Y	IF	96%	rw	7.3-7.8	210	41 d	NOEC	69[b]	a	Hooftman & Evers-de Ruiter, 1992a

a growth; NOEC=EC10; light regime: (constant light 'cool white fluorescent lamps', prucing UV-A + UV-B); ratio visible:UV-A:UV-B is 100:10:1 based on the number of photons, total intensity 40 mmol*$m^{-2}sec^{-1}$, this is comparable with natural sunlight (spectrum + intensity)

b mortality of young fish; actual conc. of the substance 27-76%, average 48%; highest conc. (180 mg/l) is tested in separate test

c growth measured as fish length; actual conc. of the substance 27-76%, average 48%; highest conc. (180 mg/l) tested in separate test

d same as c, but growth measured as wet weight

ANNEX 10 : Subgroup report - Derivation of fluoranthene EAC

4. DATA ON PARTITION COEFFICIENTS

In this paragraph the data on sediment-pore water partiton coefficients are presented.

Legend:

solid/water	solid water ratio used in experiment
mass balance	Y: checked whether total amount of substance analysed in different compartments equals total amount added at start of experiment, N: no check
equilibrium time	time after substance added before concentrations are analysed in different compartments

ANNEX 10 : Subgroup report - Derivation of fluoranthene EAC

4.1. Table : data on equilibrium partition coefficients of selected polycyclic aromatic

testsubstance	soil type	% oc	pH	CEC mmol/kg	solid/water g/l	mass bal.	equil. time	log K_{oc}	reference
fluoranthene									
	sediment	2.7	-	-	-	-	-	5.32	De Maagd & Sijm, 1995
	sediment	3.38	7.8	-	200	N	3 h	6.38[a]	Kayal & Connell, 1990
	sediment	-	-	-	10	Y	72 h	6.12[b]	Evers & Smedes, 1993
	sediment	5.5[a]	-	-	-	-	-	6.5[a]	Van Hattum, 1995

a no batch experiment, mean value of different field contaminated sediments
b co-solvent method; 'true K_{oc}" extrapolated to 100% water; without influence of "third phase" material

5. REFERENCES

5.1. References from coversheet

Long *et al*. (1995) Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management, 19, (1), 81-97.

Meador *et al*. (1995) Bioaccumulation of polycyclic aromatic hydrocarbons by marine organisms. In: G.W. Ware, Reviews of Environmental Contamination and Toxicology, Vol. 143 p. 79-166.

5.2. References 'ecotoxicological data'

Arfsten, D.P., R. Davenport and D.J. Schaeffer (1994) UV-A coexposure enhances the toxicity of aromatic hydrocarbons, munitions, and metals to *Photobacterium phosphoreum*. Biomedical and environmental Sciences, 7, 101-108.

Hooftman, R.N. and A. Evers- de Ruiter (1992a) Early life stage tests with *Brachydanio rerio* and several polycyclic aromatic hydrocarbons using an intermittent flow-through system. TNO-report no. IMW-R 92/210.

Kagan, J., E.D. Kagan, I.A. Kagan, P.A. Kagan and S. Quigley (1985) The phototoxicity of non-carcinogenic polycyclic aromatic hydrocarbons in aquatic organisms. Chemosphere, 14, (11/12), 1829-1834.

Ren. L., X.D. Huang, B.J. McConkey, D.G. Dixon and B.M. Greenberg (1994) Photoinduced toxicity of three polycyclic aromatic hydrocarbons (fluoranthene, pyrene and naphthalene) to the Duckweed *Lemna gibba* L. G-3. Ecotox. Environ. Saf., 28, 160-171.

Rossi, S.S. and J.M. Neff (1978) Toxicity of polynuclear aromatic hydrocarbons to the polychaete *Neanthes arenaceodentata*. Mar. Poll. Bull., 9, (8), 220-223.

5.3. References evaluated but rejected 'ecotoxicological data'

See factsheet for naphthalene

5.4. References 'log K_{oc} data'

De Maagd, G.J. and D.T.H.M. Sijm (1995) PAKs: Milieuchemische en milieu-toxicologische eigenschappen in het aquatische milieu. Ritox, Utrecht University; project RI-900

Evers, E.H.G., and F. Smedes (1993) Adsorptiegedrag van extreem hydrofobe verbindingen: PCBs, PAK's en dioxines. Bepalingsmethoden vertroebelen sorptiecoëfficiënten. In: symposiumverslag Kontaminanten in bodems en sediment, sorptie en biologische beschikbaarheid. 29 april, 1993, De Reehorst, Ede.

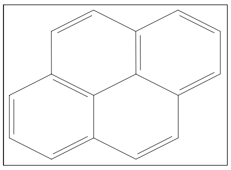
Kayal, S.I., and D.W. Connell (1990) Partitioning of unsubstituted polycyclic aromatic hydrocarbons between surface sediments and the water column in the Brisbane river estuary. Aust. J. Mar. Freshwater Res., 41, 443-456.

Van Hattum, B. (1995) Bioaccumulation of sediment-bound contaminants by the freshwater isopod *Asellus aquaticus* (L.). Thesis Vrije Universiteit Amsterdam.

5.5. References evaluated but rejected 'log K_{oc} data'

See factsheet for naphthalene

Annex 11 : Subgroup report - Derivation of pyrene EAC

EAC 3/4/5	pyrene
	CAS number: 129-00-0 **Molecular formula:** C16H10
	Structural formula: 

Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	5.10	l/kg	Meador *et al.* , 1995	
Sediment water partition coefficient (log Kp)	2.80	l/kg		Kp=0.5*Kow*0.01
BCF fish	-	l/kg fw		not relevant
BCF mussel	33,100	l/kg sp dw	McLeese & Burridge	

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	500	µg/l	Ren et al., 1994	freshwater
Lowest L(E)C50	202	µg/l	Hutchinson et al., 1980	freshwater
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOAEL for mammals	-	mg/kg bw		not relevant
Lowest NOAEL for birds	-	mg/kg bw		not relevant

Extrapolated Concentrations	result	unit	assessment factor	note
Water	0.2	µg/l	1,000	
Sediment (Equilibrium partitioning)	0.13	mg/kg dw		
Sediment (TEL/PEL)	0.15/1.40	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	0.05-0.5	µg/l	p	
Sediment	0.05-0.5	mg/kg dw	p	EP
Fish	-	mg/kg fw		not relevant
Mussel	1-10	mg/kg dw	p	calculated from Kow

Remarks	result			
Secondary poisoning taken into account	N			Y/N

Annex 11 : Subgroup report - Derivation of pyrene EAC

1. DERIVATION OF THE EACS FOR PYRENE

1.1. Derivation of the EAC for water

The toxicity data set is poor with only one NOEC determined for a freshwater macrophyte and LC50 data for two algal species and one crustacean. LC50 data on algae indicated greater sensitivity compared to the NOEC on macrophytes. Therefore an assessment factor of 1,000 was applied on the lowest L(E)C50 (fresh water) available, being 202 µg/l (Hutchinson *et al*., 1980) for the algae, *Chlamydomonas angulosa.* This results in an extrapolated concentration of 0.2 µg/l. Applying a factor 100 on the lowest NOEC of 500 µg/l for *Lemna gibba* (Ren *et al*., 1994) available, does not result in a lower value than derived from the L(E)C50 mentioned above. Thereupon, the extrapolated concentration of 0.2 µg/l is rounded to the EAC of 0.05-0.5 µg/l, which is classified as provisional.

1.2. Derivation of the EAC for sediment

Experimental sediment partitioning data was available (Table 4.1) but the source was not identified and no quality check could be made. Therefore the Log Kp value used was 2.80 derived from the Log K_{ow}. Therefore to derive the EAC the extrapolated concentration for water of 0.2 µg/l is multiplied with the Kp value of 630 l/kg (log Kp=2.8). This results in an extrapolated concentration of 0.13 mg/kg dw and an EAC of 0.05-0.5 mg/kg dw which was classified provisional.

This EAC range is a factor of 3 lower than the the TEL/PEL values from Environment Canada of 0.15/1.40 and the lower value is 3 fold higher than the highest background value (0.054 mg/kg dw normalised to 1% carbon) for the Convention area.

No spiked sediment data was available for evaluation.

1.3. Derivation of the EAC for biota

<u>Fish</u>

Not relevant, see chapter 2 on BCF values.

<u>Mussels</u>

Experimental BCF data for Mussels (McLeese and Burridge) indicates a value of 33,100 l/kg sp dw. The EAC is derived by multiplying the extrapolated concentration in water of 0.2 µg/l, with the BCF value of 33,100 l/kg. This results in a concentration in mussel of 6.62 mg/kg dw. Applying the ranging procedure on this concentration results in an EAC of 1-10 mg/kg dw, which is classified as provisional.

2. BCF DATA

BCF values for mussels for pyrene are not available. BCF values for fish are considered not relevant in connection with the current monitoring programme. The

Annex 11 : Subgroup report - Derivation of pyrene EAC

BCF for mussels on the coverpage is calculated using the following formula (see EAC 2/1).

BCF = Kow * 0.085 (soft parts dry weight) **(1)**

The calculated BCF for mussels is calculated as follows: BCF = 125,900 l/kg*0.085 <=> 10,700 l/kg dw.

3. **ECOTOXICOLOGICAL DATA**

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. **Saltwater toxicity data**

No saltwater oxicity for pyrene are available.

3.2. **Freshwater toxicity data**

- table 3.2.1: chronic toxicity data: NOECs,
- table 3.2.2: acute toxicity data: L(E)C50s,

3.2.1. *Table : Chronic toxicity of pyrene to freshwater organisms: NOECs*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Macrophyta										
Lemna gibba	Y	R	-	am	-	-	8 d	NOEC	500[a]	Ren *et al.*, 1994

a growth; light regime: (constant light 'cool white fluorescent lamps', prucing UV-A + UV-B), ratio visible: UV-A:UV-B is 100:10:1 based on the number of photons, total intensity 40 µmol*$m^{-2}s^{-1}$, which is comparable with natural sunlight (spectrum and intensity)

3.2.2. *Table : Acute toxicity of pyrene to freshwater organisms: L(E)C50s*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Algae/Chlorophyta										
Chamydomonas angulosa	N	Sc	-	am	6.5	-	? h	EC50	202 [a]	Hutchinson *et al*, 1980
Chlorella vulgaris	N	Sc	-	am	6.5	-	? h	EC50	332 [a]	Hutchinson *et al*, 1980
Crustacea										
Daphnia magna, 1.5 mm, 4-6 d	N	Sc	>97%	am	6.0-7.0	-	48 h	LC50	1,820	Bobra *et al*., 1983

a growth

Annex 11 : Subgroup report - Derivation of pyrene EAC

4. RAW DATA ON PARTITION COEFFICIENTS

In this paragraph the data on soil-water and sediment-pore water partiton coefficients are presented.

Legend:

solid/water	solid water ratio used in experiment
mass balance	Y: checked whether total amount of substance analysed in different compartments equals total amount added at start of experiment, N: no check
equilibrium time	time after substance added before concentrations are analysed in different compartments

Annex 11 : Subgroup report - Derivation of pyrene EAC

4.1. **Table : data on equilibrium partition coefficients**

testsubstance	soil type	% oc	pH	CEC mmol/kg	solid/water g/l	mass bal.	equil. time	log K_{oc}	reference
pyrene									
	sediment	-	-	-	-	-	-	4.92	EHC draft september , 1994
	sediment	-	-	-	-	-	-	4.90	EHC draft september , 1994
	sediment	-	-	-	-	-	-	4.80	EHC draft september , 1994
	sediment	-	-	-	-	-	-	4.78	EHC draft september , 1994
	sediment	-	-	-	-	-	-	3.11	EHC draft september , 1994
	sediment	-	-	-	-	-	-	3.46	EHC draft september , 1994
	sediment	-	-	-	-	-	-	6.51	EHC draft september , 1994
	sediment	-	-	-	-	-	-	4.80	EHC draft september , 1994
	sediment	-	-	-	-	-	-	5.13	EHC draft september , 1994

Annex 11 : Subgroup report - Derivation of pyrene EAC

5. REFERENCES

5.1. References from coversheet

Long *et al*. (1995) Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management, 19, (1), 81-97.

Meador *et al.* (1995) Bioaccumulation of polycyclic aromatic hydrocarbons by marine organisms. In: G.W. Ware, Reviews of Environmental Contamination and Toxicology, Vol. 143 p. 79-166.

5.2. References 'ecotoxicological data'

Bobra *et al.* (1983) A predictive correlation for the acute toxicity of hydrocarbons and chlorinated hydrocarbons to the water flea (Daphnia magna. Chemosphere, 12, (9/10), 1121-1129.

Hutchinson *et al.* (19..) Toxicity to Algae. ???. 577-586.

Ren *et al*. (1994) Photoinduced toxicity of three polycylic aromatic hydrocarbons (fluoranthene, pyrene and naphthalene) to the duckweed Lemna gibba L. G-3. Ecotox. Environ. Saf., 28, 160-171.

5.3. References evaluated but rejected 'ecotoxicological data'

See factsheet for naphthalene.

5.4. References 'log Koc data'

EHC draft (September 1994) IPCS EHC for Polycyclic Aromatic Hydrocarbons, first draft September 1994, WHO, Geneva.

5.5. References evaluated but rejected 'log Koc data'

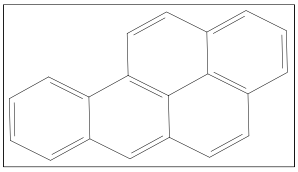
See factsheet for naphthalene.

ANNEX 12 : Subgroup report - Derivation of benzo[a]pyrene EAC

EAC 3/4/9	benzo[a]pyrene

3rd OSPAR Workshop on Ecotoxicological Assessment Criteria
NOVEMBER 25-29, 1996

CAS number: 50-32-8
Molecular formula: C20H12
Structural formula:



Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	6.20	l/kg	Meador *et al.* , 1995	
Sediment water partition coefficient (log Kp)	4.83	l/kg		Field data (n=2)
BCF fish	-	l/kg fw		not relevant
BCF mussel	135,000	l/kg sp dw		calculated from Kow

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	6.3	µg/l	TNO, 1993	freshwater
Lowest L(E)C50	5	µg/l	Trucco *et al.* (1983)	freshwater
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	-	mg/kg food		not relevant
Lowest NOEC for birds	-	mg/kg food		not relevant

Extrapolated Concentrations	result	unit	assessment factor	note
Water	0.063	µg/l	100	
Sediment (Equilibrium partitioning)	4.26	mg/kg dw		
Sediment (TEL/PEL)	0.089/0.76	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	0.01-0.1	µg/l	p	
Sediment	0.1-1.0	mg/kg dw	p	TEL/PEL
Fish	-	mg/kg fw		not relevant
Mussel	5-50	mg/kg dw	p	calculated from BCF

Remarks	result			
Secondary poisoning taken into account	N			Y/N

ANNEX 12 : Subgroup report - Derivation of benzo[a]pyrene EAC

1. DERIVATION OF THE EACS FOR BENZO[A]PYRENE

1.1. Derivation of the EAC for water

Only freshwater data was available - L(E)C50 data for two algal species and a crustacean and NOEC data for one fish species. The NOEC data was used which was 6.3 µg/l for *Brachydanio rerio* (TNO, 1993). Applying a factor of 100 this leads to an extrapolated concentration of 0.063 µg/l and an EAC of 0.01-0.1 µg/l, which is classified as provisional.

1.2. Derivation of the EAC for sediment

The Log Kp value used (assuming 1% organic carbon) was 4.83 derived from an average Log K_{oc} of 6.83 from 2 field studies detailed in Table 4.1. The extrapolated concentration for water of 0.063 µg/l is multiplied with the Kp value of 67,608 l/kg (log Kp=4.83). This results in an extrapolated concentration of 4.26 mg/kg dw and an EAC of 1-10 mg/kg dw.

This range is an order of magnitude higher than the TEL/PEL values from Environment Canada of 0.089/0.76 and therefore the TEL/PEL data was used to calculate the EAC and was set in the range 0.1-1.0 mg/kg dw which was classified as provisional.

The lowest value in this range is 3 times higher than the highest background value of 0.037 mg/kg dw (normalised to 1% carbon) for the Convention area.

Spiked sediment LC50 data (from the BEDS data base) was limited to one study by Plesha et al., 1988) which gave a value much higher than the EAC (10 mg/kg).

1.3. Derivation of the EAC for biota

<u>Fish</u>

Not relevant, see chapter 2 on BCF values.

<u>Mussels</u>

The EAC for mussels is derived by multiplying the extrapolated concentration in water of 0.063 µg/l, with the BCF value of 135,000 l/kg derived by calculation from the Log K_{ow}. This results in a concentration in molluscs of 8.5 mg/kg dw. Applying an order of magnitude on this concentration results in an EAC of 5-50 mg/kg dw, which is classified as provisional.

2. BCF DATA

BCF values for mussels for benzo[a]pyrene are not available. BCF values for fish are considered not relevant in connection with the current monitoring programme. The BCF for mussels on the coverpage is calculated using the following formula (See EAC 2/1).

$$BCF = Kow * 0.085 \quad \text{(soft parts dry weight)} \qquad (1)$$

The calculated BCF for mussels is calculated as follows: BCF = 1,585,000 l/kg*0.085 <=> 135,000 l/kg dw.

3. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. Freshwater toxicity data

Only freshwater data are available for benzo[a]pyrene. The data are presented as follows:

- table 3.1.1: chronic toxicity data: NOEC-values
- table 3.1.2: acute toxicity data: L(E)C50-values

3.1.1. *Table : Chronic toxicity of benzo[a]pyrene to freshwater organisms: NOECs*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Pisces										
Brachydanio rerio	Y	-	-	-	-	-	42 d	NOEC	6.3[1] a	TNO, 1993

1 above the water solubility, which is 3.8 mg/l at 25°C

3.1.2. *Table : Acute toxicity of benzo[*a*]pyrene to freshwater organisms: L(E)C50s*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Algae/Chlorophyta										
Scenedesmus capricornutum	N	S	³99%	am	-	-	72 h	EC50	5.0[1a]	Schoeny *et al*., 1988
Selenastrum capricornutum	N	S	³99%	am	-	-	72 h	EC50	15[1a]	Schoeny *et al*., 1988
Crustacea										
Daphnia pulex, 1.9-2.1 mm	N	S_c	-	nw	7.5	-	96 h	LC50	5.0[1b]	Trucco *et al*., 1983

1 above water solubility, which is 3.8 mg/l, at 25°C

a growth; light conditions: 16 h light and 8 h dark, illumination with 'white light'
b light regime is 12 h light and 12 h dark, with mixed fluorescent and natural light

4. DATA ON PARTITION COEFFICIENTS

In this paragraph the data on sediment-pore water partiton coefficients are presented.

Legend:

solid/water	solid water ratio used in experiment
mass balance	Y: checked whether total amount of substance analysed in different compartments equals total amount added at start of experiment, N: no check
equilibrium time	time after substance added before concentrations are analysed in different compartments

ANNEX 12 : Subgroup report - Derivation of benzo[a]pyrene EAC

4.1. Table : data on equilibrium partition coefficients of selected polycyclic aromatic hydrocarbons

testsubstance	soil type	% oc	pH	CEC mmol/kg	solid/water g/l	mass bal.	equil. time	log K_{oc}	reference
benzo[*a*]pyrene									
	sediment	3.38	7.8	-	200	N	3 h	6.26[a]	Kayal & Connell, 1990
	sediment	-	-	-	10	Y	72 h	8.37[b]	Evers & Smedes, 1993
	sediment	5.5[a]	-	-	-	-	-	7.4[a]	Van Hattum, 1995
	sediment	2.7	-	-	-	-	-	5.98	De Maagd & Sijm, 1995

a no batch experiment, mean value of different field contaminated sediments
b co-solvent method; 'true K_{oc}" extrapolated to 100% water; without influence of "third phase" material

5. REFERENCES

5.1. References from coversheet

Long *et al*. (1995) Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management, 19, (1), 81-97.

Meador *et al*. (1995) Bioaccumulation of polycyclic aromatic hydrocarbons by marine organisms. In: G.W. Ware, Reviews of Environmental Contamination and Toxicology, Vol. 143 p. 79-166.

5.2. References 'ecotoxicological data'

Cody, T.E., M.J. Radike and D. Warshawsky (1984) The phototoxicity of benzo[a]pyrene in the green alga *Selenastrum capricornutum*. Environ. Res. 35, 122-132.

Schoeny, R., T. Cody, D. Warshawsky and M. Radike (1988) Metabolism of mutagenic polycyclic aromatic hydrocarbons by photosynthtic Algae species. Mutation Research, 197, 289-302.

TNO (1993)

Trucco, R.G., F.R. Engelhardt and B. Stacey (1983) Toxicity, accumulation and clearance of aromatic hydrocarbons in *Daphnia pulex*. Environ. Pollut. ser. A, 31, 191-202.

5.3. References evaluated but rejected 'ecotoxicological data'

See factsheet on naphthalene.

5.4. References 'log K_{oc} data'

De Maagd, G.J. and D.T.H.M. Sijm (1995) PAKs: Milieuchemische en milieu-toxicologische eigenschappen in het aquatische milieu. Ritox, Utrecht University; project RI-900

Evers, E.H.G., and F. Smedes (1993) Adsorptiegedrag van extreem hydrofobe verbindingen: PCBs, PAK's en dioxines. Bepalingsmethoden vertroebelen sorptiecoëfficiënten. In: symposiumverslag Kontaminanten in bodems en sediment, sorptie en biologische beschikbaarheid. 29 april, 1993, De Reehorst, Ede.

Kayal, S.I., and D.W. Connell (1990) Partitioning of unsubstituted polycyclic aromatic hydrocarbons between surface sediments and the water column in the Brisbane river estuary. Aust. J. Mar. Freshwater Res., 41, 443-456.

Van Hattum, B. (1995) Bioaccumulation of sediment-bound contaminants by the freshwater isopod *Asellus aquaticus* (L.). Thesis Vrije Universiteit Amsterdam.

5.5. References evaluated but rejected 'log K_{oc} data'

See factsheet for naphthalene.

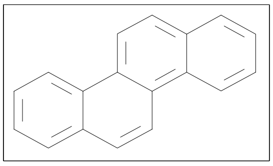
ANNEX 13 : Subgroup report - Derivation of chrysene EAC

EAC 3/4/7	chrysene

NOVEMBER 25-29, 1996
3rd OSPAR Workshop on Ecotoxicological Assessment Criteria

CAS number:	Molecular formula:
218-01-9	C18H12

Structural formula:



Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	5.80	l/kg	Meador *et al.* , 1995	
Sediment water partition coefficient (log Kp)	3.60	l/kg		Kp=0.5*Kow*0.01
BCF fish	-	l/kg fw		not relevant
BCF mussel	53,600	l/kg sp dw		calculated from Kow

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	-	µg/l		not available
Lowest L(E)C50	-	µg/l		not available
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	-	mg/kg food		not relevant
Lowest NOEC for birds	-	mg/kg food		not relevant

Extrapolated Concentrations	result	unit	assessment factor	note
Water	-	µg/l		not available
Sediment (Equilibrium partitioning)	-	mg/kg dw		not available
Sediment (TEL/PEL)	0.11/0.85	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	-	µg/l		not available
Sediment	0.1-1.0	mg/kg dw	p	TEL/PEL
Fish	-	mg/kg fw		not relevant
Mussel	-	mg/kg dw		not available

Remarks	result			
Secondary poisoning taken into account	N			Y/N

ANNEX 13 : Subgroup report - Derivation of chrysene EAC

1. DERIVATION OF THE EACS FOR CHRYSENE

1.1. Derivation of the EAC for water

No data are available.

1.2. Derivation of the EAC for sediment

Because there was no toxicity data equilibrium partitioning could not be used.

The TEL/PEL values from Environment Canada gave values of 0.11/0.85 mg/kg dw and this was used to set an EAC range of 0.1-1.0 mg/kg dw which was classified as provisional.

The highest background value for the Convention area was 0.016 mg/kg dw (normalised to 1% carbon) which is an order of magnitude lower than the TEL value.

No spiked sediment data was available.

1.3. Derivation of the EAC for biota

Fish

Not relevant, see chapter 2 on BCF values.

Mussels

For chrysene it is not possible to calculate the EAC for molluscs because no extrapolated concentration for water is available.

2. BCF DATA

BCF values for mussels for chrysene are not available. BCF values for fish are considered not relevant in connection with the current monitoring programme. The BCF for mussels on the coverpage is calculated using the following formula (EAC 2/1).

BCF = Kow * 0.085 (soft parts dry weight) **(1)**

The calculated BCF for mussels is calculated as follows: BCF = 631,000 l/kg*0.085 <=> 53,630 l/kg dw.

ANNEX 13 : Subgroup report - Derivation of chrysene EAC

3. RAW DATA ON PARTITION COEFFICIENTS

In this paragraph the data on sediment-pore water partiton coefficients are presented.

Legend:

solid/water	solid water ratio used in experiment
mass balance	Y: checked whether total amount of substance analysed in different compartments equals total amount added at start of experiment, N: no check
equilibrium time	time after substance added before concentrations are analysed in different compartments

ANNEX 13 : Subgroup report - Derivation of chrysene EAC

3.1. Table : data on equilibrium partition coefficients of selected polycyclic hydrocarbons

testsubstance	soil type	% oc	pH	CEC mmol/kg	solid/water g/l	mass bal.	equil. time	log K_{oc}	reference
chrysene									
	sediment	3.38	7.8	-	200	N	3 h	6.27[a]	Kayal & Connell, 1990
	sediment	-	-	-	10	Y	72 h	7.18[b]	Evers & Smedes, 1993
	sediment	5.5[a]	-	-	-	-	-	6.8[a]	Van Hattum, 1995
	sediment	2.7	-	-	-	-	-	5.83	De Maagd & Sijm, 1995

a no batch experiment, mean value of different field contaminated sediments
b co-solvent method; 'true K_{oc}" extrapolated to 100% water; without influence of "third phase" material

4. REFERENCES

4.1. References from coversheet

Long *et al*. (1995) Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management, 19, (1), 81-97.

Meador *et al.* (1995) Bioaccumulation of polycyclic aromatic hydrocarbons by marine organisms. In: G.W. Ware, Reviews of Environmental Contamination and Toxicology, Vol. 143 p. 79-166.

4.2. References 'log K_{oc} data'

De Maagd, G.J. and D.T.H.M. Sijm (1995) PAKs: Milieuchemische en milieu-toxicologische eigenschappen in het aquatische milieu. Ritox, Utrecht University; project RI-900

Evers, E.H.G., and F. Smedes (1993) Adsorptiegedrag van extreem hydrofobe verbindingen: PCBs, PAK's en dioxines. Bepalingsmethoden vertroebelen sorptiecoëfficiënten. In: symposiumverslag Kontaminanten in bodems en sediment, sorptie en biologische beschikbaarheid. 29 april, 1993, De Reehorst, Ede.

Kayal, S.I., and D.W. Connell (1990) Partitioning of unsubstituted polycyclic aromatic hydrocarbons between surface sediments and the water column in the Brisbane river estuary. Aust. J. Mar. Freshwater Res., 41, 443-456.

Van Hattum, B. (1995) Bioaccumulation of sediment-bound contaminants by the freshwater isopod *Asellus aquaticus* (L.). Thesis Vrije Universiteit Amsterdam.

4.3. References evaluated but rejected 'log K_{oc} data'

See factsheet for naphthalene.

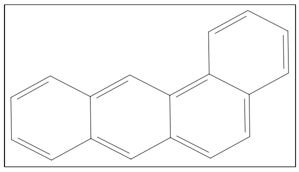
ANNEX 14 : Subgroup report - Derivation of benzo[a]anthracene EAC

EAC 3/4/6	benzo[a]anthracene

3rd OSPAR Workshop on Ecotoxicological Assessment Criteria
NOVEMBER 25-29, 1996

CAS number: 56-55-3
Molecular formula: $C_{18}H_{12}$

Structural formula:



Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	5.90	l/kg	Meador *et al.* , 1995	
Sediment water partition coefficient (log Kp)	4.75	l/kg		Field data (n=2)
BCF fish	-	l/kg fw		not relevant
BCF mussel	67,500	l/kg sp dw		calculated from Kow

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	-	µg/l		not available
Lowest L(E)C50	10	µg/l	Trucco *et al* . (1983)	freshwater
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	-	mg/kg food		not relevant
Lowest NOEC for birds	-	mg/kg food		not relevant

Extrapolated Concentrations	result	unit	assessment factor	note
Water	-	µg/l		
Sediment (Equilibrium partitioning)	-	mg/kg dw		
Sediment (TEL/PEL)	0.075/0.69	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	-	µg/l		not sufficient
Sediment	0.1-1.0	mg/kg dw		TEL/PEL
Fish	-	mg/kg fw		not relevant
Mussel	-	mg/kg dw		

Remarks	result			
Secondary poisoning taken into account	N			Y/N

ANNEX 14 : Subgroup report - Derivation of benzo[a]anthracene EAC

1. DERIVATION OF THE EACS FOR BENZO[A]ANTHRACENE

1.1. Derivation of the EAC for water

Only one L(E)C50 was available, being 10 µg/l (Trucco et al., 1983) for the crustacean *Daphnia pulex* and therefore no EAC could be derived.

1.2. Derivation of the EAC for sediment

Because there was insufficient toxicity data equilibrium partitioning could not be used.

The TEL/PEL values from Environment Canada gave values of 0.075/0.69 mg/kg dw and this was used to set an EAC range of 0.1-1.0 mg/kg dw which was classified as provisional.

The highest background value for the Convention area was 0.018 mg/kg dw (normalised to 1% carbon) which is well below the TEL value.

Only one spiked sediment data set was available from the BEDS data base (Plesha et al., 1989) which gave a higher value of 10 mg/kg in 0.9 % organic carbon.

1.3. Derivation of the EAC for biota

<u>Fish</u>
Not relevant, see chapter 2 on BCF values.

<u>Mussels</u>
Not able to be determined due to lack of aquatic toxicity data.

2. BCF DATA

BCF values for mussels for benzo[a]anthracene are not available. BCF values for fish are considered not relevant in connection with the current monitoring programme. The BCF for mussels on the coverpage is calculated using the following formula (EAC 2/1).

BCF = Kow * 0.085 (soft parts dry weight) ***(1)***

The calculated BCF for mussels is calculated as follows: BCF = 794,300 l/kg*0.085 <=> 67,500 l/kg dw.

ANNEX 14 : Subgroup report - Derivation of benzo[a]anthracene EAC

3. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test substance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. Freshwater toxicity data

Only one toxicity value is available for benzo[a]anthracene.

- table 3.1.1: acute toxicity data: L(E)C50-values

ANNEX 14 : Subgroup report - Derivation of benzo[a]anthracene EAC

3.1.1. *Table : Acute toxicity of benzo[a]anthracene to freshwater organisms: L(E)C50s*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Crustacea										
Daphnia pulex, 1.9-2.1 mm	N	S_c	-	nw	7.5	-	96 h	LC50	10[a]	Trucco *et al.*, 1983

a light regime is 12 h light and 12 h dark, with mixed fluorescent and natural light

4. RAW DATA ON PARTITION COEFFICIENTS

In this paragraph the data on sediment-pore water partiton coefficients are presented.

Legend:

solid/water	solid water ratio used in experiment
mass balance	Y: checked whether total amount of substance analysed in different compartments equals total amount added at start of experiment, N: no check
equilibrium time	time after substance added before concentrations are analysed in different compartments

ANNEX 14 : Subgroup report - Derivation of benzo[a]anthracene EAC

4.1. Table : data on equilibrium partition coefficients of selected polycyclic hydrocarbons

testsubstance	soil type	% oc	pH	CEC mmol/kg	solid/water g/l	mass bal.	equil. time	log K_{oc}	reference
benzo[*a*]anthracene									
	sediment	3.38	7.8	-	200	N	3 h	6.30[a]	Kayal & Connell, 1990
	sediment	-	-	-	10	Y	72 h	7.36[b]	Evers & Smedes, 1993
	sediment	5.5[a]	-	-	-	-	-	7.2[a]	Van Hattum, 1995
	sediment	2.7	-	-	-	-	-	5.83	De Maagd & Sijm, 1995

a no batch experiment, mean value of different field contaminated sediments
b co-solvent method; 'true K_{oc}" extrapolated to 100% water; without influence of "third phase" material

ANNEX 14 : Subgroup report - Derivation of benzo[a]anthracene EAC

5. REFERENCES

5.1. References from coversheet and chapter 1

Long *et al*. (1995) Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management, 19, (1), 81-97.

Meador *et al.* (1995) Bioaccumulation of polycyclic aromatic hydrocarbons by marine organisms. In: G.W. Ware, Reviews of Environmental Contamination and Toxicology, Vol. 143 p. 79-166.

5.2. References 'ecotoxicological data'

Trucco, R.G., F.R. Engelhardt and B. Stacey (1983) Toxicity, accumulation and clearance of aromatic hydrocarbons in Daphnia pulex. Environ. Pollut. Ser. A, 31,191-202.

5.3. References evaluated but rejected 'ecotoxicological data'

See factsheet for naphthalene.

5.4. References 'log K_{oc} data'

De Maagd, G.J. and D.T.H.M. Sijm (1995) PAKs: Milieuchemische en milieu-toxicologische eigenschappen in het aquatische milieu. Ritox, Utrecht University; project RI-900

Evers, E.H.G., and F. Smedes (1993) Adsorptiegedrag van extreem hydrofobe verbindingen: PCBs, PAK's en dioxines. Bepalingsmethoden vertroebelen sorptiecoëfficiënten. In: symposiumverslag Kontaminanten in bodems en sediment, sorptie en biologische beschikbaarheid. 29 april, 1993, De Reehorst, Ede.

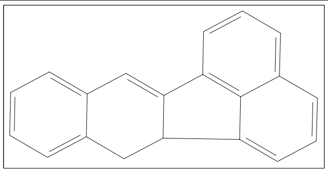
Kayal, S.I., and D.W. Connell (1990) Partitioning of unsubstituted polycyclic aromatic hydrocarbons between surface sediments and the water column in the Brisbane river estuary. Aust. J. Mar. Freshwater Res., 41, 443-456.

Van Hattum, B. (1995) Bioaccumulation of sediment-bound contaminants by the freshwater isopod *Asellus aquaticus* (L.). Thesis Vrije Universiteit Amsterdam.

5.5. References evaluated but rejected 'log K_{oc} data'

See factsheet for naphthalene.

ANNEX 15 : Subgroup report - Derivation of benzo[k]fluoranthene EAC

EAC 3/4/8	benzo[k]fluoranthene			
3rd OSPAR Workshop on Ecotoxicological Assessment Criteria, NOVEMBER 25-29, 1996	**CAS number:** 207-08-9	**Molecular formula:** C20H12		
	Structural formula: 			

Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	6.00	l/kg	Mackay *et al.*, 1992	
Sediment water partition coefficient (log Kp)	3.70	l/kg		Kp=0.5*Kow*0.01
BCF fish	-	l/kg fw		not relevant
BCF mussel	85,000	l/kg sp dw		calculated from Kow

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	0.27	µg/l	Hooftman & Evers de Ruiter, 92	freshwater
Lowest L(E)C50	-	µg/l		not available
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	-	mg/kg bw		not relevant
Lowest NOEC for birds	-	mg/kg bw		not relevant

Extrapolated Concentrations	result	unit	assessment factor	note
Water	-	µg/l		insufficient data
Sediment (Equilibrium partitioning)	-	mg/kg dw		
Sediment (ERL)	-	mg/kg dw		not available

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	-	µg/l		insufficient data
Sediment	-	mg/kg dw		Ep-method
Fish	-	mg/kg fw		not relevant
Mussel	-	mg/kg dw		

Remarks	result			
Secondary poisoning taken into account	N			Y/N

ANNEX 15 : Subgroup report - Derivation of benzo[k]fluoranthene EAC

1. DERIVATION OF THE EACS FOR BENZO[K]FLUORATHENE

1.1. derivation of the EAC for water

3 NOECs (0.27, 0.48 and 0.48 µg/l) were available but all from the same study (Hooftman and Evers de Ruiter, 1992) on one species - the fish *Brachydanio rerio*. Therefore no EAC could be derived.

1.2. derivation of the EAC for sediment

Because there was insufficient toxicity data equilibrium partitioning could not be used. No data exisited in the BEDS system and therefore no PEL/TEL values have been derived.

The highest background value for the Convention area was 0.095 mg/kg dw (normalised to 1% carbon) which is an order of magnitude lower than the TEL value.

No spiked sediment data was available.

1.3. derivation of the EAC for biota

<u>Fish</u>
Not relevant, see chapter 2 on BCF values.

<u>Mussels</u>
It was not possible to calculate and EAC for Mussels since inadequate toxicity data were available.

2. BCF DATA

BCF values for mussels for benzo[k]fluoranthene are not available. BCF values for fish are considered not relevant in connection with the current monitoring programme. The BCF for mussels on the coverpage is calculated using the following formula (See EAC 2/1).

BCF = Kow * 0.085 (soft parts dry weight) **(1)**

The calculated BCF for mussels is calculated as follows: BCF = 1,000,000 l/kg*0.085 <=> 85,000 l/kg dw.

3. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution

	N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. **freshwater toxicity data**

Only chronic data are available for benzo[k]fluoranthene.

- table 3.1.1: chronic toxicity data: NOEC-values

ANNEX 15 : Subgroup report - Derivation of benzo[k]fluoranthene EAC

3.1.1. *Table : Chronic toxicity of benzo[k]fluoranthene to freshwater organisms: NOECs*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l		Reference
Pisces											
Brachydanio rerio, eggs	Y	IF	100%	rw	7.9-8.2	206	6 w	NOEC	0.27[b]	α	Hooftman & Evers-de Ruiter, 1992b
Brachydanio rerio, eggs	Y	IF	100%	rw	7.9-8.2	206	6 w	NOEC	0.48[a]	α	Hooftman & Evers-de Ruiter, 1992b
Brachydanio rerio, eggs	Y	IF	100%	rw	7.9-8.2	206	6 w	NOEC	0.48[c]	α	Hooftman & Evers-de Ruiter, 1992b

a mortality of young fish; actual conc. 36-109% of initial conc., average 72%
b growth measured as fish length; actual conc. 36-109% of initial conc., average 72%
c same as b, but now growth measured as wet-weight

4. RAW DATA ON PARTITION COEFFICIENTS

In this paragraph the data on sediment-pore water partiton coefficients are presented.

Legend:

solid/water	solid water ratio used in experiment
mass balance	Y: checked whether total amount of substance analysed in different compartments equals total amount added at start of experiment, N: no check
equilibrium time	time after substance added before concentrations are analysed in different compartments

ANNEX 15 : Subgroup report - Derivation of benzo[k]fluoranthene EAC

4.1. **Table : raw data on equilibrium partition coefficients of selected polycyclic aromatic hydrocarbons**

testsubstance	soil type	% oc	pH	CEC mmol/kg	solid/water g/l	mass bal.	equil. time	log K_{oc}	reference
benzo[*k*]fluoranthene									
	sediment	3.38	7.8	-	200	N	3 h	5.99[a]	Kayal & Connell, 1990
	sediment	-	-	-	10	Y	72 h	8.50[b]	Evers & Smedes, 1993
	sediment	5.5[a]	-	-	-	-	-	7.4[a]	Van Hattum, 1995
	sediment	2.7	-	-	-	-	-	5.99	De Maagd & Sijm, 1995

a no batch experiment, mean value of different field contaminated sediments
b co-solvent method; 'true K_{oc}" extrapolated to 100% water; without influence of "third phase" material

ANNEX 15 : Subgroup report - Derivation of benzo[k]fluoranthene EAC

5. REFERENCES

5.1. References from coversheet and chapter 1

Mackay, D., W.Y. Shiu and K.C. Ma (1992) Illustrated handbook of physical-chemical properties and environmental fate for organic chemicals. Boca Raton, Lewis Publishers.

Meador *et al.* (1995) Bioaccumulation of polycyclic aromatic hydrocarbons by marine organisms. In: G.W. Ware, Reviews of Environmental Contamination and Toxicology, Vol. 143 p. 79-166.

5.2. References 'ecotoxicological data'

Hooftman, R.N., and A. Evers de Ruiter (1992) The toxicity and uptake of benzo[k]fluoranthene using brachydanio rerio in an early life stage test. TNO report IMW-R-92-218.

5.3. References evaluated but rejected 'ecotoxicological data'

See factsheet for naphthalene.

5.4. References 'log K_{oc} data'

De Maagd, G.J. and D.T.H.M. Sijm (1995) PAKs: Milieuchemische en milieu-toxicologische eigenschappen in het aquatische milieu. Ritox, Utrecht University; project RI-900

Evers, E.H.G., and F. Smedes (1993) Adsorptiegedrag van extreem hydrofobe verbindingen: PCBs, PAK's en dioxines. Bepalingsmethoden vertroebelen sorptiecoëfficiënten. In: symposiumverslag Kontaminanten in bodems en sediment, sorptie en biologische beschikbaarheid. 29 april, 1993, De Reehorst, Ede.

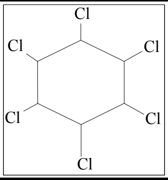
Kayal, S.I., and D.W. Connell (1990) Partitioning of unsubstituted polycyclic aromatic hydrocarbons between surface sediments and the water column in the Brisbane river estuary. Aust. J. Mar. Freshwater Res., 41, 443-456.

Van Hattum, B. (1995) Bioaccumulation of sediment-bound contaminants by the freshwater isopod *Asellus aquaticus* (L.). Thesis Vrije Universiteit Amsterdam.

5.5. References evaluated but rejected 'log K_{oc} data'

See factsheet for naphthalene.

ANNEX 16 : Subgroup report - Derivation of lindane EAC

EAC 3/3/3	lindane (HCH)
3rd OSPAR Workshop on Ecotoxicological Assessment Criteria, NOVEMBER 25-29, 1996	**CAS number:** 58-89-9 **Molecular formula:** $C_6H_6Cl_6$
	Structural formula: 

Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	3.69	l/kg	Bockting et al., 1993	
Sediment water partition coefficient (log Kp)	1.39	l/kg		Kp=0.5*Kow*0.01
BCF fish	550	l/kg fw		geom. mean
BCF mussel	1,067	l/kg sp dw		geom. mean

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	0.09	µg/l	Taylor et al., 1992	freshwater
Lowest L(E)C50	0.17	µg/l	Schimmel et al., 1977	saltwater
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOAEL for mammals	25	mg/kg bw	Frohberg & Bauer, 1972	
Lowest NOAEL for birds	1.6	mg/kg bw	Harrison et al., 1963	

Extrapolated Concentrations	result	unit	assessment factor	note
Water	0.0017	µg/l	100	
Sediment (Equilibrium partitioning)	0.000043	mg/kg dw		
Sediment (TEL)	0.00032	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	0.0005-0.005	µg/l	f	
Sediment		µg/kg dw		not relevant
Fish	0.0005-0.005	mg/kg fw	f	
Mussel		mg/kg dw		not relevant

Remarks	result			
Secondary poisoning taken into account	Y			Y/N

ANNEX 16 : Subgroup report - Derivation of lindane EAC

1. DERIVATION OF THE EACS FOR LINDANE

1.1. Derivation of the EAC for water

For salt water toxicity data for four taxonomic groups of species are available. Based on the chronic data for algae and molluscs it was concluded that these taxa are not sensitive. With respect to the remaining acute toxicity data on crustacean and fish an assessment factor of 100 was applied on the lowest value of 0.17 µg/l. This results in an extrapolated concentration of 0.0017 µg/l. Additional information is available from Andral, B., 1996 and Denkler, M., 1996 on numerous (both marine and freshwater) species which were considered not critical and were not further evaluated. More additional information is available on numerous freshwater organisms (table 3.2.1 and 3.2.2) which were also considered not critical but confirm the range of toxicity. The extrapolated concentration of 0.0017 µg/l was rounded to the EAC of 0.0005-0.005 µg/l. Although an extrapolation factor of 100 was applied on an acute toxicity value the EAC was considered firm because of the extensive data base.

1.2. Derivation of the EAC for sediment

To derive an extrapolated concentration for sediment three different methods are available. The first method is based on applying assessment factors on spiked sediment tests. For lindane however, these are not available. The second method is the equilibrium partition method (see EAC 2/1). For lindane, the extrapolated concentration for water of 0.0017 µg/l is multiplied with the calculated Kp value of 25 l/kg (log Kp=1.39). This results in an extrapolated concentration of 0.000043 mg/kg dw. The third method is the Canadian BEDS-approach (see EAC 2/1 and 2/6). For lindane a TEL-value of 0.00032 mg/kg. The extrapolated concentration based on the equilibrium partitioning approach is considered firm. As within the Monitoring Programme sediment is not the appropriate matrix no EAC is derived.

1.3. Derivation of the EAC for biota

<u>Fish</u>

Calculation of the EAC for fish is possible using two methods. The first method is multiplying the extrapolated concentration in water with the geometric mean BCF for fish: EAC fish=0.0017 µg/l*550 l/kg fw <=> 0.00094 mg/kg fw. The second method is based on secondary poisoning (see EAC 2/4). The NEC predator for lindane is 0.16 mg/kg food and is derived by applying a factor 10 on the lowest NOEC of 1.6 mg/kg food for the bird *Gallus domesticus*. The EAC fish=0.16 mg/kg*0.32 (see EAC 2/4) <=> 0.05 mg/kg fw. The lowest value is 0.00094 mg/kg fw and is rounded to the range of 0.0005-0.005 mg/kg fw. The EAC is considered firm because of the Firm EAC for water and the use of a measured BCF-value and the extensive dataset on mammals and birds.

<u>Mussels</u>

As for fish the calculation of the EAC for mussels is possible using two methods. The first method is multiplying the extrapolated concentration in water with the geometric mean BCF for mussels: The results in an extrapolated concentration for mussel =

0.0017 µg/l*1067 l/kg dw <=> 0.0018 mg/kg dw. The second method is based on secondary poisoning (see EAC 2/4). The NEC predator for lindane is 0.16 mg/kg food and is derived by applying a factor 10 on the lowest NOEC of 1.6 mg/kg food for the bird *Gallus domesticus.* The extrapolated concentration for mussel = 0.16 mg/kg*0.2 (see EAC 2/4) <=> 0.032 mg/kg dw. The lowest value is 0.0018 mg/kg dw. As within the Monitoring Programme mussels are not the appropriate matrix no EAC is derived.

2. BCF DATA

The geometric mean BCF for all fish species available is 550 l/kg fw, this value is used for the calculation of the EAC for fish.
For mussels (*Mytilus edulis*) a geometric mean BCF of 143 l/kg fw is calculated. This value is recalculated to soft parts dry weight with the correction factor of 0.134 (dw/fw) proposed in Haenen *et al*. (1993). Applying this factor results in a BCF of 1067 l/kg dw. The geometric mean BCF for all molluscs is 55 l/kg fw and 410 l/kg dw. The value of 1,067 l/kg dw is used for calculation of the EAC mussel.
The experimental BCF values for fish and molluscs are presented in table 2.1

Legend:

Exp. period	exposure period
C_{water}	water concentration applied in the test
fw	fresh weight
dw	dry weight

2.1. Table : bioconcentration factors for fish and molluscs

Species	Exp. period (d)	C_{water} (µg/l)	BCF (l/kg) fw	BCF (l/kg) dw	Reference
FISH					
Brachydanio rerio	9	9.7	920	-	Butte *et al.* (1991)
Cyprinodon variegatus	4	109	490	-	Schimmel *et al.* (1977)
Cyprinus carpio	20	0.0024	273	-	Sugiura *et al.* (1979)
Gambusia affinis					
,,	33	1.7	560	-	Metcalf *et al.* (1973)
,,	14	12.3	420 *(485)*	-	Thybaud (1990) *geometric mean*
Laludesthes s. sicculus	7	1.8	1613	-	Matsumura and Benezet (1973)
Legodon thomboides	4	31	218	-	Schimmel *et al.* (1977)

Leuciscus idus	20	0.0024	973	-	Sugiura *et al.* (1979)
not specified			324	-	Banerjee and Bauchman (1991)
Pimephales promelas					
,,	32	3.4	180	-	Veith *et al.* (1979)
,,	304		368	-	Macek *et al.* (1969)
			(290)		*geometric mean*
Poecilia reticulata					
,,	20	0.03	1485	-	Sugiura *et al.* (1979)
,,	10	0.1	697	-	Yamamoto *et al.* (1983)
			(1017)		*geometric mean*
Pseudorasbora parva	14	20	1246	-	Kanazawa (1982)
Salmo gairdneri					
,,	96	0.026	1600	-	Oliver and Niimi (1985)
,,	35	0.6	319	-	Ramamoorthy (1985)
			(714)		*geometric mean*
Salmo trutta fario	20	0.0024	658	-	Sugiura *et al.* (1979)
			-------		
			(550)		*geometric mean for all fish*
MOLLUSCS					
Mercenaria mercenaria	5		13	97	Butler (1971)
Mya arenaria	5		40	300	Butler (1971)
Mytilus edulis					
			157	1172	Geyer (1982)
		5	139	1037	Ernst (1979)
			350	2612	Geyer (1982)
		2.61	74	550	Ernst (1975)
	4	0.0013	100	750	Ernst (1977)
			150	1119	Geyer (1982)
			(143)	*(1067)*	*geometric mean*
Venerupis japonica	3	1	121	903	Yamamoto *et al.* (1983)
			------	--------	
			(55)	*(410)*	*geometric mean for all molluscs*

ANNEX 16 : Subgroup report - Derivation of lindane EAC

3. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. Saltwater toxicity data

Chronic ass well as acute data are available. The data are presented as follows:

- table 3.1.1: chronic toxicity data NOECs.
- table 3.1.2: acute toxicity data L(E)C50s.

ANNEX 16 : Subgroup report - Derivation of lindane EAC

3.1.1. *Table : chronic saltwater toxicity data for lindane*

Organism	A	Test type	Test sub. purity	Test water	pH	Salinity °/oo	Exp. time	Crite-rion	Result µg/l	Reference
Algae										
Scenedesmus quadricauda	-	-	-	-	-	-	8 d	NOEC	1,900	Bringmann and Kuhn, (1977)
Mollusca										
Crossostrea gigas	-	-	-	-	-	-	2 d	NOEC	1000 [a]	Davis & Hidu, 1979
Crossostrea gigas	-	-	-	-	-	-	2 d	NOEC	1000 [a]	Davis & Hidu, 1979
Crossostrea gigas	-	-	-	-	-	-	2 d	NOEC	1000 [a]	Davis & Hidu, 1979
Mercenaria mercenaria	-	-	-	-	-	-	10 d	NOEC	5000 [b]	Davis & Hidu, 1979
Mercenaria mercenaria	-	-	-	-	-	-	2 d	NOEC	5000 [a]	Davis & Hidu, 1979
Mercenaria mercenaria	-	-	-	-	-	-	10 d	NOEC	5000 [b]	Davis & Hidu, 1979
Mercenaria mercenaria	-	-	-	-	-	-	2 d	NOEC	5000 [a]	Davis & Hidu, 1979
Mercenaria mercenaria	-	-	-	-	-	-	10 d	NOEC	5000 [b]	Davis & Hidu, 1979
Mercenaria mercenaria	-	-	-	-	-	-	2 d	NOEC	5000 [a]	Davis & Hidu, 1979

a reproduction
b mortality

3.1.2. *Table : acute saltwater toxicity data for lindane*

Organism	A	Test type	Test sub. purity	Test water	pH	Salinity $^o/_{oo}$	Exp. time	Crite-rion	Result µg/l	Reference
Crustacea										
Gammarus duebeni, adult	-	-	-	-	-	-	96 h	LC50	13.5	Inman & Lockwood (1977)
Gammarus duebeni, adult	-	-	-	-	-	-	96 h	LC50	9.6	Inman & Lockwood (1977)
Mysidopsis bahia	-	-	99%	-	-	-	96 h	LC50	6.3	Schimmel *et al*. (1977)
Penaeus duorarum, adult	-	-	99%	-	-	-	96 h	LC50	0.170	Schimmel *et al*. (1977)
Pisces										
Lagodon rhamboides	-	-	-	-	-	-	96 h	LC50	30.6	Schimmel *et al*. (1977)

3.2. **Freshwater toxicity data**

Chronic ass well as acute data are available. The data are presented as follows:

- table 3.2.1: chronic toxicity data: NOECs.
- table 3.2.2: acute toxicity data: L(E)C50s.

3.2.1. *Table :chronic freshwater toxicity data for lindane*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness	Exp. time	Crite-rion	Result µg/l	Reference
Algae										
Scenedesmus aucutus	-	-	-	-	-	-	5 d	NOEC	250	Krishnakumari, (1977)
Crustacea										
Gammarus fasciatus	-	-	-	-	-	-	16 d	NOEC	4.3[a]	Macek *et al* (1976)
Pisces										
Oncorynchus mykiss	-	-	-	-	-	-	12 w	NOEC	2.9[b]	Mensink *et al*. (1991)
Insecta										
Chironomus riparius	-	-	-	-	-	-	10 d	NOEC	0.09[b]	Taylor *et al*. (1992)
Rotatoria										
Branchionus calyciflorus	-	-	-	-	-	-	10 d	NOEC	10000[c]	Ferrando *et al*. (1993)

a mortality
b growth
c reproduction

3.2.2. *Table : acute freshwater toxicity data for lindane*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness	Exp. time	Crite-rion	Result µg/l	Reference
Crustacea										
Asselus aquaticus	-	-	-	-	-	-	48 h	LC50	5.2	Thybaud *et al*. (1987)
Pisces										
Oncorynchus mykiss	-	-	-	-	-	-	96 h	LC50	18	Mayer and Ellersieck, (1986)
Insecta										
Chironomus riparius	-	-	-	-	-	-	72 h	LC50	6.5	Maund *et al*. (1992)
Amphibia										
Bufo woodhousei fowleri	-	-	-	-	-	-	96 h	LC50	3200	Mayer and Ellersieck, (1986)

3.3. Toxicity data for birds and mammals

In the tables on toxicity for mammals and birds the original 'reported' value and the corrected value are mentioned. The converted value is the corrected NOEC in mg/kg food. The lowest NOEC and/or LC50 values are presented in the tables in shading. The data are presented as follows:

table 3.3.1 : chronic toxicity data for birds
table 3.3.2 : chronic toxicity data for mammals

3.3.1. *Table : toxicity data for birds*

duration	parameter	species	NOEC reported	NOEC converted (mg/kg food)	reference
NOECs					
27 d	mo	*Gallus domesticus*	16	1.6[a]	Harrison *et al*., 1963
8 w	re	*Anas plathyrhynchos*	200	100[b]	Chakravarty *et al*., 1986
LC50s					
5 d		*Coturnix c. japonica*	425	425	Hill *et al*. (1975)
5 d		*Phasianus colchicus*	561	561	Hill *et al*. (1975)
5 d		*Colinus variegatus*	882	882	Hill *et al*. (1975)
5 d		*Anas plathyrhynchos*	>5000	>5000	Hill *et al*. (1975)

a NOEC from study with short duration <1 mnd., therefore an factor 10 is applied
b NOEC=LOEC/2, between 20-50% effect at lowest concentration

3.3.2. *Table : toxicity data for mammals*

duration	parameter	species	NOEC reported	NOEC converted (mg/kg food)	reference
NOECs					
9 d	re	*Mus musculus*	30	25[a]	Frohberg & Bauer, 1972
12 d	re	*Oryctolagus cuniculus*	10	33[a]	Palmer & Lovell, 1971
90 d	re	*Rattus norvegicus*	5	100[a]	Trifonova *et al*., 1970
2 y	mo	*Rattus norvegicus*	400	400	Fitzhugh *et al*., 1950
90 d	mo	*Rattus norvegicus*	50	50	Van Velsen, 1984

a data corrected for mg/kg body weight > mg/kg food with species specific correction factors, see document EAC2/4

ANNEX 16 : Subgroup report - Derivation of lindane EAC

4. REFERENCES

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EAC 3/6	tributyltin (TBT)			
3rd OSPAR Workshop on Ecotoxicological Assessment Criteria, NOVEMBER 25-29, 1996				
Physical-chemical properties	**result**	**unit**	**reference**	**note**
Octanol water partion coefficient (log Kow)	3.30	l/kg	Bockting et al., 1993	
Sediment water partition coefficient (log Kp)	2.60	l/kg	Oslo/Paris com., 1994	
BCF fish	-	l/kg fw		not relevant
BCF mussel	116,000	l/kg sp dw		geom. mean
Ecotoxicology	**result**	**unit**	**reference**	**note**
water				
Lowest NOEC	0.0004	µg/l	Gibbs & Bryan, 1987	LOEC/3
Lowest L(E)C50	0.005	µg/l	Nell & Chvojka, 1992	
sediment				
Lowest NOEC	0.1	mg/kg dw	Matthiessen & Thain, 1989	field study
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	-	mg/kg bw		not relevant
Lowest NOEC for birds	-	mg/kg bw		not relevant
Extrapolated Concentrations	**result**	**unit**	**assessment factor**	**note**
Water	0.00005	ng/l	100	*1
Sediment (Equilibrium partitioning)	0.00002	mg/kg dw		
Sediment (TEL)	-	mg/kg dw		not available
Ecotoxicological Assessment Criteria (EAC)	**result**	**unit**	**firm/provisional**	**note**
Water	0.00001-0.0001	µg/l	f	
Sediment	0.000005-0.00005	mg/kg dw	p	
Fish	-	mg/kg fw		not relevant
Mussel	0.001-0.01	mg/kg dw	f	
Remarks	**result**			
Secondary poisoning taken into account	N			Y/N

*1 A NOEC is derived applying a factor of 10 on an apparent EC50 of 0.005 µg/l and an additional extrapolation factor of 10 is applied to derive the extrapolated concentration.

ANNEX 17 : Subgroup report - Derivation of TBT EAC

1. INTRODUCTION

It appears that marine species are more susceptible to TBT than freshwater organisms. The most critical endpoints are growth reduction in molluscs and the occurrence of imposex in gastropods, the latter being a sub-lethal effect that causes reproductive impairment. As TBT causes ecotoxicological effects at very low concentrations. analysis protocols have only recently become available for the determination of relevant levels in the marine environment. Concentrations are often expressed as tin in the TBT fraction. Concentrations are 2.5 times higher when expressed as TBT.

Toxicity data have been evaluated for several TBT-salts: acetate, acrylate, benzoate, chloride, fluoride and oxide. It is well known that the toxicity of TBT salt is caused by the cation (Evers *et al*., 1995). Therefore, the toxicity data for the different TBT salts are combined to derive EACs.

2. DERIVATION OF THE EACS FOR TBT AND EXPERT JUDGEMENT

2.1. Derivation of the EAC for water

Field observation of the occurrence of imposex in the dog whelk *Nucella lapillus* showed that the no-effect level for imposex is below a TBT concentration of 1.25 ng/l (Gibbs and Bryan, 1987). Because the NOEC is below 1.25 ng/l a factor of 3 is applied to this LOEC and an estimated NOEC of 0.4 ng/l was derived. On this field NOEC an assessment factor of 1 is applied leading to an extrapolated concentration of 0.4 ng/l. In addition to field observations numerous toxicity data on laboratory experiments are available for both marine and freshwater organisms. From the dataset it appears that molluscs are the most sensitive group of species and that (juvenile) growth is even a more sensitive parameter than imposex. The lowest NOEC for direct effects (growth) available is 2.8 ng/l. In addition 'lowest test concentrations' for growth for *S. commercialis* (spat) and *C. gigas* (spat) of 5 ng/l gave 58% and 79% reduction in growth respectively (Nell & Chrojka, 1992). On these test results (treated like EC50 values) a factor of 10 was applied to calculate a NOEC of 0.5 ng/l, and an additional assessment factor of 10 to derive an extrapolated concentration of 0.05 ng/l. The extrapolated concentration of 0.05 ng/l was used to set the EAC as this value was the lowest. This leads to an EAC of 0.01-0.1 ng/l which is classified as firm.

2.2. Derivation of the EAC for sediment

To derive an extrapolated concentration for sediment three different methods are available. The first method is based on applying assessment factors on spiked sediment tests. A field experiment with artificially TBT-contaminated estuarine sediments (0.1-10 mg TBT/kg) showed a dose-response in several sediment-dwellers (Matthiessen and Thain, 1989). The burrowing activity of the polychaete *Arenicola marina* was reduced at 1 mg/kg but not at 0.1 mg/kg. An application factor of 100 to the NOEC gives an extrapolated concentration for TBT in sediment of 1 µg/kg. Recovery of affected populations of sediment dwellers other than gastropods in British estuaries has been observed at concentrations of approximately 10-20 µg/kg dw (Waite *et al.,* 1991). However, the extrapolated concentration that was derived might not be protective for species such as *N. lapillus,* which is more sensitive to TBT.

By means of the equilibrium partitioning the extrapolated concentration for water mentioned above (0.05 ng/l) results in an extrapolated concentration for sediment of 0.02 µg/kg dw. An estimated Kp of 400 for sediment with 1% organic carbon is applied in this calculation.

Equilibrium partitioning was chosen to derive the EAC as this gave the lowest value and since the spiked sediment test was carried out with a species known to be less sensitive to TBT. The EAC is set at 0.005-0.05 µg/kg dw. The EAC sediment is classified as provisional, because the Kp was calculated.

2.3. **Derivation of the EAC for biota**

<u>Fish</u>

Not relevant.

<u>Mussels</u>

Calculation of the EAC for mussels is possible using three methods. The first method is multiplying the extrapolated concentration in water with the geometric mean BCF for mussels: EAC mussels=0.05 ng/l*116,000 l/kg dw <=> 0.0058 mg/kg dw.

The second method is based on secondary poisoning (see EAC 2/4). For this method however no value is available.

The third method is a field experiment. TBT tissue residues in *N. lapillus* exposed to <1.25 ng/1 TBT in the field that were not suffering from imposex contained 195 µg/kg dw TBT (Gibbs and Bryan, 1987). A factor of 3 is applied to estimate a NOEC as *N. lapillus* is probably one of the most sensitive species and the value is derived from a field experiment. An assessment factor of 1 is applied to this NOEC leading to an extrapolated concentration of 0.065 mg/kg dw.

The lowest value of 0.0058 mg/kg dw is chosen to set the EAC. This leads to an EAC of 0.001-0.01 mg TBT/kg dw. The EAC mussels is classified as firm, because the BCF has been measured and the value for water has already been classified as firm.

3. **BCF DATA**

Bioconcentration factors for TBT in organisms are higher than expected from the log K_{ow}, because TBT can absorb to proteins aswell as by hydrophobic partitioning (Evers *et al*., 1995). The experimental BCF values for molluscs are presented in table 3.1.

Legend:

Exp. period	exposure period
C_{water}	water concentration applied in the test
fw	fresh weight
dw	dry weight

3.1. **Table : bioconcentration factors for molluscs**

Species	Exp. period (d)	C_{water} (µg/l)	BCF (l/kg) fw	BCF (l/kg) dw	Reference
MOLLUSCS					
Crassostrea gigas	21 d	0.15	6,000	45,000[a]	Evers et al., 1993
Crassostrea gigas	60 d	0.15	10,000	75,000	Waldock and Thain, 1983
			(7,750)	*(57,800)*	*geometric mean*
Mytilus edulis	51 d	0.05	60,000	450,000[b]	Zuolian & Jensen, 1989
Mytilus edulis	10 d	0.5	4,000	30,000	Laughlin et al., 1986
			(15,500)	*(116,000)*	*geometric mean*
Ostrea edulis	21 d	0.15	1,000	7,500[a]	Evers et al., 1993
			-------	-------	
			(9,650)	*(72,000)*	*geometric mean all molluscs*

a original reference Waldock et al., 1983
b field study

4. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

4.1. Saltwater toxicity data

Chronic as well as acute data are available. The data are presented as follows:

- table 4.1.1: chronic toxicity data: NOECs,
- table 4.1.2: acute toxicity data: L(E)C50s,

4.1.1. *Table : Chronic toxicity of TBT to saltwater organisms: NOECs*

Organism	A	Test type	Test sub. purity	Test water	pH	Salinity in °/oo	Exp. time	Crite- rion	Result µg/l	Reference
<u>tributyltinoxide</u>										
Algae										
Dunaliella tertiolecta	Y	S	-	nw	8.0	34-40	18 d	NOEC	0.05[l α]	Beaumont and Newman, 1986
<u>tributyltinacetate</u>										
Annelida										
Arenicola cristata, embryo	N	S	> 99.6%	nw	-	28	7 d	NOEC	2.5[a]	Walsh, 1986a
<u>tributyltinacetate</u>										
Mollusca										
Buccinum undatum, juveniles	Y	CF	-	nw	-	-	8 m	NOEC	0.0083[j]	Mensink *et al*. (1996a)
Buccinum undatum, juveniles	Y	CF	-	nw	-	-	10 m	NOEC	0.0083[j]	Mensink *et al*. (1996a)
Buccinum undatum, juveniles	Y	CF	-	nw	-	-	19 m	NOEC	0.0028[k]	Mensink *et al*. (1996a)
<u>tributyltinchloride</u>										
Mollucsa										
Mytilus edulis	-	R	-	nw	-	32	33 d	NOEC	0.006[c]	Lapota *et al*., 1993
Mytilus edulis	Y	CF	-	nw	-	-	66 d	NOEC	0.13[c]	Valkirs *et al*., 1987
<u>tributyltinoxide</u>										
Mollusca										
Acarrtia tonsa	Y	R	-	nw	-	-	144 h	NOEC	0.1[p]	U' Ren, 1983
Crassostrea gigas (spat)	-	S	-	nw	-	35[f]	28 d	NOEC	<0.005[g]	Nell & Chvojka, 1992
Crassostrea gigas	N	R	-	nw	-		56 d	NOEC	0.05[o]	Waldock and Thain, 1983
Crassostrea gigas, 0.15 g	N	R	-	nw	-	-	48 d	NOEC	0.01[m]	Fawler and Aldrich, 1987
Saccostrea commercialis (spat)	-	S	-	nw	-	35	28 d	NOEC	<0.005[h]	Nell & Chvojka, 1992
Mytilus edulis (5 m)	-	F	-	nw	-	33.7	7 d	NOEC	0.1[c]	Stromgren & Bongard, 1987
Mytilus edulis	N	CF	-	nw	-	34	7 d	NOEC	0.1	Stromgren and Bongard (1987)
<u>tributyltinchloride</u>										
Crustacea										

Eurytemora affinis, adult	Y	CF	-	nw	8	12.4	13 d	NOEC	0.01[b] α	Hall, 1988
tributyltinfluoride										
Crustacea										
Crassostrea gigas, embryo	N	R	-	nw	-	-	21 d	NOEC	0.025[d]	Cardwell & Sheldon, 1986
Gammanus oceanicus, adult, female	N	R	-	nw	-	7	8 w	NOEC	0.3[e]	Laughlin, 1984
tributyltinoxide										
Crustacea										
Palaemonetes pugio	N	R	-	nw	-	20	21 d	NOEC	0.033[n]	Khan et al. (1993)
tributyltinchloride										
Polychaeta										
Neanthes arenaceodentatat	-	-	96%	-	-	32	70 d	NOEC	0.05[c]	Moore *et al*., 1991
tributyltinfluoride										
Pisces										
Cyprinodon variegatus, embryo	N	CF	-	nw	-	-	28 d	NOEC	0.34[f]	Cardwell & Sheldon, 1986
tributyltinoxide										
Pisces										
Gasterosteus aculeatus (45-60 mm)	Y	F	-	nw	-	15-35	225 d	NOEC	0.1[i]	Holm *et al*., 1991

a mortality
b reproduction; NOEC=LOEC/10
c growth
d mortality; original reference, M & T chemicals 1984, not available
e mortality, 48 h renewal
f growth; original reference, M & T chemicals 1984, not available
g growth; 58% reduction in growth
h growth; 79% reduction in growth
i reproduction
j imposex
k length growth; NOEC=LOEC/3, 25 % effect in the lowest effect concentration
l growth; in the study this concentration was found to be significantly different from the control. However, we decided that the concentration is a NOEC because 6 % effect between control and 0.1 µg/l is not much and besides the significance was tested with a students t-test, which is less reliable in calculating NOECs; The NOEC of 0.1 µg/l is corrected for a 50% recovery
m growth rate; shell thickening observed, this effect is probably related to the decreasing shell size. The explanation is probably a stress induced, increased CO2 production, which is utilized from CaCO3 which is directly related to shell formation
n moulting; NOEC=LOEC/3, 30% effect in the lowest effect concentration; 1 ml/l aceton

o Growth; NOEC-LOEC/3 38% effect in a conc. of 0.15 µg/l
p survival; NOEC=LOEC/3 ca. 25% effect in a conc. of 0.3µg/l

4.1.2. *Table : Acute toxicity of TBT to saltwater organisms: L(E)C50-values*

Organism	A	Test type	Test sub. purity	Test water	pH	Salinity in $^{o}/oo$	Exp. time	Crite-rion	Result µg/l	Reference
tributyltinacatate										
Algae/Chlorophyta										
Skeletonema costatum	N	S	-	am	8.1	30	72 h	EC50	0.36[a]	Walsh *et al*., 1985
Thalassiosira pseudonana	N	S	-	am	8.1	30	72 h	EC50	1.3[a]	Walsh *et al*., 1985
tributyltinacrylate										
Algae/Chlorophyta										
Enteromorpha intestinalis	N	-	-	-	-	-	5 d	EC50	8.6[b]	WHO, EHC 116
tributyltinbenzoate										
Algae/Chlorophyta										
Enteromorpha intestinalis	N	-	-	-	-	-	5 d	EC50	0.027[a]	WHO, EHC 116
tributyltinchloride										
Algae/Chlorophyta										
Skeletonema costatum	N	S	-	nw	8.1	30	72 h	EC50	0.36[a]	Walsh *et al*., 1985
tributyltinfluoride										
Algae/Chlorophyta										
Skeletonema costatum	N	S	-	am	8.1	30	72 h	EC50	0.37[a]	Walsh *et al*., 1985
tributyltinchloride										
Crustacea										
Eurytemora affinis, sub-adult	Y	CF	-	am	8.2-8.3	9.8-12.1	72 h	LC50	0.6 α	Bushong *et al*., 1987/1988
Mysidopsis bahia, juvenile < 1 d	Y	CF	96%	nw	8.0	19.9	96 h	LC50	1.1 α	Goodman, 1988
Acartia tonsa, sub-adult	Y	CF	-	am	8.2-8.3	9.8-12.1	48 h	LC50	1.1 α	Bushong *et al*., 1987/1988
Gammarus sp., young	Y	CF	-	am	8.2-8.3	9.8-12.1	96 h	LC50	1.3 α	Bushong *et al*., 1988
Eurytemora affinis, sub-adult	Y	CF	-	am	8.2-8.3	9.8-12.1	48 h	LC50	1.4 α	Bushong *et al.*,1987/1988
Mysidopsis bahia, juvenile 5 d	Y	CF	96%	nw	8.0	19.9	96 h	LC50	2.0 α	Goodman, 1988
Mysidopsis bahia, juvenile 10 d	Y	CF	96%	nw	8.0	19.9	96 h	LC50	2.2 α	Goodman, 1988
Eurytemora affinis	Y	CF	-	nw	8.2	10.5	48 h	LC50	2.2 α	Hall *et al*., 1988a

Gammarus sp., young	Y	CF	-	am	8.2-8.3	9.8-12.1	72 h	LC50	4.3 α	Bushong *et al.*, 1988
Gammarus sp., adult	Y	CF	-	am	8.2-8.3	9.8-12.1	96 h	LC50	5.3 α	Bushong *et al.*, 1988
Gammarus sp., adult	Y	CF	-	am	8.2-8.3	9.8-12.1	72 h	LC50	10 α	Bushong *et al.*, 1988
Gammarus sp., young	Y	CF	-	am	8.2-8.3	9.8-12.1	48 h	LC50	13 α	Bushong *et al.*, 1988
Gammarus sp., adult	Y	CF	-	am	8.2-8.3	9.8-12.1	48 h	LC50	20 α	Bushong *et al.*, 1988
tributyltinfluoride										
Crustacea										
Nitocra spinipes, adult	N	S	-	nw	7.8	7	96 h	LC50	2.0	Lindén *et al.*, 1979
tributyltinoxide										
Crustacea										
Palaemonetes pugio, larvae	N	R	-	nw	-	20	96 h	LC50	4.1[b]	Khan et al. (1993)
Palaemonetes pugio, adult	N	R	-	nw	-	20	96 h	LC50	31[b]	Khan et al. (1993)
tributyltinchloride										
Mollusca										
Mercenaria mercenaria, embryo	Y	R	-	nw	-	18-22	48 h	LC50	1.1 α	Roberts, 1987
Crassostrea virginica, embryo	Y	R	-	nw	-	18-22	48 h	LC50	1.3 α	Roberts, 1987
Mercenaria mercenaria, larva	Y	R	-	nw	-	18-22	48 h	LC50	1.7 α	Roberts, 1987
Crassostrea virginica, larva	Y	R	-	nw	-	18-22	48 h	LC50	4.0 α	Roberts, 1987
tributyltinoxide										
Mollusca										
Scrobicularia plana	Y	S	97%	nw	-	24	48 h	EC50	0.25[a]	Ruiz *et al*. (1995)
tributyltinchloride										
Pisces										
Mysidopsis bahia, 1 d	Y	CF	96%	nw	8	20	96 h	LC50	0.75 α	Goodman et al. (1988)
Mysidopsis bahia, 5-9 d	Y	CF	96%	nw	8	20	96 h	LC50	1.36 α	Goodman et al. (1988)
Mysidopsis bahia, 10 d	Y	CF	96%	nw	8	20	96 h	LC50	1.5 α	Goodman et al. (1988)
tributyltinchloride										
Pisces										
Brevoortia tyrannus, juvenile	Y	CF	-	am	8.2-8.3	9.8-12.1	72 h	LC50	4.7 α	Bushong *et al.*, 1987/1988
Brevoortia tyrannus, juvenile	Y	CF	-	am	8.2-8.3	9.8-12.1	96 h	LC50	4.5 α	Bushong *et al.*, 1987/1988
Menidia beryllina, larva	Y	CF	-	am	8.2-8.3	9.8-12.1	72 h	LC50	4.6 α	Bushong *et al.*, 1987/1988
Brevoortia tyrannus, juvenile	Y	CF	-	am	8.2-8.3	9.8-12.1	48 h	LC50	5.8 α	Bushong *et al.*, 1987/1988
Menidia beryllina, larva	Y	CF	-	am	8.2-8.3	9.8-12.1	48 h	LC50	7.7 α	Bushong *et al.*, 1987/1988
Menidia menidia, sub-adult	Y	CF	-	am	8.2-8.3	9.8-12.1	96 h	LC50	8.9 α	Bushong *et al.*, 1987/1988
Menidia menidia, sub-adult	Y	CF	-	am	8.2-8.3	9.8-12.1	72 h	LC50	9.3 α	Bushong *et al.*, 1987/1988

Menidia menidia, sub-adult	Y	CF	-	am	8.2-8.3	9.8-12.1	48 h	LC50	13 α	Bushong *et al*., 1987/1988
Fundulus heteroclitus, larva	Y	CF	-	am	8.2-8.3	9.8-12.1	96 h	LC50	23 α	Bushong *et al*., 1988
Fundulus heteroclitus, sub-adult	Y	CF	-	am	8.2-8.3	9.8-12.1	96 h	LC50	24 α	Bushong *et al*., 1988
Cyprinodon variegatus, sub-adult	Y	CF	-	am	8.2-8.3	9.8-12.1	96 h	LC50	26 α	Bushong *et al*., 1988
Fundulus heteroclitus, sub-adult	Y	CF	-	am	8.2-8.3	9.8-12.1	72 h	LC50	28 α	Bushong *et al*., 1988
Cyprinodon variegatus, sub-adult	Y	CF	-	am	8.2-8.3	9.8-12.1	72 h	LC50	28 α	Bushong *et al*., 1988
Fundulus heteroclitus, larva	Y	CF	-	am	8.2-8.3	9.8-12.1	72 h	LC50	28 α	Bushong *et al*., 1988
tributyltinfluoride										
Pisces										
Alburnus alburnus, 8 cm	N	S	-	nw	7.8	7	96 h	LC50	7.0	Lindén *et al*., 1979

a growth
b spore development; original reference, Davies 1984, not available
a reproduction
b 1 ml/l aceton

4.2. **Freshwater toxicity data**

Chronic as well as acute data are available. The data are presented as follows:

- table 4.2.1: chronic toxicity data: NOECs,
- table 4.2.2: acute toxicity data: L(E)C50s,

4.2.1. ***Table: Chronic toxicity of TBT to freshwater organisms: NOEC-values***

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
tributyltinchloride										
Algae/Chlorophyta										
Selenastrum capricornutum	N	S	-	am	-	-	96 h	NOEC	4.0[a]	Miana *et al*., 1993
tributyltinoxide										
Chlorophyta										
Chlorella pyrenoidosa	-	-	-	-	-	-	4 d	NOEC	18[g]	Van de Meent *et al*., 1990
Scenedesmus pannonicus	-	-	-	-	-	-	4 d	NOEC	32[gh]	Van de Meent *et al*., 1990
tributyltinchloride										
Pisces										
Oncorhynchus mykiss, yolk-sac fry	N	CF	anal.	tw	7.4	101	16 w	NOEC	0.04[d]	De Vries *et al*., 1991
Oncorhynchus mykiss, yolk-sac fry	N	CF	anal.	tw	7.4	101	16 w	NOEC	0.04[f]	De Vries *et al*., 1991
Oncorhynchus mykiss, yolk-sac fry	N	CF	>98%	tw	6.8	98	16 w	NOEC	0.07[e]	Seinen *et al*., 1981
Phoxinus phoxinus, larvae	Y	R	³97%	nw	7.9-8.2	-	8 d	NOEC	0.24[c] a	Fent & Meier, 1992
Phoxinus phoxinus, 24 h, embryos	Y	R	³97%	nw	7.9-8.2	-	9 d	NOEC	0.72[b] a	Fent & Meier, 1992
Oncorhynchus mykiss, yolk-sac fry	N	CF	>98%	tw	6.8	98	16 w	NOEC	1.0[d]	Seinen *et al*., 1981
tributyltinoxide										
Pisces										
Pimephales promelas	N	CF	98%	nw	7.95	400	21 d	NOEC	0.17[a]	Triesskorn *et al*. (1994)
Poecilia reticulata (3-4 w)	-	-	-	-	-	-	91 d	NOEC	0.32[a]	Van de Meent *et al*., 1990
tributyltinoxide										
Mollusca										
Lymnea stagnalis (~3 m)	-	-	-	-	-	-	33 d	NOEC	0.32[h]	Van de Meent *et al*., 1990
tributyltinoxide										
Crustaceans										
Daphnia magna (24 h)	-	-	-	-	-	-	21 d	NOEC	0.16[b]	Van de Meent *et al*., 1990

Daphnia magna (< 1 d)	-	-	-	-	-	-	20 d	NOEC	0.56[a]	Van de Meent *et al*., 1990

a growth; conc. 2.0 mg/l showed no effect, conc. 4.0 mg/l showed stimulation, the first conc. showing effect is 8.0 mg/l
b mortality; solvent is aceton, amount unknown; renewal every 48 h; analytical results as geom. mean between initial- and 48 h results
c mortality; solvent is aceton, amount unknown; NOEC=LOEC/3, 36% effect at 0.73 mg/l; renewal every 48 h; results as geom. mean between initial- and 48 h results
d mortality; solvent is aceton, ca. 0.3 ml/l
e growth measured as body weight; NOEC=LOEC/3, 20% effect at 0.2 mg/l
f growth measured as body weight; body weight; solvent is aceton, ca. 0.3 ml/l
g growth
h reproduction

4.2.2. ***Table: Acute toxicity of TBT to freshwater organisms: L(E)C50-value***

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
tributyltin-acetate										
Pisces										
Oryzias latipes	N	R	-	tw	6.0-8.5	10-250	48 h	LC50	78[a]	Nagase *et al*., 1991
tributyltin-chloride										
Pisces										
Oncorhynchus mykiss, juvenile	N	S	-	am	6.0-8.5	10-250	96 h	LC50	13[d]	Douglas *et al*., 1986
Oryzias latipes	N	R	-	tw	6.0-8.5	10-250	48 h	LC50	36[e]	Nagase *et al*., 1991
tributyltin-chloride										
Rotifera										
Branchionus calyciflorus, cysts	N	S	>98%	am	-	-	24 h	LC50	72[b]	Crisinel *et al*., 1994
tributyltin-chloride										
Crustacea										
Daphnia magna, <24 h	N	S	-	am	7.8	137	48 h	EC50	9.8[c]	Miana *et al*., 1993
Streptocephalus texanus, cysts	N	S	>98%	am	-	-	24 h	LC50	15[b]	Crisinel *et al*., 1994
Daphnia magna	N	S	>98%	am	7.8	250	48 h	EC50	18[c]	Crisinel *et al*., 1994
Streptocephalus rubricaudatus, cysts	N	S	>98%	am	-	-	24 h	LC50	53[a]	Crisinel *et al*., 1994

a solvent (dimethyl sulfoxide + (HC40 surfactant)) at a ratio of 1:4, the absolute amount is unknown
b according to streptoxkit F
c immobility
d solvent is DMFO
e solvent is (dimethyl sulfoxide + (HC40 surfactant)) at a ratio of 1:4; derived from a QSAR

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WHO EHC (Environmental health criteria 116) TBT. WHO, Geneve

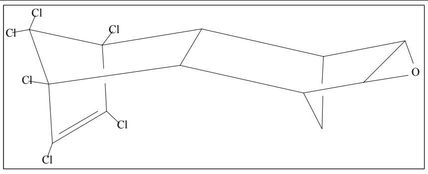
ANNEX 18 : Subgroup report - Derivation of dieldrin EAC

EAC 3/3/2	dieldrin

3rd OSPAR Workshop on Ecotoxicological Assessment Criteria — NOVEMBER 25-29, 1996

CAS number:	Molecular formula:
60-57-1	$C_{12}H_8Cl_6O$

Structural formula:



Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	6.20	l/kg	Van de Meent et al. (1990)	
Sediment water partition coefficient (log Kp)	3.89	l/kg		Kp=0.5*Kow*0.01
BCF fish	7,389	l/kg fw		geom. mean
BCF mussel	16,480	l/kg sp dw		geom. mean

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	0.1	µg/l	Adema & Vink (1981)	saltwater
Lowest L(E)C50	-	µg/l		not available
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	1	mg/kg food	Hunt et al. (1975)	
Lowest NOEC for birds	0.5	mg/kg food	De Witt (1956)	

Extrapolated Concentrations	result	unit	assessment factor	note
Water	0.001	µg/l	100	
Sediment (Equilibrium partitioning)	0.0078	mg/kg dw		
Sediment (TEL)	0.00072	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water		µg/l		not relevant
Sediment	0,0005-0,005	mg/kg dw	p	TEL
Fish	0.005-0.05	mg/kg fw	f	
Mussel	0.005-0.05	mg/kg dw	f	

Remarks	result			
Secondary poisoning taken into account	Y			Y/N

ANNEX 18 : Subgroup report - Derivation of dieldrin EAC

1. DERIVATION OF THE EACS FOR DIELDRIN

1.1. Derivation of the EAC for water

An assessment factor of 100 is selected because data are available for only 3 species and applied on the lowest NOEC available, being 0.1 µg/l (Adema & Vink, 1990) for the fish *Pleuronectus platessa.* This results in an extrapolated concentration of 0.001 µg/l. Because dieldrin in water has not been monitored within the Monitoring Programme an EAC for water is not derived.

1.2. Derivation of the EAC for sediment

To derive an extrapolated concentration for sediment three different methods are available. The first method is based on applying assessment factors on spiked sediment tests. For dieldrin however, these are not available. The second method is the equilibrium partition method (see EAC 2/1). For dieldrin, the extrapolated concentration for water of 0.001 µg/l is multiplied with the calculated Kp value of 7,792 l/kg (log Kp=3.89). This results in an extrapolated concentration of 0.0078 mg/kg dw. The third method is the Canadian BEDS-method (see EAC 2/1 and 2/6). For dieldrin a TEL-value is available of 0.000715 mg/kg. As the equilibrium method is applied on an extrapolated concentration for water based on an aquatic dataset of only 3 species the EAC sediment is derived by setting an order of magnitude on the TEL-value being the lowest value of the two methods (equilibrium partitioning and BEDS). This results in an EAC sediment of 0.0005-0.005 mg/kg dw. The EAC for sediment is classified as provisional because it is based on the BEDS approach.

1.3. Derivation of the EAC for biota

Fish

Calculation of the EAC for fish is possible using two methods. The first method is multiplying the extrapolated concentration in water with the geometric mean BCF for fish: EAC fish=0.001 µg/l*7389 l/kg fw <=> 0.0074 mg/kg fw. The second method is based on secondary poisoning (see EAC 2/4). The NEC predator for dieldrin is 0.05 mg/kg food and is derived by applying a factor 10 on the lowest NOEC of 0.5 mg/kg food for quail. EAC fish=0.05 mg/kg*0.32 (see EAC 2/4) <=> 0.016 mg/kg fw. The lowest value is 0.0074 mg/kg fw and is rounded to the range of 0.005-0.05 mg/kg fw. Considering the limited database for aquatic organisms, the reliable database on birds and mammals and the expected critical mode of action being food-chain poisoning, and the small difference between the extrapolated concentrations the EAC was set to the range of 0.005-0.05 mg/kg dw and considered firm.

Mussels

As for fish the calculation of the EAC for mussels is possible using two methods. The first method is multiplying the extrapolated concentration in water with the geometric mean BCF for mussels: EAC mussels=0.001 µg/l*16,480 l/kg dw <=> 0.017 mg/kg dw. The second method is based on secondary poisoning; the NEC predator is multiplied with a conversion factor for calloric content. The NEC predator for dieldrin is 0.05 mg/kg food and is derived by applying a factor 10 on the lowest NOEC of 0.5

mg/kg food for quail. EAC mussels=0.05 mg/kg*0.2 (see EAC 2/4) <=> 0.01 mg/kg dw. The lowest value is 0.01 mg/kg dw and is rounded to the range of 0.005-0.05 mg/kg dw, the EAC is considered firm for the same reasons as for fish.

2. BCF DATA

The geometric mean BCF for all fish species available is 7,389 l/kg fw.
For mussels (*Mytilus edulis*) a geometric mean BCF of 2,208 l/kg fw is calculated. This value is recalculated to soft parts dry weight with the correction factor of 0.134 proposed in Haenen *et al*. (1993). Applying this factor results in a BCF of 16,480 l/kg dw. The geometric mean BCF for all molluscs is 2,678 l/kg fw and 19,990 l/kg dw.
The experimental BCF values for fish and molluscs are presented in table 2.1. The geometric mean BCF values for fish and mussels are presented in shading.

Legend:

Exp. period	exposure period
C_{water}	water concentration applied in the test
fw	fresh weight
dw	dry weight

2.1. Table : bioconcentration factors for fish and molluscs

Species	Exp. period (d)	C_{water} (µg/l)	BCF (l/kg) fw	BCF (l/kg) dw	Reference
FISH					
Cottus perplexus	32	8.6	13300	-	Chadwick & Brocksen (1969)
Gambusia affinis	33	1.4	2700	-	Metcalf *et al.* (1973)
„	33	4.7	5979	-	Metcalf *et al.* (1979)
			(4017)		*geometric mean*
Poecilia reticulata	32	4.2	12500	-	Reinert (1972)
Salmo trutta	-	-	3300	-	Anonymus (1969)
„	-	-	6060	-	Van Leeuwen (1986)
			(4470)		*geometric mean*

			(7,389)		*geometric mean for all fish*
MOLLUSCS					
Mya arenaria	-	-	1740	13,000	Hawker and Connell (1986)
Mytilus edulis	6	0.0002	1570	11,720	Ernst (1977)
„			3106	23,180	Geyer (1982)
			(2208)	*(16,480)*	*geometric mean*
Crassosterea viriginica	-	-	5000	37,310	Hawker and Connell (1986)
			-------	-------	
			(2,678)	*(19,990)*	*geometric mean for all*

ANNEX 18 : Subgroup report - Derivation of dieldrin EAC

molluscs

ANNEX 18 : Subgroup report - Derivation of dieldrin EAC

3. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. Saltwater toxicity data

Only saltwater chronic toxicity data are available. The data are presented as follows:

- table 3.1.1: chronic toxicity data:NOECs

3.1.1. *Table : Chronic toxicity of dieldrin to saltwater organisms*

Organism	A	Test type	Test sub. purity	Test water	pH	Salinity °/oo	Exp. time	Crite-rion	Result µg/l	Reference
Annelida										
Ophryotrocha diadema	-	-	-	-	-	-	33 d	NOEC	0.1[a]	Adema & Vink, 1981
Ophryotrocha diadema	-	-	-	-	-	-	30 d	NOEC	1.0[b]	Adema & Vink, 1981
Ophryotrocha diadema	-	-	-	-	-	-	33 d	NOEC	0.1[a]	Adema & Vink, 1981
Ophryotrocha diadema	-	-	-	-	-	-	30 d	NOEC	1.0[b]	Adema & Vink, 1981
Crustacea										
Artemia salina	-	-	-	-	-	-	28 d	NOEC	18[a]	Adema & Vink, 1981
Artemia salina	-	-	-	-	-	-	28 d	NOEC	18[a]	Adema & Vink, 1981
Pisces										
Pleuronectus platessa	-	-	-	-	-	-	56 d	NOEC	0.1[a]	Adema & Vink, 1981
Pleuronectus platessa	-	-	-	-	-	-	56 d	NOEC	0.1[c]	Adema & Vink, 1981

a reproduction
b mortality
c growth

3.2. **Freshwater toxicity data**

Only chronic toxicity data are available. The data are presented as follows:

- table 3.2.1: chronic toxicity data:NOECs

ANNEX 18 : Subgroup report - Derivation of dieldrin EAC

3.2.1. *Table : Chronic toxicity of dieldrin to freshwater organisms*

Organism	A	Test type	Test sub. purity	Test water	pH	Salinity $^o/_{oo}$	Exp. time	Crite-rion	Result µg/l	Reference
Mollusca										
Lymnaea stagnalis, ei	-	-	-	-	-	-	19 d	NOEC	10[a]	Adema & Vink, 1981
Crustacea										
Daphnia magna, larva 1 mm	-	-	-	-	-	-	3 w	NOEC	32[a,b]	Adema & Vink, 1981
Pisces										
Lebistes reticulatus	-	-	-	-	-	-	450 d	NOEC	5	Warren, 1972
Salmo gardnerii	-	-	-	-	-	-	130 d	NOEC	0.12	Chadwick & Shumay, 1970

a reproduction
b mortality

3.3. Toxicity data for birds and mammals

In the tables on toxicity for mammals and birds the original 'reported' value and the corrected value are mentioned. The converted value is the corrected NOEC in mg/kg food. The lowest NOEC and/or LC50 values are presented in the tables in shading. The data are presented as follows:

- table 3.3.1: toxicity data for birds
- table 3.3.2: toxicity data for mammals

3.3.1. *Table : toxicity data for birds*

duration	parameter	species	reported	converted (mg/kg food)	reference
NOECs					
162 d	mo	Quail	0.5	0.5	DeWitt, 1956
>1 y	re	*Anas plathyrhynchos*	1.6	0.8[a]	Lehner and Egbert, 1969
21 m	mo	*Numida meleagris*	1.5	1.5	Wiese and Basson, 1967
-	re	*Phasianus colchicus*	2.0	2.0	DeWitt, 1956
34 w	mo	*Colinus viriginianus*	2.5	2.5	Fergin and Schafer, 1977
21 m	re	*Numida meleagris*	5.0	5.0	Wiese and Basson, 1967
13 m	re	*Gallus domesticus*	10	10	Brown *et al*., 1974
18 w	mo, re	*Coturnix c. japonica*	10	10	Walker *et al*., 1969
158 d	gr	*Coturnix c. japonica*	10	10	Stickel *et al*., 1969
34 w	re	*Colinus viriginianus*	10	10	Fergin and Schafer, 1977
LC50s					
5 d		*Numida meleagris*	107	107	Wiese *et al*. (1969)
5 d		*Colinus viriginianus*	166	166	Hill *et al*. (1975)
5 d		*Coturnix c. japonica*	278	278	Hill *et al*. (1975)
5 d		*Phasianus colchicus*	570	570	Hill *et al*. (1975)
5 d		*Anas plathyrhynchos*	1500	1500	Hill *et al*. (1975)
4 d		*Anas plathyrhynchos*	165	165	Nebeker *et al*. (1992)

a NOEC value derived by applying a factor 2 on the lowest concentration in the test, showing <20% effect: NOEC=LOEC/2

3.3.2. *Table : toxicity data for mammals*

duration	parameter	species	reported	converted (mg/kg food)	reference
NOECs					
2 y	mo	*Mus musculus*	1	1	Hunt *et al* (1975)
6 y	re	*Macaca maculatta*	1	1	Wright *et al*. (1978)
life time	re	*Rattus norvegicus*	1.25	1.25	Harr *et al*. (1970)
6 gen.-	re	*Mus musculus*	3	3	Keplinger *et al*. (1970)
14 d	mo	*Blerina brevicaudus*	50	5	Blus (1978)
25 m	gr	*Canis domesticus*	0.2	8	Fitzhugh *et al*. (1964)
25 m	mo	*Canis domesticus*	0.2	8	Fitzhugh *et al*. (1964)
270 d	mo	*Canis domesticus*	10	10	Treon & Cleveland (1955)
2 y	mo	*Rattus norvegicus*	10	10	Fitzhugh *et al*. (1964)
90 d	mo	*Damaliscus dorcas p.*	15	15	Wiese *et al* (1973)

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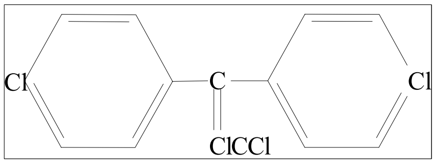
ANNEX 19 : Subgroup report - Derivation of DDE EAC

EAC 3/3/1	DDE

3rd OSPAR Workshop on Ecotoxicological Assessment Criteria
NOVEMBER 25-29, 1996

CAS number: 72-55-9
Molecular formula: C14H8Cl4

Structural formula:



Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	6.50	l/kg	Bockting et al., 1993	
Sediment water partition coefficient (log Kp)	4.20	l/kg		Kp=0.5*Kow*0.01
BCF fish	51,000	l/kg fw	Veith et al., 1979	
BCF mussel	880,000	l/kg sp dw		geom. mean

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	0.1	µg/l	Bengtsson (1978)	saltwater
Lowest L(E)C50	2.5	µg/l	idem	saltwater
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	-	mg/kg food		not available
Lowest NOEC for birds	0.15	mg/kg food	Lincer, 1975	

Extrapolated Concentrations	result	unit	assessment factor	note
Water	0.001	µg/l	100	
Sediment (Equilibrium partitioning)	0.016	mg/kg dw		
Sediment (TEL)	0.0021	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water		µg/l		not relevant
Sediment	0,0005-0,005	mg/kg dw	p	TEL
Fish	0.005-0.05	mg/kg fw	f	
Mussel	0.005-0.05	mg/kg dw	f	

Remarks	result			
Secondary poisoning taken into account	Y			Y/N

ANNEX 19 : Subgroup report - Derivation of DDE EAC

1. DERIVATION OF THE EACS FOR DDE

1.1. Derivation of the EAC for water

An assessment factor of 100 is applied on the lowest NOEC available, being 0.1 µg/l (Bengtsson, 1978) for the crustacean *Nitocra spinipes.* This results in an extrapolated concentration of 0.001 µg/l. This value is considered provisional. Because within the Monitoring Programme water is not the appropriate matrix for DDE an EAC for water is not derived.

1.2. Derivation of the EAC for sediment

To derive an extrapolated concentration for sediment three different methods are available. The first method is based on applying assessment factors on spiked sediment tests. For DDE however, these are not available. The second method is the equilibrium partition method (see EAC 2/1). For DDE, the extrapolated concentration for water of 0.001 µg/l is multiplied with the calculated Kp value of 15,850 l/kg (log Kp=4.2). This results in an extrapolated concentration of 0.016 mg/kg dw. The third method is the Canadian BEDS-approach (see EAC 2/1 and 2/6). A TEL-value for DDE is available of 0.0021 mg/kg dw. The BEDS-approach is preferred here above the EP-method. The EAC sediment is derived by setting an order of magnitude on the TEL-value of 0.0021 mg/kg dw. This results in an EAC sediment of 0.0005-0.005 mg/kg. As for water only limited aquatic toxicity data are available and the high log Kow value (>5) in combination with missing spiked sediment data the EAC for sediment is classified as provisional.

1.3. Derivation of the EAC for biota

<u>Fish</u>

Calculation of the EAC for fish is possible using two methods. The first method is multiplying the extrapolated concentration in water with a BCF for fish: EAC fish=0.001 µg/l*51,000 l/kg fw <=> 0.051 mg/kg fw. The second method is based on secondary poisoning (see EAC 2/4). The NEC predator for DDE is 0.015 mg/kg food and is derived by applying a factor 10 on the lowest NOEC of 0.15 mg/kg food for the bird *Falco sparverius*. As the test species were fed with cockerels no correction factor is needed for caloric content. The lowest value is 0.05 mg/kg fw and is rounded to the range of 0.005-0.05 mg/kg fw. Although no data for mammals are available the EAC is considered firm considering the extensive data set for birds and because birds are considered to be the most sensitive group.

<u>Mussels</u>

As for fish the calculation of the EAC for mussels is possible using two methods. The first method is multiplying the extrapolated concentration in water with the geometric mean BCF for mussels: EAC mussels=0.001 µg/l*880,000 l/kg dw <=> 0.88 mg/kg dw. The second method is based on secondary poisoning (see EAC 2/4). The NEC predator for DDE is 0.015 mg/kg food and is derived by applying a factor 10 on the lowest NOEC of 0.15 mg/kg food for the bird *Falco sparverius*. As the test species were fed with cockerels no correction factor is needed for caloric content. The lowest value is 0.0015 mg/kg dw and is rounded to the range of 0.005-0.05 mg/kg. The EAC is classified as firm for the same reason as for fish.

2. BCF DATA

Only one BCF value of 51,000 l/kg for the fish *Pimephales promelas* is available.
For mussels (*Mytilus edulis*) a geometric mean BCF of 117,920 l/kg fw is calculated. This value is recalculated to soft parts dry weight with the correction factor proposed in Haenen *et al*. (1993). This factor is 0.134 (dw/fw). Applying this factor results in a BCF of 880,000 l/kg dw. The experimental BCF values for fish and molluscs are presented in table 2.1.

Legend:

Exp. period	exposure period
C_{water}	water concentration applied in the test
fw	fresh weight
dw	dry weight

2.1. Table : bioconcentration factors for fish and molluscs

Species	Exp. period (d)	C_{water} (µg/l)	BCF (l/kg) fw	BCF (l/kg) dw	Reference
FISH					
Pimephales promelas	32 d	5.1	51,000	-	Veith *et al*. (1979)
MOLLUSCS					
Mytilus edulis	32 d	7.3	310,000[a]	2.3E+6	Risebough *et al*. (1976)
Mytilus edulis	32 d	7.3	45,000[a]	336,000	Risebough *et al*. (1976)
			(117,920)	*(880,000)*	*geometric mean*

a based on field measurements

ANNEX 19 : Subgroup report - Derivation of DDE EAC

3. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow: $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. Saltwater toxicity data

Only one chronic NOEC is available for DDE. The acute dataset is small.

- table 3.1.1: chronic toxicity data: NOECs.
- table 3.1.2: acute toxicity data: L(E)C50s

ANNEX 19 : Subgroup report - Derivation of DDE EAC

3.1.1. *Table : Chronic toxicity of DDE to saltwater organisms*

Organism	A	Test type	Test compound	Test water	pH	Salinity in ‰	Exp. time	Criterion	Result µg/l	Reference
Crustacea										
Nitocra spinipes	-	R	99.9%	-	8	7	14 d	NOEC	0.1[a]	Bengtsson,1978

a reproduction; extrapolated from graph

3.1.2. *Table : Acute toxicity of DDE to saltwater organisms*

Organism	A	Test type	Test compound	Test water	pH	Salinity in ‰	Exp. time	Criterion	Result µg/l	Reference
Crustacea										
Nitocra spinipes	-	R	99.9%	-	8	7	96 h	LC50	2.5	Bengtsson,1978
Penaeus aztecus, juvenile	-	F	-	-	-	17-27	48 h	EC50	28[a]	Butler, 1965
Penaeus aztecus, juvenile	-	F	99%	-	-	30	48 h	EC50	28[b]	Mayer, 1987
Mollusca										
Crassostea virginica, juvenile	-	F	99%	-	-	17-27	48 h	EC50	28[c]	Butler, 1965

a mortality or loss of equilibrium
b immobility
c shell growth

3.2. **Freshwater toxicity data**

Only acute toxicity data are available for freshwater organisms.

- table 3.2.1: acute toxicity data: L(E)C50s

ANNEX 19 : Subgroup report - Derivation of DDE EAC

3.2.1. *Table : Acute toxicity of DDE to freshwater organisms*

Organism	A	Test type	Test compound	Test water	pH	Hardness mg CaCO3	Exp. time	Criterion	Result µg/l	Reference
Flatworms										
Polycelis feleinas	-	S	-	-	-	-	96 h	LC50	1100	Kouyoumjian & Uglow, 1974
Pisces										
Lepomis macrochirus, 0.9 g	-	S	99%	-	7.1	44	96 h	LC50	240	Mayer and Ellersieck, 1986
Salmo gairdneri, 0.8 g	-	S	99%	-	7.1	44	96 h	LC50	32	Mayer and Ellersieck, 1986
Salmo salar, 0.5 g	-	S	99%	-	7.5	44	96 h	LC50	96	Johnson and Finley, 1980

ANNEX 19 : Subgroup report - Derivation of DDE EAC

3.3. Toxicity data for mammals and birds

No data are available for mammals. As for DDE birds are considered the most sensible group the EAC was considered firm due to large extend dird dataset. For birds the original 'reported' values are mentioned. The converted values are not reported. The lowest NOEC is presented in shading. The data for birds are presented as follows:

- table 3.3.1: toxicity data for birds

3.3.1. *Table : toxicity data for birds*

duration	parameter	species	NOEC reported (mg/kg food)	NOEC converted	reference
220 d	r	*Coturnix cot. japonica*	100	-	Robson *et al.* (1976)
220 d	m	*Coturnix cot. japonica*	50 [a]	-	Robson *et al.* (1976)
220 d	m	*Coturnix cot. japonica*	33 [b]	-	Robson *et al.* (1976)
74 d	r	*Coturnix cot. japonica*	33 [b]	-	Cecil *et al.* (1971)
3 m	c	*Coturnix cot. japonica*	100	-	Bitman *et al.* (1976)
90 d	[d]	*Streptopelia risoria*	10	-	Ritchie *et al.* (1979)
5 m	r	*Streptopelia risoria*	20 [a]	-	Haseltine *et al.* (1974)
126 d	r	*Streptopelia risoria*	20 [a]	-	Haegele & Hudson (1973)
14 d	r	*Streptopelia risoria*	5 [a]	-	Peakall *et al.* (1973)
126 d	r	*Streptopelia risoria*	4 [f]	-	Haegele & Hudson (1973)
59-63 d	e	*Streptopelia risoria*	3.3 [b]	-	Haegele & Hudson (1973)
47 d	r	*Anas platyrhynchos*	3.3 [b]	-	Vangilder & Peterle (1980)
4 m	r	*Anas platyrhynchos*	5 [a]	-	Risebourg & Anderson (1976)
4 m	-	*Anas platyrhynchos*	40	-	Risebourg & Anderson (1976)
50 d	r	*Anas platyrhynchos*	5 [a]	-	Kolaja (1977)
50 d	r	*Anas platyrhynchos*	10	-	Kolaja (1977)
1 m	g	*Anas platyrhynchos*	1.5 [a]	-	Heinz (1976)
2 y	r	*Anas platyrhynchos*	0.33 [f]	-	Haseltine *et al.* (1974)
5 m	r	*Anas platyrhynchos*	5 [a]	-	Haseltine *et al.* (1974)
5 m	r	*Anas platyrhynchos*	10	-	Haseltine *et al.* (1974)
3 m	r	Peking duck	20 [a]	-	Miller *et al.* (1976)
3 m	r	Peking duck	40	-	Miller *et al.* (1976)
14 d	r	Peking duck	20 [a]	-	Peakall *et al.* (1973)
14 d	r	Peking duck	40	-	Peakall *et al.* (1973)
cont.	r	*Anas rubripes*	1.0 [b]	-	Longcorne *et al.* (1971)
cont.	r	*Anas rubripes*	1.5 [a]	-	Longcorne *et al.* (1971)
cont.	r	*Anas rubripes*	3.0	-	Longcorne *et al.* (1971)
2 y	r	*Anas rubripes*	1.0 [a]	-	Longcorne & Stendell, (1977)
2 y	r	*Anas rubripes*	2.0	-	Longcorne & Stendell, (1977)
1 y	r	*Otus asio*	1.4 [a]	-	McLane & Hall (1972)
1 y	r	*Otus asio*	2.8	-	McLane & Hall (1972)
>2 y	r	*Falco sparverius*	1.4 [a]	-	Wiemeyer & Porter (1970)
5.5 m	r	*Falco sparverius*	0.15 [a]	-	Lincer (1975)
5.5 m	r	*Falco sparverius*	3.0	-	Lincer (1975)
-	r	*Falco sparverius*	1.5 [a]	-	Peakall *et al.* (1973)
-	r	*Falco sparverius*	6.0	-	Peakall *et al.* (1973)

r: reproduction; m: mortality

a NOEC=LOEC/2, 10-20 % effect
b NOEC=LOEC/3, 20-50 % effect
c egg Ca content
d oviparous time
e courtship behaviour
f NOEC=LOEC/10, >50% effect
g behaviour

ANNEX 19 : Subgroup report - Derivation of DDE EAC

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EAC 3/5	PCB sum 7

3rd OSPAR Workshop on Ecotoxicological Assessment Criteria
NOVEMBER 25-29, 1996

Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	-	l/kg		see chapter 1
Sediment water partition coefficient (log Kp)	-	l/kg		see chapter 1
BCF fish	500,000	l/kg fw		average sum PCB7
BCF molluscs	100,000	l/kg fw		average sum PCB7

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	0.05	µg/l	Dillon et al., 1990	PCB 101
Lowest L(E)C50	-	µg/l		
sediment				
Lowest NOEC	-	mg/kg dw		
Lowest L(E)C50	5.2	mg/kg dw	Plesha et al., 1988	sum PCB total
biota				
Lowest NOEC for mammals	0.145	mg/kg food	Leonards et al., 1994	sum PCB total
Lowest NOEC for birds	-	mg/kg food		

Extrapolated Concentrations	result	unit	assessment factor	note
Water	-	µg/l		
Sediment (Equilibrium partitioning)	-	mg/kg dw		
Sediment (TEL)	0.0011	mg/kg dw		sum PCB total

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	-	µg/l		not relevant
Sediment	0.001-0.01	mg/kg dw	p	sum PCB 7
Fish	0.001-0.01	mg/kg fw	f	sum PCB 7
Mussel	0.005-0.05	mg/kg dw	f	sum PCB 7

Remarks	result	note
Secondary poisoning taken into account	Y	Y/N

For dioxin-like PCBs EACs for fish and mussels, expressed as TEQtotal of 5-50 pg/kg fw and 50-500 pg/kg dw, respectively is derived. TEQtotal is calculated using the TEF-system proposed by WHO-ECEH/IPCS (Ahlborg et al., 1994). These values are considered provisional.

ANNEX 20 : Subgroup report - Derivation of PCB EAC

1. DERIVATION OF THE EACS FOR PCBS

PCBs are widespread environmental contaminants. They are highly lipophylic and readily stored in fatty tissues. Subsequently, high levels accumulate in predators at the top of the food-chain. As such, fish- or mussel-eating birds and mammals are at risk due to secondary poisoning. So, for PCBs this route can be regarded as the critical one for assessing environmental risks for these compounds.

Most Joint Monitoring Programme (JMP) data concern the “7 standard PCBs” (referred to in the rest of this document as ΣPCB_7): the congeners PCB 28, 52, 101, 118, 138, 153 and 180. It is well known, however that most of the toxicity is not caused by these congeners. Especially the planar or ortho-substituted congeners are believed to be more toxic, at least in mammals and birds, than the other ones due to their dioxin-like mode of action. To correct for differences in toxicity between various PCB mixtures, the concentrations of such mixtures can be expressed in TCDD-TEQs according to the following equation:

$$\boldsymbol{TEQ_i = C_i * TEF_i} \qquad \text{`} \qquad (1)$$

where:
TEQ_i: toxic equivalence concentration for an individual PCB;
TEF_i: toxic equivalence factor for an individual PCB.

TEQ_i are summed to obtain the total toxic equivalency concentration TEQ_{total}:

$$\boldsymbol{TEQ_{total} = \Sigma\, TEQ_i} \qquad (2)$$

In this concept the toxicity of biological activity of a certain PCB congener is expressed relative to the activity of 2,3,7,8-TCDD using toxic equivalence factors (TEFs). Next to EACs for ΣPCB_7 also EACs will be proposed based on this concept in the present document.

During the last decades a large number of environmental studies have focussed on PCBs. The information used for the derivation of EACs originates from several reviews and studies: Environmental Health Criteria of the WHO (WHO, 1993); Great Lake Water Quality Initiative Criteria Documents for the Protection of Wildlife (EPA, 1993); Canadian Water Quality Guidelines for Polychlorinated Biphenyls in Coastal and Estuarine Waters (Environment Canada, 1991); Walker (1992); Bockting *et al.* (1993); Leonards *et al.* (1994) and Bosveld (1995) and De Boer (1995).

1.1. Derivation of the EAC for water

In addition to Environment Canada (1991) some toxicity data for freshwater organisms have been collected.

For individual congeners the lowest NOEC for stimulation of growth is 0.05 ug/l for Daphnia magna for PCB 101 (Dillon et al., 1990).

ANNEX 20 : Subgroup report - Derivation of PCB EAC

For total-PCB in the Berlin workshop a 26 days LC50 for freshwater trout embryos of 0.32 ug/l for Aroclor 1254 was used. Applying an assessment factor of 1,000 and assuming that ΣPCB_7 is approximately 50% of ΣPCB_{total} an extrapolated concentration of 0.00016 ug/l was derived.

Environment Canada (1991) recommends an interim water quality guideline of 0.01 µg/L ΣPCB_{total} based on an LOEC for mortality of 0.16 µg/L for *Cyprinodon variegatus* in a test with Aroclor 1254 of 3 weeks (Schimmel *et al*., 1974).

Because only few toxicity data for PCBs in water were available and as PCBs are not monitored in the waterphase but in biota and sediments, it was considered not relevant in the workshop to set an EAC for PCBs in water.

1.2. **Derivation of the EAC for sediment**

Spiked sediment tests

In the Scheveningen workshop an extrapolated concentration for ΣPCB_7 of 0.0026 mg/kg dw was derived based on a spiked sediment test with *Rhepoxynius abronius* where "significant" acute toxicity was observed at 5.2 mg/kg whole sediment ΣPCB_{total} (Plesha *et al*. 1988). An assessment factor of 1,000 and 2 for extrapolation to ΣPCB_7 was used leading to a value of 2.6 µg/kg.

Equilibrium partitioning approach

Extrapolated concentrations in sediment can also be derived using equilibrium partitioning (see EAC 2/6). Partition coefficients are needed to apply this method. Bockting *et al*. (1993) reviewed experimental data for organic compounds including PCBs. By regression they derived two equations:

$$\log K_{oc} = 0.83 * \log K_{ow} - 0.37 \qquad (3)$$

$$\log K_{oc} = 1.39 * \log K_{ow} - 1.52 \qquad (4)$$

Equation (3) was based on data in which "traditional methods" like batch experiments were applied. In these experiments the separation of the solid and liquid phase is a critical step. For compounds like PCBs complete separation is often not achieved due to adsorption of the test-compound to a "third-phase" (colloids and organic macromolecules) that cannot be separated from the water phase using normal filtration and centrifugation techniques. The resulting overestimation of the concentration in the water phase leads to an underestimation of the sorption coefficient. To prevent this, recently the so called co-solvent method has been developed (Evers and Smedes, 1993). This method can be regarded as a modification of the batch method, where as an extra step a co-solvent (often methanol) is added to the sediment- or soil-water system. Evers and Smedes (1993) measured sorption coefficients for PCBs using this method. Equation (4) is based on their data.

The difference between both equations is substantial: above a log K_{ow} of 5.5 results differ by more than two orders of magnitude. Bockting *et al*. (1993) do not give preference to one of the equations as they considered the validity of the co-solvent method not yet fully accepted. As no new data on sorption of PCBs were found it is concluded here that their conclusion is still valid. Therefore, sorption coefficients are given based on both equations.

1.2.1. ***Table: log K_{ow} values from Hawker and Connell (1988) given together with log K_{oc} values calculated using equations (3) and (4).***

	log K_{ow}	log K_{oc} (L/kg) equation (3)	log K_{oc} (L/kg) equation (4)
PCB 28	5.62	4.30	6.29
PCB 52	6.09	4.69	6.95
PCB 101	6.50	5.03	7.52
PCB 118	7.12	5.34	8.38
PCB 138	7.90	6.19	9.46
PCB 153	7.75	6.06	9.25
PCB 180	8.04	6.30	9.66

Average log K_{oc} values for ΣPCB_7 are 5.42 and 8.22 L/kg using equation (3) and (4), respectively. This leads to log Kp values of 3.42 and 6.22 L/kg, respectively. Applying equilibrium partitioning using the values presented in paragraph 1.1 and these average log Kp values, lead to the following concentrations in sediment in µg/kg.

1.2.2. ***Table: Equilibrium partitioning method using the different water quality criteria and equation (3) and equation (4) respectively.***

0.017 ng/L for ΣPCB_{total} (EPA, 1993)	0.044 µg/kg dw?[1]	29 µg/kg dw?[1]
10 ng/L for ΣPCB_{total} (Environment Canada, 1991)	26[1]	17,000[1]
0.5 ng/L PCB 101 (this document)	0.5[2]	180[2]

[1]: using a log Kp of 3.42 and 6.22 L/kg, respectively
[2]: using a log Kp of 3.03 and 5.52 L/kg, respectively

Considering the uncertainties with respect to the partition coefficients and the large range in the resulting sediment concentrations the equilibrium partitioning approach was considered inappropriate to derive EACs for for PCBs in sediment.

Co-occurance approach

A TEL of 21.5 µg/kg is available for $\Sigma PCB_{total.}$ Assuming that ΣPCB_7 is 50% of ΣPCB_{total} this results in an extrapolated concentration of 11 µg/kg.

ANNEX 20 : Subgroup report - Derivation of PCB EAC

<u>Conclusion</u>
Based on both the spiked sediment test and the co-occurance approach with extrapolated concentrations of 2.6 and 11 µg/kg, respectively an EAC for ΣPCB_7 is set at 0.001-0.01 mg/kg. Although both extrapolated concentrations fall within this range the EAC is considered provisional.

1.3. **Derivation of the EAC for biota**

1.3.1. ***ΣPCB_7***

In the Scheveningen workshop the EAC was based on the study of Boon *et al*. (1987). After correcting the PCB concentrations in the fish to a standard fish with 5% fat, the total PCB in the diet of the harbour seals was estimated. Subsequently, a NOEC of 33 µg/kg ww was derived for ΣPCB_{total}. An extrapolated concentration of 1.7 µg/kg ww was derived by applying an assessment factor of 10 and assuming that ΣPCB_7 is 50% of ΣPCB_{total}.

Based on the 26 days LC50 for freshwater trout embryos of 0.32 µg/L for Aroclor 1254, an extrapolation factor of 1,000 and an average BCF for ΣPCB_7 of 10^4 L/kg lipid weight a concentration of 3.2 µg/kg per percent fat content was calculated for biota. Subsequently, extrapolated concentrations of 16 µg/kg ww and 27.2 µg/kg dw for fish and mussels, respectively were calculated.

Leonards *et al*. (1994) reviewed the available data on the effects of PCBs on the reproduction of the mink (*Mustela vison*) in order to analyze a.o. the variability of reported effect levels in relation to the composition of technical PCB mixtures and experimental conditions. Congener or isomer specific one-compartment bioaccumulation models were used to predict internal concentrations. Subsequently, a logistic model from Kooijman (1983) was used to estimate dose-effect relationships between the predicted internal concentrations and the reproduction effect endpoints, being relative litter size or kit survival. From these dose-effect relationships congener-specific effects levels, expressed on the basis of mink tissue residues, like EC50 and EC1 were estimated. These effect levels were than extrapolated to concentrations in prey organisms, i.e. fish.
The dose-effect relationships between predicted internal concentrations and reproduction showed to be very steep. This resulted in EC50 values for mink diet for ΣPCB_{total} of 371 and 730 µg/kg ww for litter size and kit survival, respectively while EC1 values were 145 and 399 µg/kg ww, respectively.
Leonards *et al*. (1994) show that their EC50 value for mink is comparable to values derived by other authors. Also, a comparison of their EC50 value for PCB_{total} for mink with effect levels for seals and sea lions showed that the value was in the same effect range as reported for marine mammals. This is illustrated in figure 1.

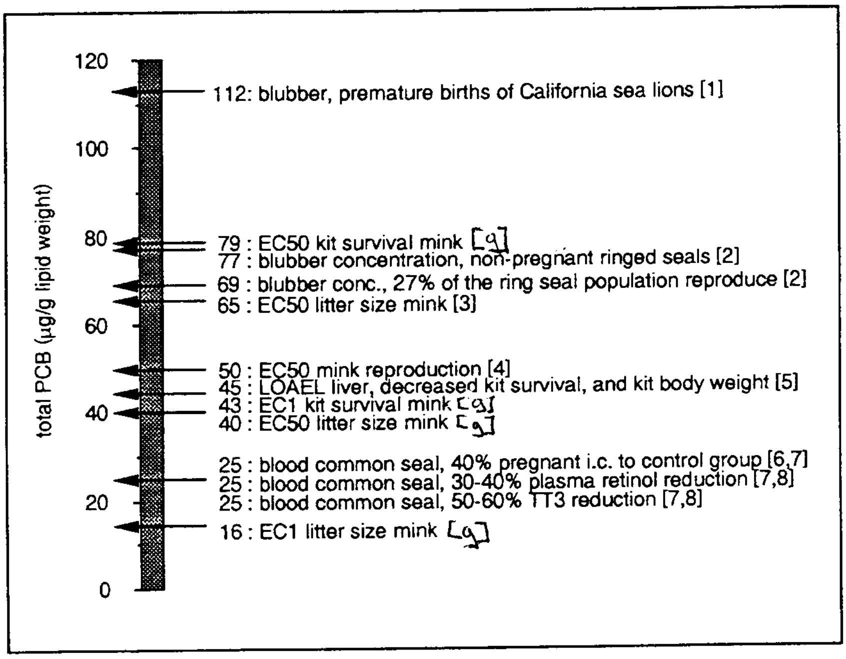

Figure 1. Reported effect levels for total PCB (lipid weight) in mammals in comparison to the estimated no-effect and critical effect levels for mink derived by Leonards *et al.* (1994). [1] DeLong *et al.* (1973); [2] Helle *et al.* (1976); [3] Kihlström *et al.* (1992); [4] Jensen *et al.* (1977); [5] Heaton (1992); [6] Reijnders (1986); [7] Boon *et al.* (1987); [8] Brouwer *et al.* (1989); [9] Leonards *et al.* (1994) (Published with permission of the author.).

Applying an assessment factor of 10 and a factor 2 to extrapolate to ΣPCB_7 on the EC1 of 145 μg/kg ww an extrapolated concentration of 7.3 μg/kg ww can be calculated. As the minks were fed with fish a correction for the caloric value of the food was not necessary.

The extrapolated concentration derived from the study of Leonards *et al.* (1994) agrees very well with the value derived in the Scheveningen workshop. Extrapolated concentrations derived in the Berlin workshop are somewhat higher but this concentration is based on direct effects on marine aquatic organisms.

A number of additional remarks can be made:

- the extrapolated concentration is based on studies with mammals only while birds may be at risk also. Bosveld (1995) concludes that , due to its relative sensitivity, the common tern (*Sterna hirundo*) is a suitable indicator species to establish early effects of polyhalogenated aromatic hydrocarbons on piscivorous avian wildlife in the Netherlands. Based on a feeding study with this species with PCB 126 he suggested that populations feeding on a diet containing 46 pg TEQ/g fish ww or more are at risk. Comparing this value to EC1 values proposed by Leonards *et al.* (1994) for reproduction of the mink of 0.2-50 TEQ/g fish ww it can be concluded that by using these values birds are also protected. This can also be concluded from the wildlife criteria from the US-EPA (1993) as their criterion for birds is a factor 10 higher than the one for mammals (see paragraph 1.1). The range for the mink is caused by application of different TEF systems (see paragraph 1).

- the extrapolated concentration of 7.3 µg/kg ww can be compared with the EQOs from the US-EPA and Environment Canada assuming a BCF for fish of $5 * 10^5$ L/kg ww (see paragraph 2). The wildlife criterion for mammals of the US-EPA of 17 pg/L results in a concentration in fish of 8.5 µg/kg ww for ΣPCB_{total}, being in agreement with the extrapolated concentration.
  Using the interim water quality guideline in coastal and marine waters of 0.01 µg/L results in 5 mg/kg ww for ΣPCB_{total}, which is much higher than the extrapolated concentration. However, indirect effects via accumulation in the food chain have not be considered by Environment Canada.
  Using the extrapolated concentration derived for PCB 101 in paragraph 1.1 of 0.5 ng/L leads to a concentration of 250 µg/kg ww, being much higher than the extrapolated concentration. Again, this value is based on direct effects on aquatic organisms only.

Conclusion

As the equilibrium partitioning approach was considered inappropriate and the BCF-approach for ΣPCB_7 was considered less reliable the EAC is derived based on secondary poisoning. Based on the EC1 of 145 µg/kg ww for mink the extrapolated concentration for ΣPCB_7 is 7.3 µg/kg ww or fish and 22.8 µg/kg dw for mussel. This leads to an EAC for fish of 1-10 µg/kg ww and an EAC for mussel of 5-50 µg/kg dw, respectively. Both EACs are considered firm.

1.3.2. *TEQ values*

Experimental data have proven that the TEF-concept is suitable for assessing the ecotoxicological risk of dioxin-like compounds (Ahlborg *et al*., 1992). Different TEF systems exist, for different species and different effects. Leonards *et al*. (1994) use three TEF systems:
1) based on aryl hydrocarbon hydroxylase (AHH) induction in rat hepatoma hydroxylase cells (Mason *et al*., 1986 and Sawyer and Safe, 1982);
2) system proposed by Safe (1993) based on mammals and various effects;
3) system proposed by the Dutch working group of Toxic equivalent factors in 1990 (Werkgroep TEF, 1990).

Bosveld *et al*. (1995) calculated TEFs for 3 coplanar PCBs based on measurements of EROD-inducing potenties in the chicken embryo. Results were comparable with TEFs proposed for mammals although differences occur. According to Bosveld (1996) it might well be that the differences for the individual PCBs are cancelled out in the result for all PCBs when using different TEF systems for birds and mammals.

Another TEF system has been proposed after an international consultation organized by WHO-European Centre for Environment and Health (WHO-ECEH) and IPCS. Purpose of this meeting was: “to analyze the data base in order to define general criteria for further development of a more comprehensive TEF approach and to derive TEFs for dioxin-like PCBs” (Ahlborg *et al*., 1994). The following criteria had to be met for a compound to be considered: 1) it should show structural relationship to the PCDDs and PCDFs; 2) it should bind to the Ah receptor; 3) it should elicit dioxin-specific biochemical and toxic responses; 4) it should be persistent and accumulate in the food chain. TEFs were recommended for human exposure for 3 non-ortho-, 8 mono-ortho- and 2 di-ortho-substituted PCBs. The TEFs were regarded as interim values (Ahlborg *et al*. 1994).

All TEF systems differ from each other and therefore lead to different results. Also, TEFs differ between different species and are sometimes effect-specific (Ahlborg *et al*. 1994; Bosveld, 1995). The Dutch Health Council recommends that different TEFs should be used for mammals, birds, fish and invertebrates (Dutch Health Council, 1996). At the moment, however only TEF systems for mammals and birds have been proposed and there is internationally agreement on a system for human exposure (Ahlborg *et al*. 1994).

In this document TEQ values based on several TEF systems will be given. The one proposed by the WHO-ECEH/IPCS meeting will be preferred although it is realized that this system is based on experimental data for mammals. With respect to TEFs in ecotoxicology the WHO-ECEH/IPCS meeting concluded (Ahlborg *et al*. 1994): “It was recognized that the recommended TEFs have been developed for use in exposure scenarios, i.e. they are intake TEFs. These values may, or may not, be appropriate for body burden assessments. They may also need to be reexamined for ecotoxicity purposes. There is some data suggesting that TEFs for mammalian systems may not be applicable for fish and birds.” and “The consultation recommended that the feasibility for developing separate TEFs for body burden and ecotoxicology should be explored. More measurements should be made of body burdens (e.g. blood, liver, fat, target organ, dosimetry etc.) in order to allow for development of TEFs based on body burdens. Tissue distribution may be species, chemical and dose dependent. Studies need to be conducted in order to develop TEFs for various forms of fish and wildlife. There is data suggesting differential sensitivity to compounds such as PCB 77, particularly for avian species.” The TEFs as proposed by the WHO-ECEH/IPCS meeting are presented in the following table (Ahlborg *et al*. 1994).

1.3.2.1. ***Table: The TEFs as proposed by the WHO-ECEH/IPCS meeting (Ahlborg et al. 1994).***

PCB	TEF	PCB	TEF
77	0.0005	156	0.0005
126	0.1	157	0.0005
169	0.01	167	0.00001
105	0.0001	189	0.0001
114	0.0005	170	0.0001
118	0.0001	180	0.00001
123	0.0001		

The following EC1 values for kit survival and litter size in mink diet are given by Leonards *et al*. (1994) expressed as TEQ_{total}:

- 0.2 and 38 pg/kg ww based on the AHH TEF-system;
- 17 and 50 pg/kg ww based on the TEF-system of Safe (1993);
- 39 and 35 pg/kg ww based on the TEF-system of the Dutch working group on TEFs (Werkgroep TEFs, 1990).

The relatively low value of 0.2 pg/kg ww is caused by the use of the AHH TEF-system. Leonards also calculated EC1 values based on the WHO/IPCS TEF-system leading to values of 51 and 17 pg/kg ww for kit survival and litter size, respectively (Leonards, 1996). The value of 17 pg/kg ww can be used as an extrapolated concentration for the dioxin-like PCBs given in the WHO/IPCS TEF-system.

Conclusion

In addition to EACs for biota expressed in mg/kg for biota, EACs for biota can be expressed as TEQ-total. The extrapolated concentration for fish is 17 pg/kg ww expressed as TEQ_{total}. This results in an EAC for fish of 5-50 pg/kg ww expressed as TEQ_{total}. Converting to a dw basis this leads for mussels to an extrapolated concentration and EAC of respectively 85 and 50-500 pg/kg dw, both expressed as TEQ_{total}. Both EACs are based on the TEF system proposed by WHO-ECEH/IPCS (Ahlborg *et al*., 1994). As the TEFs were considered interim values by the WHO-ECEH/IPCS meeting the EACs are considered provisional.

2. BCF DATA

The BCF values (dw and on fat basis) presented in this paragraph are calculated from the BCF fw with the correction factors proposed in Haenen *et al*. (1993). These factors are 0.134 (dw/fw), 0.011 (fat/fw) and 0.081 (fat/dw) for molluscs and 0.272 (dw/fw), 0.044 (fat/fw) and 0.163 (fat/dw) for fish.

Laboratory BCF values for saltwater fish and mussels are scarce. Log BCFs of 3.87 and 4.68 L/kg fw are available for PCB 52 and 153, respectively for *Crassostrea virginica*. For freshwater fish more data are available. The average log BCFs for fish are 5.15, 5.30, 5.34, 6.21 and 6.27 L/kg ww for PCB 52, 101, 118, 138 and 153, respectively. The average log BCF for all values is 5.65 L/kg ww. The only study available for freshwater molluscs gives an average log BCF of 6.35 L/kg ww for *Dreissena polymorpha*.

Data on BCFs for saltwater fish and mussels are available for the 7 standard PCBs from field studies. For *Mytilus edulis* the average log BCF per congener ranges from 3.93 L/kg ww for PCB 28 to 5.60 L/kg ww for PCB 153. The average log BCF for all these congeners is 4.93 L/kg ww. For *Platichthys flesus* log BCFs of 5.28 and 6.51 L/kg ww are available for PCB 52 and 153, respecively.

BCFs for fish are higher than mussels; measured in laboratory experiments as well as based on field measurements. Based on the data given above an average BCF for the 7 standard PCBs of 10^5 and $5*10^5$ L/kg ww is assumed for mussels and fish, respectively. These BCFs are applicable for both marine and freshwater species. Log transformed these values are 5 and 5.70, respectively.

Legend:

Exp. period	exposure period
C_{water}	water concentration applied in the test
fw	fresh weight
dw	dry weight

The data on BCF values are presented as follows:

- table: 2.1 BCFs for saltwater fish and molluscs derived from field experiments
- table: 2.2 BCFs for saltwater fish and molluscs derived from laboratory experiments
- table: 2.3 BCFs for freshwater fish and molluscs derived from laboratory experiments

ANNEX 20 : Subgroup report - Derivation of PCB EAC

2.1. Table : bioconcentration factors for saltwater fish and molluscs derived from field experiments

Organism	Exp. period	salinity prom.	calc. method	fract. lipid	BCF fw	BCF dw	BCF fat	Reference
PCB 28								
mussels								
Mytilus edulis	-	*27.5		?	8.69E+03	6.40E+04	7.90E+05	Aquapol/Duursma 1989
Mytilus edulis	-	*29.5		?	8.69E+03	6.40E+04	7.90E+05	Aquapol/Duursma 1989
PCB 52								
mussels								
Mytilus edulis	-	*27.5		?	1.43E+04	1.05E+05	1.30E+06	Aquapol/Duursma 1989
Mytilus edulis	-	*29.5		?	1.43E+04	1.05E+05	1.30E+06	Aquapol/Duursma 1989
Mytilus edulis		*15-35	Co/Cw		2.14E+04	1.60E+05	1.95E+06	Aquapol/Haenen 1993
fish								
Platichthys flesus		*15-35	Co/Cw		1.90E+05	6.99E+05	4.32E+06	Haenen *et al*., 1993
PCB 101								
mussels								
Mytilus edulis	-	*27.5		?	3.52E+04	2.59E+05	3.20E+06	Aquapol/Duursma 1989
Mytilus edulis	-	*27.5		?	5.50E+04	4.05E+05	5.00E+06	Aquapol/Duursma 1989
PCB 118								
mussels								
Mytilus edulis	-	*27.5		?	5.50E+04	4.05E+05	5.00E+06	Aquapol/Duursma 1989
Mytilus edulis	-	*29.5		?	4.40E+04	3.24E+05	4.00E+06	Aquapol/Duursma 1989
PCB 138								

mussels								
Mytilus edulis	-	*27.5		?	4.40E+04	3.24E+05	4.00E+06	Aquapol/Duursma 1989
Mytilus edulis	-	*29.5		?	5.50E+04	4.05E+05	5.00E+06	Aquapol/Duursma 1989
PCB 153								
mussels								
Mytilus edulis	-	*15-35	Co/Cw		4.00E+05	2.99E+06	3.64E+07	Aquapol/Haenen 1993
fish								
Platichthys flesus		*15-35	Co/Cw		3.20E+06	1.18E+07	7.27E+07	Haenen *et al*., 1993
PCB 180								
mussels								
Mytilus edulis	-	*27.5		?	5.06E+04	3.73E+05	4.60E+06	Aquapol/Duursma 1989
Mytilus edulis	-	*29.5		?	1.43E+04	1.05E+05	1.30E+06	Aquapol/Duursma 1989

ANNEX 20 : Subgroup report - Derivation of PCB EAC

2.2. Table : bioconcentration factors for saltwater fish and molluscs derived from laboratory experiments

Organism	Exp. period	Cwater (µg/l) *sal. in promille	calc. method	fract lipid	BCF fw	BCF dw	BCF fat	Reference
STANDARD								
PCB 52								
molluscs								
Crassostrea virginica	-	-	-	nr	7.4E+3	5.5E+4	6.7E+5	Hawker & Connell 1986 (rev)
PCB 153								
molluscs								
Crassostrea virginica	-	-	-	nr	4.8E+4	3.6E+5	4.4E+6	Hawker & Connell 1986 (rev)

ANNEX 20 : Subgroup report - Derivation of PCB EAC

2.3. **Table : bioconcentration factors for freshwater fish and molluscs derived from laboratory experiments**

Organism	Exp. period	Cwater (µg/l) *sal. in promille	calc. method	fract lipid	BCF fw	BCF dw	BCF fat	Reference
STANDARD								
PCB 52								
fish								
Brachydanio rerio, 0.243 g	30 d	0.95	k1/k2	0.0292	8.3E+4	3.1E+5	1.9E+6	Fox *et al*. 1994
*Carassius auratus,*1 yr	13 d		k1/k2	0.03	4.9E+4	1.8E+5	1.1E+6	Aquapol/Bruggeman 1981
Oncorhynchus mykiss, eggs	24 h	9.5	k1/k2	nr	1.2E+5	4.4E+5	2.7E+6	Guiney *et al*., 1980
Oncorhynchus mykiss, eggs	36 h	9.5	k1/k2	nr	7.5E+3	2.8E+4	1.7E+5	Guiney *et al*, 1980
Oncorhynchus mykiss, 120-130 g	36 h	0.008	k1/k2	nr	5.0E+5	1.8E+6	1.1E+7	Guiney *et al*, 1977
Oncorhynchus mykiss, 200 g	96 d	0.012	k1/k2	0.07	2.0E+5	7.4E+5	4.5E+6	Aquapol/Oliver&Niimi 1985
Pimephales promelas, 0.045 g	5 d	0.75	k1/k2	0.238	2.9E+4	1.1E+5	6.6E+5	Sijm & v.d. Linde 1995
Pimephales promelas, 0.068 g	5 d	0.32	k1/k2	0.0996	7.2E+4	2.7E+5	1.6E+6	Sijm & v.d. Linde 1995
Pimephales promelas, 0.22 g	5 d	0.33	k1/k2	0.0916	3.9E+5	1.4E+6	8.8E+6	Sijm & v.d. Linde 1995
Pimephales promelas, 0.41 g	5 d	0.62	k1/k2	0.0741	3.4E+5	1.2E+6	7.7E+6	Sijm & v.d. Linde 1995
*Pimephales promelas,*1.17 g	5 d	3.5	k1/k2	0.0147	5.1E+4	1.9E+5	1.2E+6	Sijm & v.d. Linde 1995
Pimephales promelas, 0.67 g	5 d	3	k1/k2	0.0358	6.5E+4	2.4E+5	1.5E+6	Sijm & v.d. Linde 1995
Poecilia reticulata, 0.1 g	12 d	16	k1/k2	0.065	6.8E+4	2.5E+5	1.5E+6	Aquapol/Gobas *et al*. 1989
Poecilia reticulata, 0.1 g	7-13 d		k1/k2	nr	4.3E+4	1.6E+5	9.8E+5	Opperhuizen & Schrap, 1987
Poecilia reticulata, males 0.1 g	6 d	sat.	k1/k2	0.035	8.4E+4	3.1E+5	1.9E+6	Bruggeman 1983 (thesis)
PCB 101								
fish								
Brachydanio rerio, 0.243 g	30 d	0.31	k1/k2	0.0292	3.0E+5	1.1E+6	6.7E+6	Fox *et al*. 1994
Oncorhynchus mykiss, 200 g	96 d	0.015	k1/k2	0.07	>2.5E+5	-	-	Aquapol/Oliver&Niimi 1985

Poecilia reticulata, 1 yr males	16 d		k1/k2	nr	4.7E+4	1.7E+5	1.1E+6	Opperhuizen & Jongeneel 1986
PCB 118								
fish								
Poecilia reticulata, 1 yr males	16 d		k1/k2	nr	5.9E+4	2.2E+5	1.3E+6	Opperhuizen & Jongeneel 1986
PCB 138								
fish								
Brachydanio rerio, 0.243 g	30 d	0.12	k1/k2	0.0292	7.6E+5	2.8E+6	1.7E+7	Fox *et al*. 1994
Poecilia reticulata, 1 yr males	16 d		k1/k2	nr	1.3E+5	4.8E+5	3.0E+6	Opperhuizen & Jongeneel 1986
PCB 153								
molluscs								
Dreissena polymorpha, adult	6 h	0.004-1 ng/l	k1/k2	nr	5.6E+5	4.2E+6	5.1E+7	Fisher *et al*. 1992
Dreissena polymorpha, adult	6 h	0.004-1 ng/l	k1/k2	nr	4.2E+4	3.1E+5	3.8E+6	Fisher *et al*. 1992
fish								
Brachydanio rerio, 0.243 g	30 d	0.12	k1/k2	0.0292	4.5E+5	1.6E+6	1.0E+7	Fox *et al*. 1994
Oncorhynchus mykiss, fry	4-5 d	0.081	k1/k2	nr	6.9E+4	2.5E+5	1.6E+6	Muir *et al*. 1985
Pimephales promelas, 0.22 g	5 d	0.046	k1/k2	0.0916	1.5E+6	5.6E+6	3.4E+7	Sijm & v.d. Linde 1995
Pimephales promelas, 0.41 g	5 d	0.087	k1/k2	0.0741	1.3E+6	4.7E+6	2.9E+7	Sijm & v.d. Linde 1995
*Pimephales promelas,*1.17 g	5 d	0.14	k1/k2	0.0147	2.2E+4	8.0E+4	5.0E+5	Sijm & v.d. Linde 1995
Pimephales promelas, 0.67 g	5 d	0.14	k1/k2	0.0358	4.8E+5	1.8E+6	1.1E+7	Sijm & v.d. Linde 1995
Poecilia reticulata, 0.1 g	7-13 d		k1/k2	nr	4.5E+5	1.7E+6	1.0E+7	Opperhuizen & Schrap, 1987
Poecilia reticulata, males 0.1 g	6 d	sat.	k1/k2	0.035	2.1E+5	7.7E+5	4.8E+6	Bruggeman 1983 (thesis)
Poecilia reticulata, 1 yr males	16 d		k1/k2	nr	1.0E+5	3.7E+5	2.3E+6	Opperhuizen & Jongeneel 1986

3. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. Toxicity data

Not much toxicity data are available for the individual congeners of the seven selected PCBs. The data are presented as follows:

- table 3.1.1: chronic toxicity data: NOECs.
- table 3.1.2: acute toxicity data: L(E)C50s

3.1.1. *Table : Chronic toxicity of PCBs*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness in mg CaCO3/l	Exp. time	Crite-rion	Result µg/l	Reference
standard										
PCB 52										
Hyalella azteca, 0-1 w	Y	R	-	tap		130	10 w	NOECa	18	Borgmann *et al*. 1990
Daphnia magna, < 24 h	N	R	99%	rw	8.3	170	21 d	NOECb	>1	Dillon *et al*. 1990
PCB 101										
Daphnia magna, < 24 h	N	R	99%	rw	8.3	170	21 d	NOECc	0.05	Dillon *et al*. 1990
PCB 118										
Daphnia magna, < 24 h	N	R	99%	rw	8.3	170	21 d	NOECb	>1	Dillon *et al*. 1990
PCB 138										
Daphnia magna, < 24 h	N	R	99%	rw	8.3	170	21 d	NOECb	>1	Dillon *et al*. 1990
PCB 153										
Daphnia magna, < 24 h	N	R	99%	rw	8.3	170	21 d	NOECb	>1	Dillon *et al*. 1990
PCB 180										
Daphnia magna, < 24 h	N	R	99%	rw	8.3	170	21 d	NOECb	>1	Dillon *et al*. 1990

a mortality, reproduction and growth; DMSO 0.5 ml/l; renewal once a week; conc. as geom. mean of nominal and measured

b mortality, growth and reproduction; 2 testconcs: 0.1 µg/l and 1 µg/l, with methanol 0.01 and 0.1 µg/l resp.

c growth; 2 testconcs: 0.1 µg/l = EC16 and 1 µg/l = EC17 with methanol 0.01 and 0.1 µg/l resp.; NOEC as EC16/2

3.1.2. *Table : Acute toxicity of PCBs*

Organism	A	Test type	Test sub. purity	Test water	pH	Hardness in mg CaCO3/l	Exp. time	Crite-rion	Result µg/l	Reference
standard										
PCB 28										
Dapnia magna, <24 h	Y	R	99%	tap	7.6-8.3	118-158	48 h	NOEC	1.5a	Dillon & Burton, 1991
Pimephales promelas, larva <24 h	Y	R	99%	tap	7.6-8.3	118-158	96 h	NOEC	1.5a	Dillon & Burton, 1991
PCB 101										
Dapnia magna, <24 h	Y	R	99%	tap	7.6-8.3	118-158	48 h	NOEC	1.2a	Dillon & Burton, 1991
Gammarus pseudolimnaeus, adult	-	S	100%	rw	7.1	44	96 h	LC50	210	Mayer *et al*. 1977
Pimephales promelas, larva <24 h	Y	R	99%	tap	7.6-8.3	118-158	96 h	NOEC	1.2a	Dillon & Burton, 1991
PCB 153										
Dapnia magna, <24 h	Y	R	99%	tap	7.6-8.3	118-158	48 h	NOEC	1.3a	Dillon & Burton, 1991
Pimephales promelas, larva <24 h	Y	R	99%	tap	7.6-8.3	118-158	96 h	NOEC	1.3a	Dillon & Burton, 1991

a only 1 testconc: saturation; no mortality occurred.

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4.3. **References 'ecotoxicological data'**

ANNEX 20 : Subgroup report - Derivation of PCB EAC

4.3.1. *Aquatic organisms*

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ANNEX 21 : Subgroup report - Derivation of Arsenic EAC

EAC 3/2/1	arsenic (As)			
NOVEMBER 25-29, 1996 — 3rd OSPAR Workshop on Ecotoxicological Assessment Criteria				
Physical-chemical properties	**result**	**unit**	**reference**	**note**
Octanol water partion coefficient (log Kow)	-	l/kg		not relevant
Sediment water partition coefficient (log Kp)	3.85	l/kg	RIKZ/OS96.117x	
BCF fish	-	l/kg fw		not relevant
BCF mussel	-	l/kg sp dw		not relevant
Ecotoxicology	**result**	**unit**	**reference**	**note**
water				
Lowest NOEC	35	µg/l	Thursby & Steele, 1984	saltwater
Lowest L(E)C50	-	µg/l		not considered
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	-	mg/kg food		not relevant
Lowest NOEC for birds	-	mg/kg food		not relevant
Extrapolated Concentrations	**result**	**unit**	**assessment factor**	**note**
Water	3.5	µg/l	10	
Sediment (Equilibrium partitioning)	-	mg/kg dw		not applied
Sediment (TEL)	7.24	mg/kg dw		
Ecotoxicological Assessment Criteria (EAC)	**result**	**unit**	**firm/provisional**	**note**
Water	1-10	µg/l	f	
Sediment	1-10	mg/kg dw	p	TEL
Fish	-	mg/kg fw		not relevant
Mussel	-	mg/kg dw		not relevant
Remarks	**result**			
Secondary poisoning taken into account	N			Y/N

ANNEX 21 : Subgroup report - Derivation of Arsenic EAC

1. DERIVATION OF EACs FOR ARSENIC

1.1. Derivation of EAC for water

An extrapolation factor of 10 was applied to the lowest NOEC available, being 35 µg/l (Thursby and Steele, 1984) for the alga *Champia parvula.* This resulted in an extrapolated concentration of 3.5 µg/l. The extrapolated concentration of 3.5 µg/l yields an EAC of 1-10 µg/l which is identical to the previously obtained range (see doc EAC 1/2). There was no NOEC available for marine fish, but chronic toxicity data for freshwater fish indicated that algae and invertebrates are more sensitive to As than fish. Therefore an extrapolation factor of 10 was chosen. The acute toxicity data available were orders of magnitude higher than the data for chronic toxicity. The EAC for As in water is classified as "firm".

1.2. Derivation of EAC for sediment

The equilibrium partitioning method (see EAC 2/1) was not applied to As (or any other metal) due to uncertainties in the partitioning coefficients. The TEL-value for arsenic is 7.24 mg/kg dw. This results in a sediment EAC for As of 1-10 mg/kg dw which is identical to the previously obtained criterion (see doc EAC 1/2). The EAC for As in sediment is classified as "provisional".

1.3. Derivation of EAC for biota

Not relevant.

ANNEX 21 : Subgroup report - Derivation of Arsenic EAC

2. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test sustance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

2.1. Saltwater toxicity data

Not much chronic toxicity data are available for saltwater organisms. The data are presented as follows:

- table 2.1.1: chronic toxicity data: NOECs.
- table 2.1.2: acute toxicity data: L(E)C50s

ANNEX 21 : Subgroup report - Derivation of Arsenic EAC

2.1.1. *Table : Chronic toxicity of Arsenic to saltwater organisms*

Organism	A	Test type	Test compound	Test water	pH	Salinity in ‰	Exp. time	Criterion	Result µg/l	Reference
Alga, macrophytic										
Champia parvula	-	R	-	am	-	-	14 d	NOEC[a]	35	Thursby & Steele, 1984
Crustacea										
Mysidopsis bahia, 24 h	Y	F	$NaAsO_2$	nw	-	30	5 w	NOEC[b]	630	Lussier *et al*, 1985
Mysidopsis bahia, 24 h	Y	F	$NaAsO_2$	nw	-	30	5 w	NOEC[c]	630	Lussier *et al*, 1985

a growth
b mortality or immobility
c reproduction

2.1.2. *Table : Acute toxicity of Arsenic to saltwater organisms*

Organism	A	Test type	Test compound	Test water	pH	Salinity in ‰	Exp. time	Criterion	Result µg/l	Reference
Bacteria										
Photobacterium phosphoreum	-	-	-	-	-	-	5 min	EC50	142	Hartung, 1987
Crustacea										
Daphnia magna	-	-	-	-	-	-	48 h	LC50	7400	Biesinger and Christensen, 1972
Daphnia magna	-	-	-	-	-	-	48 h	LC50	2850	Biesinger and Christensen, 1972
Molluscs										
Crassostrea virginica	-	-	-	-	-	-	48 h	LC50	7.5	Calabrese et al., 1973
Argopecten irridians	-	-	-	-	-	-	96 h	LC50	3.5	Nelson et al., 1976

a growth
b mortality or immobility
c reproduction

2.2. **Freshwater toxicity data**

An extensive chronic freshwater toxicity data set is available. The data are presented as follows:

table 2.2.1: chronic toxicity data: NOECs

ANNEX 21 : Subgroup report - Derivation of Arsenic EAC

2.2.1. *Table: Chronic toxicity of Arsenic to freshwater organisms*

Organism	A	Test type	Test compound	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Bacteria										
Pseudomonas putida	N	S	Na_2HAsO_4	nw	-	-	16 h	NOEC[a]	9700	Bringmann & Kühn, 1980a
Cyanophyta										
Microcystis aeruginosa	N	S	Na_2HAsO_4	nw	-	-	8 d	NOEC[a]	11000	Bringmann & Kühn, 1978
Alga										
Ankistrodesmus falcatus	N	S	Na_2HAsO_4	nw	7	-	14 d	NOEC[a]	10	Vocke *et al*., 1980
Asterionella formosa	Y	F	AsO_4	am	8.2	-	24 d	NOEC[a]	86	Conway, 1978
Scenedesmus quadricauda	N	S	Na_2HAsO_4	nw	-	-	7 d	NOEC[a]	4700	Bringmann & Kühn, 1980a
Selenastrum capricornutum	N	S	Na_2HAsO_4	nw	7	-	14 d	NOEC[a]	10000	Vocke *et al*., 1980
Protozoa										
Entosiphon sulcatum	N	S	Na_2HAsO_4	nw	-	-	72 h	NOEC[a]	4800	Bringmann & Kühn, 1980a
Crustacea										
Gammarus pseudolimnaeus	Y	F	As_2O_3	nw	7	42-45	14 d	NOEC[b]	88	Spehar *et al*., 1980
Daphnia magna	Y	S	$NaAsO_4$	nw	7.7	45	21 d	NOEC[a,c]	520	Biesinger & Christensen, 1972
Ceriodaphnia dubia, 24 h	Y	R	Na_8AsO_4	nw	8.2	100	7 d	NOEC[b,c,d]	570	Spehar and Fiandt, 1986
Daphnia magna, < 24 h	Y	R	$NaAsO_2$	am	7.2-8.1	48	28 d	NOEC[a,c]	630	Lima *et al*., 1984
Daphnia magna, < 24 h	Y	R	As_2O_5	nw	8.1	225	21 d	NOEC[e,f]	1100	Enserink *et al*., 1991
Daphnia magna	Y	F	As_2O_5	nw	8.1	225	17 d	NOEC[g]	2200	Enserink *et al*., 1991
Daphnia magna	Y	F	As_2O_5	nw	8.1	225	21 d	NOEC[b,a,f]	3300	
Pisces										
Oncorhynchus kisutcht	N	F	As_2O_3	nw	8.2	69	6 m	NOEC	76	Nichols *et al*., 1984
Pimephales promelas, 30 d 0.15 g	Y	F	Na_8AsO_4	nw	7.4	44	32 d	NOEC[b,c,d]	1700	Spehar and Fiandt, 1986
Channa punctatus, fingerling	N	S	As_2O_3	tap	7.2	124	31 d	NOEC[e,h,i]	2100	Shukla *et al*., 1987
Jordanella floridae	Y	F	$NaAsO_2$	am	7.2-8.1	48	31 d	NOEC[b,a]	2100	Lima *et al*., 1984
Pimephales promelas, egg/fry	Y	F	$NaAsO_2$	am	7.2-8.1	48	29 d	NOEC[b,a,j]	2100	Lima *et al*., 1984
Oncorhynchus mykiss, fingerling	Y	F	Na_2HAsO_4	nw	7.9	377	11 w	NOEC[b,h]	8400	McGeachy and Dixon, 1990

a	growth	g	final yield of population
b	mortality or immobility	i	weight
c	reproduction	j	EC 11 - 19%: NOEC = EC/2
d	NOEC calculated as MATC/2	k	hatchability
e	length		
f	EC 20 - 49%: NOEC = EC/3		

ANNEX 21 : Subgroup report - Derivation of Arsenic EAC

3. REFERENCES

3.1. References from coversheet and chapter 1

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3.2. References 'ecotoxicological data'

<u>saltwater</u>

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<u>freshwater</u>

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3.3. References evaluated but rejected

Not available.

ANNEX 22 : Subgroup report - Derivation of Cadmium EAC

EAC 3/2/2	cadmium (Cd)

NOVEMBER 25-29, 1996
3rd OSPAR Workshop on Ecotoxicological Assessment Criteria

Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	-	l/kg		not relevant
Sediment water partition coefficient (log Kp)	4.23	l/kg	RIKZ/OS96.117x	
BCF fish	35	l/kg fw		geometric mean
BCF molluscs	1,990	l/kg sp dw		geometric mean

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	0.56	µg/l	Brand et al., 1986	saltwater
Lowest L(E)C50	-	µg/l		not considered
sediment				
Lowest NOEC	3	mg/kg dw	Robinson et al. (1988)	
Lowest L(E)C50	8.2	mg/kg dw	Robinson et al. (1988)	
biota				
Lowest NOEC for mammals	3.0	mg/kg food	Nomiyama et al., 1987	
Lowest NOEC for birds	0.20	mg/kg food	Supplee, 1961	

Extrapolated Concentrations	result	unit	assessment factor	note
Water	0.056	µg/l	10	
Sediment (Equilibrium partitioning)	-	mg/kg dw		not applied
Sediment (TEL)	0.676	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	0.01-0.1	µg/l	f	
Sediment	0,1-1,0	mg/kg dw	p	TEL
Fish	0.0005-0.005	mg/kg fw	p	
Mussel	0.001-0.01	mg/kg dw	f	sec. poisoning

Remarks	result			
Secondary poisoning taken into account	Y			Y/N

ANNEX 22 : Subgroup report - Derivation of Cadmium EAC

1. DERIVATION OF EACs FOR CADMIUM

1.1. Derivation of EAC for water

An extrapolation factor of 10 was applied to the lowest NOEC available, 0.56 µg/l (Brand *et al.*, 1986), for the alga *Peridinium sp. A1569.* This resulted in an extrapolated concentration of 0.056 µg/l. The extrapolated concentration of 0.056 µg/l yielded an EAC for water of 0.01-0.1 µg/l. This range is a factor of 10 lower than the range obtained earlier (see doc EAC 1/2). Since there is an extensive chronic data set for Cd the EAC for Cd in water is classified as "firm".

1.2. Derivation of EAC for sediment

The equilibrium partitioning method (see EAC 2/1) was not applied to Cd (or any other metal) due to uncertainties in the partitioning coefficients. The TEL-value for Cd was 0.676 mg/kg dw. This resulted in a sediment EAC for Cd of 0.1-1 mg/kg dw, which is a factor of 5 lower than the criterion range obtained previously (see doc EAC 1/2). The EAC for Cd in sediment is classified as "provisional".

1.3. Derivation of EAC for biota

<u>Fish</u>

Two methods for the development of EACs for fish were agreed on. The first method is multiplying the extrapolated concentration in water with an appropriate BCF (measured values) for fish:

(1) EAC fish = 0.056 µg/l * 35 l/kg fw = 0.002 mg/kg fw

The second method agreed on was based on secondary poisoning (see EAC 2/4). The NEC predator for cadmium is 0.02 mg/kg food and is derived by applying a factor 10 on the lowest NOEC of 0.2 mg/kg food for the bird *Meleagris galopova*, which was more sensitive than any mammal.

(2) EAC fish = 0.02 mg/kg * 0.32 (see EAC 2/4) = 0.0064 mg/kg fw

The lowest value is 0.002 mg/kg fw and is rounded to the range of 0.0005-0.005 mg/kg fw. The EAC is considered "provisional" since the obtained result is based on BCF values available for fish, values which show a large variablility.

<u>Mussels</u>

As for fish the calculation of EAC for mussels is possible using two methods. The first method is multiplying the extrapolated concentration in water with the geometric mean BCF (measured values) for mussels:

(1) EAC mussel = 0.056 µg/l * 1,990 l/kg dw = 0.11 mg/kg dw

The second method is based on secondary poisoning. The NEC predator for cadmium is 0.02 mg/kg food and is derived by applying a factor 10 on the lowest NOEC of 0.2 mg/kg food for the bird *Meleagris galopova*, which was more sensitive than any mammal.

(2) EAC mussel = 0.02 mg/kg * 0.2 (see EAC 2/4) = 0.004 mg/kg dw

The lowest value is 0.004 mg/kg dw and is rounded to the range of 0.001-0.01 mg/kg dw. The EAC for Cd in mussels is considered “firm” since chronic toxicity data are available for both mammals and birds.

2. BCF DATA

The geometric mean BCF for the fish *Platichthys flesus* is 40 l/kg fw. The geometric mean BCF for all fish species available is 35 l/kg fw, this value is used for the calculation of the EAC for fish.
For mussels (*Mytilus edulis*) a geometric mean BCF of 1,509 l/kg fw is calculated. This value is recalculated to soft parts dry weight with the correction factor proposed in Haenen *et al*. (1993). This factor is 0.134 (dw/fw). Applying this factor results in a BCF of 11,270 l/kg dw. The geometric mean BCF for all molluscs is 266 l/kg fw and 1,990 l/kg dw. The latter value is used for calculation of the EAC mussel. The experimental BCF values for fish and molluscs are presented in table 2.1.

Legend:

Exp. period	exposure period
C_{water}	water concentration applied in the test
fw	fresh weight
dw	dry weight

ANNEX 22 : Subgroup report - Derivation of Cadmium EAC

2.1. Table : bioconcentration factors for fish and molluscs

Species	Exp. period {d)	C_{water} (µg/l)	BCF (l/kg) fw	BCF (l/kg) dw	Reference
FISH					
Anguilla anguilla	60	130	4.3	-	Noel-Lambot &
				-	Bouquegneau (1977)
Belone belone (eggs)	24	96	22	-	Von Westernhagen (1965)
Fundulus heteroclitus	21	10	15	-	Eisler *et al.* (1972)
„	11	400	39.5	-	Eisler (1971)
			(24)		*geometric mean*
Leopomis macrochirus	183	3	12.2	-	Cearly and Coleman (1974)
„	28	8	60	-	Cope *et al.* (1994)
not specified			18	-	Taylor (1983)
			(27)		*geometric mean*
Pimephales promelas	63	48	48	-	Sullivan *et al.* (1978)
Platichthys flesus	-	-	38.5	-	Haenen *et al.*, 1993
					Romijn *et al.*, 1992
Poecilia reticulata	180	45	280	-	Canton and Slooff (1982)
			(133)		*geometric mean*
Salmo gairdneri	70	10	33	-	Kumada *et al.* (1980)
„	140	10	540	-	Kumada *et al.* (1973)

			35	-	*geom. mean all fish*
MOLLUSCS					
Anodonta anatina	84	15	7	52	Streit and Winter (1993)
Cerastoderma edule	32		800	6000	Sarala Devi and Everaats (1990)
Crassostrea virginica	280	5	2376	17730	Zaroogian and Cheer (1976)
„	21	10	116	870	Eisler *et al.* (1972)
			(525)	*(3920)*	*geometric mean*
Dreissena polymorpha	27	44	3300	24600	Mersch *et al.* (1993)
Elliptio complanata	20	100	65	485	Tessier *et al.* (1994)
Macoma balthica	32		100	750	Sarala Devi and Everaats (1990)
Mytilus edulis	32	-	120	890	Sarala Devi and Everaats (1990)
"	25	-	640	4780	Van Haren (1990)
"	166	10	8585	64070	Riisgard *et al.* (1987)
"	-	-	7880	58800	Haenen *et al.*, 1993
			(1509)	*(11270)*	*geometric mean*
			--------	--------	
			266	*1990*	*geom. mean all molluscs*

ANNEX 22 : Subgroup report - Derivation of Cadmium EAC

3. ECOTOXICOLOGICAL DATA

As many chronic data were available for saltwater and freshwater species acute toxicity data have not been considered. Also, chronic data are considered more relevant than acute data for the derivation of EACs (see document EAC 2/1).

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test-compound	specification of the compound used in the test
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. Saltwater toxicity data

An extensive chronic toxicity data set is available for cadmium. The data are presented as follows:

- table 3.1.1: chronic toxicity data: NOECs.

3.1.1. *Table : Chronic toxicity of Cadmium to saltwater organisms*

Organism	A	Test type	Test compound	Test water	pH	Salinity in ‰	Exp. time	Criterion	Result µg/l	Reference
Bacteria										
L-60 (sulfate reducing bacterium)	N	S	$CdSO_4$	am	-	-	14d	NOEC[a,b]	17000	Bharathi *et al*, 1990,
L-60 (sulfate reducing bacterium)	N	S	$CdSO_4$	am	-	-	14d	NOEC[c,b]	17000	Bharathi *et al*, 1990,
Cyanophyta										
Anabaena variabilis	N	S	$CdCl_2$	am	-	-	7d	NOEC[d,e]	39	Kosakowska *et al*, 1988
Algae										
Peridinium sp. (A1569)	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f,h]	0.56	Brand *et al*, 1986
Asterionella glacialis	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	1.1	Brand *et al*, 1986
Emiliania huxleyi (A1168)	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	1.1	Brand *et al*, 1986
Hymenomonas carterae	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	1.1	Brand *et al*, 1986
Prorocentrum micans	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	1.1	Brand *et al*, 1986
Biddulphia mobiliensis	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	3.4	Brand *et al*, 1986
Heterocapsa triquetra	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	3.4	Brand *et al*, 1986
Lithodesmium undulatum	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	3.4	Brand *et al*, 1986
Synechococcus bacillaris	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	3.4	Brand *et al*, 1986
Synechococcus sp. (WH7808)	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	3.4	Brand *et al*, 1986
Thoracosphaera heimii	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	3.4	Brand *et al*, 1986
Bacteriastrum delicatulum	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	11	Brand *et al*, 1986
Bacteriastrum hyalinum	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	11	Brand *et al*, *1986*
Gymnodinium sp. (A890)	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	11	Brand *et al*, 1986
Rhizosolenia setigera	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	11	Brand *et al*, 1986
Streptotheca tamesis	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	11	Brand *et al*, 1986
Thallassiosira pseudonana	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	11	Brand *et al*, 1986
Ditylum brightwellii	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	34	Brand *et al*, 1986
Skeletonema costatum	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	34	Brand *et al*, 1986
Thalassiosira oceanica	N	R	$CdSO_4$	nw	8.2	36	4-5w	NOEC[f]	34	Brand *et al*, 1986
Chlorella vulgaris	N	S	$CdCl_2$	am	-	-	7 d	NOEC[d,e]	39	Kosakowska *et al*, 1988
Dicrateria zhanjiangenis	N	S	$CdCl_2$	nw	-	-	6 d	NOEC[g]	110	Zhang *et al*, 1992

Dunaliella sp.	N	S	$CdCl_2$	nw	-	-	6 d	NOEC[g]	1100	Zhang *et al*, 1992
Nematoda										
Monhystera microphthalma, 0.35 mm	N	S	$CdCl_2$	am	7-7.5	20	13 d	NOEC[i,h]	500	Vranken *et al*, *1985*
Monhystera disjuncta, 0.35 mm	N	S	$CdCl_2$	am	7-7.5	30	11 d	NOEC[i]	5000	Vranken *et al*, 1985
Pellioditis marina, 0.42 mm	N	S	$CdCl_2$	am	7-7.5	30	8 d	NOEC[i]	25000	Vranken *et al*, 1985
Mollusca										
Isognomon californium, larva	N	R	$CdCl_2$	nw	-	34	28 d	NOEC[k,b]	0.7	Ringwood, 1992
Crassostrea virginica	-	-	-	-	-	20-22	9 m	NOEC[f]	5	Zaroogian & Morrison, 1981
I Murex trunculus	N	IF	$CdCl_2$	nw	-	29-34	5 w	NOEC[c,e]	5	Dalla Via *et al*, 1989
Isognomon californium, larva	N	R	$CdCl_2$	nw	-	34	28 d	NOEC[l]	20	Ringwood, 1992
lyanassa obsoleta, fert. eggs	N	S	$CdCl_2$	nw	8	-	11 d	NOEC[j]	110	Conrad, 1988
Mytilus edulis	-	-	-	-	-	-	17 d	NOEC[a]	110	Poulsen *et al*, 1982
Annelida										
Ophryotrocha labronica	-	-	-	-	-	-	30 d	NOEC[a,f]	200	Roed, 1980
Capitella capitata	-	-	-	-	-	-	25-40 d	NOEC[f]	320	Reish, 1978
Ophryotrocha diadema	-	-	-	-	-	-	28 d	NOEC[f]	500	Reish, 1978
Ophryotrocha diadema	-	-	-	-	-	-	28 d	NOEC[f]	500	Reish & Carr, 1978
Nereis arenaceodentata	-	-	-	-	-	-	4 m	NOEC[f]	560	Reish, *1978*
Ctenodrilus serratus	-	-	-	-	-	-	28-31 d	NOEC[f]	1000	Reish, 1978
Ctenodrilus serratus	-	-	-	-	-	-	21 d	NOEC[f]	1000	Reish & Carr, 1978
Crustacea										
Mysidopsis bahia, < 24 h	Y	F	Cd..	nw	-	21	28 d	NOEC[i,h]	0.6	Voyer and McGovern, 1991
Mysidopsis bahia, < 24 h	Y	F	Cd..	nw	-	29	28 d	NOEC[i,b]	0.6	Voyer and McGovern, 1991
Mysidopsis bahia, < 24 h	Y	F	Cd..	nw	-	29	28 d	NOEC[n,h]	0.9	Voyer and McGovern, 1991
Artemia salina, encysted embryos	N	S	$CdCl_2$	am	-	24.7	48 h	NOEC[m,e]	1.1	Bagshaw *et al*, 1986
Mysidopsis bahia, 24-48 h juvenile	N	IF	$CdCl_2$	nw	-	30	5 w	NOEC[o,h]	2	Carr *et al*, 1985
Allorchestes compressa,	Y	F	$CdCl_2$	nw	8	31	28 d	NOEC[k,e]	2.1	Ahsanullah and Williams, 1991
Mysidopsis bahia, < 24 h	Y	F	Cd..	nw	-	13	28 d	NOEC[i]	2.5	Voyer and McGovern, 1991
Mysidopsis bahia, < 24 h	Y	F	Cd..	nw	-	13	28 d	NOEC[n]	2.5	Voyer and McGovern, 1991
Mysidopsis bahia, 24-48 h juvenile	N	IF	$CdCl_2$	nw	-	30	5 w	NOEC[i]	4	Carr *et al*, 1985
Cancer anthonyi, embryo	N	S	$CdCl_2$	nw	7.8	34	7 d	NOEC[i,h]	5	MacDonald *et al*, 1988
Mysidopsis bahia, 8 d	N	R	$CdCl_2$	nw	7.5-8.2	25	7 d	NOEC[i]	5	Khan *et al*, 1992
Mysidopsis bahia, 8 d	N	R	$CdCl_2$	nw	7.5-8.2	25	7 d	NOEC[k]	5	Khan *et al*, 1992
Mysidopsis bahia, 8 d	N	R	$CdCl_2$	nw	7.5-8.2	25	7 d	NOEC[f]	5	Khan *et al*, 1992
Mysidopsis bahia, 8 d	N	R	$CdCl_2$	nw	7.5-8.2	25	7 d	NOEC[k]	5	Khan *et al*, 1992

Mysidopsis bahia, 8 d	N	R	$CdCl_2$	nw	7.5-8.2	25	7 d	NOEC[k]	5	Khan *et al*, 1992
Mysidopsis bahia	-	-	-	-	-	-	7 w	NOEC[f]	5.1	Gentile *et al*, 1982
Mysidopsis bigelowi	-	-	-	-	-	-	7 w	NOEC[f]	5.1	Gentile *et al*, 1982
Mysidopsis bahia, 24 h	Y	F	$CdCl_2$	nw	-	30	7 w	NOEC[i]	5.1	Lussier *et al*, 1988
Mysidopsis bahia, < 24 h	Y	F	Cd..	nw	-	21	28 d	NOEC[n]	6.1	Voyer and McGovern, 1991
Mysidopsis bahia, 24-48 h juvenile	N	IF	$CdCl_2$	nw	-	30	5 w	NOEC[n]	8	Carr *et al*, 1985
Mysidopsis bahia, 24 h	Y	F	$CdCl_2$	nw	-	30	7 w	NOEC[n]	10	Lussier *et al*, 1988
Callianassa australiensis	-	-	-	-	-	-	7 d	NOEC[m]	10	Ahsanullah *et al*, 1981
Allorchestes compressa first instar juveniles							28 d	NOEC[i,h]	11	Ahsannullah & Williams, 1991
Mysidopsis bahia, 8 d	N	R	$CdCl_2$	nw	7.5-8.2	25	7 d	NOEC[i]	15	Khan *et al*, 1992
Mysidopsis bahia, 8 d	N	R	$CdCl_2$	nw	7.5-8.2	25	7 d	NOEC[f]	15	Khan *et al*, 1992
Mysidopsis bahia, 8 d	N	R	$CdCl_2$	nw	7.5-8.2	25	7 d	NOEC[f]	15	Khan *et al*, 1992
Mysidopsis bahia, 8 d	N	R	$CdCl_2$	nw	7.5-8.2	25	7 d	NOEC[i]	25	Khan *et al*, 1992
Callianassa australiensis	-	-	-	-	-	-	14 d	NOEC[i]	320	Ahsanullah *et al*, 1981
Pisces										
Mugil cephalus, fry	N	R	$CdCl_2$	nw	-	37.3	8 w	NOEC[i]	20	Hilmy *et al*, 1985
Clupea harengus, ELS	-	-	-	-	-	16-32	15 d	NOEC[f]	100	Westernhage *et al*, 1974
Mugil cephalus, juvenile	N	R	$CdCl_2$	nw	-	37.3	8 w	NOEC[i]	100	Hilmy *et al*, 1985
Pleuronectes flesus, ELS	-	-	-	-	-	25-42	21 d	NOEC[f]	1000	Westerhagen & Dethlefsen, 1975

a growth
b EC 20 - 49%: NOEC = EC/3
c oxygen consumption, resp. rate
d chlorophyll content
e EC 50 - 90%: NOEC = EC/10
f reproduction
g cell number
h EC 11 - 19%: NOEC = EC/2
i immortality or immobility
j abnormalities embryo
k weight
l length
m hatchability
n number young
o shell

ANNEX 22 : Subgroup report - Derivation of Cadmium EAC

3.2. **Freshwater toxicity data**

An extensive freshwater data set is available for cadmium. The data are presented as follows:

- table 3.2.1: chronic toxicity data: NOECs.

ANNEX 22 : Subgroup report - Derivation of Cadmium EAC

3.2.1. ***Table : Chronic toxicity of Cadmium to freshwater organisms***

Organism	A	Test type	Test compound	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Bacteria										
Pseudomonas putida	-	-	-	-	-	-	16 h	NOEC[a]	80	Bringmann & Kühn, 1980a
Salmonella typhimurium	N	S	-	-	-	-	8 h	NOEC[a,b]	220	Canton & Slooff, 1982
Cyanophyta										
Anabaena flos-aquae	N	S	$CdCl_2$	am	-	-	10 d	NOEC[c,d,e]	50	Badr and Ashmawy, 1991
Microcystis aeruginosa	-	-	-	-	-	-	8 d	NOEC[a]	70	Bringmann & Kühn, 1978
Algae										
Selenastrum capricornutum	N	S	$Cd(NO_3)_2$	am	7.8	-	48 h	NOEC[c]	2	Thompson *et al*., 1987
							96 h	NOEC[c]	4	
Selenastrum capricornutum	N	S	Cd..	am	-	-	5 d	NOEC[c,b]	10	Thompson and Couture, 1991
Scenedesmus subspicatus, 6.10^{4}c/ml	N	S	$CdCl_2$	am	7.1-7.2	-	72 h	NOEC[c,e]	11	Schäfer *et al*., 1994
Scenedesmus quadricauda	-	-	-	-	-	-	7 d	NOEC[a]	31	Bringmann & Kühn, 1980a
Chlorella vulgaris, 10^5 cells/ml	N	S	$CdCl_2$	am	6.9	-	96 h	NOEC[c,b]	33	Rachlin and Grosso, 1991
Chlorella pyrenoidosa	Y	F	$CdCl_2$	am (+EDTA)	-	-	17 gen	NOEC[c,b]	36	Bennet, 1990
Chlamydomonas reinhardtii, 2.10^{5}c/ml	N	S	$CdCl_2$	am	7.1-7.2	-	72 h	NOEC[c,e]	38	Schäfer *et al*., 1994
Chlamydomonas reinhardtii, 10^{3}c/ml	*Y*	F	$CdCl_2$	am	6.2	-	10 d	NOEC[c,e]	70	Schäfer *et al*., 1994
Chlorella fusca, 8.10^4 cells/ml	N	S	$Cd(NO_3)_2$	am	-	-	10 d	NOEC[f,b,e]	83	Wong, 1985
Chlorella vulgaris	-	-	-	-	-	-	96 h	NOEC[g,b]	500	Canton & Slooff, 1982
Chlorella ellipsoidea, 1.3.10^{4}c/ml	N	F	$Cd(NO_3)_2$	am	-	-	10 d	NOEC[c]	560	Aoyama and Okamura, 1993
Selenastrum capricornutum	-	-	-	-	-	-	96 h	NOEC[a]	700	Slooff *et al*., 1983
Scenedesmus pannonicus	-	-	-	-	-	-	48 h	NOEC[a]	900	Slooff *et al*., 1983
Chlorella pyrenoidosa	-	-	-	-	-	-	48 h	NOEC[a]	3100	Slooff *et al*., 1983
Macrophyta										
Chara vulgaris	Y	S	$CdSO_4$	am	-	-	14 d	NOEC[h]	1.1	Heumann, 1987
Salvinia minima,										

(200 mg monoculture)	N	S	Cd..	am	6.4	-	30 d	NOEC[i,l]	1	Outridge, 1992
(400 mg monoculture)	N	S	Cd..	am	6.4	-	30 d	NOEC[i,b]	3.3	Outridge, 1992
(200 mg monoculture)	N	S	Cd..	am	6.4	-	30 d	NOEC[i,b]	3.3	Outridge, 1992
Spirodela punctata										
(200 mg monoculture)	N	S	Cd..	am	6.4	-	30 d	NOEC[i,b]	3.3	Outridge, 1992
Limnanthemium cristatum,	N	S	$CdCl_2$	am	-	-	7 d	NOEC[k]	5	Chandra and Garg, 1992
(rooted leaves)										
Lemna trisculca	N	R	Cd..	am	7.8	50	14 d	NOEC[f,d]	9	Huebert and Shay, 1991
frond fragment	N	R	Cd..	am	7.8	50	14 d	NOEC[,d]	9	Huebert and Shay, 1991
Spirodela punctata										
(200 mg monoculture)	N	S	Cd..	am	6.4	-	30 d	NOEC[i]	10	Outridge, 1992
(400 mg monoculture)	N	S	Cd..	am	6.4	-	30 d	NOEC[i]	10	Outridge, 1992
Lemna polyrriza	N	S	$CdSO_4$	am	-	-	14 d	NOEC[c]	20	Charpentier *et al*., 1987
Eichornia crassipes	N	R	$Cd(NO_3)_2$	am	4.75	-	27 d	NOEC[i,b]	33	Nir *et al*., 1990
Protozoa										
Entosiphon sulcatum	-	-	-	-	-	-	72 h	NOEC[a]	11	Bringmann & Kühn, 1980a
Tetrahymena pyriformis 1000 cells/ml	N	S	$CdCl_2$	am	7.1-7.2	-	96 h	NOEC[c,e]	670	Schäfer *et al*., 1994
Rotatoria										
Brachionus calyciflorus, 0.25 mm	Y	S	Cd..	am	-	-	48 h	NOEC[m]	40	Snell and Moffat, 1992
Mollusca										
Aplexa hypnorum	-	-	-	-	-	45	26 d	NOEC[g,m]	2.5	Holcombe *et al*., 1984
Dreissena polymorpha	Y	R	$CdCl_2$	nw	7.9	150	10 w	NOEC[n,b]	3	Kraak *et al*., 1992
Lampsilis ventricosa	Y	F	$CdCl_2$	rw	8.1	165	28 d	NOEC[o,b]	7.3	Naimo *et al*., 1992
Lamellidens marginalis, 5.6-6.0 cm	N	R	Cd..	nw	8.2	-	30 d	NOEC[i,l]	50	Raj and Hameed, 1991
Annelida										
Aelosoma headleyi	-	R	-	-	-	60	20 d	NOEC[p]	17	Niederlehner *et al*., 1984
Aelosoma headleyi	-	R	-	-	-	180	20 d	NOEC[p]	54	Niederlehner *et al*., 1984
Crustacea										
Daphnia pulex, < 24 h	N	R	$CdCl_2$	rw	-	-	21 d	NOEC[qe]	0.03	Roux *et al*., 1993
Daphnia magna	-	R	-	-	7.4-8.2	45	21 d	NOEC[m,d]	0.085	Biesinger & Christensen, 1972
Daphnia magna, < 24 h	N	R	$CdCl_2$	dsw	8.4	150	14 d	NOEC[i,l]	0.1	Bodar *et al*., 1988a
Daphnia magna, 0-24 h	N	IF	$CdCl_2$	nw	8.4	200	21 d	NOEC[j,b]	0.11	Van Leeuwen *et al*., 1985
Daphnia magna	-	R	-	-	-	-	20 d	NOEC[g,b]	0.12	Canton & Slooff, 1982

Daphnia magna, < 24 h	N	R	$CdSO_4$	rw	-	100	25 d	NOEC[q,l]	0.15	Winner and Whitford, 1987
Daphnia magna, 0-24 h	N	R	$CdCl_2$	nw	8.4	200	21 d	NOEC[t]	0.16	Van Leeuwen *et al*., 1985
Ceriodaphnia reticulata, < 24 h	N	R	$CdCl_2$	nw	8.0	240	7 d	NOEC[m]	0.25	Elnabarawy *et al*., 1986
Daphnia pulex, < 24 h	N	R	$CdCl_2$	rw	-	-	21 d	NOEC[g,e]	0.3	Roux *et al*., 1993
Ceriodaphnia dubia, neonate	N	R	$CdSO_4$	am	-	90	7 d	NOEC[q,b]	0.33	Winner, 1988
Daphnia magna, < 24 h	N	R	$CdCl_2$	dsw	8.4	150	21 d	NOEC[i,b]	0.33	Bodar *et al*., 1988a
Daphnia magna, 0-24 h	N	R	$CdCl_2$	nw	8.1	224	21 d	NOEC[q,b]	0.33	Van Leeuwen *et al*., 1985
Daphnia magna, < 24 h	N	R	$CdSO_4$	rw	-	100	25 d	NOEC[g,q,b]	0.5	Winner and Whitford, 1987
Daphnia magna, adult	N	R	Cd..	rw	8.2	180	28 d	NOEC[g,s,q]	0.5	Dillon and Suedel, 1986
Hyalella azteca, 0-1 w	Y	R	$Cd(NO_3)_2$	tw	8.2-8.8	130	6 w	NOEC[g]	0.57	Borgmann *et al*., 1989
Daphnia magna, ≤ 24 h	N[8]	R	$CdCl_2$	am	8.0	250	21 d	NOEC[m]	0.6	Kühn *et al*., 1989
Echinisca triserialis, neonate	N	R	$CdCl_2$	am	7.0	-	±20 d	NOEC[m,b,e]	0.8	Chandini, 1991
Daphnia magna, adult	Y	R	$Cd(NO_3)_2$	tw	8.2-8.8	130	21 d	NOEC[q,d]	0.98	Borgmann *et al*., 1989
Daphnia magna, neonate	N	R	$CdSO_4$	am	-	90	7 d	NOEC[t]	1	Winner, 1988
Daphnia magna, 0-24 h	N	R	$CdCl_2$	nw	8.1	224	21 d	NOEC[g,b]	1	Van Leeuwen *et al*., 1985
Daphnia magna, < 24 h	N	R	$CdCl_2$	dsw	8.4	150	14 d	NOEC[n]	1	Bodar *et al*., 1988a
Ceriodaphnia dubia, neonate	N	R	$CdSO_4$	am	-	90	7 d	NOEC[g]	1	Winner, 1988
Moina macrocopa, 24 h neonate	N	R	$CdCl_2$	tap	6.5	-	11 d	NOEC[m]	1	Wong and Wong, 1990
Daphnia magna, ≤ 24 h	N	R	$CdCl_2$	nw	8.1	225	21 d	NOEC[t,e]	1.2	Enserink *et al*., 1993
Daphnia magna, ≤ 24 h	N	R	$CdCl_2$	nw	8.1	225	21 d	NOEC[p,q,d]	1.2	Enserink *et al*., 1993
Gammarus fasciatus, 0-1 w	Y	R	$Cd(NO_3)_2$	tw	8.2-8.8	130	6 w	NOEC[g]	1.5	Borgmann *et al*., 1989
Daphnia magna, ≤ 24 h	N	R	$CdCl_2$	nw	8.1	225	21 d	NOEC[p,d]	2	Enserink *et al*., 1993
Daphnia magna, < 24 h	N	R	$CdCl_2$	nw	8.0	240	14 d	NOEC[m]	2.5	Elnabarawy *et al*., 1986
Echinisca triserialis, < 24 h	N	R	$CdCl_2$	am	7.0	-	≤33 d	NOEC[q,t]	2.5	Chandini, 1988
Daphnia magna, 0-24 h	N	R	$CdCl_2$	nw	8.4	200	21 d	NOEC[p,q]	3.2	Van Leeuwen *et al*., 1985
Daphnia magna, ≤ 24 h	N	R	$CdCl_2$	nw	8.1	225	21 d	NOEC[q,d]	3.5	Enserink *et al*., 1993
Daphnia pulex	Y	R	$CdSO_4$	rw	8.3-9.0	58	6 w	NOEC[g,m]	3.8	Winner, 1986
Daphnia magna, ≤ 24 h	N	R	$CdCl_2$	nw	8.1	225	21 d	NOEC[t,e]	4.1	Enserink *et al*., 1993
Daphnia magna, ≤ 24 h	Y	R	$CdCl_2$	dsw	8.4	150	25 d	NOEC[i,q]	5	Bodar *et al*., 1988b
Moina macrocopa, 24 h neonate	N	R	$CdCl_2$	tap	6.5	-	11 d	NOEC[g]	5	Wong and Wong, 1990
Echinisca triserialis, < 24 h	N	R	$CdCl_2$	am	7.0	-	≤33 d	NOEC[q]	5	Chandini, 1988
Daphnia magna, 0-24 h	N	R	$CdCl_2$	nw	8.4	200	21 d	NOEC[g]	10	Van Leeuwen *et al*., 1985
Daphnia pulex	Y	R	$CdSO_4$	rw	8.3-9.0	115	6 w	NOEC[m]	7.5	Winner, 1986
Daphnia pulex	Y	R	$CdSO_4$	rw	8.3-9.0	230	6 w	NOEC[m]	7.5	Winner, 1986
Daphnia pulex, < 24 h	N	R	$CdCl_2$	nw	8.0	240	14 d	NOEC[m]	7.5	Elnabarawy *et al*., 1986
Daphnia magna, adult	Y	R	$Cd(NO_3)_2$	tw	8.2-8.8	130	21 d	NOEC[g]	7.8	Borgmann *et al*., 1989
Daphnia pulex	Y	R	$CdSO_4$	rw	8.3-9.0	115	6 w	NOEC[g]	13	Winner, 1986

Daphnia pulex	Y	R	$CdSO_4$	rw	8.3-9.0	230	6 w	NOEC[g]	13	Winner, 1986
Daphnia carinata, < 24 h	N	R	$CdCl_2$	am	7.0	-	6 w	NOEC[g,q,b]	17	Chandini, 1989
Barytelphusa guerini	N	R	$CdCl_2$	tw	7.4	-	15 d	NOEC[o,l]	60	Reddy and Venugopal, 1993
Insecta										
Chironomus riparius, first instar	Y	R	$CdCl_2$	nw	-	-	4-8 w	NOEC[g,q,i]	2	Postma *et al*., 1994
Polypedilum nubifer, egg	N	F	$CdCl_2$	am	8	68	≤40 d	NOEC[u]	10	Hatakeyama, 1987
Chironomus riparius, 1 h first instar	N	R	Cd..	tw	7.6	98	17 d	NOEC[a]	15	Pascoe *et al*., 1989
Pisces										
Salvelinus fontinalis, ELS	-	-	-	-	-	33-51	9 w	NOEC[a]	1	Sauter *et al*., 1976
Salvelinus fontinalis, ELS	-	-	-	-	-	45	9-18 w	NOEC[a]	1.1	Eaton *et al*., 1978
Oncorhynchus kisutch, ELS	-	-	-	-	-	45	27/47 d	NOEC[g]	1.3	Eaton *et al*., 1978
Oncorhynchus mykiss, 50 mm	Y	F	Cd..	tw	6.9	50	14 w	NOEC[g]	1.3	Davies *et al*., 1993
Salvelinus fontinalis	-	-	-	-	-	44	3 gen	NOEC[g,a]	1.7	Benoit *et al*., 1976
Oncorhynchus mykiss, 50 mm	Y	F	Cd..	tw	6.9	200	14 w	NOEC[g]	2.6	Davies *et al*., 1993
Oncorhynchus mykiss, 50 mm	Y	F	Cd..	tw	6.9	400	14 w	NOEC[g]	2.6	Davies *et al*., 1993
Jordanella floridae	-	-	-	-	-	45	30 d	NOEC[g]	3	McKim, 1977
Oncorhynchus trutta, ELS	-	-	-	-	-	45	9 w	NOEC[g]	3.8	Eaton *et al*., 1978
Jordanella floridae	-	-	-	-	-	44	14 w	NOEC[m]	4.1	Spehar, 1976
Catostomus commersoni, ELS	-	-	-	-	-	45	6 w	NOEC[g]	4.2	Eaton *et al*., 1978
Esox lucius, ELS		-	-	-	-	45	5 w	NOEC[g]	4.2	Eaton *et al*., 1978
Micropterus dolomieui, ELS	-	-	-	-	-	45	5 w	NOEC[g]	4.3	Eaton *et al*., 1978
Salvelinus namaycush, ELS	-	-	-	-	-	45	41/64 d	NOEC[g]	4.4	Eaton *et al*., 1978
Pimephales promelas, 30 d 0.15 g	Y	F	$Cd(NO_3)_2$	nw	7.4	44	32 d	NOEC[a,r]	5	Spehar and Fiandt, 1986
Salvelinus fontinalis, ELS	-	-	-	-	-	164-213	9 w	NOEC[g,a]	7	Sauter *et al*., 1976
Stizostedion vitreum, ELS	-	-	-	-	-	32-39	9 w	NOEC[g]	9	Sauter *et al*., 1976
Notropis cornutis, young	N	R	$CdCl_2$	tw	7.8-8.2	-	7 d	NOEC[a,d]	10	Borgmann and Ralph, 1986
Ictalurus punctatus, ELS	-	-	-	-	-	35-38	9 w	NOEC[g]	11	Sauter *et al*., 1976
Ictalurus punctatus, ELS	-	-	-	-	-	142-223	9 w	NOEC[a]	12	Sauter *et al*., 1976
Pimephales promelas, ELS	Y	F	$CdCl_2$	rw	7.7	102	8 d	NOEC[g]	12	Birge *et al*., 1985
Pimephales promelas, ELS	Y	R	$CdCl_2$	rw	7.7	101.6	8 d	NOEC[g]	12	Birge *et al*., 1985
Catostomus commersoni, larva	N	R	$CdCl_2$	tw	7.8-8.2		7 d	NOEC[a,e]	20	Borgmann and Ralph, 1986
Lepomis macrochirus	-	-	-	-	-	200	11 m	NOEC[g,a]	31	Eaton, 1974
Pimephales promelas	-	-	-	-	-	200	11 m	NOEC[m]	37	Pickering & Gast, 1972
Lepomis macrochirus, adult	Y	F	$CdCl_2$	tap	7.6	363	5 m	NOEC[g]	3900	Versteeg and Giesy, 1986
							5 m	NOEC[t,i]	1100	

Amphibia										
Xenopus laevis, ELS	-	-	-	-	-	hard	14 w	NOEC[v,w,b]	3	Canton & Slooff, 1982

a growth
b EC 20 - 49%: NOEC = EC/3
c cell number
d EC 11 - 19%: NOEC = EC/2
e extrapolated from graph
f multiplication rate
g mortality or immobility
h number internodes
i weight
j final yield of population
k chlorophyll content
l EC 50 - 90%: NOEC = EC/10
m reproduction
n filtration or feeding rate
o oxygen consumption, resp. rate
p population growth rate
q number young
r NOEC calculated as MATC/2
s photosynthesis
t length
u emergence
v abnormalities embryo
w abnormalities young

ANNEX 22 : Subgroup report - Derivation of Cadmium EAC

3.3. Toxicity of Cadmium to saltwater organisms in sediment-water systems: L(E)C50 and NOEC values

The data on toxicity of cadmium to saltwater organisms in sediment-water systems are presented as follows:

- table 3.3.1: Toxicity of Cadmium to saltwater organisms in sediment-water systems: L(E)C50 and NOEC values.

Legends

A	Nominal concentration (N) or Analyzed concentration (A);
test type	Static (S) or continuous Flow through (F).
% O.m.	% organic matter in sediment (if presented in % organic carbon a factor of 1.7 was used to calculate % om)
exp. time	Exposure time given in hours (h); days (d)
pH,	measured in water phase

ANNEX 22 : Subgroup report - Derivation of Cadmium EAC

3.3.1. *Table : Toxicity of Cadmium to saltwater organisms in sediment-water systems: L(E)C50 and NOEC values*

Organism	Test compound	A	Test type	pH	% O.m.	% Clay	Temp °C	Salinity in ‰	Exp. time	Criterion	Result mg/kg	Reference
Crustaceans												
Rhepoxynius abronius (juv., 1-2 mm length)	Cd	N[a]	F	-	1.5	4	15	25	10d	LC50	8.2	Robinson, 1988
Rhepoxynius abronius (adult, 3-5 mm length)	Cd	N[a]	F	-	1.5	4	15	25	10d	LC50	11.5	Robinson, 1988
Rhepoxynius abronius (juv., 1-2 mm length)	Cd	N[a]	F	-	1.5	4	15	25	10d	NOEC[b]	3	Robinson, 1988
Rhepoxynius abronius (adult, 3-5 mm length)	Cd	N[a]	F	-	1.5	4	15	25	10d	NOEC[b]	6	Robinson, 1988

a nominal concentration was confirmed by analysis

b mortality or immobility

3.4. Toxicity data for mammals and birds

In the tables on toxicity for mammals and birds the original 'reported' value and the corrected value are mentioned. The converted value is the corrected NOEC in mg/kg food. The lowest NOEC and/or LC50 values are presented in the tables in shading. The data are presented as follows:

- table 3.4.1: toxicity data for birds
- table 3.4.2: toxicity data for mammals

3.4.1. *Table : toxicity data for birds*

duration	parameter	species	reported (mg/kg food)	converted	reference
NOECs					
2 w	gr	*Meleagris galopavo*	2.0	0.20[a]	Supplee, 1961
90 d	re	*Anas platyrhynchos*	1.6	1.60	White *et al*., 1978
48 w	mo, re	*Gallus domesticus*	12	12	Leach *et al.,* 1978
6 w	gr	*Coturnix c. japonica*	75	38[b]	Richardson *et al*., 1987
5 m	re	*Streptopelia risoria*	1.7	1.9	Scheudhammer, 1987
LC50s					
20 d		*Gallus domesticus*	562	562	Pritzl *et al.,* 1974
5 d		*Phasianus colchicus*	767	767	Hill *et al*. (1975)
5 d		*Coturnix c. japonica*	1584	1584	Hill *et al*. (1975)
5 d		*Anas platyrhynchos*	>3065	>3065	Hill *et al*. (1975)

a factor 10 applied because of the uncertainty in deriving a chronic NOEC
b NOEC=LOEC/2; <20% effect at the lowest concentration tested

3.4.2. *Table : toxicity data for mammals*

duration	parameter	species	reported (mg/kg food)	converted	reference
NOECS					
3 y 1987	gr	*Macaca mulatta*	3	3	Nomiyama *et al*.,
191 d	gr	*Ovis amon aries*	15	15	Doyle *et al.,* 1974
6 m	gr	*Rattus norvegicus*	45	45	Fitzhugh & Meiller, 1941
41 w Sugawara	mo	*Rattus norvegicus*	10	10	Sugawara & , 1974
12 w	gr	*Bos primigenius taurus*	40	40	Powell *et al*., 1964
5 m	re	*Sus scrofa domesticus*	40	40	Kranjc *et al*., 1973

ANNEX 22 : Subgroup report - Derivation of Cadmium EAC

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ANNEX 23 : Subgroup report - Derivation of chromium EAC

EAC 3/2/3	chromium VI

3rd OSPAR Workshop on Ecotoxicological Assessment Criteria
NOVEMBER 25-29, 1996

Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	-	l/kg		not relevant
Sediment water partition coefficient (log Kp)	5.70	l/kg	RIKZ/OS-96.117.x	
BCF fish	-	l/kg fw		not relevant
BCF mussel	-	l/kg sp dw		not relevant

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	25	µg/l	Mears et al., 1976	saltwater
Lowest L(E)C50	-	µg/l		not considered
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	-	mg/kg food		not relevant
Lowest NOEC for birds	-	mg/kg food		not relevant

Extrapolated Concentrations	result	unit	assessment factor	note
Water	2.5	µg/l	10	
Sediment (Equilibrium partitioning)	-	mg/kg dw		not applied
Sediment (TEL)	52.3	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	1-10	µg/l	f	
Sediment	10-100	mg/kg dw	p	TEL
Fish	-	mg/kg fw		not relevant
Mussel	-	mg/kg dw		not relevant

Remarks	result			
Secondary poisoning taken into account	N			Y/N

ANNEX 23 : Subgroup report - Derivation of chromium EAC

1. DERIVATION OF EACs FOR CHROMIUM

Chromium occurs in several oxidation states, two of which can be stable in the environment: Cr(III) and Cr(VI). Cr(VI) compounds are generally more soluble in water than Cr(III) and do not usually form complexes with inorganic and organic ligands (Nieboer and Jusys, 1988), so that Cr(VI) is relatively mobile. Although Cr(III) is hardly soluble, it can nevertheless form readily soluble complexes, which remain stable over a broad pH range (Bartlett and Kimble, 1976). Cr(III) and Cr(VI) can be interconverted depending on the conditions. However in surface water, especially marine surface water, either Cr(III) or Cr(VI) can be stable.

1.1. Derivation of EAC for water

Experimental data for marine organisms were available for both Cr(III) and Cr(VI). The lower end of the available NOECs for Cr(VI) for alga, crustaceans and fish is much lower than those for Cr(III), and the hexavalent form will be the predominant in well-oxygenated waters. Therefore, toxicity data for Cr(VI) was used to derive EACs for **total chromium**.

An extrapolation factor of 10 was applied to the lowest NOEC available, 25 µg/l (Mears et al., 1976), for the polychaete *Neanthes arenaceodentata*. This resulted in an extrapolated concentration of 2.5 µg/l, which yielded an EAC for water of 1-10 µg/l. This range is identical to the range previously obtained (see doc EAC 1/2). There is an extensive chronic data set for marine organisms, but no data for fish. Freshwater data clearly indicated that fish are less sensitive than algae and invertebrates. The EAC for Cr in water was therefore classified as "firm".

1.2. Derivation of EAC for sediment

The equilibrium partitioning method (see EAC 2/1) was not applied to Cr (or any other metal) due to uncertainties in the partitioning coefficients. The TEL-value for Cr was 52.3 mg/kg dw. This resulted in a sediment EAC for Cr of 10-100 mg/kg dw which is a factor of 2 higher than the criterion obtained previously (see doc EAC 1/2). EAC for Cr in sediment is classified as "provisional".

1.3. Derivation of EAC for biota

Not relevant.

ANNEX 23 : Subgroup report - Derivation of chromium EAC

2. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test sustance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

2.1. Saltwater toxicity data

An extensive chronic saltwater data set is available for chromium VI. The data are presented as follows:

- table 2.1.1: chronic toxicity data NOECs

ANNEX 23 : Subgroup report - Derivation of chromium EAC

2.1.1. *Table : Chronic toxicity of Chromium(VI) to saltwater organisms*

Organism	A	Test type	Test compound	Test water	pH	Salinity in ‰	Exp. time	Criterion	Result µg/l	Reference
Algae										
Skeletonema costatum	N	S	$K_2Cr_2O_7$	enw	-	20	72 h	NOEC[d]	60	Kusk & Nyholm, 1992
Skeletonema costatum, 2.10⁴ cells/ml	N	S	$K_2Cr_2O_7$	am	8.2	30	96 h	NOEC[b]	300	Missimer *et al*, 1989
Skeletonema costatum	N	S	$K_2Cr_2O_7$	am	8.3	30	5 d	NOEC[d]	350	Cowgill *et al*, 1989
Skeletonema costatum, 2.10⁴ cells/ml	N	S	$K_2Cr_2O_7$	am	8.2	30	96 h	NOEC[c]	600	Missimer *et al*, 1989
Skeletonema costatum, 2.10⁴ cells/ml	N	S	$K_2Cr_2O_7$	am	8.2	30	96 h	NOEC[b]	800	Missimer *et al*, 1989
Skeletonema costatum, 2.10⁴ cells/ml	N	S	$K_2Cr_2O_7$	am	8.2	30	96 h	NOEC[c]	1400	Missimer *et al*, 1989
Annelida										
Neanthes arenaceodentata, juvenile	Y	R	$K_2Cr_2O_7$	-	7.9	33.5	10 m	NOEC[a]	25	Mears *et al*, 1976
Dinophilis gyrociliatus	Y	S	$K_2Cr_2O_7$	nw	7.8	25	7 d	NOEC[a,f]	33	Jop, 1989
Neanthes arenaceodentata, juvenile	Y	R	$K_2Cr_2O_7$	-	7.9	33.5	10 m	NOEC[e]	50	Mears *et al*, 1976
Capitella capitata, larva	N	S	$K_2Cr_2O_7$	-	-	35	5 m	NOEC[e,a]	50	Reish, 1975
Dinophilis gyrociliatus , 24-48 h juvenile	Y	S	$K_2Cr_2O_7$	nw	7.8	25	7 d	NOEC[a]	100	Jop, 1989
Ophryotrocha diadema, adult	N	S	CrO_3	-	-	-	21 d	NOEC[e,a]	500	Reish & Carr, 1978
Dinophilis gyrociliatus , 24-48 h juvenile	Y	S	$K_2Cr_2O_7$	nw	7.8	25	7 d	NOEC[e]	1000	Jop, 1989
Dinophilis gyrociliatus	Y	S	$K_2Cr_2O_7$	nw	7.8	25	7 d	NOEC[e]	1000	Jop, 1989
Crustacea										
Mysidopsis bahia, 24 h	Y	F	$K_2Cr_2O_7$	nw	8	30	5 w	NOEC[g]	88	Lussier *et al*, 1985
Mysidopsis bahia, 7 d	N	R	$K_2Cr_2O_7$	am	-	25	7 d	NOEC[g]	320	Goodfellow and Rue, 1989
Tisbe battagliai, juvenile	N	R	$K_2Cr_2O_7$	nw	7.9	35	8 d	NOEC[e]	320	Hutchinson *et al*, 1994
Tisbe battagliai, adult	N	R	$K_2Cr_2O_7$	nw	7.9	35	8 d	NOEC[a]	320	
Rhithropanopeus harrisii, larva	Y	R	Na_2CrO_4	-	-	20	21 d	NOEC[e]	360	Bookhout *et al*, 1984
Mysidopsis bahia, 7 d	N	R	$K_2Cr_2O_7$	am	-	25	7 d	NOEC[g]	420	Goodfellow and Rue, 1989
Mysidopsis bahia, 7 d	N	R	$K_2Cr_2O_7$	am	-	25	7 d	NOEC[g]	420	Goodfellow and Rue, 1989
Tisbe holothuriae, adult	N	S	Na_2CrO_4	-	-	-	28 d	NOEC[e]	500	Verriopoulos *et al*, 1981
Palaemon elegans, larva	N	R	Na_2CrO_4	am	8.3	33	5 w	NOEC[i]	520	Van der Meer *et al*, 1988
Mysidopsis bahia, < 9 d	Y	R	$K_2Cr_2O_7$	nw	7.8	30	7 d	NOEC[h]	650	Jop, 1989

Mysidopsis bahia, < 9 d	Y	R	$K_2Cr_2O_7$	nw	7.8	30	7 d	NOEC[e]	650	Jop, 1989
Callinectes sapidus,larva	Y	R	Na_2CrO_4	-		30	6 w	NOEC[e]	770	Bookhout *et al*, 1984
Praunus flexuosus, adult	N	R	Na_2CrO_4	am	8.3	23	23 d	NOEC[e]	1000	Bookhout *et al*, 1984
Mysidopsis bahia, 7 d	N	R	$K_2Cr_2O_7$	am	-	25	7 d	NOEC[e]	1200	Goodfellow and Rue, 1989
Mysidopsis bahia, 7 d	N	R	$K_2Cr_2O_7$	am	-	25	7 d	NOEC[e]	1200	Goodfellow and Rue, 1989
Palaemon elegans, larva	N	R	Na_2CrO_4	am	8.3	33	5 w	NOEC[e]	1600	Van der Meer *et al*, 1988
Mysidopsis bahia, < 9 d	Y	R	$K_2Cr_2O_7$	nw	7.8	30	7 d	NOEC[a]	1600	Jop, 1989
Mysidopsis bahia, < 9 d	Y	R	$K_2Cr_2O_7$	nw	7.8	30	7 d	NOEC[e]	1600	Jop, 1989
Mysidopsis bahia, < 9 d	Y	R	$K_2Cr_2O_7$	nw	7.8	30	7 d	NOEC[a]	1600	Jop, 1989
Mysidopsis bahia, < 9 d	Y	R	$K_2Cr_2O_7$	nw	7.8	30	7 d	NOEC[h]	1600	Jop, 1989
Palaemonetes varians, adult	N	R	Na_2CrO_4	am	8.3	23	28 d	NOEC[e]	5200	Van der Meer *et al*, 1988
Palaemonetes varians larva	N	R	Na_2CrO_4	am	8.3	23	23 d	NOEC[e]	5200	Van der Meer *et al*, 1988
Palaemonetes varians larva	N	R	Na_2CrO_4	am	8.3	33	30 d	NOEC[e]	5200	Van der Meer *et al*, 1988

a reproduction
b biomass
c cell number
d growth
e mortality or immobility
f EC 20 - 49%: NOEC = EC/3
g number young
h weight
i hatchability

2.2. **Freshwater toxicity data**

An extensive chronic freshwater toxicity data set is available. The data are presented as follows:

- table 2.2.1: chronic toxicity data: NOECs,

2.2.1. *Table : Chronic toxicity of Chromium(VI) to freshwater organisms*

Organism	A	Test type	Test compound	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Bacteria										
Escherichia coli	N	S	K_2CrO_4	am	-	-	24 h	NOEC[a,b,c]	130	Gaur and Bhattacherjee, 1991
Pseudomonas putida	N	S	$Na_2Cr_2O_7$	am	7	77	16 h	NOEC[d]	380	Bringmann & Kühn, 1980a
Escherichia coli	N	S	$K_2Cr_2O_7$	am	-	-	24 h	NOEC[a,c]	2500	Gaur and Bhattacherjee, 1991
Cyanophyta										
Microcystis aeruginosa	N	S	$Na_2Cr_2O_7$	am	7	60	8 d	NOEC[d]	1.9	Bringmann & Kühn, 1978
Microcystis aeruginosa	Y	S	$K_2Cr_2O_7$	am	7.8	24	96 h	NOEC[d]	110	Hanstveit *et al*., 1985
Microcystis aeruginosa	Y	S	$K_2Cr_2O_7$	am	8.8	24	96 h	NOEC[d]	110	Hanstveit *et al*., 1985
Microcystis aeruginosa	Y	S	$K_2Cr_2O_7$	am	7.8	36	8 d	NOEC[d]	200	Adema *et al*., 1981
Microcystis aeruginosa	Y	S	$K_2Cr_2O_7$	am	7.8	36	8 d	NOEC[d]	200	Adema *et al*., 1981
Microcystis aeruginosa	N	S	$K_2Cr_2O_7$	am	7.8	36	96 h	NOEC[d]	350	Slooff & Canton, 1983
Nostoc muscorum	N	S	$K_2Cr_2O_7$	am	-	-	15 d	NOEC[e,f]	3300	Rai & Raizada, 1988
Algae										
Chlorella spec.	N	S	K_2CrO_4	am	6.8	-	10 d	NOEC[e,c]	0.21	Wong & Chang, 1991a
Stephanodiscus hantzschii	Y	S	$K_2Cr_2O_7$	am	7.5	8	7 d	NOEC[d]	0.35	Adema *et al*., 1981
Thalassiosira pseudonana	Y	S	$Na_2Cr_2O_7$	nw	-	-	12 d	NOEC[d]	20	Frey *et al*., 1983
Scenedesmus subspicatus	N	S	$K_2Cr_2O_7$	am	8.6	54	72 h	NOEC[d]	32	Kühn & Pattard, 1990
Scenedesmus quadricauda	N	S	$Na_2Cr_2O_7$	am	7	77	7 d	NOEC[g,f]	33	Bringmann & Kühn, 1980a
Euglena gracilis	Y	S	$K_2Cr_2O_7$	am	7.7	54	96 h	NOEC[d]	35	Adema *et al*., 1981
Gomphonema parvulum	Y	S	$K_2Cr_2O_7$	am	7.8	24	96 h	NOEC[d]	35	Hanstveit *et al*., 1985
Chlorella pyrenoidosa	Y	S	$K_2Cr_2O_7$	am	7.7	54	96 h	NOEC[d]	64	Adema *et al*., 1981
Selenastrum capricornutum	Y	S	Cr^{6+}..	nw	5.6-8.9	-	96 h	NOEC[h]	70	Greene *et al*., 1988
Scenedesmus pannonicus	Y	S	$K_2Cr_2O_7$	am	7.7	54	14 d	NOEC[d]	110	Adema *et al*., 1981
Scenedesmus pannonicus	N	S	$K_2Cr_2O_7$	am	7.8	36	96 h	NOEC[d]	110	Slooff & Canton, 1983
Selenastrum capricornutum	N	S	$K_2Cr_2O_7$	am	-	24	96 h	NOEC[d]	110	Nyholm, 1991
Selenastrum capricornutum	N	S	$K_2Cr_2O_7$	am	8.1	-	72 h	NOEC[e]	180	Nyholm, 1990
Selenastrum capricornutum	Y	S	$K_2Cr_2O_7$	am	7.7	54	96 h	NOEC[d]	200	Adema *et al*., 1981
Scenedesmus subspicatus	N	S	$K_2Cr_2O_7$	am	8.5	-	72 h	NOEC[e]	230	Nyholm, 1990

Chlorella pyrenoidosa	N	S	K_2CrO_4	am	6.8	-	-	NOEC[e]	250	Wong & Chang, 1991b
Scenedesmus quadricauda	N	S	$Na_2Cr_2O_7$	am	7	77	7 d	NOEC[d]	580	Bringmann & Kühn, 1980a
Macrophyta										
Lemna minor 'M 19'	Y	S	$K_2Cr_2O_7$	nw	8	255	7 d	NOEC[d]	11	Adema & De Zwart, 1984
Lemna paucicostata '6746'	-	S	$K_2Cr_2O_7$	nw	7.1	-	7 d	NOEC[d,i]	50	Nasu & Kugimoto, 1981
Lemna gibba	Y	S	Na_2CrO_4	am	7.3	-	8 d	NOEC[d]	100	Staves & Knaus, 1985
Spirodela polyrhiza	Y	S	Na_2CrO_4	am	7.3	-	8 d	NOEC[d]	100	Staves & Knaus, 1985
Spirodela punctata	Y	S	Na_2CrO_4	am	7.3	-	8 d	NOEC[d]	100	Staves & Knaus, 1985
Lemna minor 'M 19'	N	S	$K_2Cr_2O_7$	nw	-	255	7 d	NOEC[d]	110	Slooff & Canton, 1983
Protozoa										
Chilomonas paramecium	N	S	$Na_2Cr_2O_7$	am	6.9	106	48 h	NOEC[d]	0.058	Bringmann *et al*., 1980c
Vorticella microstoma	N	S	$K_2Cr_2O_7$	am	6.5	103	48 h	NOEC[d]	100	Sudo & Aiba, 1973
Uronema parduczi	N	S	$Na_2Cr_2O_7$	am	6.9	107	20 h	NOEC[d]	1000	Bringmann & Kühn, 1980b
Colpidium campylum	N	S	$K_2Cr_2O_7$	am	6.5	103	48 h	NOEC[d]	3200	Sudo & Aiba, 1973
Opercularia spec.	N	S	$K_2Cr_2O_7$	am	6.5	103	48 h	NOEC[d]	6400	Sudo & Aiba, 1973
Entosiphon sulcatum	N	S	$Na_2Cr_2O_7$	am	6.9	77	72 h	NOEC[d]	9600	Bringmann & Kühn, 1980a
Coelenterata										
Hydra oligactis, 24 h juvenile	N	R	$K_2Cr_2O_7$	am	8.2	208	21 d	NOEC[d]	1100	Slooff & Canton, 1983
Rotatoria										
Brachionus calyciflorus, 0.25 mm	Y	S	Cr^{6+}..	am	-	-	48 h	NOEC[j]	2000	Snell and Moffat, 1992
Mollusca										
Atlanto-astacus pallipes, adult	Y	F	..Cr_2O_7	nw	6.9	-	20 w	NOEC[a,d,j]	9	Chaisemartin, 1978
Lymnaea stagnalis, 5 m adult	N	R	$K_2Cr_2O_7$	am	8.2	208	6 w	NOEC[j]	110	Slooff & Canton, 1983
							6 w	NOEC[a]	3500	
Crustacea										
Daphnia magna, ≤24 h	N	R	$K_2Cr_2O_2$	nw[9]	8.1	225	21 d	NOEC[m,b]	0.045	Enserink *et al*., 1993
Daphnia magna, ≤24 h	N	R	$K_2Cr_2O_2$	nw[9]	8.1	225	21 d	NOEC[k,b]	0.14	Enserink *et al*., 1993
Daphnia magna, ≤24 h	N	R	$K_2Cr_2O_2$	nw[9]	8.1	225	21 d	NOEC[n,b]	0.27	Enserink *et al*., 1993
Ceriodaphnia reticulata, < 24 h	N	R	$Na_2Cr_2O_7$	nw	8.0	240	7 d	NOEC[k,f]	0.17	Elnabarawy *et al*., 1986
Daphnia magna, < 24 h	N	R	$Na_2Cr_2O_7$	nw	8	240	14 d	NOEC[k]	0.5	Elnabarawy *et al*., 1986
Daphnia magna, < 24 h	N	R	$Na_2Cr_2O_7$	nw	8	240	14 d	NOEC[j]	0.5	Elnabarawy *et al*., 1986
Daphnia magna, 24-48 h	N	R	Cr^{6+}..	nw	7.6-7.8	63.3-66.5	21 d	NOEC[k,i]	0.5	Münzinger & Monicelli, 1991
Asellus aquaticus, juvenile	N	R	$K_2Cr_2O_7$	nw	7.2-7.4	240	13 d	NOEC[a,i]	1	Migliore & de Nicola Giudici, 1990

Asellus aquaticus, adult	N	R	$K_2Cr_2O_7$	nw	7.2-7.4	240	27 d	NOEC[a,i]	1	Migliore & de Nicola Giudici,
Daphnia magna, < 24 h	Y	R	Na_2CrO_4	nw	8.3	-	28 d	NOEC[a,i]	1	Trabalka & Gehrs, 1977
Daphnia pulex, < 24 h	N	R	$Na_2Cr_2O_7$	dnw	8	240	14 d	NOEC[a,i]	1.5	Elnabarawy *et al*., 1986
Daphnia magna, 24-48 h	N	R	Cr^{6+}..	nw	7.6-7.8	63.3-66.5	21 d	NOEC[a,f]	1.7	Münzinger & Monicelli, 1991
Daphnia magna, 24-48 h	N	R	Cr^{6+}..	nw	7.6-7.8	63.3-66.5	21 d	NOEC[l,if]	1.7	Münzinger & Monicelli, 1991
Daphnia magna, 24-48 h	N	R	Cr^{6+}..	nw	7.6-7.8	63.3-66.5	21 d	NOEC[a]	5	Münzinger & Monicelli, 1991
Ceriodaphnia dubia, 24 h	Y	R	$K_2Cr_2O_7$	am			7 d	NOEC[j]	5.7	De Graeve *et al*., 1992
Ceriodaphnia dubia, 24 h	Y	R	$K_2Cr_2O_7$	am			7 d	NOEC[a]	9	De Graeve *et al*., 1992
Daphnia magna, < 24 h	N	R	$Na_2Cr_2O_7$	nw	8	240	14 d	NOEC[a]	15	Elnabarawy *et al*., 1986
Daphnia magna, ≤ 24 h	N	R	$K_2Cr_2O_7$	am	8	250	21 d	NOEC[j]	18	Kühn *et al*., 1989
Moina macrocopa, 24 h	N	R	$K_2Cr_2O_7$	am	6.7	-	14 d	NOEC[j]	20	Wong, 1993
Ceriodaphnia dubia, 24 h	Y	R	$Na_2Cr_2O_7$	nw	8.2	100	7 d	NOEC[a,j,l]	32	Spehar and Fiandt, 1986
Daphnia magna, 24 h	Y	R	$K_2Cr_2O_7$	am	8.2	200	21 d	NOEC[a,j]	35	Adema *et al*., 1981
Daphnia magna, ≤ 24 h	Y	F	$K_2Cr_2O_7$	nw	8.1	225	21 d	NOEC[m]	60	Van Leeuwen *et al*., 1985
Ceriodaphnia dubia, 24 h	Y	S	K_2CrO_4	am	8	157	7 d	NOEC[a]	95	Patterson *et al*., 1992
Ceriodaphnia dubia, 24 h	Y	S	K_2CrO_4	am	8	157	7 d	NOEC[j]	65	Patterson *et al*., 1992
Ceriodaphnia dubia, 24 h	Y	S	K_2CrO_4	am	8	182	7 d	NOEC[i]	110	Patterson *et al*., 1992
Ceriodaphnia dubia, 24 h	Y	S	K_2CrO_4	am	8	182	7 d	NOEC[j]	120	Patterson *et al*., 1992
Ceriodaphnia dubia, 24 h	Y	S	K_2CrO_4	am	8	182	7 d	NOEC[a]	250	Patterson *et al*., 1992
Ceriodaphnia dubia, 24 h	Y	S	K_2CrO_4	am	8	182	7 d	NOEC[a]	340	Patterson *et al*., 1992
Daphnia magna, ≤ 24 h	Y	F	$K_2Cr_2O_7$	nw	8.1	225	21 d	NOEC[a,j]	350	Van Leeuwen *et al*., 1985
Insecta										
Culex pipiens, 24 h larva	N	R	$K_2Cr_2O_7$	am	8.2	208	25 d	NOEC[a,o]	1100	Slooff & Canton, 1983
Pisces										
Oncorhynchus salar, eggs	Y	R	$Na_2Cr_2O_7$	nw	6.3	11	16 w	NOEC[a]	10	Grande & Anderson, 1983
Oncorhynchus mykiss eggs	Y	F	Na_2CrO_4	tap	6.5	80	7 m	NOEC[a]	20	Van der Putte *et al*., 1982
Oncorhynchus mykiss, eggs	Y	F	$Na_2Cr_2O_7$	nw	6.8	33	13 w	NOEC[d]	51	Sauter *et al*., 1976
Oncorhynchus mykiss, juvenile	Y	F	$Na_2Cr_2O_7$	nw	7.5	45	8 m	NOEC[a]	100	Benoit, 1976
Salvelinus fontinalis, eyed eggs	Y	F	$Na_2Cr_2O_7$	nw	7-8	45	8 m	NOEC[a,d]	100	Benoit, 1976
Salvelinus namaycush, 24 h eggs	Y	F	$Na_2Cr_2O_7$	nw	6.9	34	16 w	NOEC[d]	110	Sauter *et al*., 1976
Ictalurus punctatus, 3 d eggs	Y	F	$Na_2Cr_2O_7$	nw	7.2	36	6 w	NOEC[a,d]	150	Sauter *et al*., 1976
Oncorhynchus mykiss, eggs	Y	F	Na_2CrO_4	tap	7.8	80	7 m	NOEC[a,d]	200	Van der Putte *et al*., 1982
Oncorhynchus mykiss 9 w juvenile	Y	F	Na_2CrO_4	tap	7.8	80	7 m	NOEC[a]	200	Van der Putte *et al*., 1982
Oncorhynchus mykiss 9 w juvenile	Y	F	Na_2CrO_4	tap	6.5	80	7 m	NOEC[a]	200	Van der Putte *et al*., 1982
Oncorhynchus mykiss14 m juv/adult	Y	F	Na_2CrO_4	tap	6.5	80	12 w	NOEC[a]	200	Van der Putte *et al*., 1982
Catostomus commersoni, eggs	Y	F	Na_2CrO_4	nw	7	32-46	9 w	NOEC[d]	290	Sauter *et al*., 1976
Salvelinus fontinalis, alevins LC	Y	F	$Na_2Cr_2O_7$	nw	7-8	45	22 m	NOEC[a,d,j]	350	Benoit, 1976

Oncorhynchus mykiss, eggs	Y	F	$Na_2Cr_2O_7$	nw	6.8	33	13 w	NOEC[a]	380	Sauter *et al*., 1976
Lepomis macrochirus, eggs	Y	F	$Na_2Cr_2O_7$	nw	6.9	33-45	9 w	NOEC[d]	520	Sauter *et al*., 1976
Pimephales promelas, 3-14 d	Y	S	$K_2Cr_2O_7$	dtw	7.9-8.1	88-108	30 d	NOEC[a,i]	900	Gendusa *et al*., 1993
Pimephales promelas, 1 m juvenile	Y	F	$K_2Cr_2O_7$	nw	7.8	209	14 m	NOEC[a]	1000	Pickering, 1980
Jordanella floridae, 24 h eggs	Y	R	$K_2Cr_2O_7$	am	8.2	200	28 d	NOEC[d]	1100	Adema *et al*., 1981
Pimephales promelas, 30 d 0.15 g	Y	F	$Na_2Cr_2O_7$	nw	7.4	43.9	32 d	NOEC[a,d,l]	1100	Spehar & Fiandt, 1986
Pimephales promelas, 24 h larve	Y	S	$Na_2Cr_2O_7$	am	8.2	-	28 d	NOEC[d]	1200	Barron & Adelman, 1984
Ictalurus punctatus, 2 w	Y	S	$K_2Cr_2O_7$	dtw	7.9-8.1	88-108	30 d	NOEC[a,i]	1500	Gendusa *et al*., 1993
Channa punctatus, 20 cm	-	-	$K_2Cr_2O_7$	tap	7.1	160	17 w	NOEC[a]	2600	Sastry & Sunita, 1983
Salvelinus namaycush, 24 h eggs	Y	F	$Na_2Cr_2O_7$	nw	6.9	34	16 w	NOEC[a]	2900	Sauter *et al*., 1976
Jordanella floridae, 24 h eggs	Y	R	$K_2Cr_2O_7$	am	8.2	200	28 d	NOEC[a]	3500	Adema *et al*., 1981
Oryzias latipes, 24 h eggs	N	R	$K_2Cr_2O_7$	am	8.2	200	6 w	NOEC[a]	3500	Slooff & Canton, 1983
Oryzias latipes, 24 h eggs	Y	R	$K_2Cr_2O_7$	am	8.2	200	28 d	NOEC[a,d]	3500	Adema *et al*., 1981
Poecilia reticulata, 24 d juvenile	Y	R	$K_2Cr_2O_7$	am	8.2	200	28 d	NOEC[d]	3500	Adema *et al*., 1981
Poecilia reticulata, 24 d juvenile	N	R	$K_2Cr_2O_7$	am	8.2	200	28 d	NOEC[a,d]	3500	Slooff & Canton, 1983
Brachydanio rerio, eggs	N	R	$K_2Cr_2O_7$	am	8.2	200	5 w	NOEC[d]	4700	Canton *et al*., 1984
Poecilia reticulata, 24 d juvenile	Y	R	$K_2Cr_2O_7$	am	8.2	200	28 d	NOEC[a]	6300	Adema *et al*., 1981
Gasterosteus aculeatus, 5 h eggs	Y	R	$K_2Cr_2O_7$	am	8.2	200	5 w	NOEC[d]	6700	Van den Dikkenberg *et al*., 1989
Brachydanio rerio, eggs	N	R	$K_2Cr_2O_7$	am	8.2	200	5 w	NOEC[a]	7000	Canton *et al*., 1984
Brachydanio rerio, ELS	N	R	$K_2Cr_2O_7$	rw	7.5	100	≤16d	NOEC[a]	7500	Dave *et al*., 1987
Brachydanio rerio, ELS	N	R	$K_2Cr_2O_7$	rw	7.5	100	≤16d	NOEC[a]	7500	Dave *et al*., 1987
Gasterosteus aculeatus, 5 h eggs	Y	R	$K_2Cr_2O_7$	am	8.2	200	5 w	NOEC[a]	12000	Van den Dikkenberg *et al*., 1989
Brachydanio rerio, ELS	N	R	$K_2Cr_2O_7$	rw	7.5	100	≤16d	NOEC[a]	30000	Dave *et al*., 1987
Brachydanio rerio, ELS	N	R	$K_2Cr_2O_7$	rw	7.5	100	≤16d	NOEC[a]	30000	Dave *et al*., 1987
Oryzias latipes, 24 h eggs	N	R	$K_2Cr_2O_7$	am	8.2	200	6 w	NOEC[o]	35000	Slooff & Canton, 1983
Brachydanio rerio, ELS	N	R	$K_2Cr_2O_7$	rw	7.5	100	≤16d	NOEC[a]	60000	Dave *et al*., 1987
Brachydanio rerio, ELS	N	R	$K_2Cr_2O_7$	rw	7.5	100	≤16d	NOEC[a]	60000	Dave *et al*., 1987
Brachydanio rerio, ELS	N	R	$K_2Cr_2O_7$	rw	7.5	100	≤16d	NOEC[a]	60000	Dave *et al*., 1987
Brachydanio rerio, ELS	N	R	$K_2Cr_2O_7$	rw	7.5	100	≤16d	NOEC[a]	60000	Dave *et al*., 1987
Brachydanio rerio, ELS	N	R	$K_2Cr_2O_7$	rw	7.5	100	≤16d	NOEC[a]	60000	Dave *et al*., 1987
Amphibia										
Xenopus laevis, 48 h eggs	N	R	$K_2Cr_2O_7$	am	8.2	208	14 w	NOEC[a]	350	Slooff & Canton, 1983
Xenopus laevis, 48 h eggs	N	R	$K_2Cr_2O_7$	am	8.2	208	14 w	NOEC[d]	1100	Slooff & Canton, 1983

a mortality or immobility	i EC 50 - 90%: NOEC = EC/10
b EC 11 - 19%: NOEC = EC/2	j reproduction
c extrapolated from graph	k number young
d growth	l NOEC calculated as MATC/2
e cell number	m length
f EC 20 - 49%: NOEC = EC/3	n population growth rate
g chlorophyll content	o hatchability
h weight	

ANNEX 23 : Subgroup report - Derivation of chromium EAC

3. REFERENCES

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3.3. **References evaluated but rejected**

Not available.

ANNEX 24 : Subgroup report - Derivation of copper EAC

EAC 3/2/4	copper (Cu)

NOVEMBER 25-29, 1996
3rd OSPAR Workshop on Ecotoxicological Assessment Criteria

Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	-	l/kg		not relevant
Sediment water partition coefficient (log Kp)	4.27	l/kg	RIKZ/OS96.117x	
BCF fish	201	l/kg fw	Haenen et al., 1993	
BCF mussel	5,910	l/kg sp dw	Haenen et al., 1993	

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	0.2	µg/l	MacRae & Pandey, 1991	saltwater
Lowest L(E)C50	-	µg/l		not considered
sediment				
Lowest NOEC	12.4	mg/kg dw	Phelps, 1985	
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOAEL for mammals	-	mg/kg food		not relevant
Lowest NOAEL for birds	-	mg/kg food		not relevant

Extrapolated Concentrations	result	unit	assessment factor	note
Water	0.02	µg/l	10	
Sediment (Equilibrium partitioning)	-	mg/kg dw		not applied
Sediment (TEL)	18.7	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	0.005-0.05	µg/l	f	
Sediment	5-50	mg/kg dw	p	TEL
Fish	0.001-0.01	mg/kg fw	p	
Mussel	0.05-0.5	mg/kg dw	p	

Remarks	result			
Secondary poisoning taken into account	N			Y/N

ANNEX 24 : Subgroup report - Derivation of copper EAC

1. DERIVATION OF EACs FOR COPPER

1.1. Derivation of EAC for water

An extrapolation factor of 10 was applied on the lowest NOEC available, being 0.2 µg/l (McRae & Pandey, 1991) for the hatchability of *Artemia salina* cysts. This resulted in an extrapolated concentration of 0.02 µg/l, which yielded an EAC for Cu in water of 0.005-0.05 µg/l. This range is 20 times lower than the original range set (see doc EAC 1/2). Because of the extensive chronic data set the EAC for Cu in water is classified as "firm".

1.2. Derivation of EAC for sediment

The equilibrium partitioning method (see EAC 2/1) was not applied to Cu (or any other metal) due to uncertainties in the partitioning coefficients. The TEL-value for Cu was 18.7 mg/kg dw. This resulted in a sediment EAC for Cu of 5-50 mg/kg dw. The derived interval is identical to the one found earlier (see doc EAC 1/2). The EAC for Cu in sediment is classified as "provisional".

1.3. Derivation of EAC for biota

<u>Fish</u>

Calculation of EAC for fish is possible using the BCF (measured value) for fish from Haenen et al. (1993):

EAC fish = 0.02 µg/l * 201 l/kg fw = 0.004 mg/kg fw

This value of 0.004 mg/kg fw yields an EAC for Cu in fish of 0.001-0.01 mg/kg fw. It was noted that only one BCF was available in the data set but that additional BCFs were available in the AQUIRE database (Milkfish, *Chanos chanos*: Fresh weight based BCFs in the range 37-109). The obtained EAC for Cu in fish is considered "provisional" since only one BCF (201 l/kg fw) for *Platichthys flesus* was used to set the criterion.

<u>Mussels</u>

Calculation of EAC for mussels is possible using the BCF (measured value) for mussels from Haenen et al. (1993):

EAC mussels = 0.02 µg/l * 5,910 l/kg dw = 0.12 mg/kg dw

This value of 0.12 mg/kg dw is rounded to the range of 0.05-0.5 mg/kg dw. This EAC is considered "provisional" since only one measured BCF was taken into account.

ANNEX 24 : Subgroup report - Derivation of copper EAC

2. BCF DATA

The BCF for the fish *Platichthys flesus* presented in Haenen et al. (1993) is 201 l/kg fw.
For mussels the BCF from Haenen et al. (1993) is 792 l/kg fw. Recalculation into soft parts dry weight with the correction factor of 0.134 (dw/fw) proposed in Haenen *et al.* (1993), results in a BCF of 5,910 l/kg dw. The experimental BCF values for fish and molluscs are presented in table 2.1.

Legend:

Exp. period	exposure period
C_{water}	water concentration applied in the test
fw	fresh weight
dw	dry weight

2.1. Table : bioconcentration factors for fish and molluscs

Species	Exp. period {d)	C_{water} (µg/l)	BCF (l/kg) fw	BCF (l/kg) dw	Reference
FISH					
Platichthys flesus	-	-	201	-	Haenen *et al*., 1993
MOLLUSCS					
Mytilus edulis	-	-	792	5,910	Haenen *et al*., 1993

ANNEX 24 : Subgroup report - Derivation of copper EAC

3. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. Saltwater toxicity data

For copper an extensive chronic toxicity data set is available. The data are presented as follows:

- table 3.1.1: chronic toxicity data NOECs

ANNEX 24 : Subgroup report - Derivation of copper EAC

3.1.1. *Table : Chronic toxicity of Copper to saltwater organisms*

Organism	A	Test type	Test compound	Test water	pH	Salinity in ‰	Exp. time	Criterion	Result µg/l	Reference
Cyanophyta										
Anabaena variabilis	N	S	$CuSO_4$	am	-	-	7 d	NOEC[a,b]	5.0	Kosakowska *et al*, 1988
Algae										
Cyclococcolithina leptopora	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	0.64	Brand *et al*, 1986
Prorocentrum sp. (A1568)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	0.64	Brand *et al*, 1986
Synechococcus sp. (WH8008)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	0.64	Brand *et al*, 1986
Synechococcus bacillaris	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	0.64	Brand *et al*, 1986
Thoracosphaera heimii	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	0.64	Brand *et al*, 1986
Macrocystis pyrifera motile zoöspore	Y	R	Cu..	am	7.8-8.3	35-37	19 d	NOEC[g,b]	1	Anderson *et al*, 1990
Nitzschia closterium	N	S	Cu..	nw	-	-	96 h	NOEC[d,b]	1	Stauber and Florence, 1989
Thalassiosira pseudonana	N	S	$CuCl_2$	am	8.0	-	96 h	NOEC[d]	1.3	Kazumi *et al*, *1987*
Thalassiosira pseudonana	Y	S	$CuCl_2$	nw	8.0	24.8	96 h	NOEC[d,h]	1.4	Kazumi *et al*, 1987
Chaetoceros sp.	N	S	$CuSO_4$	am	-	-	7 d	NOEC[d]	2.5	Zhang *et al*, 1992
Bacteriastrum hyalinum	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	6.4	Brand *et al*, 1986
Emiliania huxleyi (Bt6)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	6.4	Brand *et al*, 1986
Peridinium sp. (A1572)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	6.4	Brand *et al*, 1986
Peridinium sp. (A1570)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	6.4	Brand *et al*, 1986
Synechococcus sp.	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	6.4	Brand *et al*, 1986
Synechococcus sp. (WH7805)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	6.4	Brand *et al*, 1986
Synechococcus sp. (WH7808)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	6.4	Brand *et al*, 1986
Thoracosphaera sp. (A1396)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	6.4	Brand *et al*, 1986
Thoracosphaera heimii	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	6.4	Brand *et al*, 1986
Umbilicosphaera hulburtiania	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	6.4	Brand *et al*, 1986
Laminaria saccharina, gametophytes	N	R	$CuSO_4$	am	-	-	21 d	NOEC[f]	10	Chung and Brinkhuis, 1986
Chlorella vulgaris	N	S	$CuSO_4$	am	-	-	7 d	NOEC[a,e]	17	Kosakowska *et al*, 1988
Asterionella glacialis	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[a]	64	Brand *et al*, 1986
Emiliania huxleyi (A530)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	64	Brand *et al*, 1986
Gephyrocapsa oceanica	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	64	Brand *et al*, 1986

Hymenomonas carterae	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	64	Brand *et al*, 1986
Prorocentrum sp. (A1391)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	64	Brand *et al*, 1986
Prorocentrum sp. (A1565)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	64	Brand *et al*, 1986
Rhizosolenia stolterfothii	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	64	Brand *et al*, 1986
Streptotheca tamesis	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	64	Brand *et al*, *1986*
Streptotheca tamesis	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	64	Brand *et al*, 1986
Synechococcus sp. (WH6501)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	64	Brand *et al*, 1986
Synechococcus sp. (WH8003)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	64	Brand *et al*, 1986
Synechococcus sp. (WH8016)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	64	Brand *et al*, 1986
Thoracosphaera sp. (A1392)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	64	Brand *et al*, 1986
Bacteriastrum delicatulum	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	130	Brand *et al*, 1986
Hemiaulus sinensis	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	130	Brand *et al*, 1986
Rhizosolenia setigera	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	130	Brand *et al*, 1986
Thalassiosira pseudonana	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	130	Brand *et al*, 1986
Umbilicosphaera sibogae	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	130	Brand *et al*, 1986
Skeletonema costatum	N	S	$CuSO_4$	am	-	30	12 d	NOEC[d,e]	170	Rao *et al*, *1989*
Emiliania huxleyi (A1183)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	190	Brand *et al*, 1986
Gymnodinium sp. (A1389)	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	190	Brand *et al*, 1986
Hymenomonas carterae	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	190	Brand *et al*, 1986
Biddulphia moluliensis	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	250	Brand *et al*, 1986
Ditylum brightwellii	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	250	Brand *et al*, 1986
Emiliania huxleyi (A1168)	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	250	Brand *et al*, 1986
Lithodesmium undulatum	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	250	Brand *et al*, 1986
Skeletonema costatum	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	250	Brand *et al*, 1986
Thalassiosira oceanica	N	R	$CuSO_4$	nw	8.2	37	4-5w	NOEC[c]	250	Brand *et al*, *1986*
Skeletonema costatum	N	R	$CuSO_4$	nw	8.2	33	4-5w	NOEC[c]	640	Brand *et al*, 1986
Coelentherata										
Hydra littoralis	N	S	-	am	-	-	14 d	NOEC[i]	2.5	Stebbing & Pomroy, 1978
Campanularia flexuosa	N	R	-	am	-	-	14 d	NOEC[i]	10	Stebbing, 1976
Eirene viridula	N	R	-	-	-	-	13 w	NOEC[i]	10	Karbe, 1972
Mollusca										
Mytilus edulis, 0.15 mm larva	N	R	$CuSO_4$	nw	-	32	10 d	NOEC[l]	0.5	Stromgren and Nielsen, 1991
Argopecten irradians, 4 m, 31 mm	N	F	$CuCl_2$	nw	-	26	18 w	NOEC[j,e]	0.7	Nelson *et al*, 1988
Mytilus edulis, ca. 15 mm	N	R	$CuCl_2$	nw	-	-	20 d	NOEC[n,h]	0.7	Redpath, 1985
Mytilus edulis, 0.15 mm larva	N	R	$CuSO_4$	nw	-	32	10 d	NOEC[j]	1	Stromgren and Nielsen, 1991
Mytilus edulis, 50 mm adult	N	F	$CuCl_2$	nw	-	26	18 w	NOEC[j,h]	1	Nelson *et al*, 1988
Mytilus edulis, adult	Y	F	$CuSO_4$	nw	-	32	30 d	NOEC[m]	1.3	Stromgren and Nielsen, 1991

Spisula solidissima, 4 m, 30 mm	N	F	$CuCl_2$	nw	-	26	18 w	NOEC[j]	2	Nelson *et al*, 1988
Mytilus edulis, 10-15 mm	N	R	$CuCl_2$	nw	-	-	10 d	NOEC[n]	3.9	Redpath, 1985
Mercenaria mercenaria, larva	N	R	-	nw	-	-	7 d	NOEC[i]	5	Calabrese *et al*, 1977
Ilyanassa obsoleta, fertilized eggs	N	S	$CuCl_2$	nw	8	8.0	11 d	NOEC[k]	6.3	Conrad, 1988
Pecten maximus, larva	N	R	$CuCl_2$	nw	-	32	15 d	NOEC[j,e]	6.7	Beaumont *et al*, 1987
Pecten maximus, larva	N	R	$CuCl_2$	nw	-	32	15 d	NOEC[n,e]	6.7	Beaumont *et al*, 1987
Crassostrea virginica, larva	N	R	-	nw	-	-	14 d	NOEC[i]	10	Calabrese *et al*, 1977
Saccostrea commercialis, eyed larva	N	R	$CuCl_2$	nw	7-8.5	30	5 d	NOEC[o,b]	10	Nell and Holliday, 1986
Mytilus edulis	N	R	$CuCl_2$	nw	-	32	15 d	NOEC[n,h]	10	Beaumont *et al*, 1987
Mytilus edulis	N	R	$CuCl_2$	nw	-	32	15 d	NOEC[j]	100	Beaumont *et al*, 1987
Busicon canaliculatum	N	R	-	nw	-	-	8 w	NOEC[j]	100	Betzer & Yevich, 1975
Annelida										
Neanthes arenaceodentata, 3-4 w larva	Y	F	$CuCl_2$	nw	-	29	28 d	NOEC[j,b]	3.9	Pesch *et al*, 1986
Neanthes arenaceodentata, 3-4 w larva	Y	F	$CuCl_2$	nw	-	29	28 d	NOEC[j,b]	8	Pesch *et al*, 1986
Ctenodrilus serratus	-	-	-	-	-	-	21-31 d	NOEC[c]	50	Reish & Carr,1978
Nereis diversicolor	N	R	-	nw	-	-	6 w	NOEC[j]	100	Bryan & Hummerstone,1971
Ophryotrocha diadema	-	-	-	-	-	-	28 d	NOEC[c]	100	Reish & Carr,1978
Crustacea										
Artemia salina, cysts	N	S	$CuSO_4$	am	-	-	72 h	NOEC[q,e]	0.2	MacRae and Pandey, 1991
Allorchestes compressa,	N	F	$CuSO_4$	nw	8	31	28 d	NOEC[j,b]	1	Ahsanullah and Williams,
first instar juvenile							28 d	NOEC[p,b]	1	1991
Cancer anthonyi, embryo	N	R	$CuCl_2$	nw	7.8	34	7 d	NOEC[q,e]	3.3	MacDonald *et al*, 1988
Pandalus danae, larva	Y	F	-	nw	-	-	6 w	NOEC[i]	10	Young *et al*, 1979
Mysidopsis bahia, 24 h	Y	F	$CuCl_2$	nw	-	30	5 w	NOEC[r]	38	Lussier *et al*, 1985
Callianassa australiensis	-	-	-	-	-	-	14 d	NOEC[j]	60	Ahsanullah *et al*, 1981
Mysidopsis bahia, 24 h	Y	F	$CuCl_2$	nw	-	30	5 w	NOEC[j]	77	Lussier *et al*, 1985
Cancer anthonyi, embryo	N	R	$CuCl_2$	nw	7.8	34	7 d	NOEC[j]	100	MacDonald *et al*, 1988
Pisces										
Atherinops affinis,	Y	S	$CuCl_2$	nw	7.1-7.7	33	12 d	NOEC[s]	55	Anderson *et al*, 1991
early blastula embryos, stage 8-9	Y	S	$CuCl_2$	nw	7.1-7.7	33	12 d	NOEC[q]	55	Anderson *et al*, 1991
	Y	S	$CuCl_2$	nw	7.1-7.7	33	12 d	NOEC[t]	55	Anderson *et al*, 1991
Atherinops affinis,	Y	S	$CuCl_2$	nw	7.1-7.7	33	12 d	NOEC[t]	63	Anderson *et al*, 1991
early blastula embryos, stage 8-9										
Atherinops affinis,	Y	S	$CuCl_2$	nw	7.1-7.7		12 d	NOEC[t]	68	Anderson *et al*, 1991

early blastula embryos, stage 8-9										
Atherinops affinis,	Y	S	$CuCl_2$	nw	7.1-7.7	33	12 d	NOEC[s]	120	Anderson *et al*, 1991
early blastula embryos, stage 8-9	Y	S	$CuCl_2$	nw	7.1-7.7	33	12 d	NOEC[q]	120	Anderson *et al*, 1991
Atherinops affinis,	Y	S	$CuCl_2$	nw	7.1-7.7	33	12 d	NOEC[s]	120	Anderson *et al*, 1991
early blastula embryos, stage 8-9	Y	S	$CuCl_2$	nw	7.1-7.7	33	12 d	NOEC[q]	120	Anderson *et al*, 1991

a chlorophyll content
b EC 50 - 90%: NOEC = EC/10
c reproduction
d cell number
e EC 20 - 49%: NOEC = EC/3
f meiospore release
g sporophyte production
h EC 11 - 19%: NOEC = EC/2
i effect parameter not reported
j mortality or immobility
k spawning frequentie
l length
m spawning frequency
n shell
o settlement rate larvae
p weight
q hatchability
r number young
s abnormalities embryo
t abnormalities young

3.2. **Freshwater toxicity data**

For copper an extensive chronic toxicity data set is available. The data are presented as follows:

- table 3.2.1: chronic toxicity data: NOECs,

3.2.1. ***Table : Chronic toxicity of Copper to freshwater organisms***

Organism	A	Test type	Test compound	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Bacteria										
Nitrosomonas europaea	N	S	Cu..	am	8.5	-	5 d	NOEC[a,b]	10	Sato *et al.,* 1986
Algae										
Chlorella spec.	N	S	$CuCl_2$	am (+EDTA)	6.8	-	10 d	NOEC[a,e]	0.26	Wong and Chang, 1991a
Selenastrum capricornutum	N	S	$CuSO_4$	am	6	-	5 d	NOEC[a,b]	2	Roberts *et al*., 1990
Selenastrum capricornutum	N	S	$CuSO_4$	am	8	-	5 d	NOEC[a,b]	2.8	Roberts *et al*., 1990
Chlamydomonas spec.	N	S	$CuSO_4$	am	8.0	19	7 d	NOEC[a,e,g]	3	Masuda and Boyd, 1993
Chlorella pyrenoidosa	N	S	Cu..	am (no EDTA)	-	-	96 h	NOEC[a,g]	3.3	Stauber and Florence, 1989
Chlamydomonas reinhardtii	Y	S	$CuSO_4$	rw	8.0	76	72 h	NOEC[c]	5	Garvey *et al*., 1991
Chlorella fusca	N	S	$CuCl_2$	am	-	-	10 d	NOEC[k,g,e]	5.3	Wong, 1985
Chlamydomonas spec.	N	S	$CuSO_4$	am	8.5	19	7 d	NOEC[a,e,g]	8.3	Masuda and Boyd, 1993
Chlamydomonas reinhardtii	Y	S	Cu..	nw	8.0-8.3	133	72 h	NOEC[a,e]	8.5	Winner and Owen, 1991
Melosira spec.	N	S	$CuSO_4$	nw	-	115	9 d	NOEC[l]	10	Horne & Goldman, 1974
Oocystus spec.	N	S	$CuSO_4$	nw	-	115	9 d	NOEC[l]	10	Horne & Goldman, 1974
Chlamydomonas reinhardtii	Y	S	Cu..	nw	8.0-8.3	95	72 h	NOEC[c,e,f]	12	Winner and Owen, 1991
Camydomonas reinhardtii (1000 cells/ml)	N	S	$CuSO_4$	am	7.1-7.2	-	72 h	NOEC[a,e]	13	Schäfer *et al.,* 1994
Chlamydomonas reinhardtii	Y	S	Cu..	nw	8.0-8.3	133	72 h	NOEC[c,e,f]	14	Winner and Owen, 1991
Selenastrum capricornutum	Y	S	$CuCl_2$	nw	-	85	96 h	NOEC[a,e]	15	Blaylock *et al*., 1985
Selenastrum capricornutum	N	S	$CuSO_4$	am	7.5-8.5	-	72 h	NOEC[a]	19	Nyholm, 1990
Chlamydomonas reinhardtii	Y	S	$CuSo_4$	rw	8.0	76	72 h	NOEC[d]	19	Garvey *et al*., 1991
Chlamydomonas reinhardtii (200,000 cells/ml)	Y	S	Cu..	nw	8.0-8.3	95	72 h	NOEC[ae,f]	19	Schäfer *et al*., 1994
Selenastrum capricornutum	N	S	$CuSO_4$	am	7.5-8.5	-	5 d	NOEC[a]	21	Nyholm, 1990
Chlamydomonas reinhardtii (*200,000 cells/ml)*	N	F	$CuSO_4$	am	6.2	-	10 d	NOEC[a,e]	22	Schäfer *et al.,* 1994

Chlamydomonas reinhardtii (1000 cells/ml)	Y	F	$CuSO_4$	am	6.2	-	10 d	NOEC[a]	22	Schäfer *et al.,* 1993
Selenastrum capricornutum	N	S	$CuSO_4$	am	7.5-8.5	-	72 h	NOEC[a]	24	Nyholm, 1990
Chlamydomonas spec.	N	S	$CuSO_4$	am	7.2	19	7 d	NOEC[a,e]	25	Masuda and Boyd, 1993
Chlamydomonas spec.	N	S	$CuSO_4$	am	8.0	119	7 d	NOEC[a,e]	25	Masuda and Boyd, 1993
Chlamydomonas spec.	N	S	$CuSO_4$	am	8.0	50	7 d	NOEC[a,e]	25	Masuda and Boyd, 1993
Chlamydomonas spec.	N	S	$CuSO_4$	am	8.4	17	7 d	NOEC[a,e]	25	Masuda and Boyd, 1993
Scenedesmus quadricauda	N	S	$CuSO_4$	am	8	-	72 h	NOEC[h,g]	33	Starodub *et al*., 1987a
Chlorella pyrenoidosa	N	S	$CuCl_2$	am	6.8	-	-	NOEC[j,g]	33	Wong and Chang, 1991b
Scenedesmus quadricauda	N	S	$CuSO_4$	am	4.5	-	15 d	NOEC[a]	50	Starodub *et al*., 1987b
Scenedesmus quadricauda	N	S	$CuSO_4$	am	6.5	-	15 d	NOEC[a]	50	Starodub *et al*., 1987b
Chlamydomonas spec.	N	S	$CuSO_4$	am	6.6	19	7 d	NOEC[a,e]	50	Masuda and Boyd, 1993
Chlorella vulgaris	Y	S	$CuCl_2$	nw	-	85	96 h	NOEC[a,e]	50	Blaylock *et al.,* 1985
Chlorella pyrenoidosa	N	S	$CuCl_2$	(+EDTA)	6.8	-	-	NOEC[h,i]	50	Wong and Chang, 1991b
Selenastrum capricornutum	N	S	$CuSO_4$	am (+ EDTA)	7-7.5	4.1	96 h	NOEC[a]	57	Nyholm and Damgaard, 1990
Selenastrum capricornutum	N	S	Cu^{2+}	dsw	-	-	72 h	NOEC[a]	64	Van de Meent *et al*., 1993
Scenedesmus subspicatus, 6.10^4 c/ml	N	S	$CuSO_4$	am	7.1-7.2	-	72 h	NOEC[a,e]	64	Schäfer *et al*., 1994
Chlorella pyrenoidosa	N	S	$CuCl_2$	am	6.8	-	-	NOEC[a]	100	Wong and Chang, 1991b
Chlorella saccarophila[10]	N	S	Cu..	am (no EDTA)	3	-	10 d	NOEC[a,g,e]	330	Folsom *et al.,* 1986
Protozoa										
Tetrahymena pyriformis, 1000 cells/ml	N	S	$CuSO_4$	am	7.1-7.2	-	96 h	NOEC[a,e]	3800	Schäfer *et al*., 1994
Rotatoria										
Brachionus calyciflorus	N	R	Cu..	am	7.4-7.8	80-100	5 d	NOEC[m,b]	0.25	Ferrando *et al*., 1993
Brachionus calyciflorus, 0.25 mm	Y	S	Cu..	am	-	-	48 h	NOEC[n]	20	Snell and Moffat, 1992
Porifera										
Ephydatia fluviatilis, gemmules	N	F	$CuSO_4$	am	7.0	-	10 d	NOEC[l]	3.2	Francis and Harrison, 1988
Mollusca										
Campeloma decisum, 11-27 mm, PLC	Y	F	$CuSO_4$	nw	7.7	45	6 w	NOEC[m]	8	Arthur & Leonard, 1970
Physa integra, 4-7 mm, PLC	Y	F	$CuSO_4$	nw	7.7	45	6 w	NOEC[m,l,n]	8	Arthur & Leonard, 1970
Dreissena polymorpha	Y	R	$CuCl_2$	nw	7.9	150	11 w	NOEC[o,g]	17	Kraak *et al*., 1992
6 -6 cm Lamellidens marginalis, 5.	N	R	Cu..	nw	8.2	-	30 d	NOEC[p]	250	Raj and Hameed, 1991

Crustacea										
Daphnia pulex, < 24 h	N	R	$CuCl_2$	rw	-	-	21 d	NOEC[m]	0.03	Roux *et al*., 1993
Daphnia pulex, < 24 h	N	R	$CuCl_2$	rw	-	-	21 d	NOEC[q]	0.3	Roux *et al*., 1993
Ceriodaphnia dubia, neonate	Y	R	$Cu(NO_3)_2$	rw	8.4	111	10 d	NOEC[m]	0.34	Cowgill and Millazo, 1991
Bosmina longirostris, first instar	N	R	$CuSO_4$	nw	-	34	21 d	NOEC[m,g]	0.63	Koivisto *et al*., 1992
Proasellus coxalis, juvenile	N	R	$CuSO_4$	nw	7.2	300	21 d	NOEC[m,b]	1	Giudici *et al*., 1987
Patya australiensis, adult	Y	F	Cu^{2+}..	tap	6.96	17	9 d	NOEC[m,b]	1	Daly *et al*., 1990
Asellus aquaticus, juvenile	N	R	$CuSO_4$	nw	7.2	300	30 d	NOEC[m,b]	1	Giudici *et al*., 1987
Chydorus sphaericus, first instar	N	R	$CuSO_4$	nw	-	34	21 d	NOEC[m,g]	1.3	Koivisto *et al*., 1992
Daphnia galeata, first instar	N	R	$CuSO_4$	nw	-	34	21 d	NOEC[m,i]	1.9	Koivisto *et al*., 1992
Daphnia magna, first instar	N	R	$CuSO_4$	nw	-	34	21 d	NOEC[m,b]	2.6	Koivisto *et al*., 1992
Patya australiensis, adult	Y	F	Cu(tot)	tap	6.96	17	9 d	NOEC[m,b]	2.9	Daly *et al*., 1990
Gammarus pulex, juvenile 2nd/3rd molt	Y	R	$CuSO_4$	am	6.8-7.2	151	10 d	NOEC[m,b]	3.3	Taylor *et al*., 1991
Proasellus coxalis, male	N	R	$CuSO_4$	nw	7.2	300	27 d	NOEC[m,g]	3.3	Giudici *et al*., 1987
Proasellus coxalis, female	N	R	$CuSO_4$	nw	7.2	300	32 d	NOEC[m,g]	3.3	Giudici *et al*., 1987
Asellus aquaticus, male	N	R	$CuSO_4$	nw	7.2	300	29 d	NOEC[m,g]	3.3	Giudici *et al*., 1987
Asellus aquaticus, female	N	R	$CuSO_4$	nw	7.2	300	6 w	NOEC[m,i]	5	Giudici *et al*., 1987
Daphnia magna, neonates, LC	Y	R	$CuCl_2$	nw	8.1	225	14 d	NOEC[n]	5	Van Leeuwen *et al*., 1988
Daphnia pulex, < 24 h, LC	Y	R	$CuSO_4$	am	8.5	106	10 w	NOEC[m]	5	Ingersoll & Winner, 1982
Gammarus pseudolimnaeus, LC	Y	F	$CuSO_4$	nw	7.7	45	15 w	NOEC[r]	5	Athur & Leonard, 1970
Daphnia pulex, < 24 h	Y	R	$CuSO_4$	rw	>8.0	58	6 w	NOEC[m]	6	Winner, 1985
Ceriodaphnia dubia, 2-8 h	Y	R	Cu..	nw	8.15	94	7 d	NOEC[n]	6.3	Belanger *et al*., 1989
Ceriodaphnia dubia, 2-8 h	Y	R	Cu..	nw	8.31	179	7 d	NOEC[n,g]	6.4	Belanger *et al*., 1989
Daphnia pulex, first instar	N	R	$CuSO_4$	nw	-	33.8	21 d	NOEC[m]	6.4	Koivisto *et al*., 1992
Daphnia pulex, < 24 h	Y	R	$CuSO_4$	rw	>8.0	115	6 w	NOEC[m]	7.5	Winner, 1985
Daphnia pulex, < 24 h	Y	R	$CuSO_4$	am	8.4-8.7	58	28-40d	NOEC[m]	8	Winner and Gauss, 1986
Daphnia pulex, < 24 h	Y	R	$CuSO_4$	am	8.4-8.7	115	28-40d	NOEC[m]	9	Winner and Gauss, 1986
Daphnia pulex, < 24 h	Y	R	$CuSO_4$	am	8.4-8.7	230	28-40d	NOEC[m]	10	Winner and Gauss, 1986
Daphnia magna, ≤24 h	N	R	$CuCl_2$	nw	-	85	14 d	NOEC[q]	10	Blaylock *et al*., 1985
Daphnia pulex, < 24 h, LC	Y	R	$CuSO_4$	am	8.5	106	10 w	NOEC[n]	10	Ingersoll & Winner, 1982
Gammarus pulex, mixed size classes	Y	F	$CuSO_4$	dtw	7.5	410	14 w	NOEC[r,h]	11	Maund *et al*., 1992
Daphnia magna, ≤24 h	-	-	-	nw	-	45	21 d	NOEC[n]	11	Biesinger & Christensen, 1972
Daphnia pulex, < 24 h	Y	R	$CuSO_4$	rw	>8	230	6 w	NOEC[m]	11	Winner, 1985
Ceriodaphnia dubia, < 4 h, LC	Y	R	$CuCl_2$	nw	.2	32	7 d	NOEC[m,n]	12	Carlson *et al*., 1986
Daphnia magna, neonates, LC							21 d	NOEC[l]	13	Van Leeuwen *et al,* 1988
Daphnia ambigua, ≤24 h, LC	N	R	$CuSO_4$	nw	8.8	145	6 w	NOEC[l]	20	Winner & Farrell, 1976
Ceriodaphnia dubia (24h)	Y	R	$Cu(NO_3)_2$	nw	8.2	100	7 d	NOEC[m,n,f]	23	Spehar and Fiandt, 1986
Ceriodaphnia dubia, < 12 h	Y	R	Cu..	nw	8.0-8.3	75	7 d	NOEC[q,e,f]	27	Winner and Owen, 1991

Daphnia pulex, < 24 h	Y	R	$CuSO_4$	nw[6]	>8	104	6 w	NOEC[m]	35	Winner, 1985
Daphnia magna, LC							21 d	NOEC[m]	37	Van Leeuwen *et al*., 1988
Daphnia ambigua, ≤ 24 h, LC	N	R	$CuSO_4$	nw	8.8	145	6 w	NOEC[m]	40	Winner & Farrell, 1976
Ceriodaphnia dubia, < 12 h	Y	R	Cu..	nw	8.0-8.3	13	7 d	NOEC[q,e,f]	40	*Winner & Owen,*., 1991
Ceriodaphnia dubia, neonate	Y	R	Cu-metal[12]	rw	8.4	111	10 d	NOEC[m]	79	Cowgill and Millazo, 1991
Ceriodaphnia dubia, neonate	Y	R	Cu-metal[12]	rw	8.4	111	10 d	NOEC[q]	79	Cowgill and Millazo, 1991
Ceriodaphnia dubia, neonate	Y	R	$Cu(NO_3)_2$	rw	8.4	111	10 d	NOEC[q]	96	Cowgill and Millazo, 1991
Insecta										
Polypedilum nubifer,										
eggs ->exuviciae	N	F	$CuSO_4$	tap	7.9-8.0	68	32 d	NOEC[t,g]	3.3	Hatakeyama, 1988
Clistoronia magnifica 5th instar PLC	Y	F	$CuCl_2$	nw	7.3	26	8 m	NOEC[s]	8	Hatakeyama, 1988
Polypedilum nubifer, eggs->adults	N	F	$CuSO_4$	tap	7.9-8.0	-	32 d	NOEC[m]	10	Hatakeyama, 1988
Clistoronia magnifica 5th instar PLC	Y	F	$CuCl_2$	nw	7.3	26	8 m	NOEC[n]	13	Hatakeyama, 1988
Chironomus riparius, 2nd instar	Y	R	$CuSO_4$	am	6.8-7.2	151	10 d	NOEC[m,b]	20	Taylor *et al*., 1991
Chironomus tentans, 4th instar, PLC	Y	F	$CuCl_2$	nw	7.4	36	21 d	NOEC[m]	34	Nebeker *et al*., 1984
Paratanytarsus parthe, larva, LC	-	F	$CuSo_4$	am	7	25	21 d	NOEC[l,n]	40	Hatakeyama & Yasuno, 1981
Paratanytarsus parthe, larva, LC		F	$CuSo_4$	am	7	25	21 d	NOEC[m,s]	320	Hatakeyama & Yasuno, 1981
Pisces										
Brachydanio rerio, blastula stage	N	R	$CuSO_4$	rw	7.5-7.7	100	16 d	NOEC[u,e]	0.05	Dave and Xiu, 1991
Brachydanio rerio, blastula stage	N	R	$CuSO_4$	rw	7.5-7.7	100	16 d	NOEC[m,e]	0.25	Dave and Xiu, 1991
Salvelinus fontinalis, egg	Y	F	$CuSO_4$	nw	6.8	38	9 w	NOEC[l]	3	Sauter *et al*., 1976
Pimephales promelas, 30 d 0.15 g	Y	F	$Cu(NO_3)_2$	nw	7.4	43.9	32 d	NOEC[m,l,f]	3.1	Spehar and Fiandt, 1986
Salvelinus fontinalis, egg	Y	F	$CuSO_4$	nw	6.9	187	9 w	NOEC[l]	5	Sauter *et al*., 1976
Salvelinus fontinalis, egg	Y	F	$CuSO_4$	nw	6.8	38	9 w	NOEC[n]	7	Sauter *et al*., 1976
Pimephales promelas, ELS							4 m	NOEC[m]	8	Mount & Stephan, 1969
Salvelinus fontinalis, alevins, PLC							11 m	NOEC[l]	9	McKim & Benoit, 1971
Salvelinus fontinalis, yearlings, LC	Y	F	$CuSO_4$	nw	7.5	45	22 m	NOEC[m,l]	9	McKim & Benoit, 1971
Pimephales promelas, 1 h post-hatch	Y	R	Cu..	nw	-	48	7 d	NOEC[p]	9.9	Norberg and Mount, 1985
Pimephales promelas, ELS							4 m	NOEC[l]	11	Mount & Stephan, 1969
Oncorhynchus mykiss, eyed egg, ELS	Y	F	$CuSO_4$	nw	7.6	45	7 w	NOEC[m,n]	11	McKim *et al*., 1978
Pimephales promelas, fry, LC	Y	F	$CuSO_4$	nw	7	30	11 m	NOEC[m,l,n]	11	Mount & Stephan, 1969
Ictalurus punctatus, ELS	Y	F	$CuSO_4$	nw	7.5	36	9 w	NOEC[m,l]	12	Sauter *et al*., 1976
Ictalurus punctatus, ELS	Y	F	$CuSO_4$	nw	7.5	186	9 w	NOEC[m,l]	13	Sauter *et al*., 1976
Stizostedion vitreum, egg	Y	F	$CuSO_4$	nw	7	35	4 w	NOEC[m,l]	13	Sauter *et al*., 1976
Salvelinus fontinalis, egg	Y	F	$CuSO_4$	nw	6.8	38	9 w	NOEC[m]	13	Sauter *et al*., 1976
Catostomus commersoni,										
eyed egg, ELS	Y	F	$CuSO_4$	nw	7.6	45	6 w	NOEC[m,l]	13	McKim *et al*., 1978

Pimephales promelas, fry, LC	Y	F	$CuSO_4$	nw	7.9	198	11 m	NOEC[m,n]	15	Mount, 1968
Oncorhynchus mykiss, ELS	Y	F	$CuCl_2$	nw	7.4	120	11 w	NOEC[l]	16	Seim *et al*., 1984
Salvelinus fontinalis, yearlings, LC	Y	F	$CuSO_4$	nw	7.5	45	22 m	NOEC[n]	17	McKim & Benoit, 1971
Pimephales promelas, 2 d post-hatch	Y	IF	$CuSO_4$	nw	8.17	-	28 d	NOEC[p,g]	20	Scudder *et al*., 1988
Salvelinus fontinalis, egg	Y	F	$CuSO_4$	nw	6.9	187	9 w	NOEC[m]	21	Sauter *et al*., 1976
Stizostedion vitreum, egg	Y	F	$CuSO_4$	nw	7	35	4 w	NOEC[n]	21	Sauter *et al*., 1976
Lepomis macrochirus, larva, PLC	Y	F	$CuSO_4$	nw	7.	45	13 w	NOEC[m]	21	Benoit, 1976
Salvelinus fontinalis, eyed egg	Y	F	$CuSO_4$	nw	7.6	45	11 w	NOEC[m,l]	22	McKim *et al*., 1978
alvelinus namaycush, eyed egg	Y	F	$CuSO_4$	nw	7.6	45	13 w	NOEC[m,l]	22	McKim *et al*., 1978
Oncorhynchus trutta, green egg, ELS	*Y*	F	$CuSO_4$	nw	7.6	45	18 w	NOEC[m,l]	22	McKim *et al*., 1978
Oncorhynchus mykiss, ELS	Y	F	$CuCl_2$	nw	7.4	120	11 w	NOEC[m,n]	31	Seim *et al*., 1984
Pimephales promelas, 2 d post-hatch	Y	IF	$CuSO_4$	nw	8.17	-	28 d	NOEC[v,i]	31	Scudder *et al*., 1988
Pimephales promelas, fry, LC	Y	F	$CuSO_4$	nw	7.9	198	11 m	NOEC[l]	33	Mount, 1968
Esox lucius, green egg, ELS	Y	F	$CuSO_4$	nw	7.6	45	6 w	NOEC[m,l]	35	McKim *et al*., 1978
Micropterus dolomieui, eyed egg, ELS	Y	F	$CuSO_4$	nw	7.6	45	5 w	NOEC[m,l]	37	McKim *et al*., 1978
Lepomis macrochirs, juvenile, PLC	Y	F	$CuSO_4$	nw	7.5	45	22 m	NOEC[m]	40	Benoit, 1976
Lepomis macrochirus, larva, PLC	Y	F	$CuSO_4$	nw	7.	45	13 w	NOEC[l]	40	Benoit, 1976
Corogonus artedi, eyed egg, ELS	Y	F	$CuSO_4$	nw	7.6	45	9 w	NOEC[m,l]	43	McKim *et al*., 1978
Oncorhynchus trutta, early eyed egg	Y	F	$CuSO_4$	nw	7.6	45	14 w	NOEC[m,l]	46	McKim *et al*., 1978
Salvelinus fontinalis, egg	Y	F	$CuSO_4$	nw	6.9	187	9 w	NOEC[n]	49	Sauter *et al*., 1976
Cyprinus carpio, 7-9 cm PLC	-	R	$CuSO_4$	tap	7	11	13 w	NOEC[m]	50	Muramoto, 1982
Pimephales promelas, 5-10 h eggs	Y	IF	$CuSO_4$	nw	8.17	-	8 d	NOEC[m]	61	Scudder *et al*., 1988
Pimephales promelas, 2 d post-hatch	Y	IF	$CuSO_4$	nw	8.17	-	28 d	NOEC[m]	61	Scudder *et al*., 1988
Lepomis macrochirs, juvenile, PLC	Y	F	$CuSO_4$	nw	7.5	45	22 m	NOEC[l,n]	77	Benoit, 1976
Oncorhynchus trutta, late eyed egg	Y	F	$CuSO_4$	nw	7.6	45	10 w	NOEC[m,l]	100	McKim *et al*., 1978
Noemacheilus barbatulus , > 15 m, PLC	Y	F	$CuSO_4$	bw	8.3	249	9 w	NOEC[m]	120	Solbe & Cooper, 1976
Pimephales promelas, 2 d post-hatch	Y	IF	$CuSO_4$	nw	8.17	-	28 d	NOEC[m,u]	340	Scudder *et al*., 1988
Pimephales promelas, 2 d post-hatch	Y	IF	$CuSO_4$	nw	8.17	-	28 d	NOEC[w]	200	Scudder *et al*., 1988

a cell number	i EC 11 - 19%: NOEC = EC/2	q number young
b EC 50 - 90%: NOEC = EC/10	j chlorophyll content	r population growth rate
c deflagellation	k multiplication rate	s mortality
d encysted cells	l growth	t emergence
e extrapolated from graph	m mortality or immobility	u hatchability
f NOEC calculated as MATC/2	n reproduction	v length
g EC 20 - 49%: NOEC = EC/3	o filtration or feeding rate	w teratogenic effects
h photosynthesis	p weight	

ANNEX 24 : Subgroup report - Derivation of copper EAC

3.3. Toxicity of copper to saltwater organisms in sediment-water systems: L(E)C50 and NOEC values

The data on toxicity of copper to saltwater organisms in sediment-water systems are presented as follows:

- table 3.3.1: Toxicity of copper to saltwater organisms in sediment-water systems: L(E)C50 and NOEC values.

Legends

A	Nominal concentration (N) or Analyzed concentration (A);
test type	Static (S) or continuous Flow (F).
% O.m.	% organic matter in sediment (if presented in % organic carbon a factor of 1.7 was used to calculate % om)
exp. time	exposure time given in hours (h); days (d)
pH	measured in water phase

3.3.1. ***Table : Toxicity of copper to saltwater organisms in sediment-water systems: L(E)C50 and NOEC values***

Organism	Test compound	A	Test type	pH	% O.m.	% Clay	Temp °C	Salinity in ‰	Exp. time	Criterion	Result mg/kg	Reference
Mollusca												
Protothaca staminea	Cu(NO3)2	A	F	-	0.15	0	-	-	48 h	NOEC	12.4	Phelps, 1985

ANNEX 24 : Subgroup report - Derivation of copper EAC

4. REFERENCES

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ANNEX 25 : Subgroup report - Derivation of mercury EAC

EAC 3/2/5	mercury (Hg)

NOVEMBER 25-29, 1996
3rd OSPAR Workshop on Ecotoxicological Assessment Criteria

Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	-	l/kg		not relevant
Sediment water partition coefficient (log Kp)	4.66	l/kg	RIKZ/OS96.117x	
BCF fish	3,655	l/kg fw	Pentreath, 1976	*1
BCF molluscs	13,061	l/kg sp dw	Breitmayer,1983/Pelletier,1986	geom. mean *1

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	0.1	µg/l	Piraino, 1991	saltwater *1
Lowest L(E)C50	-	µg/l		not considered
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	0.22	mg/kg food	Kawasaki et al., 1986	*1
Lowest NOEC for birds	0.25	mg/kg food	Heinz, 1979	*1

Extrapolated Concentrations	result	unit	assessment factor	note
Water	0.01	µg/l	10	
Sediment (Equilibrium partitioning)	-	mg/kg dw		not applied
Sediment (TEL)	0.13	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	0.005-0.05	µg/l	f	
Sediment	0.05-0.5	mg/kg dw	p	TEL
Fish	0.001-0.01	mg/kg fw	f	
Mussel	0.001-0.01	mg/kg dw	f	

Remarks	result			
Secondary poisoning taken into account	Y			Y/N

*1 Based on data for inorganic mercury

ANNEX 25 : Subgroup report - Derivation of mercury EAC

1. DERIVATION OF EACS FOR MERCURY

For mercury, studies are evaluated for inorganic- as well as for the organic form of mercury.

1.1. Derivation of EAC for water

In natural water systems inorganic mercury is continuously methylated into its organic form, methyl-mercury. This transformation is carried out by micro-organisms in the water column and sediment (Korthals and Winfrey, 1987). In seawater inorganic mercury constitutes from 60% (surface coastal water) to 90% (oceanic surface water) of the total mercury (Cossa & Thibaud, 1990). Consequently, the EAC for water has been set using chronic toxicity data for inorganic Hg.

An extrapolation factor of 10 is applied on the lowest NOEC available for inorganic Hg tested on saltwater species, being 0.1 µg/l (Piraino, 1991) for the hydrozoa *Clavopsella michaeli.* This results in an extrapolated concentration of 0.01 µg/l. Thereupon, the extrapolated concentration of 0.01 µg/l is rounded to an EAC of 0.005-0.05 µg/l. Because of the extensive set of chronic toxicity tests for inorganic Hg performed with saltwater species, the EAC for Hg in water is classified as "firm".

1.2. Derivation of EAC for sediment

The equilibrium partitioning method (see EAC 2/1) was not applied to Hg (or any other metal) due to uncertainties in the partitioning coefficients. The TEL-value for Hg was 0.13 mg/kg dw. This resulted in a sediment EAC for Hg of 0.05-0.5 mg/kg dw. The derived interval is identical to that found earlier (see doc EAC 2/1). EAC for Hg in sediment is classified as "provisional".

1.3. Derivation of EAC for biota

Fish

Calculation of EAC for fish is possible using two methods. The first method is multiplying the extrapolated concentration in water with the geometric mean BCF for fish. Since mercury is predominately present in the inorganic form in seawater only BCFs (measured values) for inorganic mercury have been used: EAC fish=0.01 µg/l*3,655 l/kg fw (Pentreath, 1976) <=> 0.037 mg/kg fw.

The second method is based on secondary poisoning (see EAC 2/4). The NEC predator for mercury is 0.022 mg/kg food and is derived by applying a factor 10 on the lowest NOEC of 0.22 mg/kg food for the mammal *Macaca sp.*: EAC fish=0.022 mg/kg*0.32 (see EAC 2/4) <=> 0.007 mg/kg fw. The lowest value is 0.007 mg/kg fw and is rounded to the range of 0.001-0.01 mg/kg fw. Since chronic data for inorganic Hg are available for both mammals and birds the estimated EAC is considered "firm".

Mussels

As for fish the calculation of EAC for mussels is possible using two methods. The first method is multiplying the extrapolated concentration in water with the geometric mean BCF for mussels. Again only BCFs for inorganic mercury have been used. The geometric mean of the BCFs obtained for *Mytilus edulis* by Breittmayer (1983) and Pelletier (1986) have been used: EAC mussels=0.01 µg/l*13,061 l/kg dw <=> 0.13 mg/kg dw.

The second method is based on secondary poisoning. The NEC predator for mercury is 0.022 mg/kg food and is derived by applying a factor 10 on the lowest NOEC of 0.22 mg/kg food for the mammal *Macaca sp*. EAC mussels=0.022 mg/kg*0.2 (see EAC 2/4) <=> 0.0044 mg/kg dw. The lowest value is 0.0044 mg/kg dw and is rounded to the range of 0.001-0.01 mg/kg dw. Since chronic data are available for inorganic Hg for as well birds as mammals the estimated EAC is considered “firm”.

2. BCF DATA

inorganic mercury

For marine fish one BCF of 3,655 l/kg fw is available (Pentreath, 1976). The geometric mean BCF for all fish species available is 3,030 l/kg fw.
For mussels (*Mytilus edulis*) a geometric mean BCF of 1,750 l/kg fw is calculated. This value is recalculated to soft parts dry weight with the correction factor proposed in Haenen *et al*. (1993). This factor is 0.134 (dw/fw). Applying this factor results in a BCF of 13,061 l/kg dw.

organic mercury

The geometric mean BCF for all fish species available is 3,640 l/kg fw.
For mussels (*Mytilus edulis*) a BCF of 13,333 l/kg fw is available. This value is recalculated to soft parts dry weight with the correction factor proposed in Haenen *et al*. (1993). This factor is 0.134 (dw/fw). Applying this factor results in a BCF of 99,500 l/kg dw. The geometric mean BCF for all molluscs is 5,490 l/kg fw and 40,970 l/kg dw.

The experimental BCF values for fish and molluscs for inorganic- and organic mercury are presented in table 2.1 and table 2.2, respectively. It seems that BCF values for molluscs for organic mercury are higher than the BCFs for inorganic mercury. For fish the BCFs for organic and inorganic mercury are comparable.

ANNEX 25 : Subgroup report - Derivation of mercury EAC

Legend:

Exp. period	exposure period
C_{water}	water concentration applied in the test
fw	fresh weight
dw	dry weight

ANNEX 25 : Subgroup report - Derivation of mercury EAC

2.1. Table : Bioaccumulation of inorganic mercury

Organism/ lifestage	A/N	Test-type	Test-comp.	Test-water	Temp. (°C)	pH	Hardness $CaCO_3$ (mg/l)	Exp. time (d)	Exp. conc. (µg Hg/l)	BCF fw	BCF dw	Reference.
MOLLUSCS												
Lymnaea stagnalis	-	F	$HgCl_2$	-	15,2	-	-	14	0,05	297	2220	Hannerz,1968 [1,*]
Mytilus edulis	A	R	$HgNO_3$	-	-	-	Sal.	28	10	2200	16420	Breittmayer,
	-	-	-	-	-	-	38 $^0/_{00}$	28	10	1000	7460	1983 [6]
	-	-	-	-	-	-	-	28	1	800	5970	
Mytilus edulis	A	F	$HgCl_2$	-	-	-	Sal. 22 $^0/_{00}$	50	30	5333	39800	Pelletier, 1986 [6]
										(1750)	*(13061)*	*gemetric mean*
Planorbis sp.	-	F	$HgCl_2$	-	15,2	-	-	49	0.05	795	5930	Hannerz,1968 [1,*]
Venerupis philippinarum	-	-	$HgCl_2$	-	-	-	-	8	50	190	1420	Tsuruga,1963 [*]
PISCES												
Raja clavata	A	-	$HgCl_2$	sea	10	-	-	64	0,02	3655	-	Pentreath,1976 [2]
Pimephales promelas (4-6 d)	A	F	$HgCl_2$	nw	23-24	7.4	3.1±0.4	287	0.26	2384	-	Snarski,1982
Salmo gairdneri (ca. 12 g)	-	-	$HgCl_2$	-	15	7.5	-	60	1	1800	-	Boudou,1984 [3,4]
Salmo gairdneri	A	F	$HgCl_2$	-	10	-	-	30	0.1	5670	-	Ribeyre,1984 [3,4]

										(3200)		*geometric mean*

										(3030)		*geometric mean all fish*

1) radiometrically calculated
2) BCF based on uptake and elimination rate (k_1 en k_2)
3) Also in Romijn *et al*., 1991a.
4) *Salmo gairdneri* = *Oncorhynchus mykiss*

*) derived fromt WHO, 1986

2.2. Bioaccumulation of organic mercury

Organism/ lifestage	A/N	Test- type	Test- comp.	Test- water	Temp. (°C)	pH (mg/l)	Hardness $CaCO_3$ (d)	Exp. tijd (µg Hg/l)	Exp. conc.	BCF fw	BCF dw	Reference
MOLLUSCS												
Lymnaea stagnalis	F	-	MeHgOH	-	-	-	-	32	3	3480	25970	Hannerz,1968 [1,*]
Mytilus edulis	**A**	**F**	**MeHgCl**	**-**	**-**	**-**	**Sal. 26 $^0/_{00}$**	**32**	**0.3**	**13333**	**99500**	**Pelletier, 1986 [8]**
Planorbis sp.	-	F	MeHgOH	-	-	-	-	32	3	3570	26640	Hannerz,1968 [1,*]
										------- *(5490)*	-------- *(40970)*	*geometric mean all molluscs*
PISCES												
Esox lucius												Hannerz,1968
-liver	-	S	MeHgOH	-	-	-	-	10	0.3	2002	-	(1,*)
-kidney	-	S	MehgOH	-	-	-	-	10	0.3	2198	-	(1,*)
										(2100)		*geometric mean*
Lepomis macrochirus	A	S	MeHgCl	-	9	7.8	-	29	0.2	524	-	Cember,1978 [1,2,3]
Lepomis macrochirus	A	S	MeHgCl	-	21	7.8	-	29	0.5	1138	-	Cember,1978 [1,2,3]
Lepomis macrochirus	A	S	MeHgCl	-	33	7.8	-	29	0.2	2431	-	Cember,1978 [1,2,3]
										(1130)	-	*geometric mean*
Poecilia reticulata [6,7	A	R	MeHgCl	-	24-26	-	-	10	0.1	1850	-	Kramer,1975
Gambusia affinus(2d)	-	R	MeHgCl	-	18	-	-	30	1	4300	-	Boudou,1979
Salmo gairdneri (yearling, 40 g)	A	F	MeHgCl	-	5	7.4- 7.9	242 292	84	0.263	4532	-	Reinert,1974 [4,5]
Salmo gairdneri (yearling, 40 g)	A	F	MeHgCl	-	10	7.4- 7.9	242 292	84	0.258	6622	-	Reinert,1974 [4,5]

Salmo gairdneri (yearling, 40 g)	A	F	MeHgCl	-	15	7.4 7.9	242 292	84	0.234	8049	-	Reinert,1974 [4,5]
Salmo gairdneri (12,5 g)	-	-	MeHgCl	-	15	7.5	-	30	1	7500	-	Boudou,1984 [5,6]
Salmo gairdneri	A	F	MeHgCl	-	10	-	-	30	0.1	35000	-	Ribeyre,1984 [5,7]
										(9130)	-	*geometric mean*
Salvelinus fontinalis (yearling, 50-70 g)	A	F	MeHgCl	-	9-15	6.9-7.6	45	273	0.93	10110	-	McKim,1976 [8]
Salvelinus fontinalis (yearling, 50-70 g)	A	F	MeHgCl	-	9-15	6.9-7.6	45	273	0.29	11720	-	McKim,1976 [8]
Salvelinus fontinalis (yearling, 50-70 g)	A	F	MeHgCl	-	9-15	6.9-7.6	45	273	0.09	12220	-	McKim,1976 [8]
Salvelinus fontinalis (yearling, 50-70 g)	A	F	MeHgCl	-	9-15	6.9-7.6	45	273	0.03	23330	-	McKim,1976 [8]

										(13560)	-	*geometric mean*

										(3640)	-	*geometric mean all fish*

1) radiometrically calculted
2) Romijn *et al*. (1991a) mentioned a BCF of >939 for *Lepomis macrochirus*.
3) Less reliable study
4) Romijn *et al*. (1991a) mentioned a BCF of 6395 for *Salmo gairdneri*
5) *Salmo gairdneri = Oncorhynchus mykiss*
6) Romijn *et al*. (1991a) mentioned a BCF of 6395 for *Salmo gairdneri*, 60 d exposure. This BCF of 11000 is not reliable due to 60% mortality between day 30 and 60. No mortality until day 30.
7) Also in Romijn *et al*. 1991a.
8) Romijn *et al*. (1991a) mentioned a BCF of 14953 for *Salvelinus fontinalis* based on this study at exposure concentrations of 0,03-0,09 µg/l.

*) derived from WHO,1986

ANNEX 25 : Subgroup report - Derivation of mercury EAC

3. ECOTOXICOLOGICAL DATA

As many chronic data were available for saltwater and freshwater species acute toxicity data have not been considered. Also, chronic data are considered more relevant than acute data for the derivation of EACs (see document EAC 2/1).

Legend:

organism life stage	Species used in the test, followed by age, length, weight and/or
A	Y test substance analysed in test solution N test substance not analysed in solution
test-compound	specification of the compound used in the test
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tw water; nw : natural water; rw : reconstituted water;
exposure time	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and ≥ value indicated is highest concentration used in the test. < and ≤ value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

3.1. Saltwater toxicity data

An extensive dataset is available for inorganic mercury. The dataset for organic mercury is small. The data are presented as follows:

- table 3.1.1: chronic toxicity of inorganic mercury to saltwater organisms: NOECs.
- table 3.1.2: chronic toxicity of organic mercury to saltwater organisms: NOECs.

ANNEX 25 : Subgroup report - Derivation of mercury EAC

3.1.1. *Table : Chronic toxicity of inorganic mercury to saltwater organisms*

Organism/ lifestage	A/N	Test-type	Test-comp.	Test-water	pH	Temp. (°C)	Salin. (‰)	Exp. time	Criterium	Result ($\mu g\ Hg.l^{-1}$)	Reference
Algae (brown) (Chrysophyta)											
Fucus serratus	N	F	$HgCl_2$	nw		6,5	33	10d	NOEC	0.9[a]	Strömgren, 1980
Ascophyllum nodosum	N	F	$HgCl_2$	nw		6,5	33	10d	NOEC	0.9[a]	Strömgren, 1980
Pelvetia canaculata	N	F	$HgCl_2$	nw		6,5	33	10d	NOEC	5[a]	Strömgren, 1980
Fucus spiralis	N	F	$HgCl_2$	nw		6,5	33	10d	NOEC	9[a]	Strömgren, 1980
Fucus vesiculosus	N	F	$HgCl_2$	nw		6,5	33	10d	NOEC	9[a]	Strömgren, 1980
Protozoa											
Cristigera sp. (log phase)	N	S	$HgCl_2$	nw	-	16	34	4-9h	NOEC	2.5[b]	Gray, Ventilla, 1973
Hydrozoa											
Clavopsella michaeli	N	R(1d)	$Hg(NO_3)_2$	filtrated nw	-	-	-	8d	NOEC	0.1[b]	Piraino, 1991
Annelida											
Ctenodrilus serratus	N	S	$HgCl_2$	filtrated nw	-	-	-	21d	NOEC	10[b]	Reish, Carr,1978
Ctenodrilus serratus (larvae)	N	S	$HgCl_2$	-	-	-	-	28-31d	NOEC	10[b]	Reish, 1978
Ophryotrocha diadema	N	S	$HgCl_2$	filtrated nw	-	-	-	28d	NOEC	50[b]	Reish, Carr,1978
Ophryotrocha diadema (larvae)	N	S	$HgCl_2$	-	-	-	-	28d	NOEC	100[b]	Reish, 1978
Mollusca											
Crepidula fornicata	A	R(1d)	$HgCl_2$	filtrated nw	-	21	29-33	112d	NOEC NOEC	0.25b 0.42[a]	Thain, 1984
Crassostrea virginica	N	S	$HgCl_2$	am am	-	26	25	42-48h	NOEC	1[c]	Calabrese, *et al*,1973

(embryos)											
Crassostrea (eggs)	-	S	$HgCl_2$	nw	7,25	26	25	2d	NOLC	1	Calabrese, *et al*,1973
Crassostrea virginica (2d larvae)	-	R(1d)	$HgCl_2$	filtrated nw	-	25	24	12d	NOEC NOEC	2.6[a] 3.3[d]	Calabrese, *et al*,1977 [1]
Ilyanassa obsoleta (eggs)	-	S	$HgCl_2$	filtrated nw	8,0	-	-	2,5h	NOEC	2[e]	Conrad, 1988
Mercenaria mercenaria (2d larvae)	-	R(1d)	$HgCl_2$	filtrated nw	-	25	24	8-10d	NOEC	4[a,d]	Calabrese, *et al*.1977
Crustacea											
Mysidopsis bahia (life cycle)	A	F (D=12h)	Hg..	filtrated nw	-	21	30	44d	NOEC	0.8 [b,d]	Gentile, *et al*,1982
Mysidopsis bahia (life cycle)	A	F (50% in 4h)	$HgCl_2$	nw	8,0	23	30	35d	NOEC	0.8[b,d]	Lussier,et al,1985[3]
Artemia franciscana (eggs)	N	S	$HgCl_2$	am	8,6	28	-	3d	NOEC	2[c,f]	Go *et al*., 1990
Callinectes sapidus (larvae)	A	R(1d)	$HgCl_2$	filtrated nw	-	20-30	10-40	10-35d	NOLC	4.9	McKenny, Costlov, 1981 [2]
Penaeus indicus (post larval stage)	A	F	$HgCl_2$	nw	-	19-24	35	28d	NOEC	6[a]	McClurgh, 1984
Pisces											
Fundulus heteroclitus (eggs)	A	R(1d)	$HgCl_2$	am	-	25	20	32d	NOEC NOEC NOEC	10[c] 20[g] 40[c]	Sharp, Neff, 1980

a growth
b reproduction
c hatching
d mortality

e development
f emergence
g teratogenicity

3.1.2. ***Table : Chronic toxicity of organic mercury to saltwater organisms***

Organisme lifestage	A/N	test-type	Test comp	Test water	pH	Temp (C)	Salin. (‰)	Exp. time	Criterium	Result- (µg Hg/l)	Reference
Mollusca											
Mytitus edutis (3,6 cm)	N	F	metHgOH	nw	8,0	9	26	32d	NOEC	0.3[a]	Peltetier, 1988

a growth; carrier is TiO_2 .

3.2. **Freshwater toxicity data**

An extensive freshwater dataset is available for mercury, for the organic and inorganic form. The data are presented as follows:

- table 3.2.1: chronic toxicity of inorganic mercury to freshwater organisms: NOECs,
- table 3.2.2: chronic toxicity of organic mercury to freshwater organisms: NOECs

3.2.1. ***Table : Chronic toxicity of inorganic mercury to freshwater organisms***

Organism/ lifestage	A/N	Test-type	Test-comp.	Test-water	pH	Temp. (°C)	Hardness $CaCO_3$ (mg/l)	Exp. time	Criterium	Result (µg Hg/l)	Reference
Bacteria											
Bactera (not adapted)	N	S	$HgCl_2$	enriched nw	8.2	20	-	18h	NOLC	1[a]	Liebert et al. 1991
Pseudomonas putida (1d)	N	S	$HgCl_2$	nw	-	-	-	16h	NOEC	5[a]	Bringmann Kühn, 1979 [1]
Pseudomonas putida	N	S	$HgCl_2$	nw	-	27	-	6h	NOEC	25[a]	Slabbert, 1986 [2]
Algae											
Microcystis aeruginosa	N	S	$HgCl_2$	nw	-	27	500	8d	NOEC	2.5[a]	Bringmann, Kühn, 1978 [1]
Scenedesmus acutus (log phase)	N	S	$HgCl_2$	nw	7.5	-	-	10d	NOEC	20[a]	Huisman et al., 1980 [5]
Scenedesmus quadricauda	N	S	$HgCl_2$	nw	-	27	500	8d	NOEC	35	Bringmann, Kühn, 1978 [1]
Chlorella vulgaris	N	R (1*/2wk)	$HgCl_2$	Bristol nw	-	21	-	33d	NOEC	100[a]	Rosko,Rach lin, 1977
Cladophora glomerata	N	S	-	nw (sea) & 10% river	8.4	20	-	3d	NOEC	100[a]	Whitton, 1967 [3,4]
Macrophyta											
Chara vulgaris	A	S	$HgCl_2$	nw	-	-	-	14d	NOEC	20[a]	Heumann, 1987 [6]
Protozoa											
Chilomonas paramecium (3-4d)	N	S	$HgCl_2$	nw	-	-	-	48h	NOEC	8[a]	Bringmann, Kühn, 1981 [1]

Entosiphon sulcatum (3-4d)	N	S	$HgCl_2$	nw	-	-	-	72h	NOEC	9[a]	Bringmann, Kühn, 1981 [1]
Uronema parduczi (2d)	N	S	$HgCl_2$	nw	-	-	-	20h	NOEC	34[a]	Bringmann, Kühn 1981
Tetrahymena pyriformis (stationary phase)	N	S	$HgCl_2$	aqua dest. + 400 mg/l $CaCO_3$	-	-	400	4d	NOLC	375	Carter, Cameron 1973 [20]
Poteriochromonas malhamensis	-	S	$HgCl_2$	nw	-	-	-	3d	NOEC	500[a]	Röderer, 1983 [7]
Tetrahymena pyriformis (log phase)	N	S	$HgCl_2$	nw	7,2	-	-	2-6h	NOEC	775[a]	Thrasher, adams, 1972
Tetrahymena pyriformis (stationary phase)	N	S	$HgCl_2$	aqua dest. + 20 mg/l $CaCO_3$	-	-	20	4d	NOLC	2250	Carter, Cameron 1973
Mollusca											
Viviparus bengalensis (23-26 mm shell size)	N	R(½d)	$HgCl_2$	-	8.5	28-31	163	7d	NOLC	20	Muley,Mane 1988 [14]
					7.6	26-28	136	7d	NOLC	40	[15]
					7.5	18-21	120	7d	NOLC	100	[16]
Viviparus bengalensis (23-26 mm shell size)	N	R(½d)	$HgSO_4$	-	8.5	28-31	163	7d	NOLC	20	Muley,Mane 1988 [14]
					7.6	26-28	136	7d	NOLC	60	[15]
					7.5	18-21	120	7d	NOLC	90	[16]
Crustacea											
Daphnia magna (< 1d)	A	R (3*/wk)	$Hg(NO_3)_2$	filtrated nw	8.1	20	225	21d	NOEC	0.07[b]	Enserink *et al*,1991
Daphnia magna	-	-	Hg^{2+}	-	-	-	-	chron	NOEC	1.1	EPA, 1986
Daphnia magna	-	R (1*/wk)	$HgCl_2$	nw.	7.74	-	45,3	21d	NOEC	1.7[b]	Biesinger, Christensen, 1972 [11,12]
Daphnia magna (varying age)	A	F	$Hg(NO_3)_2$	filtrated nw	8.1	20	225	21d	NOEC	2.2[c]	Enserink, *et al.*, 1991
									NOEC	3 [b]	
									NOEC	10 [a]	
Ceriodaphnia dubia (1d)	A	R	$Hg(NO_3)_2$	river	8.2	10	100	7d	NOEC	8.5 [b,c]	Spehar, Fiandt,

											1986 [10]
Daphnia similis (1d)	N	R(1d)	$HgCl_2$	- - nw	8.2.	28-30	-	28d	NOEC NOEC	10[c] 50[a]	Soundra-pandian, 1990 [13]
Cyclops sp. (nauplii)	A	S	$HgCl_2$	filtrated river	7.6-8.8	15	139	14d	NOEC NOEC	18[b] 32[c]	Borgmann, 1980 [8,9]
Pisces											
Pimephales promelas (F_1)	A	F	$HgCl_2$	nw	7.4	23,5	45,7	30d 30d	NOEC NOEC	0.09[a] 3.69[c]	Snarski, Olson,1982 [19]
Pimephales promelas (4-6d) (F_0)	A	F	$HgCl_2$	nw	7.4	23,5	45,7	30d 60d 60d	NOEC NOEC NOEC	0.26[a] 1.02[a] 3.69[c]	Snarski, Olson, 1982 [18]
female								287d	NOEC	0.50[a]	
male								287d	NOEC	2.01[a]	
Pimephales promelas (30d, 0,15g)	A	F	$Hg(NO_3)_2$	nw	7.4	10	43,9	32d	NOEC	0.63[a,c]	Spehar, Fiandt, 1986 [10]
Pimephales promelas (4-6d) (F_0)	A	F	$HgCl_2$	nw	7.4	23,5	45,7	60d 30d 60d	NOEC NOEC NOEC	0.31[a] 0.58[a] 2.43[c]	Snarski, Olson,1982 [17]
Brachydanio rerio (egg larvae)	N	R(1d)	$HgCl_2$	nw	7.5	-	100	14d 14d	NOEC $NOEC_d$	1[c] 8[d]	Dave, Xiu, 1991

a	growth
b	reproduction
c	mortality
d	development
1	NOEC as TGK
2	Minimum growth media
3	No EDTA
4	increased length growth with a factor 2 in 21-26h.
5	N-, methyl-iminodiacetine acid added as solvent. A part of the mercury is probably evaporated.
6	Nominal concentration
7	Probably a static experiment
8	Composed of: *Cyclops vernalis*, *Cyclops bicuspidatus* en *Diaptomus sp.*.
9	80% recovery after 14 d incubation.
10	97% of the added mercury was recovered, 90% is organic mercury
11	NOEC= LOEC/2, 16% effect at the lowest concentration.
12	Recovery is 96,6 $\pm$ 6,7%
13	Cow manure biogas used as substrate.
14	Performed in the summer.
15	Performed during the moeson.
16	Performed during the winter.
17	Fish fed with "dry trout starter".
18	Fish fed with *"Artemia"*.
19	NOEC=LOEC/3, 26% effect in the lowest concentration.
20	LOEC=LOEC/3, 23% in the lowest conc.
~	Ungepublished experiment reffered to in McKim, 1977.

3.2.2. *Table : Chronic toxicity of organic mercury to freshwater organisms*

Organism/ lifestage	A/N	Test-type	Test-comp.	Test-water	pH	Temp. (°C)	Hardness $CaCO_3$ (mg/l)	Exp. time	Criterium	Result (µg Hg/l)	Reference
Bacteria											
Bacteria (not adapted)	N	S	metHgCl	enriched nw	8.2	20	-	18h	NOLC	0.2	Liebert et al., 1991
Protozoa											
Poteriochromonas malhamensis	-	S	metHgCl	nw	-	-	-	3d	NOEC	0.2[a]	Röderer, 1983 [1]
Tetrahymena pyriformis (log phase)	N	S	metHgCl	nw	7.2	-	-	2-6h	NOEC	14[a]	Thrasher, Adams,1972
Tetrahymena pyriformis (log phase)	N	S	etHgCl	nw	7.2	-	-	2-6h	NOEC	20[a]	Thrasher, Adams,1972
Tetrahymena pyriformis	N	S	phen HgAc	nw	7.2	-	-	2-6h	NOEC	22[a]	Thrasher, Adams,1972
Planaria											
Dugesia dorotocephala (16 mm)	N	R(3d)	metHgCl	-	-		-	14d 14d 15d 10d	NOEC NOEC NOEC NOEC	0.03[b] 20[c] 80[d] 200[e]	Best et al., 1981
Crustacea											
Daphnia duplex (3 generaties)	-	R(3d)	metHgCl	filtrated nw	-	20	-	30d	NOEC	0.09[f,e]	Tian-yi, McNaught, 1992

Pisces											
Salvelinus fontinalis (yearling--> F_1 larvae)	A	F	metHgCl	tw	7.74	-	45	248d	NOEC	0.08[a]	Christen-sen, 1975 [2]
Pimphales promelas (adult - life stage)	-	-	metHg..	-	-	-	-	60d	NOEC NOEC	0.07[e] 0.13[f]	Mount, Olson~
Jordanella floridae (juvenile, adult)	-	-	metHg..	-	-	-	-	30d	NOEC	0.17[a,f]	Smith~
Salvelinus fontinalis (three generations)	A	F (90% 4h)	metHgCl	tw	7.5	-	45	144wk	NOEC	0.29[a,e,f,d]	McKim, *et al.*, 1976
Poecilia reticulata (28 d)	A	R (3d)	metHgCl	DSW	8.2	-	208	90d	NOEC	0.8[c,e,g]	Wester, Canton, 1992
Oncorhynchus kisutch (embryos)	A	R(1d)	metHgOH	tw	-	-	-	48d	NOLC	13	Devlin, Mottet, 1992
Oncorhynchus kisutch (embryos)	A	R(1d)	metHgOH	tw	-	-	-	48d	NOLC	29	Devlin, Mottet, 1992

a growth (weight, length and growth).
b fissioning
c neurotoxic (behaviour).
d teratogenic effects
e mortality rate
f reproduction
g histopathological efects

1 NOEC = LOEC/10, 50% effect at the lowest conc.
2 Yearlings were exposed for 7 m, followed by exposure of the F1 generation. The NOEC concerns F1 growth.
~ Unpublished experiment cited in McKim, 1977.

3.3. Toxicity data for mammals and birds

In the tables on toxicity for mammals and birds the original 'reported' value and the corrected value are mentioned. The converted value is considered the corrected NOEC in mg/kg food. The lowest NOEC and/or LC50 values are presented in the tables in shading. The data are presented as follows:

- table 3.3.1: toxicity data for birds and mammals for inorganis mercury
- table 3.3.2: toxicity data for birds and mammals for organis mercury

3.3.1. *Table : toxicity of inorganic mercury to birds and mammals*

Organism	Test-comp	Exp. time	Criteria	Result (mg Hg/kg food)	estimated NOEC (mg Hg/kg food)	Reference
Birds						
Sturnus vulgaris	$HgCl_2$	56d	NOEC mortality	1	1	Nicholson en Osborn,
(juvenile)			EC kidney damage	1	-	1984
Coturnix coturnix japonica	$HgCl_2$	365d	NOEC egg fertility	4	4	Hill en Schafner, 1975 [1,2]
Coturnix coturnix japonica	$HgCl_2$	84d	NOEC body weight	8	8	Dieter, 1974
			EC enzymactivity	8		
Gallus domesticus	$HgCl_2$	21d	NOEC hatching	100	10	Scott, 1977 [1,3]
Mammals						
Mustela vison	$HgCl_2$	135d	NOEC mortality	7	7	Aulerich *et al.*
(2 generations)			reproduction			1974 [4]
Mus musculus	-	560d	NOEC body weight	20	20	Ganser en Kirchner 1985 [1]

1 Also in Romijn *et al*. (1991a,b)
2 Secundary literature: Romijn *et al*. (1991a,b).
3 An extra factor due to a short exposure time, according to Romijn *et al*. (1991a).
4 The effect was only a temporarily effect that disappeared after 4 weeks

ANNEX 25 : Subgroup report - Derivation of mercury EAC

3.3.2. *Table : toxicity of organic mercury to birds and mammals*

Organism	Test-comp	Exp. time	Criteria	Result (mg CH_3Hg/ kg food)	Estimated NOEC (mg CH_3Hg/kg food)	Reference
Birds						
Anas platyrhynchos (3 generaties)	metHg	-	EC egg production	0.5	0.25	Heinz, 1979 [1,2,4]
Anas platyrhynchos	metHg	20d	NOEC mortality growth	3.6	0.36	Gardiner, 1972 [1,2,3]
Anas platyrhynchos (2 generations)	MKD	33d	EC behaviour	3.2	-	Heinz, 1975 [5]
Pasianus colchicus	metHg	20d	NOEC mortality	3.6	0.36	Gardiner, 1972 [1,2,3]
	metHg	20d	NOEC mortality	3.6	0.36	Gardiner, 1972 [1,2,3]
Gallus domesticus	metHg	21d	NOEC mortality	8.6	0.86	Fimreite, 1970 [1,2,3]
Coturnix coturnix japonica	metHg	63d	NOEC mortality	1.7	1.7	Hill en Soares, 1984 [1]
Poephila guttata	metHg	67d	NOEC mortality	2.7	2.7	Scheuhammer, 1988
Mammals						
Macaca sp.	metHg	365d	NOEC growth (mg/kg bw)	0.01	0.22	Kawasaki *et al.*, 1986 [1,2,7]
Rattus norvegicus (3 generaties)	metHg	-	NOEC growth, reproduction	0.43	0.43	Verschuuren *et al.*, 1976 [1,2]
Mustela vison	metHg	60d	NOEC mortality EC mortality	0.5 1.0	0.5 -	Wren, 1987
Mustela vison	metHg	93d	NOEC mortality EC mortality	1.2 1.9	1.2 -	Wobeser *et al.*, 1976 [1,6]
Mustela vison	metHg	100d	NOEC mortality	2.5	2.5	Jernelöv *et al.* 1976
Mustela vison	metHg	30d	EC mort.(100%)	5.0	-	Aulerich *et al.*, 1974
Mus musculus	metHg	60d	NOEC growth (mg/kg bw)	0.27	2.25	Berthoud *et al.*, 1976 [1,2,7]
Lutra lutra	metHg	184d	EC mortality	2.0	-	O'Connor en Nielson, 1980 [5]
Mustela putorius	metHg	58d	EC mortality	5.0	-	Hanko *et al.*, 1970 [6]
Mustela putorius furo	metHg	58d	EC mortality	5.0	-	Hanko *et al.*, 1970 [6]

1 The NOEC in 6th column of the table is also mentioned in Romijn *et al*. (1991a,b), expresed as (CH_3Hg). The result in the 5th column in Romijn *et al*. is in some cases different from the results in table 2.3.2, because in Romijn *et al*. the original reported values are mentioned, that are not always reported in (CH_3Hg).
2 Secundary literature: derived form Romijn *et al*. (1991a,b).
3 Factor 10 due to short exposure time.
4 NOEC=LOEC/2, less than 20% effect
5 Secundary literature: Wit, 1988.
6 Secundary literature: Wren, 1986.
7 Result in mg/kg bodyweight. Recalculation to mg/kg food using the following factors, 20 (ape) en 8,3 (mous).

ANNEX 25 : Subgroup report - Derivation of mercury EAC

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ANNEX 25 : Subgroup report - Derivation of mercury EAC

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ANNEX 26 : Subgroup report - Derivation of lead EAC

EAC 3/2/7	lead (Pb)			
Physical-chemical properties	**result**	**unit**	**reference**	**note**
Octanol water partion coefficient (log Kow)	-	l/kg		not relevant
Sediment water partition coefficient (log Kp)	5.65	l/kg	RIKZ/OS96.117x	
BCF fish	3.25	l/kg fw	Aquire database	
BCF mussel	130	l/kg sp dw	Aquire database	
Ecotoxicology	**result**	**unit**	**reference**	**note**
water				
Lowest NOEC	9	µg/l	Steele and Thursby, 1983	saltwater
Lowest L(E)C50	480	µg/l	Martin et al., 1981	
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	-	mg/kg food		not relevant
Lowest NOEC for birds	-	mg/kg food		not relevant
Extrapolated Concentrations	**result**	**unit**	**assessment factor**	**note**
Water	0.9	µg/l	10	
Sediment (Equilibrium partitioning)	-	mg/kg dw		not applied
Sediment (TEL)	30.2	mg/kg dw		
Ecotoxicological Assessment Criteria (EAC)	**result**	**unit**	**firm/provisional**	**note**
Water	0.5-5.0	µg/l	f	
Sediment	5-50	mg/kg dw	p	TEL
Fish	0.005-0.05	mg/kg fw	p	not relevant
Mussel	0.5-5.0	mg/kg dw	p	not relevant
Remarks	**result**			
Secondary poisoning taken into account	N			Y/N

ANNEX 26 : Subgroup report - Derivation of lead EAC

1. DERIVATION OF EACS FOR LEAD

1.1. Derivation of EAC for water

An extrapolation factor of 10 is applied on the lowest NOEC available, being 9 µg/l (Steele and Thursby, 1983) for the alga *Champia parvulla.* This results in an extrapolated concentration of 0.9 µg/l. Thereupon, the extrapolated concentration of 0.9 µg/l is rounded to EAC of 0.5-5 µg/l. This range is a factor of 5 higher than that previously obtained (see doc EAC 1/2). Because of the extensive chronic data set for lead the EAC water is classified as "firm".

1.2. Derivation of EAC for sediment

The equilibrium partitioning method (see EAC 2/1) was not applied to Pb (or any other metal) due to uncertainties in the partitioning coefficients. The TEL-value for Pb was 30.2 mg/kg dw. This resulted in a sediment EAC for Pb of 5-50 mg/kg dw. The derived interval is identical to that found earlier (see doc EAC 1/2). The EAC for Pb in sediment is classified as "provisional".

1.3. Derivation of EAC for biota

<u>Fish</u>

Calculation of EAC for fish is possible using two methods. The first method is multiplying the extrapolated concentration in water with the geometric mean BCF for fish: EAC fish=0.9 µg/l*3.25 l/kg fw (*Oncorhynchus kisutch*, AQUIRE database) <=> 0.029 mg/kg fw. The BCF values used for this calculation were measured values.

The second method is based on secondary poisoning (see EAC 2/4), however, this method was not employed for lead.

The EAC for fish calculated as outlined above was rounded to the range of 0.005-0.05 mg/kg fw. Since the EAC for fish is based on calculations involving BCFs the criterion is considered to be "provisional".

<u>Mussels</u>

As for fish the calculation of EAC for mussels is possible using two methods. The first method is multiplying the extrapolated concentration in water with the geometric mean BCF for mussels. The geometric mean for green mussel *Perna viridis* of 130 l/kg fw (AQUIRE database) was converted to a geometric mean of 970 (dry weight based) using the correction factor of 0.134 (dw/fw) proposed by Haenen et al. (1993).

The EAC for mussels were calculated as: EAC mussels=0.9µg/l*970 l/kg dw =0.87 mg/kg dw)

The second method is based on secondary poisoning (see EAC 2/4), however, this method was not employed for lead.

ANNEX 26 : Subgroup report - Derivation of lead EAC

The EAC for mussel calculated as outlined above was rounded to the range of 0.5-5 mg/kg dw**.** Since the EAC for mussel is based on calculations involving BCFs the criterion is considered as being “provisional”.

ANNEX 26 Subgroup report - Derivation of lead EAC

2. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	A test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; F: Flow; c: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and => value indicated is highest concentration used in the test. < and =< value indicated is lowest concentration used in the test.
-	no information available
(T)	total lead concentration
(D)	dissolved lead concentration)

2.1. Saltwater toxicity data

For lead an extensive chronic and acute saltwater data set are available. The data are presented as follows:

- table 2.1.1: chronic toxicity data: NOECs,
- table 2.1.2: acute toxicity data: L(E)C50 values

ANNEX 26 : Subgroup report - Derivation of lead EAC

2.1.1. *Table: Chronic toxicity of inorganic lead to saltwater organisms NOECs*

Organism	A/N	Test-type	Test compound	Test water	pH	Sali-nity (‰)	Expo-time	Criterion	Result ($\mu g\ Pb.l^{-1}$)	References
Algae										
Champia parvula	A	R	$Pb(NO_3)_2$	sea (sterile) + EDTA	-	30	14 d	$NOEC_a$	9	Steele, 1983
Asterionella japonica	N	S	$Pb(NO_3)_2$	sea (0,22 mm filtrated)	-	30	3 d	$NOEC_b$	60	Fisher, 1981
Protozoa										
Cristigera sp.	N	S	$Pb(NO_3)_2$	sea (sterile)	-	34	12 u	$NOEC_c$	150	Gray, 1973
Coelenterata										
Eirene viridula	N	R (2 d)	$Pb(NO_3)_2$	-	7.9-8.2	30	3 m	$NOEC_b$	300	Karbe, 1972
Annelida										
Ctenodrilus serratus	N	S	$Pb(CH_3COO)_2$	sea (filtrated)	7.8	-	21 d	$NOEC_a$	500	Reish, 1978
Ophryotrocha diadema	N	S	$Pb(CH_3COO)_2$	sea (filtrated)	7.8	-	21 d	$NOEC_a$	1000	Reish, 1978
Mollusca										
Crassostrea virginea	-	-	-	-	-	-	20 w	NOLC	200	Eisler, 1977a [1]
Mercenaria mercenaria	-	-	-	-	-	-	20 w	NOLC	200	Eisler, 1977a [1]
Mya are-naria	N	S	$Pb(NO_3)_2$	sea (not-filtrated)	8.0	30	7 d	NOLC	5000	Eisler, 1977b
Crustacea										

Cancer anthonyi (embryo larvae)	N	R	$Pb(NO_3)_2$ (2 d)	sea (filtrated)	7.8	34	11 d	$NOEC_d$	10	MacDonald, 1988
Mysidopsis bahia (le-life cycle)	A(T)	F	$Pb(NO_3)_2$	sea (filtrated)	-	30	44 d	$NOEC_a$	17	Lussier, 1985
Rhithropa-nopeus harrissii (larvae)	-	R	$PbCl_2$	sea (filtrated)	-	20	> 14 d	$NOEC_e$	50	Benijts Claus, 1975
Artemia salina (larvae)	N	R	$Pb(NO_3)_2$ (2 d)	sea	>7.9	-	10 d	$NOEC_b$	1000	Brown, 1971

a reproduction
b growth
c population density
d embryonal development
e development

[1] secundary literature Eisler (1977b)

ANNEX 26 : Subgroup report - Derivation of lead EAC

2.1.2. *Table: Acute toxicity of inorganic lead to saltwater organisms L(E)C50s*

Organism	A/N	Test-type	Test compound	Test water	pH	Sali-nity (‰)	Expo-time	Criteria	Result ($\mu g\ Pb.l^{-1}$)	Reference
Mollusca										
Mytilus edulis	N	S	$Pb(NO_3)_2$	sea (treated)	8.1	34	96 h	LC50	476	Martin, 1981
Crassostrea ligas	N	S	$Pb(NO_3)_2$	sea (treated)	8.1	34	96 h	LC50	758	Martin, 1981
Crangon spp. (adult)	A	F	$PbCl_2$	sea (filtrated)	8.1	29	96 h	LC50	> 2100	Dinnel, 1989
Loligo opalescens (larvae)	A	S	$PbCl_2$	sea (iltrated)	8.1	30	96 h	LC50	> 2100	Dinnel, 1989
Crustacea										
Cancer magister (zoea, Ie stadium)	N	S	$Pb(NO_3)_2$	sea (treated)	8.1	34	96 h	LC50	575	Martin, 1981
Cancer magister (zoea)	-	S	$PbCl_2$	sea (filtrated)	8.1	30	96 h	LC50	600	Dinnel, 1989
Echinodermata										
Dendraster excentricus (embryo)	A	S	$PbCl_2$	sea (filtrated)	8.0-8.1	30	72 h	EC50a	700-1500	Dinnel, 1989

a embryonal development

ANNEX 26 : Subgroup report - Derivation of lead EAC

2.2. **Freshwater toxicity data**

For lead an extensive chronic freshwater data set is available. The data are presented as follows:

- table 2.2.1: chronic toxicity data: NOECs,

2.2.1. *Chronic toxicity of inorganic lead to freshwater organisms: NOECs*

Organism	A/N	Test-type	Test compound	Test water	pH	Hard-ness (mg $CaCO_3.l^{-1}$)	Expo-time	Criteria	Result ($\mu g\ Pb.l^{-1}$)	Reference
Bacteria										
Escherichia coli	-	-	$Pb(NO_3)_2$	-	-	-	-	$NOEC_a$	650	Bringmann, 1959a [1, 2]
Pseudomonas putida	-	-	$Pb(CH_3COO)_2$	-	-	-	16 u	$NOEC_a$	900	Bringmann, 1979 [2]
Algae										
Selenastrum capricornutum	N	S	$Pb(CH_3OO)_2$	n.m. + EDTA	-	62	13 d	$NOEC_a$	10	Christensen 1979
Microcystis aeruginosa	N	S	$Pb(CH_3COO)_2$	n.m. bidest	7.0	66	8 d	$NOEC_a$	225	Bringmann, 1978 [2, 3]
Cladophora glomerata 1 cm fragmenten	N	S	-	n.m. without EDTA	8.4	35	3 d	$NOEC_a$	300	Whitton, 1967 [11]
Ankistrodes-mus sp.	N	S	$PbCl_2$	n.m. (P-poor) met EDTA	6.2	27	7 d	$NOEC_a$	500	Monahan, 1976
Ankistrodes-mus falcatus	N	S	$PbCl_2$	n.m.	-	-	10 d	$NOEC_a$	500	Devi Prasad, 1982
Navicula incerta	N	S	$PbCl_2$	n.m. no chelator	8.3-8.4	-	4 d	$NOEC_a$	500	Rachlin, 1983
Scenedesmus obliquus	N	S	$PbCl_2$	n.m.	-	-	10 d	$NOEC_a$	500	Devi Prasad, 1982
Scenedesmus quadricauda	N	S	$PbCl_2$	n.m.	6.5	-	15 d	$NOEC_a$	500	Starodub, 1987 [12]
Scenedesmus quadricauda	N	S	$PbCl_2$	n.m.	8.5	-	15 d	$NOEC_a$	1000	Starodub, 1987
Chlorococcum spp.	N	S	$PbCl_2$	n.m.	-	-	10 d	$NOEC_a$	1000	Devi Prasad, 1982

Scenedesmus quadricauda	N	S	$Pb(NO_3)_2$	river (sterile)	7.5-7.8	84	4 d	$NOEC_a$	1250	Bringmann, 1959b
Scenedesmus quadricauda	N	S	$Pb(CH_3COO)_2$	n.m. bidest	7.0	66	8 d	$NOEC_a$	1850	Bringmann, 1978 [2, 3]
Scenedesmus quadricauda	N	S	$PbCl_2$	n.m.	4.5	-	15 d	$NOEC_a$	3000	Starodub, 1987
Anacystis nidulans	N	S	$Pb(NO_3)_2$	n.m. without EDTA	6.9	-	2 w	$NOEC_a$	50.000	Lee, 1992 [3]
Anacystis nidulans	N	S	$Pb(NO_3)_2$	n.m. met EDTA	5.4	-	2 w	$NOEC_a$	200.000	Lee, 1992 [3]
Charophyta										
Chara vulgaris	A	S	$Pb(NO_3)_2$	n.m.	-	-	14 d	$NOEC_a$	2070	Heumann, 1987 [4]
Protozoa										
Entosiphon sulcatum	N	S	$Pb(CH_3COO)_2$	-	-	-	3 d	$NOEC_a$	10	Bringmann, 1979 [2]
Uronema parduczi	N	S	$Pb(CH_3COO)_2$	-	-	-	20 u	$NOEC_a$	35	Bringmann, 1981 [2]
Chilomonas paramecium	N	S	$Pb(CH_3COO)_2$	-	-	-	2 d	$NOEC_a$	110	Bringmann, 1981 [2]
Microregma heterosoma	N	S	$Pb(NO_3)_2$	river (sterile)	7.5-7.8	84	28 u	$NOEC_b$	625	Bringmann, 1959b [2]
Mollusca										
Lymnea palustris (adult)	A(T)	F	$Pb(NO_3)_2$	tap	7.2-8.4	139	120 d	NOLC	12	Borgmann, 1978
Lymnea palustris (eggs)	A(T)	F	$Pb(NO_3)_2$	tap	7.2-8.4	139	30 d	$NOEC_c$	31	Borgmann, 1978
Crustacea										
Daphnia magna - P 2-3 d --> F		R	$Pb(CH_3COO)_2$	artificial	7.2	250	19 d	$NOEC_{d,e}$	1	Berglind, 1985 [23]
Daphnia magna P --> F (life cycle)	-	-	$Pb(NO_3)_2$	-	-	52 102 151	- - -	NOEC NOEC NOEC	9 78 85	Chapman, manuscript [1, 5, 6]

Daphnia magna	-	S	$PbCl_2$	lake	7.4-8.2	44-53	21 d	$NOEC_d$	15	Biesinger, 1972 [7]
Ceriodapnia P <1 d --> F (life cycle)	A(D) A(T) A(D) A(T)	F	$Pb(NO_3)_2$	river (110 mm gefiterd)	8.2	100	7 d	$NOEC_d$ $NOEC_d$ ($NOEC_e$ ($NOEC_e$	19 26 > 19) > 26)	Spehar, 1986 [18,20]
Daphnia magna - P < 1d		R	$Pb(CH_3COO)_2$	artificial	7.2	250	8 d	$NOEC_a$	64	Berglind, 1985 [23]
Daphnia magna population	A	F	$PbNO_3)_2$	lake (25 mm ((filtrated)	8.1	225	17 d	$NOEC_{d,e}$	670	Enserink, 1991 [17]
Daphia magna P <1 d --> F (life cycle)	A	R	$Pb(NO_3)_2$	lake (25 mm gefiterd)	8.1	225	21 d	$NOEC_d$ $NOEC_e$ $NOEC_a$	250 750 2650	Enserink, 1991
Pisces										
Brachydanio rerio	N	R	$Pb(CH_3COO)_2$	artificial	7.5	100	16 d	$NOEC_e$ $NOEC_c$	120 240	Dave, 1991
Catostomus commersoni (egg/larvae)	A(T)	F	$Pb(NO_3)_2$	pond	6.7-7.1	32-48	60 d	$NOEC_{aef}$ $NOEC_c$	119 > 483	Sauter, 1976 [21]
Esox lucius (egg/larvae)	A(T)	F	$Pb(NO_3)_2$	pond	6.7-7.3	31-45	60 d	$NOEC_{e,f}$ $NOEC_{a,c}$	253 >483	Sauter, 1976 [21]
Ictalurus punctuatus (egg/larvae)	A(T)	F	$Pb(NO_3)_2$	pond	6.8-7.3	25-37	60 d	$NOEC_{a,e}$ $NOEC_{c,f}$	75 > 460	Sauter, 1976 [21]
Lepomis macrochirus (egg/larvae)	A(T)	F	$Pb(NO_3)_2$	pond	6.7-7.2	31-52	60 d	$NOEC_{a,e}$ $NOEC_f$ $NOEC_c$	70 120 > 447	Sauter, 1976 [21]
Pimephales promelas juvenile	A(D) A(T) A(D) A(T)	F	$Pb(NO_3)_2$	lake (((filtrated)	7.4	43	32 d	$NOEC_a$ $NOEC_a$ $NOEC_e$ $NOEC_e$	124 165 124 165	Spehar, 1986 [19,20]
Salmo gairdneri 'fingerlings' (8 cm)	A(D) A(T) A(D) A(T) A(D)	F	$Pb(NO_3)_2$	pond filtrated	7.6-8.2	353	19 m	$NOEC_f$ $NOEC_f$ $NOEC_e$ $NOEC_e$ $NOEC_a$	18 190 41 850 > 64	Davies, 1976 [13,14]

	A(T)							$NOEC_a$	>	2310	
Salmo	D	F	$Pb(NO_3)_2$	tap	6.7-7.3	28	19 m	$NOEC_f$		7	Davies, 1976
gairdneri	A(T)			dechlor.				$NOEC_f$		7	[13,15]
'sac fry'	D							$NOEC_e$		7	
(25 mm)	A(T)							$NOEC_e$		7	
	D							$NOEC_a$	>	62	
	A(T)							$NOEC_a$	>	62	
Salmo	D	F	$Pb(NO_3)_2$	tap	6.7-7.3	28	19 m	$NOEC_f$		8	Davies, 1976
gairdneri	A(T)			dechlor.				$NOEC_f$		8	[13,15]
'eyed eggs'	D							$NOEC_e$		27	
	A(T)							$NOEC_e$		27	
	D							$NOEC_a$	>	55	
	A(T)							$NOEC_a$	>	55	
Salmo	A(T)	F	-	tap	8.2	135	27 w	$NOEC_f$		28	Hodson, 1980
gairdneri				(filtrated				$NOEC_{a,e}$	>	87	[10]
`sac fry'				& dechlor.							
Salmo	A(T)	F	$Pb(NO_3)_2$	pond	6.9-7.4	32-42	60 d	$NOEC_e$		71	Sauter,
gairdneri								$NOEC_a$		146	1976
(egg/juv.)								$NOEC_f$		250	[21]
								$NOEC_c$		443	[21]
Salmo	A(T)	F	$Pb(NO_3)_2$	tap	7.7	135	32 w	$NOEC_f$		60	Hodson, 1978
gairdneri				(filtrated				$NOEC_{a,e}$		120	[22]
`underyearlings'				& dechlor.)							
Salmo salar	A	S	$Pb(NO_3)_2$	-	6.3	11	90 d	$NOEC_{a,e,g}$		20	Grande, 1983
`swim-up fry'											[8]
Salvelinus	A(D)	F	$Pb(NO_3)_2$	lake	6.8-7.6	44	3 yr	$NOEC_{a,c,f}$		39	Holcombe,
fontinalis	A(T)							$NOEC_{a,c,f}$		58	1976
(life cycle	A(D)							$NOEC_{d,e}$		84	[16]
3 generations)	A(T)							$NOEC_{d,e}$		119	
Salvelinus	A(T)	F	$Pb(NO_3)_2$	pond	7.0-7.3	25-38	60 d	$NOEC_e$		48	Sauter,
namaycush								$NOEC_a$		198	1976
								$NOEC_{c,f}$	>	483	[21]
Stizostedion	A(T)	F	$Pb(NO_3)_2$	pond	6.7-7.1	32-45	30 d	$NOEC_{e,f}$		237	Sauter,
vitreum								$NOEC_{a,c}$		397	1976
											[21]

a growth
b feeding rate
c hatching
d reproduction
e survival
f abnormalities: black tail; (lordo)scoliosis; atrophy of tail region)
g development

[1] Time not specified
[2] NOEC= TGK
[3] Constant illumination
[4] Secondary literature: Van de Meent et al. (1990).
[5] Secondary literature: EPA (1984).
[6] Effect not specified
[7] NOEC=LOEC/2 (16% reproduction inhibition)
[8] Secondary literature: Mance (1987).
[9] NOEC=EC1.
[10] Analysis of lead with AAS (total-lead). 'black tail' en `lordoscoliosis'
[11] Hardness from the same study in the zinc document (Janus, 1992).
[12] NOEC=LOEC/2 (18% growth inhibition at 1000 mg/l)
[13] `deformities',`black tail', `lordoscoliosis'and caudal fin erosion'
[14] Analysis of lead with AAS (total-lead) and PP (solved-lead) in non acid water after precipitation of lead complexes
[15] Analysis of lead with AAS (total-lead), afther extraction of lead from the water (method Fishman & Midgett, 1968). The lead concentration was seen as total lead due to the very soft water
[16] Analysis of lead met AAS, after extraction of lead from the acidified sample (pH 2,5-3)(total lead) and not acidified sample (solved lead). Total-lead concentration is also measured with anodic stripping voltammetry (ASV), after acid destruction with flame AAS.
[17] NOEC=EC10
[18] NOEC not reported. In tests with (As, Cd, Cr, Cu, Hg en Pb), reproduction was a more sensitive parameter than survival except for Cr.
[19] $NOEC_s$ not reported. In tests with (As, Cd, Cr, Cu, Hg en Pb), growth was a more sensitive parameter than survival
[20] Analysis of lead as `total acid-exchangeable' fraction (total-lead)
[21] Analysis of lead with flame AAS. In unfiltrated watersamples (total-lead).
[22] Measured concentrations as total lead. ‘black tail' observed. The parameter growth was also determined, but no data were reported.
[23] Test in Milli Q water (Millipore).

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ANNEX 27 : Subgroup report - Derivation of nickel EAC

EAC 3/2/6	nickel (Ni)			
NOVEMBER 25-29, 1996 3rd OSPAR Workshop on Ecotoxicological Assessment Criteria				
Physical-chemical properties	**result**	**unit**	**reference**	**note**
Octanol water partion coefficient (log Kow)	-	l/kg		not relevant
Sediment water partition coefficient (log Kp)	4.19	l/kg	RIKZ/OS96.117x	
BCF fish	-	l/kg fw		not relevant
BCF mussel	-	l/kg sp dw		not relevant
Ecotoxicology	**result**	**unit**	**reference**	**note**
water				
Lowest NOEC	200	µg/l	Aquatox, 1995	saltwater
Lowest L(E)C50	61	µg/l	IPCS EHC 108	saltwater
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	-	mg/kg food		not relevant
Lowest NOEC for birds	-	mg/kg food		not relevant
Extrapolated Concentrations	**result**	**unit**	**assessment factor**	**note**
Water	0.61	µg/l	100	
Sediment (Equilibrium partitioning)	-	mg/kg dw		not applied
Sediment (TEL)	15.9	mg/kg dw		
Ecotoxicological Assessment Criteria (EAC)	**result**	**unit**	**firm/provisional**	**note**
Water	0.1-1.0	µg/l	p	
Sediment	5-50	mg/kg dw	p	
Fish	-	mg/kg fw		not relevant
Mussel	-	mg/kg dw		not relevant
Remarks	**result**			
Secondary poisoning taken into account	N			Y/N

ANNEX 27 : Subgroup report - Derivation of nickel EAC

1. DERIVATION OF EACS FOR NICKEL

1.1. Derivation of EAC for water

An extrapolation factor of 100 is applied on the lowest LC50 available, being 61 µg/l (IPCS EHC 108) for the mollusc *Villotoria cyprinoides*. This results in an extrapolated concentration of 0.61 µg/l. Thereupon, the extrapolated concentration of 0.61 µg/l is rounded to EAC of 0.1-1.0 µg/l. The EAC for water is classified as "provisional" because only one chronic saltwater NOEC is available for Ni. The EAC for nickel in water is comparable to previously obtained values (see doc EAC 1/2).

1.2. Derivation of EAC for sediment

The equilibrium partitioning method (see EAC 2/1) was not applied to Ni (or any other metal) due to uncertainties in the partitioning coefficients. The TEL-value for Ni was 15.9 mg/kg dw. This resulted in a sediment EAC for Ni of 5-50 mg/kg dw. The EAC for Ni in sediment is classified as "provisional".

1.3. Derivation of EAC for biota

Not relevant.

ANNEX 27 : Subgroup report - Derivation of nickel EAC

2. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	Y test substance analysed in test solution N test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; $_c$: closed testvessels
test water	am : artificial medium; tw : tap water; nw : natural water; rw : reconstituted water;
test subtance purity:	percentage active ingredient; anal. : analytical grade; tech. : technical grade; high : high but unknown purity
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and =>^{3} value indicated is highest concentration used in the test. < and =< value indicated is lowest concentration used in the test.
α	given value based on measured concentrations
-	no information available

2.1. Saltwater toxicity data

Only one chronic NOEC is available for saltwater organisms. The data are presented as follows:

- table 2.1.1: chronic toxicity data: NOECs,
- table 2.1.2 acute toxicity data: L(E)C50s.

ANNEX 27 : Subgroup report - Derivation of nickel EAC

2.1.1. *Table : Chronic toxicity of nickel to saltwater organisms*

Organism	A	Test type	Test compound	Test water	pH	salinity ‰	Exp. time	Crite-rion	Result mg/l	Reference
Mollusca										
Mytilus edulis, adult	-	-	-	-	-	-	8 d	NOEC	0.20[a]	Aquatox, 1995

a growth

2.1.2. *Table : Acute toxicity of nickel to saltwater organisms*

Organism	A	Test type	Test compound	Test water	pH	salinity ‰	Exp. time	Crite-rion	Result mg/l	Reference
Mollusca										
Villotoria cyprinoides	-	-	-	-	-	-	96 h	LC50	0.061	IPCS EHC 108
Mercenaria mercenaria	-	-	-	-	-	-	48 h	EC50	0.31[a]	Aquatox, 1995
Crossostrea gigas	-	-	-	-	-	-	48 h	EC50	0.35[a]	Aquatox, 1995
Mytilus edulis	-	-	-	-	-	-	48 h	EC50	0.89[a]	Aquatox, 1995
Crassostrea virginica	-	-	-	-	-	-	96 h	LC50	1.18	Aquatox, 1995
Crassostrea virginica	-	-	-	-	-	-	96 h	EC50	1.21[b]	Aquatox, 1995
Macoma balthica	-	-	-	-	-	-	96 h	LC50	95	Aquatox, 1995
Crustacea										
Heteromysis formosa	-	-	-	-	-	-	96 h	LC50	0.15	Aquatox, 1995
Mysidopsis bahia	-	-	-	-	-	-	96 h	LC50	0.51	Aquatox, 1995
Nitrocra spinipes	-	-	-	-	-	-	96 h	LC50	0.60	Aquatox, 1995
Acartia clausi	-	-	-	-	-	-	96 h	LC50	2.08	Aquatox, 1995
Pisces										
Menidia menidia	-	-	-	-	-	-	96 h	LC50	7.9	Aquatox, 1995
Chelon labrosus	-	-	-	-	-	-	96 h	LC50	118	Aquatox, 1995
Fundulus heteroclitus	-	-	-	-	-	-	96 h	LC50	350	Aquatox, 1995

2.2. **Freshwater toxicity data**

A large chronic dataset is available for freshwater organisms. The data are presented as follows:

- table 2.2.1: chronic toxicity data: NOECs,

2.2.1. ***Table : Chronic toxicity of nickel to freshwater organisms***

Organism	A	Test type	Test compound	Test water	pH	Hardness mg $CaCO_3$/l	Exp. time	Crite-rion	Result µg/l	Reference
Bacteria										
Pseudomonas putida	-	-	-	-	-	-	24 h	NOEC[a]	1.25	Bringmann & Kuhn, 1976
Escherichia coli	-	-	-	-	-	-	5 h	NOEC[a]	5000	Babich & Stotzky, 1983
TAM							6 h	NOEC[a]	6000	Ahring & Westermom,1985
Methanobacterium thermo-autotrophicum	-	-	-	-	-	-	6 h	NOEC[a]	100000	Ahring & Westermam,1985
Pseudomonas tabaci	-	-	-	-	-	-	25 h	NOEC[a]	130000	Sigee & At-Rabaec, 198.6
Algae/Chlorophyta										
Scenedesmus quadricauda	-	-	-	-	-	-	8 d	NOEC[a]	650	Bringmann, 1978
Chlamydomonas sp.	-	-	-	-	-	-	12 d	NOEC[a]	10000	Folsom *et al*., 1986
Algae/Cyanophyta										
Microcystis aeruginosa	-	-	-	-	-	-	8 d	NOEC[a]	25	Bringmann & Kuhn, 1978
Anabaena inequalis	-	-	-	-	-	-	12 d	NOEC[a]	25	Babich & Stotzky, 1983
Nostoc muscorum	-	-	-	-	-	-	15 d	NOEC[a]	<500	Rai & Raizada, 1987
Protozoa										
Uronema parduczi	-	-	-	-	-	-	20 h	NOEC[a]	21	Bringmann *et al*., 1980
Entosiphon sulcatum	-	-	-	-	-	-	72 h	NOEC[a]	70	Bringmann & Kuhn, 1978
Chilomonas paramaecium	-	-	-	-	-	-	48 h	NOEC[a]	410	Bringmann *et al*., 1980
Crustacea										
Daphnia magna	-	-	-	-	-	-	21 d	NOEC[bc]	<30	Skidmore & Firth, 1983
Daphnia magna	-	-	-	-	-	-	21 d	NOEC[bc]	90	Kuhn et al., 1989

Pisces										
Salmo gairdnerii, PLC,eieren	-	-	-	-	-	-	85 d	NOEC[a c]	62	Nebeker *et al*., 1985
Salmo qairdnerii,PLC, eieren	-	-	-	-	-	-	52 d	NOEC[ac]	134	Nebeker *et al*., 1985
Salmo qairdnerii, PLC, larven	-	-	-	-	-	-	38 d	NOEC[ac]	134	Nebeker *et al*., 1985
Pimephales promelas	-	-	-	-	-	-	365 d	NOEC[a b c]	380	Mance, 1987
Pimephales promelas, larven	-	-	-	-	-	-	25 d	NOEC[a c]	380	Mance, 1987

TAM thermophilic acetate decarboxylating methanogenic bacteriurn.

a groei
b reproductie
c sterfte

ANNEX 27 : Subgroup report - Derivation of nickel EAC

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ANNEX 28 : Subgroup report - Derivation of zinc EAC

EAC 3/2/8	zinc (Zn)

NOVEMBER 25-29, 1996
3rd OSPAR Workshop on Ecotoxicological Assessment Criteria

Physical-chemical properties	result	unit	reference	note
Octanol water partion coefficient (log Kow)	-	l/kg		not relevant
Sediment water partition coefficient (log Kp)	5.04	l/kg	RIKZ/OS96.117x	
BCF fish	-	l/kg fw		not relevant
BCF mussel	-	l/kg sp dw		not relevant

Ecotoxicology	result	unit	reference	note
water				
Lowest NOEC	10	µg/l	Maritox 5/385	saltwater
Lowest L(E)C50	-	µg/l		not considered
sediment				
Lowest NOEC	-	mg/kg dw		not available
Lowest L(E)C50	-	mg/kg dw		not available
biota				
Lowest NOEC for mammals	-	mg/kg food		not relevant
Lowest NOEC for birds	-	mg/kg food		not relevant

Extrapolated Concentrations	result	unit	assessment factor	note
Water	1	µg/l	10	
Sediment (Equilibrium partitioning)	-	mg/kg dw		not applied
Sediment (TEL)	124	mg/kg dw		

Ecotoxicological Assessment Criteria (EAC)	result	unit	firm/provisional	note
Water	0.5-5.0	µg/l	f	
Sediment	50-500	mg/kg dw	p	TEL
Fish	-	mg/kg fw		not relevant
Mussel	-	mg/kg dw		not relevant

Remarks	result	
Secondary poisoning taken into account	N	Y/N

ANNEX 28 : Subgroup report - Derivation of zinc EAC

1. DERIVATION OF EACS FOR ZINC

1.1. Derivation of EAC for water

An extrapolation factor of 10 is applied on the lowest NOEC available, being 10 µg/l (Maritox 5/385) for the echinodermata *Arbacia lixula.* This results in an extrapolated concentration of 1.0 µg/l. Thereupon, the extrapolated concentration of 1.0 µg/l is rounded to EAC of 0.5-5.0 µg/l. This EAC is equivalent to the range previously obtained (see doc EAC 1/2). Because of the extensive chronic data set EAC water is classified as “firm”.

1.2. Derivation of EAC for sediment

The equilibrium partitioning method (see EAC 2/1) was not applied to Zn (or any other metal) due to uncertainties in the partitioning coefficients. The TEL-value for Zn was 124 mg/kg dw. This resulted in a sediment EAC for Zn of 50-500 mg/kg dw. The derived interval is a factor of 5 higher than the one set earlier (see doc EAC 1/2). EAC for Zn in sediment is classified as “provisional”.

1.3. Derivation of EAC for biota

Not relevant.

2. ECOTOXICOLOGICAL DATA

Legend:

organism	Species used in the test, followed by age, length, weight and/or life stage
A	+ test substance analysed in test solution - test substance not analysed in solution
test type	S: static; R: renewal; CF: continuous flow; IF: Intermittent flow; F: flow; $_c$: closed testvessels
test water	am(w) : artificial medium (water); tw : tap water; nw : natural water; rw : reconstituted water; sw: soft water
exposure time:	min: minute(s); h: hour(s); d: day(s); w: week(s); m: month(s);
results	> and => value indicated is highest concentration used in the test. < and =< value indicated is lowest concentration used in the test.
-	no information available
√	geometric mean of two values

2.1. saltwater toxicity data

An extensive saltwater chronic data set is available. The data are presented as follows:

- table 2.1.1: chronic toxicity data: NOECs,

ANNEX 28 : Subgroup report - Derivation of zinc EAC

2.1.1. *Table : Chronic toxicity of zink to saltwater organisms*

organism	A	Test-type	Test-comp	Test water	Salinity ppm	Exp.-time	Criterion	Result µg Zn/l	Reference [& footnote]
Algae									
Amphidinium cameri	-	S	ZnS04	aw	-	9-d	NOECg MATCg	100 140	 √ (100 x 200) Braek *et al*.1976 [1]
Asterionella japonica clone AST N1.1	-	S	ZnS04	sw (BS)	35	3-d	NOECg MATCg	30 42	[2] √ (30 x 60) Fisher & Jones 181
Asterionella japonica clone AST C2 or N1.1	-	S	ZnS04	sw (BS)	35	3-d	NOECg	7	[2,3]
Asterionella japonica clone AST C2 or N1.1	-	S	ZnS04	sw (CB)	35	3-d	NOECg	20	[2,4]
Asterionella japonica clone AST N1.1	-	S	ZnS04	sw (BS)	35	3-d	NOECg	7	[5,6]
Asterionella japonica clone AST N1.1	-	S	ZnS04	sw (CB)	35	3-d	NOECg	7	[5,7]
Asterionella japonica clone AST C4	-	S	ZnS04	sw (BS)	35	3-d	NOECg MATCg	20 28	[2] √ (20 x 40)
Asterionella japonica clone AST C4	-	S	ZnS04	sw (CB)	35	3-d	NOECg MATCg	40 49	[2] √ (40 x 60) Fisher & Frood 1980
Chaetoceros compressum clone Chaet C2	-	S	ZnS04	sw (BS)	35	3-d	NOECg	10	[2,8]
Chaetoceros compressum Clone Chaet C2	-	S	ZnS04	sw (CB)	35	3-d	NOECg	60	[2] Fisher & Frood 1980
Gymnodinium splendens	-	S	ZnS04	sw	32	5-w	NOECg MATCg	500 700	[9] √ (500 x 1,000) Kayser 1977 [10]
Nitzschia closterium clone Nitz C.1	-	S	ZnS04	sw (BS)	35	3-d	NOECg MATCg	40 49	[2] √ (40 x 60)

Nitzschia closterium	-	S	ZnS04	sw	35	3-d	NOECg	≥60	[2]
clone Nitz C.1				(CB)					
Nitzschia closterium	-	S	ZnS04	sw	35	3-d	NOECg	10	[2,11]
Clone Flag 8.4				(BS)					
Nitzschia closterium	-	S	ZnS04	sw	35	3-d	NOECg	≥60	[2]
clone Flag 8.4				(CB)					Fisher & Frood 1980
Phaeodactylum	+	F	ZnCl2	sw	-	2-w	NOECg	10,000	
tricornutum							MATCg	16,000	√ (10,000 x 25,000)
									Jensen *et al.*1974 [12]
Phaeodactylum	-	S	ZnS04	aw	-	10-d	NOECg	4,000	[13]
tricornutum							MATCg	4,470	√ (4,000 x 5,000)
Phaeodactylum	-	S	ZnS04	aw		10-d	NOECg	500	[14]
tricornutum							MATCg	705	√ (500 x 1,000)
									Braak *et al.* 1976 [1]
Prorocentrum micans	-	S	ZnS04*2H2O	sw	32	5-w	NOECg	100	
							MATCg	225	√ (100 x 500)
									Kayser 1977 [10]
Rhizosolenia spp.	+	S	-	sw	-	12/			
						24hr	NOECg	15	
							MATCg	19	√ (15 x 25)
									Davies & Sleep 1979 [15]
Schroederella	-	S	ZnS04*2H2O	sw	32	11-d	NOECg	10	[9]
schroederi							MATCg	22	√ (10 x 50)
									Kayser 1977 [10]
Scrippsiella faeroense	-	S	ZnS04*7H2O	sw	32	7-w	NOECg	100	[9]
							MATCg	315	√ (100 x 1,000)
									Kayser 1977 [10]
Skeletonema costatum	+	F	ZNCI2	sw	-	2-w	NOECg	25	[9]
clone Skel-5							MATCg	35	√ (25 x 50)
									Jensen *et al.*1974 [12]
Skeletonema costatum	-	S	ZnS04	aw	-	10-d	NOECg	50	
Clone Skel-5							MATCg	70	√ (50 x 100)
Skeletonema costatum	-	S	ZnS04	aw	-	10-d	NOECg	100	
Clone Skel-0							MATCg	140	√ (100 x 200)
									Break *et al.*1976 [1]
Skeletonema costatum	-	S	ZnS04	sw	35	3-d	NOECg	20	[2]
clone Skel C7				(BS)			MATCg	28	√ (20 x 40)
Skeletonema costatum	-	S	ZnS04	sw	35	3-d	NOECg	60	[23]

clone Skel C7				(CB)					
Skeletonema costatum	-	S	ZnS04	sw	35	3-d	NOECg	7	[5,16]
clone Skel C7				(BS)					
Skeletonema costatum	-	S	ZnS04	sw	35	3-d	NOECg	7	[5,17]
clone Skel C7				(CB)					
Skeletonema costatum	-	S	ZnS04	sw	35	3-d	NOECg	30	[2,18]
clone Skel C6				(BS)					Fisher & Frood 1980
Skeletonema costatum	-	-	-	-	-	10/ 14-d	NOECg	200	MARITOX 9761 [19]
Sketetonema costatum	-	-	-	-	-	10/ 14-d	NOECg	50	MARITOX 9761 [19]
Thalassiosira pseudonana	+	F	ZnCl2	sw	-	2-w	NOECg MATCg	100 160	[9] √ (100 x 250) Jensen *et al.*1974 [12]
Thalassiosira pseudonana	-	S	ZnS04	aw	-	9-d	NOECg MATCg	200 280	√ (200 x 400) Break *et al.*1976 [1]
Thalassiosira rotuta	-	S	ZnS04*7H2O	sw	32	14-d	NOECg MATCg	10 22	[20] √ (10 x 50) Kayser 1977 [10]
Thalassiosira guillardii	-	-	-	-	-	10/ 14-d	NOECg	200	MARITOX 9761 [19]
Algae (multicellular)									
Laminaria hyperborea zoospores --> sporophytes	-	R	ZnS04	sw	-	4-w	NOECg MATCg	100 160	√ (100 x 250) Hopkins & Kain 1971 [21]
Coelenterata									
Eirene viridula	-	R	ZnS04	sw	30	3-m	NOECmc MATCmc	300 550	√ (300 x 1,000) Karbe, 1972 [22]
Annelida									
Capitella capitata	-	-	-	-	-	25/ 40-d	NOECr	320	MARITOX 51618 [19]
Ctenodrilus serratus	-	S	ZnS04*7H2O	sw	-	3-w	NOECr,s	100	

P --> F [lc]							MATCr,s	225	√ (100 x 500) Reish & Carr 1978 [23]
Ctenodrilus serratus	-	-	-	-	-	28/ 31-d	NOECr	100	MARITOX 51618 [19]
Nereis arenaceodentata	-	-	-	-	-	4-m?	NOECr	100	MARITOX 51618 [19]
Ophryotrocha diadema	-	S	ZnS04*7H2O	sw	-	3-w	NOECr,s	100	
P --> F [lc]							MATCr,s	225	√ (100 x 500) Reish & Carr 1978 [23]
Ophryotrocha diadema	-	-	-	-	-	4-w	NOECr	100	MARITOX 51618 [19]
Mollusca									
Crassostrea gigas	+	R	ZnS04	sw	29	5-d	NOECd,g	50	
eggs --> Larvae							MATCd,g	70	√(50 x 100) Brereton *et al*. 1973 [24]
Haliotis refescens	-	-	-	-	-	9-d	NOECr	19	MARITOX 50173 [19]
Mercenaria mercenaria	-	R	ZnCI2	sw	24	8-d	NOECs,g	50	
2-d old Larvae									Calabrese *et al*. 077 [25]
Scrobicularia plana	+	R	Zn(NO3)2	sw	31	2-w	NOLC	1,000	
length 4-5 cm							MATC	2,235	
									Akberali *et al*., 1981 [26]
Crustacea									
Cattlanassa australiensis	-	-	-	-	-	14-d	NOLC	440	MARITOX 15338 [19]
Holmesimysis costata	+	R	ZnS04*7H2O	sw	35	1-w	NOECs,g	18	
9-d old juveniles							MATCs,g	24	√ (18 x 32) Martin *et al*., 1989 [27]
Mysidopsis bahia	-	-	-	-	-	lc	NOECr	120	MARITOX 51549 [19] (from U.S. EPA)
Tigriopus brevicornis	-	-	-	-	-	-	NOECr	297	MARITOX 51537 [19]
Echinodermata									
Arbacia lixula	-	-	-	-	-	20-d	NOLC	1,000	MARITOX 51385 [19]
	-	-	-	-	-	4-d	NOECr	10	MARITOX 51385 [19]

d = developmental effects (deformities); g = growth; mc = morphological changes; r = reproduction; s = survival lc: life cycle test.

[1] No statistics reported. Test medium sterilized either by autoclaving or by filter sterilization (0.2 µm filter) no further data on test medium reported. Growth parameter: maximum growth rate (divisions/day), calcutated on the basis of cell counts.

[2] No statistics reported. Test water (seawater enriched with nutrients Cu, Zn or EDTA) was sterilized by 0.22, µm filter. BS and CB: seawater from 2 different locations. (BS usually contained somewhat less dissolved organic carbon and lower background levels of Zn (1.5 versus 5.2 mg/l total-Zn) and Cu. Growth parameter: relative growth rate (divisions/day) during log-linear growth phase.

[3] The NOEC was estimated from the lowest effect concentration (35% inhibition at 20 µg/l) using a factor of 3.

[4] The NOEC was estimated from the lowest effect concentration (18% inhibitionat 40 µg/l) using a factor of 2.

[5] No statistics reported. Test water sterilized by uv-irradiation. BS and CB: seawater from 2 different locations (see [2]); the seawater was not enriched with nutrients. Growth parameter: retative growth rate (divisions/day) during Log-linear growth phase.

[6] The NOEC was estimated from the lowest effect concentration (26% inhibition at 20 µg/l) using a factor of 3.

[7] The NOEC was estimated from the lowest effect concentration (21% inhibition at 20 µg/L) using a factor of 3.

[8] The NOEC was estimated from the lowest effect concentration (19% inhibition at 20 µg/L) using a factor of 2.

[9] At the NOEC indicated, growth rate was not (or hardly) affected in the exponential growth phase, but the maximum and/or final cell densities were lower'than control values when the test was continued beyond this phase.

[10] No statistics reported. Test water: seawater, enriched with nitrate, phospate and silicate; test water steritized by 0.22 µm filter. Growth parameter: number of cells.

[11] The NOEC was estimated from the lowest effect concentration (14% inhibition at 20 µg/l using a factor of 2.

[12] No statistics reported. Only stock solutions and highest test concentration were analysed for zinc. Growth parameter: retative growth rate, calculated on the basis of cell counts.

[13] No statistics reported. Test medium steritized either by autoclaving or by filter steritization (0.2 µm filter); EDTA-free. Growth parameter: maximum growth rate (divisions/day), catculated on the basis of cell counts.

[14] No statistics reported. Test medium sterilized either by autoclaving or by filter sterilization (0.2 µm filter); test medium contained 2.3 µM EDTA (which can chelate 76 mg Zn/l) and a trace mineral mixture. Growth parameter: maximum growth rate (divisions/day), calcutated on the basis of cell counts.

[15] No statistics reported. Growth parameter: carbon fixation rate (,ug C.t hr Test population: natural phytoplankton, being almost exclusively diatoms of the genus Rzizosotenia.

[16] The NOEC was estimated from the lowest effect concentration (32% inhibition at 20 µg/l) using a factor of 3.

[17] The NOEC was estimated from the lowest effect concentration (23% inhibition at 20 µg/l) using a factor of 3.

[18] The NOEC was estimated from the lowest effect concentration (20% inhibition at 60 µg/l) using a factor of 2.

[19] MARITOX: TNO/DGW ecotoxicological data base on marine organisms; the NOEC values indicated in the table have been reported by Schotten *et al*. (1991). The number following MARITOX refers to the TWO literature system. Data in MARITOX have been evaluated for reliability, in accordance with the system used in QUIRE; all NOEC values indicated in the table were considered to be reliable.

[20] During the exponential growth phase, growth rate was reduced at 50 µg/l, but the maximum and final cell numbers were not adversely affected at this concentration.

[21] No statistics reported. Growth parameter: number of sporophytes.

[22] No statistics reported. Parameter: macroscopic morphological changes.

[23] Statistics ($p \leq 0.05$) reported for reproduction. Reproductive parameter: number of worms. Based on the number of initial worms that survived the first 4 days of exposure, reproduction was affected at much lower concentrations than survival.

[24] No statistics reported. Test medium: UV-steritized seawater. The 5-d exposure period was followed by a 5-d depuration period; growth was measured up to day 10.

[25] The NOEC indicated is the LC5 reported by Catabrese *et al*. (1977). The estimated percent growth at this concentration was 100%. Background zinc level in seawater: 18 µg/l.

[26] No statistics reported.

[27] Statistics: $p \leq 0.05$. Growth parameter: carapace length. Abotts correction used for control mortatity (22%).

2.2. **Freshwater toxicity data**

An extensive chronic freshwater data set is available for zinc. The data are presented as follows:

- table 2.2.1: chronic toxicity data: NOECs,

ANNEX 28 : Subgroup report - Derivation of zinc EAC

2.2.1. *Table : Chronic toxicity of zink to freshwater organisms*

organism	A	Test-type	Test-comp	Test water	pH	Hardness	Exp.-time	Criterion	Result µg Zn/l	Reference [& footnote]
Algae										
Chlorella vulgaris	-	S	ZnSO4	am	-	-	2 w	NOECg	400	[1]
Chlorella vulgaris	-	S	ZnSO4	am	-	-	2 w	MATCg	1,265	Ahluwalia & Kaur, 1988
Chlorella vulgaris	-	S	ZnCl2	am	7-9	-	5 w	NOECg	560	[2]
Chlorella vulgaris	-	S	ZnCl2	am	7-9	-	5 w	MATCg	1,160	Rosko & Rachlin, 1977
Chroococcus vulgaris	-	S	ZnSO4*7H2O	am	7.8	54	10 d	NOECg	200	[3]
Chroococcus vulgaris	-	S	ZnSO4*7H2O	am	7.8	54	10 d	MATCg	280	Les & Walker, 1984
Kirchneriella subcapitata	-	-	Zn(NO3)2	am	-	-	2 w	NOECg	95	[4]
										Dragos *et al.*1988 [5]
Monoraphidium contortum	-	-	ZN(NO3)2	am.	-	-	2-w	NOECg	190	[6]
							`	MATCg	375	(190 x 750)
										Dragos *et al.*1988 [5]
Navicula incerta	-	S	ZnCl2	am.	8.5	-	4-d	NOECg	1,000	
								MATC	2,370	(1,000 x 5,600)
										Rachlin *et al.* 1983 [7]
Scenedesmus quadricauda	-	S	ZnS04	am.	6.5	-	2 w	NOECg	100	
								MATCg	150	√(100 x 225)
	-	S	ZnS04	am.	8.5	-	2-w	NOECg	225	
								MATCg	335	√(225 x 500**)**
										Starodub & Wong 1987 [8]
Scenedesmus quadricauda	-	S	ZnS04*7H20	river	7.5	200	4 d	NOECg	700	
										Bringmann & Kühn 1959 [9]
Selenastrum capricornutum	-	S	ZnCl2	am.	7	15	4-d	NOECg	15	
										Bartlett *et al.*1974 [10]
Selenastrum capricornutum	-	S	-	am.		"very soft"	2-w	NOECg	5	
								MATCg	7	(5 x 10)
										Kuwabara 1985
Synechococcus 6301	-	S	ZnS04	am	-	-	14-d	NOECg	390	
								MATCg	475	√(390 x 585)

										Mohanty 1989 [12]
Algae (unicellular)										
Ctedophora glomerata	-	S	-	am	8.4	35	3 d	NOECg	60	
1 cm fragments									69	√(60 x 80)
										Hargreaves & whitton 1967 [13]
Hormidium rivulare	**-**	**S**	ZnSO4/ZnCl2	am.	6	35	1 w	NOECg	1,000	
								MATC	3,150	√(1,000 x 10,000)
										Hargreaves &Whitton 1976a [14]
Poriferans										
Ephydatia fluviatilis	-	F	ZNCL2	am.	7	150	10-d	NOECg,t-d	3.2	
								MATCg,t-d	4.5	√(3.2 x 6.5)
										Francis & Harrison 1988 [15]
Mollusca										
Corbicula sp.	+	F	ZnS04	river	8.2	68	4-w	NOECg,s	25	
adult								MATCg,s	35	√(25 x 50)
										Belanger *et al*. 1986 [16]
Crustacea										
Ceriodaphnia dubia	+	R		New river	6	81	1 w	NOECr	25	
p < 1 d --> F1 [lc]								MATC	35	√(25 x 50)
Ceriodaphnia dubia	+	R		New river	8	81	1 w	NOECr	8	[17]
p < 1 d --> F1 [lc]								MATC	35	√(25 x 50)
Ceriodaphnia dubia	+	R		New river	9	81	1 w	NOECr	25	
p < 1 d --> F1 [lc]								MATC	35	√(25 x 50)
Ceriodaphnia dubia	+	R		Amy Bayou	6	118	1 w	NOECr	25	[18]
p < 1 d --> F1 [lc]										√(25 x 50)
Ceriodaphnia dubia	+	R		Amy Bayou	8	118	1 w	NOECr	50	[17]
p < 1 d --> F1 [lc]								MATC	70	√(25 x 50)
Ceriodaphnia dubia	+	R		Amy Bayou	9	118	1 w	NOECr	25	[19]
p < 1 d --> F1 [lc]										√(25 x 50)
Ceriodaphnia dubia	+	R		Clinch						

				river	6	168	1 w	NOECr	25	
p < 1 d --> F1 [lc]										√(25 x 50)
Ceriodaphnia dubia	+	R		Clinch						
				river	8	168	1 w	NOECr	50	[17]
p < 1 d --> F1 [lc]								MATC	70	√(25 x 50)
Ceriodaphnia dubia	+	R		Clinch						
				river	9	168	1 w	NOECr	17	[20]
p < 1 d --> F1 [lc]										√(25 x 50)
										Belanger & Cherry, 1990 [22]
Daphnia magna	-	R	ZnS04*7H20	pond	8.3	50	7-w	NOECr	25	
P < 1 d--> F1 [lc]								MATC	35	√(25 x 50)
								NOEC	75	
Daphnia magna	-	R	ZnS04*7H20	pond	8.3	100	7-w	NOECs	75	
P < 1 d--> F 1 [lc]								MATCr	85	√(75 x 100)
								NOEC	100	
Daphnia magna	-	R	ZnS04*7H20	pond	8.3	200	7-w	NOECs	150	
P < 1 d--> F1 [lcl]								MATCr,s	160	√(150 x 175)
										Paulauskis & Winner 1988 [23]
Daphnia magna	+	R	ZnCl2	Lake	7.7	45	3-w	NOECr	35	
P < 1 d-> F1 [lc]										Biesinger & Christensen 1972 [24]
Daphnia magna	+	R	ZnCI2	Lake	7.7	45	3-w	NOECr	74	
P < 1 d --> F1 [lc]								MATCr	100	√(74 x 140)
										Biesinger *et al*. 1986
										[25]
Daphnia magna	+	R	ZnCI2	Lake	8.1	225	21-d	NOEC	37	[26]
P < 1 d --> F [lc]								MATC	67	√(37 x 120)
								NOECg	310	[26]
Daphnia magna	+	F	ZnCl2	Lake	8.1	225	17-d	NOECs,r	420	[27]
										Enserink *et al*.1991 [28]
Daphnia magna	+	R		Lake	7.7	65	21-d	NOECs,r	100	
P < 2 d F1 [lc]								MATCs,r	120	√(100 x 150)
(poputation ‘I’ and ‘L’)										
Daphnia magna	+	R		Lake	7.7	65	21-d	NOECr	25	[29]
P < 2 d --> F1 [lc]								NOEC	100	
(population ‘p’)										Münzinger &
										Monicelli 1991 [30]

Insecta

Epeorus latifolium	-	F	ZnS04	ground	7.9	83	4-w	NOECe	3	
larvae, length 6 mm								MATCe	5	√(3 x 10)
								NOEC	30	
										Hatakeyama 1989 [31]
Fish										
Brachydanio rerio	-	R	ZnS04*7H20	am.	7.5	100	2-w	NOECh	1,290	
eggs < 4 hr --> larvae [els]							2-w	NOECs	6,095	
										Dave *et al*. 1987 [32]
Jordanella floridae	+	F	ZnS04*7H20	Lake	7.5	44	>3-m	NOEC	26	
P (Larvae) --> F1(tarvae)										
[lc]								MATC	36	√(26 x 51)
1-d (from unexposed eggs)								NOECs,r,h	51	
Jordanella ftoridae	+	F	ZnS04*7H20	Lake	7.5	44	>3-m	NOECs,g,r,h	75	[33]
P (larvae) --> F1 (Larvae) [lc]								MATCs.g.r:h	102	√(75 x139)
1-d (from exposed eggs)										Spehar 1976 [34]
Phoxinus phoxinus	+	F	ZnN03*4H20	tap	7.5	70	5-m	NOECs,g	50	
yearlings								MATCs,g	80	√(50 x 130)
										Bengtsson 1974b [31]
Pimephales promelas	+	R	ZnS04*7H20	am.	7.0	100	l-w	NOECd	120	
embryos --> larvae {Els)								MATCd	225	√(120 x 430)
										Dawson *et al*.1988 [35]
Pimephales promelas	+	R	-	Lake	7.5	48	l-w	NOECs	85	
Larvae < 1 d								MATCs	125	√(85 x 184)
								NOECg	184	
										Norberg & Mount 1985 [36]
Pimephales promelas	-	F	ZnS04*7H20	Lake	7.5	46	>8-m	NOECs h	145	
P> F [lc]								MATCs:h	205	√(145 x 295)
(eggs < 1 d) (larvea 2m)								NOECm,r	295	
								NOECg	575	
										Benoit & Holcombe 1978 [37]
Pimephales promelas	+	F	ZnS04*7H20	well	-	220	4-w	NOECg	300	
Larvae 1 d --> fry								MATCg	370	√(300 x 450)
								NOEC	700	
										Broderius & Smith jr 1979 [38]
Salmo qairdneri	+	F	ZnS04	well	7.8	330	2-yr	NOECs	320	[39,40]

fingerlings --> adults								MATCs	450	√(320 x 640)
								NOEC	>2,200	
Salmo qairdneri	+	F	ZnS04	tap	6.8	26	2-yr	NOEC	140	[41]
eyed eggs --> sexual maturity								MATCs	190	√(140 x 260)
								NOECs	545	
Salmo qairdneri	+	F	ZnS04	tap	6.8	26	3-w	NOECg	36	[42,40]
"fish" (unexposed as eggs)								MATCs	50	√(36 x 71)
										Sinley *et al*. 1974 [31]
Salvelinus fontinalis	+	F	ZnS04*7H20	Lake	7.5	45	3-yr	NOECh	535	[43]
P--> F [lc]								MATCh	850	√(535 x 1,360)
(yeartings) (larvae 3 m)								NOECs,g,r	> 1,360	
Salvelinus fontinalis	+	F	ZnS04*7H20	Lake	7.5	45	>3-m	NOECs	715	[31]
eggs 6 hr --> Larvae 3 m [ELSI								MATCs	990	√(715 x 1,370)
								NOECg	2,060	
										Holcombe *et al*.1979 [44]

Parameters:
d = developmental effects (deformities); e = emergence; 9 = growth; h = hatchabitity;
m = maturation (sexual development); r = reproduction; s = survival; t-d = tissue-deterioration.
lc: life cycle test; els: early life stage test (egg-larval test)

[ll Test medium according to Allen and Arnon (1955); the medium contained 4 mg/L EDTA-complex (10x10' 3 nMol/L), and macro- and micro-elements including 0.05 mg Zn/L. According to the authors, growth was significantty reduced at 4,000 µgl, but statistical data were not reported.

[2] No statistics reported. Test medium: sterile aristot's mediun containing macro- and micro-etements (assumed to be chelator free, see [7]. Chlorophylt a content per cell was reduced 15% at 560 µg/1, but the number of cetls was increased 10%. At 2,400 µg/t both paramters were reduced at teast 20%.

[3] No statistics reported. Test wediun according to Allen (1968); the mdium contairbed EDTA (3x10 mMoL/L), ard macro- and micro-elements including 0.05 mg Zn/L. Growth parameter: opticat density, measured by spectrometry

[4] Growth parameter: generation time. The NOEC was estimated from the lowest effect concentration (15% increase in generation time at 190 µgl) using a factor of 2.

[5] No statistics reported. Test medium: modified Zehrder *et al*. (1960) no. 11 medium; EDTA ornitted. Test concentrations reported: 0.187, 0.750, 1.5, 3 and 4 mg/1, without data on analysis.

[6] Growth parameters: cell number, chlorophyll a content (in medium and per cell), opticat density and generation time. Chlorophyll content per cell increased with increasing zinc concentration.

[7] No statistics reported. Test medium: sterile, chelator free LDM medium (100 mL/L Bristolls solution and 900 ml/l seawater). Bristol's sotution contains macro- and microelements. Growth parameter: number of cells.

[8] Statistics: p <= 0.05. Test medium: CHU-10 medium; this EDTA-free medium represents a retatively unpolluted lake water (Wong *et al*., 1982, 1978; Chu, 1942). Growth rate (increase in opticat density) measured by spectrometry.

[9] Test water: filtered river water. "Toxic threshold" for growth (number of cells) 1,400 µg/l. The NOEC was estimated from the toxic threshold using a factor of 2 -3

[10] Test medium: AAPST-medium (EPA, 1971) containing 300 µg/l Na 2- EDTA (equivalent to 0.9x10-3 mmol/l). The NOEC was estimated frorn the lowest effect concentration (20% decrease in dry weight at 30 µg/t) using a factor of 2. Zinc was completety inhibitory and atgicidal at 100 ard 700 µg/l, respectivety.

[11] No statistics reported. Test medium: nutrient medium eluted through Chetex-100 to remove cationic impurities Test media (S-3) were finally filter steritized (0.45 µm). Computed free Zn-ion concentrations were equal to total-zinc concentrations. Growth parameters: lag phase, growth rate, ard stationary phase cell density.

[12] No statistics reported. Test medium: BG-11 medium, containing 1 µg/ml FE-EDTA (3x10-3 mmol/l). After about 2 weeks of growth, a known quantity of cells were transferred to fresh medium for repeated culture for 7 to 10 times. During each transfer growth parameters were measured. At the NOEC irdicated (390 µg/l) the increase in cell number was marginal untilt the end of day 7, after which a sharp increase up to day 14 was seen, while in control cultures (65 µg/l) the lag phase was only 2 days followed by a progresssive increase in the number of cells up to day 11. Due to the increased lag phase at 390 µg/L, the growth parameters chtorophyll a content, phycocyanin content, protein content (att expressed as µg/l medium), total CO2- fixation capacity ard totat dry mass of algae were reduced. However, on a per cell basis there was no adverse effect on these parameters. Furthermore, exponentiat growth rate after the lag phase and the total number of cells after the growth phase were not adversely affected, while total inhibition of cell growth was observed at 585 µg/1.

[13] No statistics reported. Test medium: EDTA-free modified no. 10 medium of CHU (1942), enriched with 10% river water and trace elements. Hardness catculated from originat Chu (1942) medium

[14] No statistics reported. Test medium according to Hargreaves and Whitton (1976b); the medium contained 6x10-3 mMol/1 EDTA, and macro-and micro-etements. A series of tests was conducted, at different hardness (range 35500). in a second series of tests, conducted at a calcium Level of 0 mg/L (hardness 10 mg/l, due to the presence of 0.1 nMoL Mg/l), growth was reduced at 1,000 µg/l, within the range of ph-vatues of 3 to 7. Because control growth in the absence of calcium was poor, the results of the second series of tests were not used to derive a NOEC.

[15] Test medium contained 6 mg/L Na2EDTA.2H20 (16x10-3 mMol/l), and macro- and microetements. At 1x10-7 MoL Zn/l and higher concentrations, a "pronounced toxicity" existed (progresively deterioration of interior tisues), although growth continued. Required for normal growth: 1x10-9 to 1x10-8- Mol Zn/1 (0.065 - 0.65 µg/L).

[16] Statistics (p <= 0.05) on growth data only (shell length and total weight). At 25 µg/l mortality was 5%. Tests were conducted in field-located artificial streams containing coarse sand sediment (diameter 2-9 mm); the cages with clams were buried in the sand.

[17] The NOEC was estimated from the lowest effect concentration (28% inhibition at 25 µg/[) using a factor of 3.

[18] The NOEC was estimated from the lowest effect concentration (16% inhibition at 50 µglt) using a factor of 2.

[19] The NOEC was estimated from the lowest effect concentration (13% inhibition at 50 µg/L) using a factor of 2.

[20] The NOEC was estimated from the lowest effect concentration (20% inhibition at 50 µglt) using a factor of 2.

[21] The NOEC was estimated from the lowest effect concentration (30% inhibition at 50 µglt) using a factor of 3.

[22] Reproductive parameter: number of young per female. The NOEC-vatues tisted in the table sometimes differ from the NOEC-values reported by Belanger and Cherry (1990), because in their statistical analysis of the reproduction data, the pH = 8 and 0 µg//1 Zn treatment in each test water was considered to be the control value. The NOEC-vatues in table 1.1 are based on comparisons (per test water) with the 0 µglt Zn control at corresponding pH. Data on survival reported incompletely, but it appears that survivat was not affected at the test concentrations used (0, 25 and 50 µg/l in New river water; 0, 50 and 100 µg/l in Amy Bayou and Clinch river water). The parent pH of the test water was approximatety 8.

[23] Statistics: p <= 0.05. Soft test water (hardness 50) was prepared by diluting pond water with distilted, deionized, carbon-fittered, Organex-Q-fittered water; this dilution of water contains essentially no trace organic compounds. Medium (hardness 100) and hard (hardness 200) test waters were prepared from soft water by adding CaS04, and MgS04, in quantities that would maintain the approximate 2:1 ratio of calcium to magnesium in the pord water. Reproductif parameter: brood size.

[24] Test mediun: Lake Superior water, strained through # 20 bolting cloth. Reproductive parameter: total number of young. A 16% reproductive impairment concentration representing "the minimat reproducible value below which the variability in reproduction could not be detected from controls was reported at 70 µg/l. The NOEC was estimated from the lowest effect concentration (16% impairment at 70 µg/L) using a factor of 2. Survival and growth of initial animals were reported to be tess sensitive than reproduction, without further details.

[25] Statistics: p <= 0.05. Test water: Lake Superior water, strained through # 20 bolting cloth. In one out of two test performed, reproduction was considerably reduced (40-50%) at 74 µg/1, but this effect was not statistically significant. Tests were conducted at sublethat concentrations (see also Biesinger & Christensen, 1972). Reproductive parameter: total number of young.

[26] Statistics: p <= 0.01. Because only the lowest effect concentrations with respect to growth (120 µg/L) and survival and reproduction (1,000 µg/l) were reported, the NOEC-values were derived from these concentrations using a factor of 3.2, i.e. the ratio used between test concentrations.
[27] Tests were started with exponentially growing populations. The NOEC is the EC10 for yield (mean maximum number of daphnids) reported by Enserink *et al*. (1991).
[28] Test water: Lake ijsset water filtered through a 25 i£m mesh and UV-treated.
[29] No statistics reported. The NOEC has been estimated from the towest concentration (14% inhibition at 50 µglt) using a factor of 2.
[30] Test water: 40 µm filtered lake water. Three different populations were tested separately. Reproductive parameter: number of young. In additional 3-w tests under the same test conditions, brood size (eggs/animal) and body length of primiparous animals of all three pcpulations were significantty (p <= 0.05) affected (p <=s 0.05) at 150 µg/l, the only test concentration used in these additionat tests.
[31] Statistics (p <= 0.05) reported on growth data only. Background zinc concentration in test water 9 µg/1.
[32] Parameter h: hatching time. The NOEC-values indicated for hatching and survival are the reported arithmetic mean values from 10 ring tests conducted in 5 kaboratories. The towest NOEC-vatues for hatching and survival were 180 and 2,875 µg/L, respectively.
[33] At 139 µg/l, only growth of matl fish was significantty (p <= 0.05) reduced. However, reproductive parameters were also strongly reduced, although not statistically significant due to the variable response.
[34] Statistics: p<= 0.05. Test medium: untreated Lake Superior water. -
[35] Statistics (p <= 0.05) on growth data only. Concentrations were analysed in stock solutions, not in test waters. Survival and growth were affected at higher concentrations than that resulting in larval deformities; NOEC-values for survival and growth could not be derived from the data reported.
[36] Statistics: p <=: 0.05. Test medium: Lake Superior water; pH based on Lake Superior water characteristics reported by Spehar (1976). No data on pretreatment of Lake Superior test water.
[37] Statistics: p <= 0.05. Test medium: Lake Superior water, passed through an ultraviotet steritizer. Total number of spawnings fourd on substrates, adhesiveness to spawning substrate and egg fragility (chorion rupture during removal from substrate) were affected at 145 µg/l. However, maturation and the total number of spawnings were not affected up to 295 µg/1. Eight-week survival was determined for both parental fish and offspring.
[38] No statistics reported. NOEC for growth (dry weight) derived from figure. Control survival was low, about 60%.
[39] Mortatity 6.4% at 640 µg/l, versus 0% at concentrations up to 320 µg/l. The investigators reported a MATC between 320 and 640 µg/l. The test did not yield valid reproduction data, but mate and female fertitity appeared to be unaffected up to the highest concentration tested (2,200 µg/l)
[40] In this study the NOEC and EC were derived in accordance with the view of the authors, although mortality at the effect concentration indicated was less than 10% (versus 0% in the controt groups)-
[41] MortaLity at 260 µg/l was 13.1% for yolk-sac fry and 6.9% for feeding fry, versus 5.5% end 2.6%, respect-vety, in the experimental control group. The investigators reported a MATC between 140 end 260 µg/l. At Lower concentrations mortality was very similar to both experimentat controls and hatchery controls.
[42] Mortality 8% at 71 µg/l versus 0% in the control group; the investigators reported a MATC between 36 end 71 µg/l
[43] Egg fragitity (force required to rupture egg chorions) was reduced at 266 µg/l, but hatchability was not affected at 535 µg/l.
[44] Statistics: p <= 0.05. Test medium: lake Superior water, passed through an uttraviolet sterilizer.

ANNEX 28 : Subgroup report - Derivation of zinc EAC

3. REFERENCES

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OSLO AND PARIS CONVENTIONS FOR THE PREVENTION OF MARINE POLLUTION
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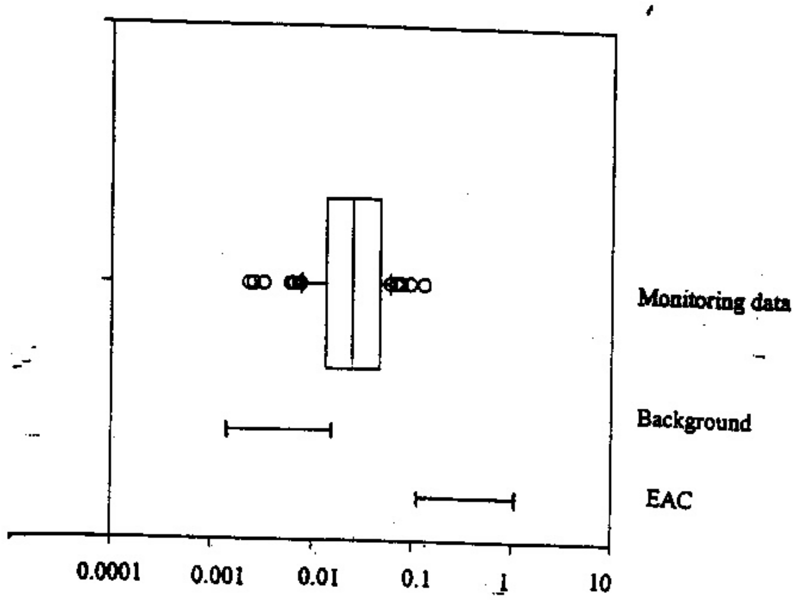
THE HAGUE: 25-29 NOVEMBER 1996

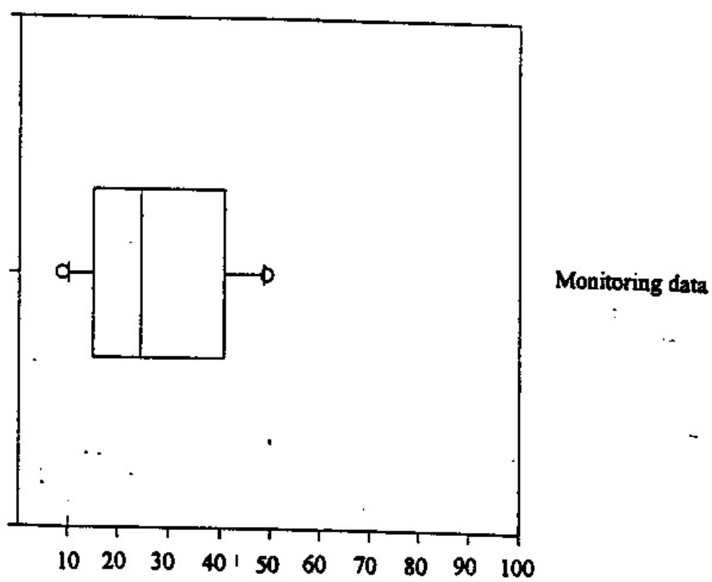
Comparison of EACs with Monitoring Data and Background Concentrations

1. Benzo[a]pyrene in sediment
2. Benzo[a]pyrene in *Mytilus*
3. Fluoranthene in *Mytilus*
4. Lindane in water
5. Lindane in *Mytilus*
6. Lindane in fish muscle
7. ΣPCB_7 in sediment
8. ΣPCB_7 in *Mytilus*
9. ΣPCB_7 in flounder
10. Lead in sediment

Benzo(a)pyrene in sediment with 1% TOC ; concentrations in mg/kg.

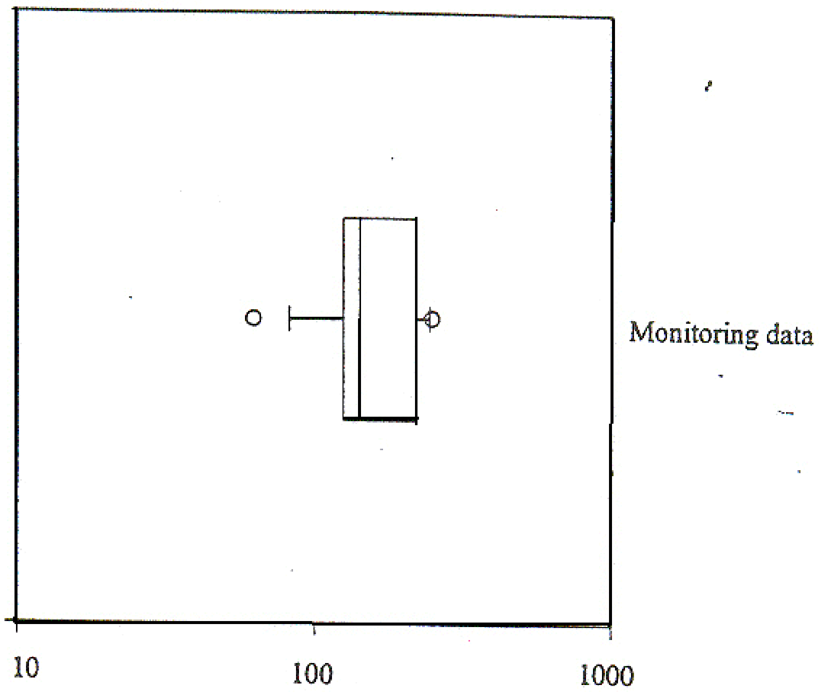


Benzo(a)pyrene in Mytilus ; concentrations in μg/kg dw.



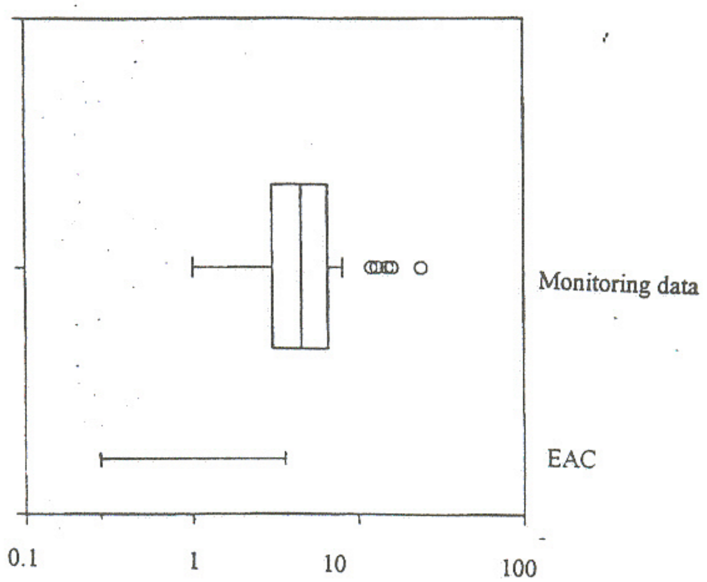
EAC = 5000-50000 μg/kg dw.

Fluoranthene in Mytilus ; concentrations in μg/kg dw.

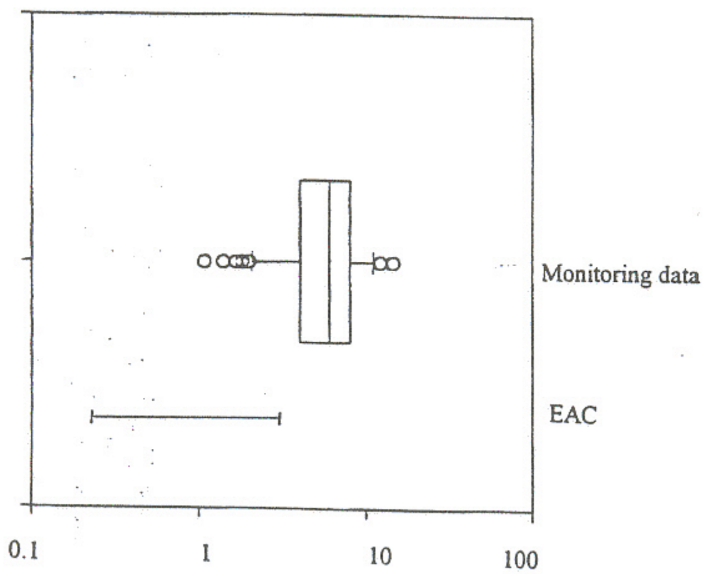


EAC = 1000-10.000 μg/kg dw.

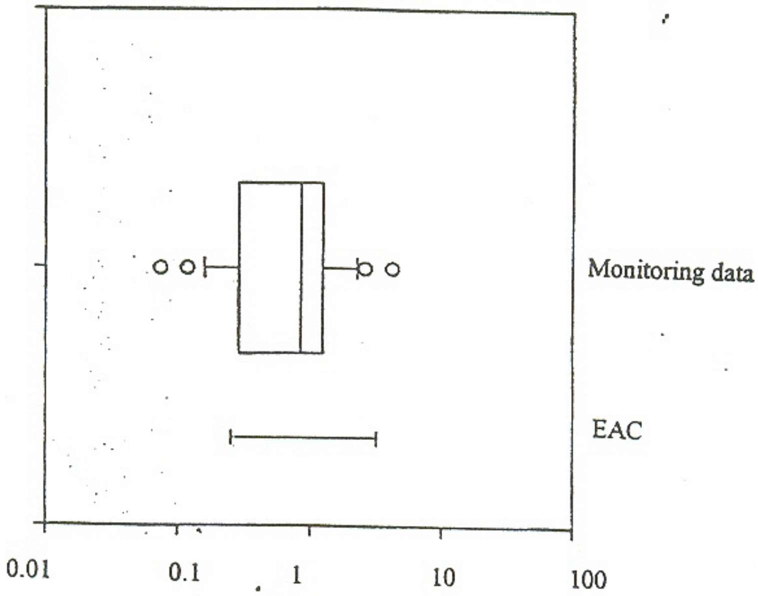
Lindane in water : concentrations in ng/l.



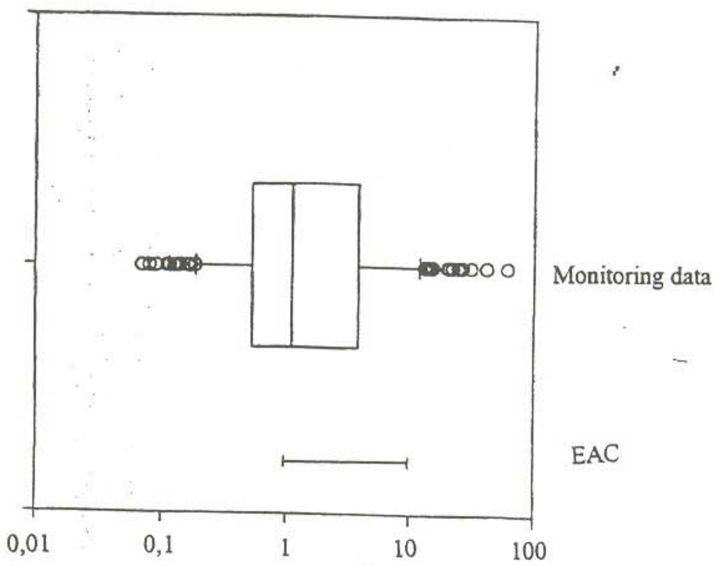
Lindane in Mytilus : concentrations in μg/kg dw.



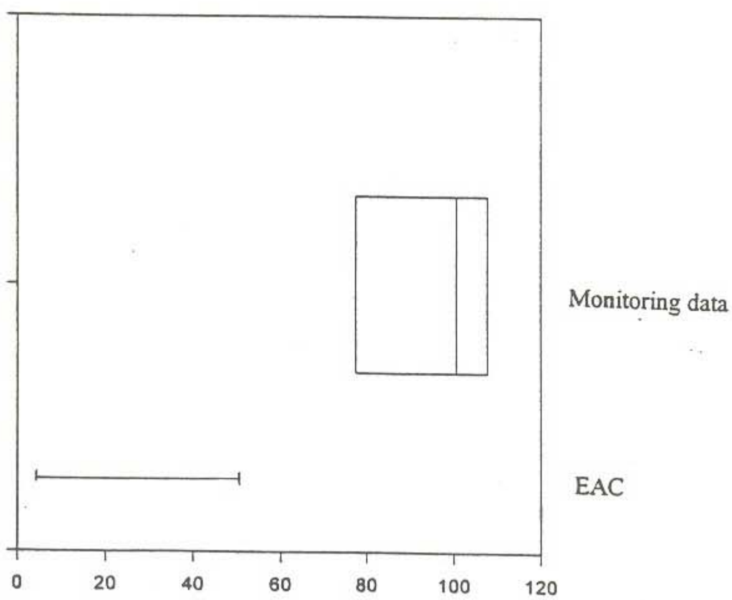
Lindane in fish muscle : concentrations in μg/kg fw.



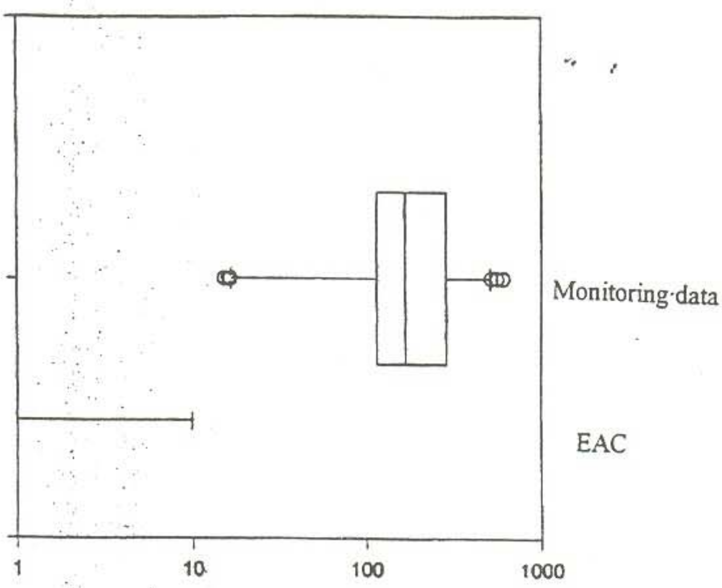
$\sum$PCB 7 in sediment ; concentrations in μg/kg dw.



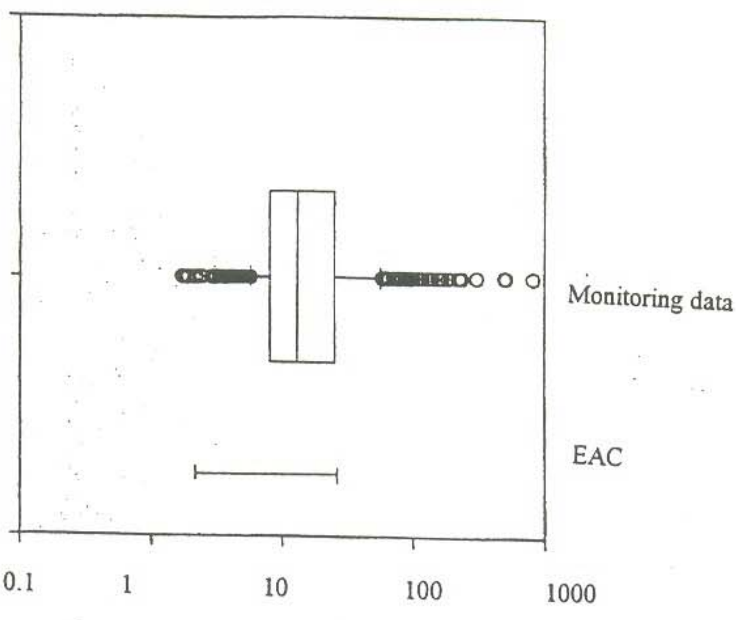
$\sum$PCB 7 in Mytilus : concentrations in μg/kg dw.



∑PCB 7 in flounder liver : concentrations in μg/kg fw.



Lead in sediment : concentrations in mg/kg dw.



OSLO AND PARIS CONVENTIONS FOR THE PREVENTION OF MARINE POLLUTION

THIRD WORKSHOP ON ECOTOXICOLOGICAL ASSESSMENT CRITERIA

THE HAGUE: 25-29 NOVEMBER 1996

Abbreviations used in the report

ADI	Allowable Daily intake
ASTM	American Society for Testing and Materials
AQUIRE	Aquatic Toxicity Information Retrieval Data Base of US-EPA
ASMO	Assessment and Monitoring Committee(OSPAR)
BCFs	Bioconcentration Factors
BEDS	Biological Effect Database for Sediments
CSR	Centre for Substances and Risk Assessment
CSTE	Scientific Advisory Committee on Toxicity and Ecotoxicity of Chemicals
DDE	2,2-bis (p-chlorophenyl)-1,1-dichloroethylene
DOE	Department of the Environment (UK)
DW	Dry Weight
EAC	Ecotoxicological Assessment Criterium
EC	European Community
EC_{50}	Concentration at which a 50 % reduction of a parameter (e.g. growth) is observed
EPA	Environmental Protection Agency
ERL	Effect Range Low (information from BEDS)
ERM	Effect Range Medium (information from BEDS)
EqP	Equilibrium Partitioning
EQS/EQO	Environmental Quality Standards/Objectives
ICES	International Council for Exploration of the Sea
JAMP	Joint Assessment and Monitoring Programme
JMG	Joint Monitoring Group
JMP	Joint Monitoring Program
Kow	1-octanol/water partition coefficient
Kp	Sediment-water partitioning coefficient
LC_{50}	Lethal Concentration for 50% of the individuals
MARITOX	Marine Toxicity Database of TNO
MTCs	Maximum Tolerable Concentrations
NECs	No Effect Concentrations
NOECs	No Observed Effect Concentrations
NOEL	No Obseved Effect Level (information from BEDS)
NRC	Negligible Risk Concentrations
NSTF	North Sea Task Force
NSTPA	National Status and Trends Programm Approach
OC	Organic Carbon
OECD	Organisation for Economic Cooperation and Development
OSPAR	Oslo and Paris Commissions
PAHs	Polycyclic Aromatic Hydrocarbons
ΣPCBs	sum of PCB congeners 28, 52, 101, 118, 138, 153, 170
PCBs	Polychlorinated bi-phenyls
PEL	Probable Effects Level
QSR 2000	Quality Status Report for the OSPAR convention area
QSAR	Quantitative Structure-Activity Relationship
SETAC	Society of Environmental Toxicity and Chemistry
SSTA	Spiked-Sediment Toxicity Test Approach
TBT	TriButylTin
TEL	Threshold Effect Level
TNO	Dutch Insitute of Environmental Sciences
TRL	Tolerable Residue Level
WW	Wet Weight