Hazardous Substances Series

Polychlorinated Biphenyls (PCBs)

OSPAR Commission

2001 (2004 Update)

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

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

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Executive Summary

Polychlorinated biphenyls (PCBs) are produced by introducing elemental chlorine into biphenyls. They have been a source of concern since the 1970s. They are toxic and, since they are hydrophobic, bioconcentrate particularly in fatty tissues. They can adversely affect reproduction, and may affect immune systems so as to make disease epidemics worse. The higher levels of the food web, especially fish-eating birds and marine mammals, are particularly affected. OSPAR adopted measures on them in 1992, and therefore added them to the List of Chemicals for Priority Action in 1998.

PCBs have been produced commercially since 1929, both for “closed” uses, such as use as insulation and cooling fluids in transformers, dielectric fluid in capacitors and as hydraulic fluids, and for “open” uses, such as grouting and sealants and as plasticisers in paints. Production in Europe was stopped in the mid-1980s. Since then, the main sources have been losses from PCB-containing units, waste disposal, remobilisation of PCB-containing sediments and, to an unknown extent, formation as by-products in various thermal and chemical processes. In contaminated estuaries, concentrations in sediments can reach several hundred µg/kg (dry weight). In remote areas, the range found is 0,1 – 20 µg/kg (dry weight). Concentrations in biota can be as high as 1 900 µg/kg (wet weight). Emissions and concentrations have dropped since the 1970s, but concentrations may now be levelling off as remobilised sediments become the major source.

The main existing OSPAR measure on PCBs is Decision 92/3 on their phasing-out, which requires the destruction of all identifiable PCBs. EC Directives ban their use in open applications, as raw material and intermediates, and require PCBs to be inventoried and destroyed. The UN Economic Commission for Europe Protocol on Persistent Organic Pollutants (POPs) has a similar requirement for destruction, while the newly signed UNEP POPs Convention will ban PCB production and require destruction of stockpiles and careful handling of wastes.

The action recommended is: to support the development of an EC strategy to reduce the presence of PCBs and dioxins in the environment; to support the development of a CEN standard for analysis of PCBs in products and the use of this to establish a cut-off for PCBs in cable sheathings for recycling; to develop a monitoring strategy for PCBs as part of the revised Joint Assessment and Monitoring Programme; and to ask other relevant international forums to take account of the background document.

A monitoring strategy for polychlorinated biphenyls is annexed to this background document.

Récapitulatif

Les polychlorobiphényles (PCB) sont obtenus en introduisant du chlore élémentaire dans des biphényles. Ces substances suscitent des préoccupations depuis les années 1970. Les PCB sont en effet toxiques, et, étant en outre hydrophobes, ils se concentrent biologiquement en particulier dans les tissus graisseux. Ils peuvent avoir une influence préjudiciable sur la reproduction, tout en pouvant porter atteinte au système immunitaire et aggraver ainsi les épidémies. Les niveaux supérieurs de la chaîne alimentaire, en particulier les oiseaux piscivores et les mammifères marins, sont particulièrement affectés. En 1992, OSPAR a adopté des mesures les concernant, et en 1998, les a en conséquence inscrits sur la Liste des produits chimiques devant faire l'objet de mesures prioritaires.

Les PCB sont fabriqués à l'échelle commerciale depuis 1929, tant pour des applications «en circuit fermé», comme par exemple comme fluides d'isolation et de refroidissement dans les transformateurs, comme fluides diélectriques dans les condensateurs et comme fluides hydrauliques, que pour des applications «en circuit ouvert», comme mortiers et comme produits d'étanchéité, de même que comme plastifiants des peintures. En Europe, leur fabrication a cessé au milieu des années 80. Depuis lors, les principales sources ont été constituées par les fuites des appareils contenant des PCB, par l'élimination des déchets, par la remobilisation des sédiments contenant des PCB, et, dans une mesure inconnue, par leur formation sous forme de sous-produits de divers processus thermiques et chimiques. Dans les estuaires contaminés, les teneurs dans les sédiments peuvent atteindre plusieurs centaines de µg/kg (poids à sec). Dans les zones écartées, la fourchette constatée se situe entre 0,1 et 20 µg/kg (poids à sec). Dans le biote, les teneurs peuvent atteindre 1 900 µg/kg (poids humide). Les émissions et les teneurs ont baissé depuis les années 1970, quoiqu'il se peut que les teneurs se stabilisent maintenant que les sédiments remobilisés en deviennent la principale source.

La principale mesure OSPAR actuelle visant les PCB est la Décision 92/3 relative à leur abandon, laquelle exige la destruction de tous les PCB identifiables. Les directives communautaires européennes interdisent leur utilisation en circuit ouvert, comme matières premières et comme intermédiaires, et exigent en outre que les PCB soient inventoriés et détruits. Le Protocole sur les polluants organiques persistants (POP) de la Commission économique des Nations Unies pour l'Europe comporte aussi une exigence analogue de destruction, tandis que la Convention du PNUE sur les POP, nouvellement signée, va interdire la production des PCB et exiger la destruction des stocks ainsi qu'un traitement précautionneux des déchets.

Les actions recommandées sont les suivantes : apporter un soutien à l'élaboration d'une stratégie communautaire européenne visant à réduire le volume de PCB et de dioxines présents dans l'environnement ; apporter un soutien à l'élaboration d'une norme CEN applicable à l'analyse des PCB dans les produits, ainsi qu'à l'application de cette norme afin de fixer un seuil de coupure pour les PCB dans les gaines des câbles devant être recyclés ; élaborer une stratégie de surveillance des PCB à titre de partie intégrante du nouveau Programme conjoint d'évaluation et de surveillance, et demander aux autres instances internationales compétentes de prendre en considération le document de fond.

Une stratégie de surveillance sur les polychlorobiphényles est annexée à ce document de fond.

1. Identification of main sources of PCBs

1.1 Production

1. PCBs are produced by introducing elementary chlorine into biphenyl. The chlorination of the product lies between 20 - 70%. Commercial use of PCB began in 1929. Since then over 1 million tonnes of PCB have been produced worldwide. In this document, PCBs are addressed in general since, for the identification of the main sources and emissions, a distinction between individual PCB congeners and isomers as well as a distinction between co-planar PCB (with dioxin-type effect) and non co-planar PCB was not considered necessary.

2. In principal, emissions will occur from production, from use, from waste and from waste disposal. Throughout the Convention area, the production of PCBs ceased in 1985 at the latest. With regard to the emissions of PCBs in use, it is nevertheless important to consider production volumes up until that time.

1.2 Uses

3. When looking at the use of products containing PCBs a distinction has to be made between closed and open applications.

Table 1.1: Applications of PCBs

Category	***Application***	**Chlorine content [wt. %]**
Closed system	Transformers	40-60
	Capacitors	20-55
Circulatory systems	Hydraulic oils	30-60
	Thermal oils	ca. 40
	Lubricating oils	20-55
Open systems	Plasticiser for rubber	20-70
	Plasticiser for synthetic resins	50-70
	Carbonless copy paper	ca. 40
	Adhesives	20-55
	Paints, printing inks, sealants	ca. 55

The main uses in closed systems were in the electricity and mining industries and involved:

- transformers (insulation and cooling fluids);
- capacitors (dielectric); and
- hydraulic fluids (incl. fireproofing).

4. PCBs are used pure or in mixtures with other substances. Such mixtures, for example, are the askarels which are used in power transformers. They consist of approximately 65 % PCB and approximately 35 % tri- or tetrachlorobenzene.

5. Closed application means that - in principle - PCBs cannot be released to the environment during use (e.g. PCBs as dielectric fluid in transformers). However, according to an estimate (Callahan, 1983 cited in Ifeu, 1998), 2 % of transformers and 3 % of large capacitors in the USA had leaks so that significant releases also from such closed applications can be assumed. Such releases were estimated (by EMEP in 1992) to reach 5,2 tonnes/year for Belgium.

1.3 Disposal

6. In order to examine the emissions of PCBs which can arise at the end of a product's life cycle, it is necessary to consider the legal provisions for its disposal. Council Directive 96/59/EC contains stipulations regarding the elimination of PCBs. The Directive applies to wastes with PCB concentrations ≥ 50 ppm and volumes ≥ 5 litres of PCBs.

7. Key features of the Directive are:

- within 3 years of its adoption in 1996, EU Member States must submit an inventory and detailed plans for the disposal of the relevant PCB wastes and the decontamination/disposal of the relevant equipment. These will have to cover all equipment containing more than 5 litres[1] of PCB;
- the year 2010 has been set as a deadline for complete disposal or decontamination of equipment containing PCBs (although OSPAR Contracting Parties should still be bound by the 1999 deadline set out in PARCOM Decision 92/3 on the Phasing Out of PCBs and Hazardous PCB Substitutes). The only exception is for transformers containing between 500 and 50 ppm of PCB, which are allowed to remain in service until their end of life.

8. Disposal options therefore depend on the PCB content. For the disposal of transformers, the PCB content in the cooling fluid is the decisive criterion. In Germany, there are six hazardous waste incinerators and one hydrogenation plant officially authorised to destroy wastes containing liquid PCBs. Solid wastes with high concentrations of PCBs are deposited in underground facilities. Additional facilities are available to dispose of liquid wastes containing low levels of PCB.

9. Because of this classification as special waste it can be assumed that at least the PCBs in public and commercial institutions are disposed of properly. This applies particularly for PCB transformers because there is a labelling obligation for these in connection with the Hazardous Substances Ordinance. This is why the disposal of transformers and large capacitors probably does not represent a significant source of emissions of PCBs in Germany.

10. However, not all amounts of PCBs produced and used have been disposed of properly. This is particularly the case with regard to small capacitors used in private households, because they are widely distributed.

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1 As the interpretation of Directive 96/59/EC is rather complex, parts of the text of Article 4 and Article 9 concerning the cut off values are repeated:

Article 4: [...] Member States shall ensure that inventories are compiled of equipment with PCB volumes of more than 5 dm^3, and shall send summaries of such inventories to the Commission at the latest three years after the adoption of this Directive. […] Equipment in respect of which it is reasonable to assume that the fluids contain between 0,05 % and 0,005 % by weight of PCBs may be inventoried […]

Article 9: Member States shall take the necessary measures to ensure that transformers containing more than 0,05 % by weight of PCBs are decontaminated under the following conditions:

a. the objective of the decontamination must be to reduce the level of PCBs to less than 0,05 % by weight and, if possible, to no more than 0,005 % by weight;

b. the replacement fluid not containing PCBs must entail markedly lesser risks;

c. the replacement of the fluid must not compromise the subsequent disposal of the PCBs;

d. the labelling of the transformer after its decontamination must be replaced by the labelling specified in the Annex hereto.

11. Another difficulty with regard to the proper disposal of PCBs is that they arrive at the disposal site predominantly as constituents of equipment and materials. This means that the quantity of PCB-containing wastes yet to be disposed of is considerably higher than the quantity of PCBs used. A study carried out in 1993 forecasts the following PCB waste quantities in Germany between 1996 and 2000:

- liquid waste for incineration: 132 000 tonnes;
- solid waste contaminated with PCBs: 120 000 tonnes.

In a recent study (UBA, 1999) it has been shown that approximately 274 000 tonnes of PCB containing equipment (former West Germany, 1998: up to 286 000 tonnes; former German Democratic Republic (GDR), 1991: up to 23 000 tonnes) have been disposed of by 1998. By extrapolating the quantity disposed of by 1998, it was estimated that by the end of 2000, an additional 15 000 tonnes of PCB material will have been disposed of. This means that approximately 20 000 tonnes of PCB-containing material and equipment may still be in use in Germany. It is however not possible to distinguish between the different uses and therefore no PCB quantities can be estimated based on these figures. From the available figures it is assumed that this amounts to about 16 000 pieces of PCB-containing equipment. For this, sufficient disposal capacities are available in Germany. In order to comply with the provisions of Council Directive 96/59/EC a new questionnaire has been sent out to the 'Länder' administrations to establish an inventory of PCB/PCT containing material. Also waste handling programmes and action plans with regard to PCB/PCT are to be reported. The inventory and action plan were submitted to the EC at the end of March 2001. The number of PCB-containing equipment (> 5 litres) still to be disposed of is about 380 appliances with about 395 tonnes of liquid PCBs.

12. It can be assumed that uncontrolled disposal via household wastes is mainly restricted to smaller electrical appliances. Studies currently available indicate a proportion of these small appliances in household waste of approximately 1 % by weight of the overall quantity of household waste.

13. When small capacitors containing PCBs are dumped in landfill sites, PCBs are released due to rotting casings. PCB containing capacitors may also be damaged as a result of compacting. At the beginning of the 1980s the PCB content of the residual waste disposal of a household waste incinerating plant was between 0,26 - 0,35 g/t dry material or 0,175 - 0,25 g/t moist waste. These values are probably also valid for solid waste landfills.

14. The routes of PCB releases from small capacitors are summarised in figure 1.1.

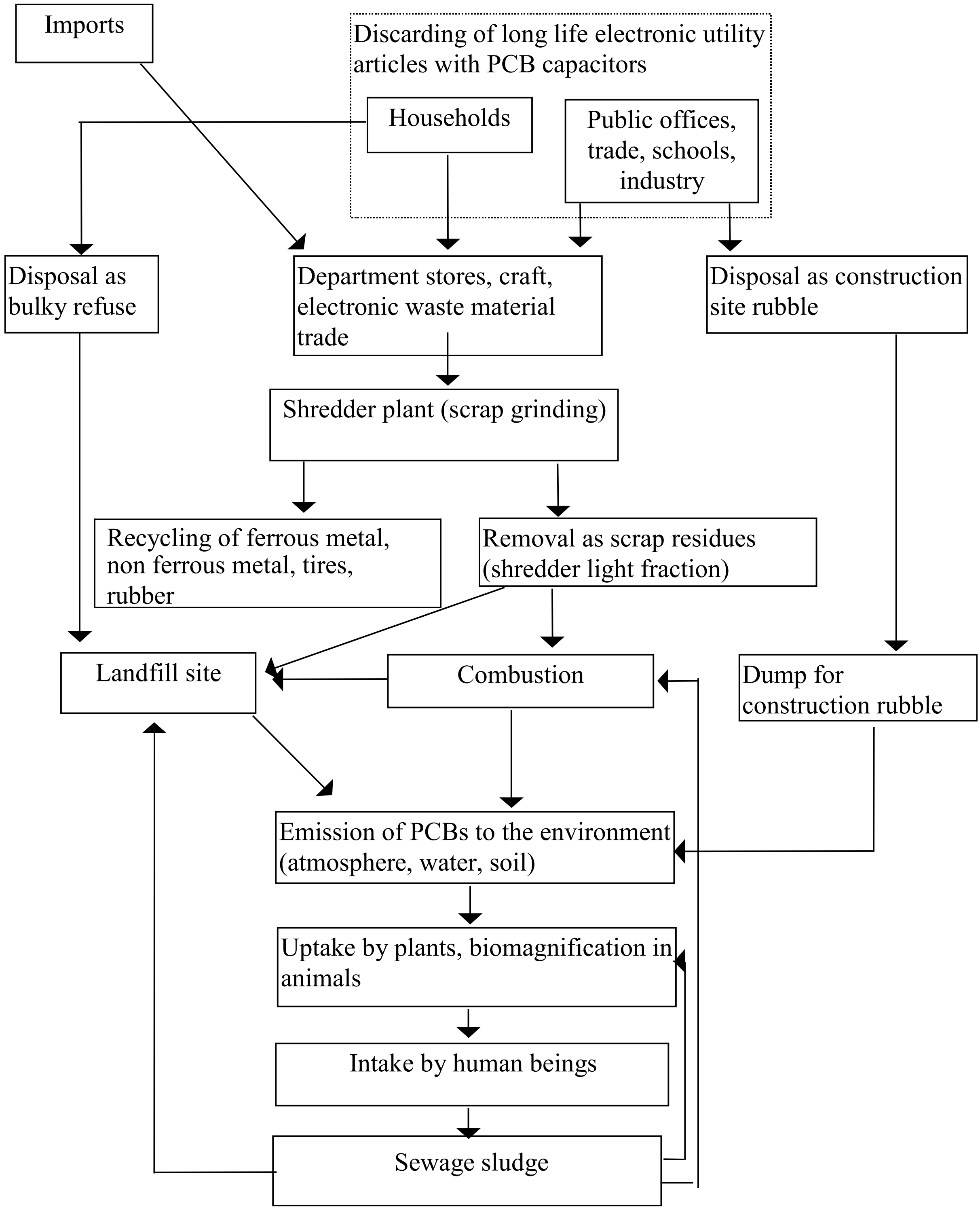

Figure 1.1: Pollutant routes taken by PCB from small capacitors

1.4 Thermal processes, by-product formation, new products

15. Emissions can also be expected from various thermal processes. *De-novo* synthesis of PCB may occur in the presence of impurities with chlorine compounds and organic components. Although there is little information available on emissions of PCBs during thermal processes, relevant emission estimates have been calculated for sinter plants and secondary steel production. However, efforts to minimise dioxin emissions from this sector are also likely to substantially reduce emissions of PCBs.

16. In theory, the forming of PCB as a by-product is possible in any chemical process involving chloride and organic carbon. Data on PCB contamination of products cannot be found in chemical databases or obtained from industry.

17. In 1983, the US-EPA made a list of potentially PCB-containing products, based on a theoretical study of 200 chemical processes that can generate PCBs as a by-product. The processes were ordered according to their potential for PCB formation; the substances produced by processes with a high potential were put on the EPA list. It is expected that these substances contain 25 - 50 ppm PCBs. There is a second list of products which contain more than 50 ppm PCBs, products for which manufacturers have requested the EPA for an exception of regulations within the framework of US Toxic Substances Control Act.

18. In the framework of OSPAR Belgium has outlined in 1997 that if one assumes that the products on these US-EPA lists actually contain a certain PCB contamination, this would entail that per year several tonnes of PCB could be brought on the Belgian market as by-products in chemical bulk products. Since there is no obligation to monitor PCB in products, relevant data are not available. Estimates are therefore indicative and it is not possible to give a conclusive statement on the actual quantities. Further calculations and estimates on the basis of the EPA List are provided in table 2.8.

19. Otherwise there are strong indications that some countries (e.g. the People's Republic of China) may still be producing PCBs. This explains why PCB containing capacitors can still occasionally be found in new appliances.

1.5 Re-emission

20. Another important source is the deposition of PCBs from the air subsequent to volatilisation from contaminated water and soil. The diffuse re-circulation of PCBs from soils, sewage sludge etc. has been estimated to become the relatively most important source of PCBs in a long-term perspective (Annema, 1995).

21. Contamination of sewage sludge with PCBs possibly occurs via contamination through recycled hygiene paper. A summary of the data provided by various authors showed that at the end of the 1980s 100 % of the sewage sludge in the Federal Republic of Germany was contaminated with PCBs. The PCB contamination varied between 0,05 - 15 mg/kg dry material.

2. Monitoring data, quantification of sources and assessment of the extent of the problem

2.1 Monitoring Data

22. In the OSPAR Quality Status Report (QSR 2000), the assessment of monitoring programmes in the different regions of the North-East Atlantic is given and relevant information is extracted from this report in the following paragraphs.

23. Individual PCB congeners have a range of toxicity and physical properties, such as their solubility and vapour pressure. Thirteen of them, which have a flat (planar) structure, cause effects similar to those of the chlorinated dioxins, but they are not as potent as the most toxic dioxins. PCB concentrations are often reported as the sum of seven congeners (ΣPCB_7, IUPAC Nos. 28, 52, 101, 118, 138, 153, 180) or as 'total PCB'.

24. Concerning wildlife, the effects on reproduction of PCBs, along with other organochlorine contaminants, have been associated with the decline of the otter in European rivers, and the decline of dolphins and porpoises in the North Sea (Han, 1994; cited by WWF, 2000). Furthermore, the detrimental effects of certain organochlorine compounds and PCBs on the immune system may have been a factor in the disease epidemics in marine mammals. In the North Sea alone, such epidemics have killed literally thousands of animals (Hall *et al*., 1992; cited by WWF, 2000).

2.1.1 Sea water

25. PCBs are hydrophobic compounds; i.e. their water solubility is extremely low. Concentrations in ocean water are generally very low and this makes reliable quantification difficult. Concentrations of PCBs in filtered ocean water are usually reported to be in the low pg/l range.

2.1.2 Sediments

26. The ΣPCB_7 concentrations found in sediments depend not only on the distance from point sources, but also on the organic carbon content of the sediment. Therefore, in more contaminated estuarine areas, concentrations of several hundred µg/kg dry weight (dw) have been measured, and in areas distant to the coasts levels are relatively low (0,1- > 20µg/kg dw). These sediment-bound PCBs may re-enter overlying waters as a result of resuspension of the sediment.

2.1.3 Biota

27. As a consequence of their hydrophobic and persistent character PCBs are bio-accumulated and high concentrations are found in biota. PCBs are accumulated by marine organisms, especially within the fatty tissues of piscivorous birds and marine mammals. Abnormally high concentrations of PCBs were found during the early 1990s in cetaceans from Cardigan Bay in the southern Irish Sea and in otters from south-west Ireland.

28. Most of the reported concentrations of ΣPCB_7 in fish exceed the ecotoxicological assessment criteria (1 – 10 µg/kg fw), sometimes by several orders of magnitude. In the livers of whiting from Liverpool Bay and Morecambe Bay the levels of ΣPCB_7 recorded in 1996 were 1 900 µg/kg and 1 700 µg/kg ww, respectively. The range in cod liver from the OSPAR Region I (Arctic Waters is 28 to 615 µg/kg ww. Seabirds and marine mammals, at the top of the food chain, contain still higher ΣPCB_7 concentrations in some regions.

29. The declining use and progressive elimination of PCBs have been reflected in the decreasing concentrations observed in ten of the long-term monitoring programmes evaluated. An example is gannet eggs from Ailsa Craig and Scar Rocks where PCB concentrations decreased by more than 90 % between the 1970s and the mid-1980s. In recent years, a decline in PCBs has been observed in cod liver from Iceland and in seabirds from northern Norway and Svalbard. The same trend has been observed elsewhere, but the rate of reduction decreased in the 1990s and concentrations appear to have levelled off. There is however weak evidence that PCB concentrations in biota generally decreased. A small number of significant downward trends were observed along the south-west coast of Norway and in the southern North Sea (the Oyster Ground and along the west coast of Belgium).

30. With regard to the observed trends in relation to measures it is concluded in the QSR for Region II (Greater North Sea) that despite the ban on PCB use before 1980, only a slow downward trend could be observed due to the fact that polluted sediment acts as a source of these contaminants.

2.1.4 Safe destruction and environmentally sound disposal / incineration

31. The following are decontamination processes for PCB-contaminated equipment:

- removal of liquid PCBs from equipment to allow safe disposal or recycling of the solid components (heating might facilitate the drainage of the liquid);
- solvent extraction or heat treatment (170 – 550 ºC) of metal components;
- fine cleaning of metal parts in an ultrasonic bath;
- dissolving of the remaining porous substances (paper wrappings of the coils) in so-called Low Temperature Recycling;
- decontaminated equipment may then be recycled in conventional plants such as metal foundries;
- contaminated components can be treated in a destruction facility;
- contaminated solvents should be distilled;
- propane, butane or hexane can be used to treat soils and sludge;
- PCB containing residues have to be disposed in an environmentally sound manner;
- retro-filling: removal of PCBs from equipment (e.g. transformers), washing of internals with a solvent, refill with a substitute oil and return to service; disadvantages: complex internal parts are difficult to wash, process has to be repeated several times, PCB amounts remain after retro-filling, efficiency is difficult to assess.

32. Decontamination is never completely applied to all components, this means that a residue remains which must be incinerated. For capacitors this washing technique might not be appropriate because of its construction. They have then to be shredded or cut into pieces and incinerated.

2.1.5 Current PCB destruction technologies

33. A comprehensive overview is given in the UNEP Chemicals "Survey of currently available non-incineration PCB destruction technologies" (August 2000):

- incineration (minimum temperature 1200 ºC, 2-5 sec residence time, atmosphere with at least 6 % surplus oxygen and a turbulence of the gas stream equivalent to at least 65 000 Re);
- rotary kiln incinerators;
- liquid injection incinerators;
- static kiln incinerators;
- fluidised bed incinerators;
- cement kilns;
- dechlorination processes: designed to allow the reuse/recycling of chlorine free oil;
- chemical dechlorination: based on reactions with either an organically bound alkali metal or an alkali metal oxide or hydroxide;
- hydrotreating/hydration: treatment of oils with high pressure hydrogen gas in the presence of a catalyst; PCBs are thus converted to hydrogen chloride and hydrocarbons;
- solvated electron technology;
- Plasma Arc Systems: pyrolysis into ions and atoms at a temperature above 3000 ºC.

Table 2.1: Features of PCB destruction processes

Process	Waste types	Advantages	Disadvantages
Incineration (above 1200 ºC)	oils, residues from separation processes PCB-containing waste equipment	High destruction efficiencies, calorific contribution of waste facilities can treat chlorinated as well as non-chlorinated wastes	PCB content only as a fuel, solid feeds may require some pre-processing costly (1 000-3 000 US$/t)
Chemical dechlorination and hydrotreating	Liquid PCBs	Dechlorinated oil can be used for other purposes	need to establish treatment conditions for individual components
Plasma Arc Systems	Liquid PCBs and pumpable solids	Low process inventory	limited operational experience high investment costs

Data from United Nations Environment Programme: Inventory of world-wide PCB destruction capacity. First issue December 1998. Prepared by UNEP Chemicals.

34. UNEP Chemicals has prepared an inventory of world-wide PCB destruction capacity in 1998 performing information about different facilities, offered services and wastes and equipment accepted. The points included in paragraphs 31-34 have been extracted from a HELCOM document (HELCOM 2001).

2.2 Quantification of sources

35. In Germany (including the former GDR), the total production, up to 1985 when production ceased, amounted to 76 000 tonnes. In addition, 27 000 tonnes were imported, which brings the total amount of use of PCB to 103 000 tonnes. By subtracting exports amounting to 16 000 tonnes, a figure of approximately 87 000 tonnes is obtained for the quantity remaining in Germany.

36. Cumulative data for former West Germany for closed and open applications up to 1984 are shown in the following table (Table 2.2) with a total use of > 72 500 tonnes:

Table 2.2: Cumulative data on the PCB quantity used in former West Germany up to 1984

PCB applications (former West Germany)	Production [t]	Applied [t]
Closed systems (71%)		
Electrical Industry		
Askarel transformers	27 900	22 826
Capacitors	18 600	13 127
Mining	12 500	12 500
Oil radiators	< 0,05	
Coils	< 0,46	
Open systems (29%)		
Sealing materials, paints, plastics, etc.	24 000	> 24 000
Total	**83 000**	**approx. 72 500**

37. Because disposal of waste containing PCBs is subject to a mandatory registration, information on quantities of PCB already disposed of is available, and the quantity at present in use can be estimated. For example, Askarel transformers can be assumed to have a minimum service life of 25 years. As the oldest transformers were made in 1960, their replacement must have begun in 1985. At the end of 1988, 10 361 drained and cleaned askarel transformers were stored in West Germany in underground waste disposal

facilities. Assuming an average quantity of 870 kg PCB per transformer, a quantity of 9 014 tonnes PCB can be estimated to have been disposed of. This means that based on the cumulative applied quantity of 22 826 tonnes in 1984, in 1988, approximately 13 812 tonnes PCBs may be still in use in askarel transformers in the former West Germany.

38. In table 2.3, a rough material balance of PCBs is shown for Belgium, Germany (including data/estimates for the former GDR), the Netherlands, Norway and the UK. Most of the values have to be considered indicative and are extracted from different reports and from the responses from Contracting Parties to the Belgian OSPAR questionnaire on non-controlled uses of PCB in small units and in material/products.

39. Finland indicated that it had estimated that 2 000 tonnes of PCBs were used in closed applications and 350 tonnes in open applications during the 1960s. In 1997 in the UK, it was estimated that a significant proportion of PCBs was held in some 1 800 transformers and 450 000 capacitors (Department of the Environment UK, cited in WWF, 2000).

Table 2.3: Overview of a mass balance of PCB in Belgium, Germany, the Netherlands, Norway and the UK

	Estimate of PCB quantity marketed/ in use in					***Extrapolation of PCB quantity still in use in***	
	Belgium (1960-1980)	**Norway (1952-1980)**	**UK (1951-1976)**	**Netherlands (1990)**	**Germany (status 1989/1994)**	**Belgium in 1999**	**Germany in 1998**
Production/Import	-		66 500 t		approx. 103 000 t		-
Application		1 250-1 300 t	39 500 t		approx. 85 000 t		-
Closed systems/applications			**12 000 t** (4 000-4 500 t incinerated)		**approx. 60 000 t**	**ca 4 400-4 600**	**ca 1 600**
Askarel transformers	used 1 950-1 982	Disposed of, no registration realised	8 000 t remain for disposal corresponding to 40 000 - 50 000t of waste)	83 t in transformers in general	13 850 t 9 040 t disposed	4 000 t	520 t*
Transformers contaminated with PCBs	1 950-?				> 100 t	> 0	100 t*
Capacitors					11 080 t 12 710 t disposed		
Large capacitors	276 - 750 t	Disposed of, no registration realised		37 t	8180 t	174 - 352 t	10 t*
Small capacitors	1 000 t	150-190 t		52 t	2 900 t	250 t	950 t
Mining - hydraulic systems	-	-			12 500 t		disposed
Open systems/applications	**4 000 t**	**340**	**25 500 t**		**approx. 25 000**	**250**	**2 350 t**
Building products Grouting Sealant		240 - 260 t 40-60 200			-		2 250 t
Plasticisers/ paints	> 3 470	80 t			-	> 160	100 t

* According to the Hazardous Substances Ordinance (see § 1.9), these applications should not be in use anymore in Germany by the year 2000. No requests for exemptions to continue to use this equipment/material have been received by the 'Länder' administrations and also in a query to important users, no PCB containing equipment in use has been found (UBA, 1999).

2.2.1 Uncontrolled applications

40. Because of the definitions applied, a number of PCB-containing products and wastes there is no requirement to carry out an inventory under Council Directive 96/59/EC.[2] These include large volume wastes with a low PCB concentration (e.g. mineral oil contaminated with PCB) and products with a small volume of pure PCBs (e.g. capacitors in strip light fittings). Such uses are called 'uncontrolled' applications.

2.2.2 Open applications

41. The PCB quantities used in open applications are especially difficult to retrieve and estimate. All open applications can be considered uncontrolled. Until the use in open applications was banned in the early 1970s, approximately 25 000 tonnes PCBs went into open applications in Germany and 4 000 tonnes in Belgium (see table 2.3). With a service life of the relevant products of 15-25 years, most of these open applications would already have been forwarded to waste treatment by the year 1994.

42. On the other hand, it can be assumed that certain applications, for example in construction materials, were designed for longer periods of use (40 years for some paints and sealing materials). Consequently, sealing materials probably represent the most important still relevant source of emissions from open applications during the 1990s. Recent findings in Switzerland confirm that sealing materials could still represent an important source. Until now only a few samples have been analysed and the PCB concentrations found varied considerably. A monitoring campaign will be started in order to get an idea about the extent of the problem.

43. According to the German Federal Health Office, the total quantity of sealing material containing PCBs used in the construction sector was approximately 20 000 tonnes. In this context, sealants produced on the basis of polysulphide polymer (trade name Thiokol) are particularly relevant. In measurements conducted by the German Federal Environmental Agency at the beginning of the 90's PCB concentrations of 5 - 210 g/kg were found in 12 of 34 sealing materials examined. The 12 samples showed an average PCB content of 110 g/kg. A general estimate using this value for sealants containing PCBs results in 2 200 tonnes PCBs in this sector.

44. Another source of relevant emissions to the hydrosphere was the use of PCBs in the production of carbonless copy paper. This use is responsible for the fact that elevated PCB values were still measured in recycled paper for a long time after discontinuation of the production in 1972. In the first half of the 1980s values of > 10 ppm and at the start of the 1990s up to 4 ppm were found in Germany. The use of such recycled paper in toilet paper presumably led to a considerable contribution into the hydrosphere. However no exact quantitative data can be supplied.

45. Refurbishment of metallic constructions such as pylons and bridges coated with paints against corrosion can also be an important source for PCB emissions and emissions of other hazardous substances such as PAH or lead, if the work is not done properly. In Switzerland a guideline is in preparation defining strict rules to be followed when carrying out such work.

46. In Belgium, a more detailed inventory of PCB volumes in open applications has been established and the information is presented in tables 2.4-2.8.

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[2] For the purposes of this Directive:

'PCBs' means: - polychlorinated biphenyls,- polychlorinated terphenyls,- Monomethyl-tetrachlorodiphenyl methane, Monomethyl-dichloro-diphenyl methane, Monomethyl-dibromo-diphenyl methane, - any mixture containing any of the abovementioned substances in a total of more than 0,005 % by weight.

47. In the following tables an estimate of the emissions of PCBs from small, uncontrolled applications is shown. In the different columns the estimated PCBs quantities are shown with the titles "Estimate of PCB quantity marketed", "Extrapolation of PCB quantity still present in 2000" and "End of life in Environment in 2000 since 1980". Some explanation of the method used to make the estimates is necessary:

a. the distribution of quantities between the two last mentioned columns in the tables is calculated with regard to the period of use;

b. in the general approach, emissions during the "use" (and thus before the "end of life") have been intentionally omitted. If they had been taken into account, the "Quantity still present (in use) in 2000" figures would be slightly inferior whereas the "End of life in Environment" quantites would have been slightly superior. It has been assumed that the appliances/material at the end of the life are finally disposed of on landfills.

"Paints" (uncontrolled and open applications)

48. These PCB-containing paints can be found in some sectors (e.g. transport and infrastructure, households, office, SME, waste disposal....) and constitute an important source of emissions of PCBs during life cycle and at the end of life stage.

Table 2.4: Inventory of PCB-containing paints in Belgium

The "paint" terminology includes :	Period of Application	Estimate of PCB quantity Marketed	Life Cycle (in years)	Extrapolation of PCB quantity still present in 2000	Emission T/y in 2000	End-of-life in Environment in 2000 since 1980
Chlorinated rubber paint	Up to 1973	2 625 t	25	13 t	0 – 0,86	2 612 t
Vinyl chloride paint	Up to 1973	800 t	25	4 t	0 - 0,28	796 t
Latex paint	Up to 1963	45 t	40	6,4 t	0 – 0,65	38,6 t
Other paint	1960-1982					
Not specified						
	Total:	3 470 t		23,4 t ->	1,79 t/y	3 446 t
The yearly emissions are 0-7 % (RIVM 1995)						

49. The extrapolation of PCBs still present in Belgium in 1999 is calculated without considering emissions during life cycle.

50. It is important to note that the confinement of PCBs within paints (matrix) leads to emissions that are more important than for condensators (where PCBs are confined into a metallic capsule). This is due to the physical and photochemical alterations of these paints (emissions up to 7%). At the end of their technical life, the paints are taken away (chemical, thermic or physical treatment of the painted surfaces); in some cases, the treated material itself is destroyed. In all of these cases, the destruction of the old paint is the general rule. The destruction of the matrix gives rise to even higher emissions of PCBs. But these have not, so far, been documented.

Concrete (uncontrolled and open applications)

51. Concrete is a source of emissions in the air during use and during waste disposal. The concrete terminology includes:

- concrete additives
- grouting
- polymer composite cement (PCC)
- other

- not specified

Table 2.5: Emission inventory of PCB-containing concrete in Belgium

Countries	Concrete	Period of application	Estimate of PCB quantity Marketed	life cycle (in years	Extrapolation of PCB quantity still present in 1999	Emission t/year	End-of-life in Environment In 1999 since 1969
Belgium	PCC	1960 – 1969	40 t	40	2,9 t	0,198 t/y	37,16 t
The yearly emissions are 0-7 % (RIVM 1995)							*

Note that the "end of life" consideration for paints are also valid in this case.

Emission inventory of PCB-containing Mastic

52. Mastic is a source of emissions in air and in the waste disposal.

Table 2.6: Belgium

Countries	Mastic	Period of application	Estimate of PCB quantity marketed in Belgium	life cycle (in years)	Extrapolation of PCB quantity still present in Belgium in 1999	Emission t/year in 1999	End-of-life in environment in 1999 since 1973
Belgium	Thiokol	Up to 1973	63 t	40	5,46 t	0,38 t/y	57,54 t
The yearly emissions are 0- 7 % (RIVM 1995)							

53. The extrapolation of PCBs still present in Belgium in 1999 is calculated without dispersion and emissions during the life cycle. Note that the "end of life"" considerations for paint and concrete are also valid here.

Glue (uncontrolled and open applications) (table 2.7)

54. Glue is a source of emissions in air during use and during waste disposal. The glue terminology includes:

- glue;
- not specified.

Table 2.7: Emission inventory of PCB containing glue in Norway

Countries	glue	Period of application	Estimate of PCB quantity marketed	life cycle (in years)	Extrapolation of PCB quantity still present in 1999	Emission t/year in 1999	End-of-life in Environment In 1999 since 1975
Norway	1	1965-1975	250	40	35	2,45 t/y*	215 t

* the same emission coefficient as the one for thiokol (0 – 7%) has been used.
Note that the "end of life" considerations for paint, concrete and mastic are also valid here.

Other products

55. In 1983, the US-EPA made a list of potentially PCB-containing products, based on a theoretical study of 200 chemical processes that can generate PCB as a by-product. The processes were ordered according to

their potential for PCB creation; the substances produced this way and with a high potential were put on the EPA list. It is expected that these substances contain 25 – 50 ppm PCBs (see table 2.8).

56. No analysis data on the PCB content is available for any of these products, because the European industry is not bound to analyse PCBs in products.

57. In Belgium, PVC dust has been analysed[3] and PCB concentrations were about 40 ppb. This dust is used by companies who manufacture their PVC products by modifying the formulation with adjuvants and pigments. As the dust is reworked, contamination of PCBs might increase. No further data on these products are available.

Table 2.8: List of substances that contain PCBs and estimation of the by-production for the EU

Substances	**CAS**	**Europe** High volume chemical[4]
1,1,1 trichloroethane (methyl chloroform)	71-55-6	*
Monochloroethylene		
Tetrachloroethylene	127-18-4	*
Tetrachloromethane	56-23-5	*
1,2 dichlorobenzene	(m) 541-73-1 (o) 95-50-1 (p) 106-46-7	* * *
(1,2,3) trichlorobenzene	87-61-6	Not a high volume chemical
(1,2,4) trichlorobenzene	120-82-1	No data
1,3,5) trichlorobenzene	108-70-3	
Pentachlorophenol PCP	87-86-5	
Aluminium chloride	7446-70-0	*
Diphenyls oxide and derivates		
Phthalocyanine bleu and green pigments	147-14-8	*
Polysiloxane intermediate and silicone diffusion pump fluids		
Recycled oil		
2,4,5 trichlorophenol	95-95-4	
2,4,6 trichlorophenol	88-06-2	No data
1,2 dichloroethane (ethylene dichloride)	107-06-2	*
(1,2) dichloroethylene (acethylene dichloride)	540-59-0	
Trichloroethylene (trichloroethene)	79-01-6	*
Tetrachloroethylene (perchlorethylene)	127-18-4	*
Pentachloronitrobenzene (quintozene)	82-68-8	Not a high volume chemical
Benzene phosphorous dichloride		
Phenyl chlorosilanes		
Diarylide yellow and orange pigments		
alkylated dichlorobenzene		
PVC		
Chlorinated paraffins (SCCPs)	85535-84-8	
TOTAL for * (* means where high production data was found for the EU on the IUCLID CD Rom 2000)		1 810 000 - 4 750 000t/y
Production (based on a 25 ppm contamination)	-	45,25 – 118,75 t/y

58. The environmental contamination with PCBs from these products will occur rather quickly because of their use during a short period of time (for example, 5 years for plastic in cars).

3 International standard CEI 61619
4 IUCLID-CD Rom 2000

Closed applications

59. With regard to closed applications, PCBs are released through leaks and partly also as a result of fires when electrical plants and appliances containing PCBs burn. As most of the Askarel transformers and large power capacitors ought to be disposed of by the end of 1999, mainly small PCB containing capacitors are still in use.

60. To date, about a third of the small PCB-containing capacitors is still in use (see table 2.11). These mainly involve capacitors in strip light fittings. However, the number of capacitors that were installed in lights along motorways and municipal roads cannot be neglected. This use entails a possible danger to the public health because capacitors sometimes leak or even explode. Another likely area in which many PCB containing capacitors are found is in washing machines and domestic fuel oil burners and central heating circulation pumps. When waste is shredded, the small capacitors contribute largely to the contamination with PCBs.

61. The situation with regard to closed applications in Belgium is given in table 2.9.

Small capacitors

62. These are found in some important sectors/locations (e.g. agricultural activities, transport and infrastructure, households, office, waste disposal,) and constitute an important source of emission (end of life) and discharge (during life cycle).

Table 2.9: Belgium

The capacitor terminology includes :	Period of application	Estimate of PCB quantity marketed in Belgium	life cycle (in years)	Extrapolation of PCB quantity still present in Belgium in 2000	Emission t/y in 2000	End-of-life in environment in 2000 since 1980
1. Capacitors in strip light fittings (indoors),	1960-1982	690 t	20	127 t	2,03	563 t
2. public lights on motorways and national roads, municipal roads	1960-1982	103 t	25	33 t	0,53	70 t
3. capacitors in burners of CH installations	1960-1982	28 t	20	5 t	0,08	23
4. capacitors in pump of CH installations	1960-1982	73 t	15	7 t	0,1	66
5. capacitors in washing machines	1960-1982	29-100 t	15	14 t	0,224	86
6. capacitors in UPS installations	Up to 1982	> 0	3-5 small 15 large	> 0		0
7. electrical bushings						
8. other small capacitors (oil radiators)	1960-1986	23 t	25	12 t	0,192	11
9. not specified						
	Total:	1 017		198 t	3,16 t/y	819 t

CH: central heating
UPS: Uninterrupted Power Supply

63. It should be noted that the extrapolation of PCBs still present in Belgium in 2000 is calculated without considering dispersion and emissions during the period of use.

64. The last column gives an estimate of the amount of PCBs in the environment after the "end of the application's life" ». This particular period is complex as it is composed of a period of "retirement" followed, in the absence of identification criteria for the dangerous potential of these products, by a redirection to landfills, "household waste" incineration facilities or to metal recovery facilities. In all these cases, the period during which the condensator's "physical integrity" has been intact is difficult to estimate. Therefore, calculation hypotheses are, thus far, difficult exercises.

65. Furthermore, the list in table 2.11 gives an indication of the potentially relevant equipment sectors and illustrates the risk potential still existing in this sector.

Table 2.11: Occurrence of PCB capacitors in electrical equipment (Schiemann, 1996, cited in Ifeu, 1998)

Type of equipment	*Number of units examined*	*Equipment with PCB Capacitors*	*Proportion*
Office machinery	20	5	25,0
Extractor hood	12	4	33,3
Electric motor	11	2	18,2
Television	670	10	1,5
Dishwasher	143	6	4,2
Other domestic appliances	16	2	12,5
Cooling equipment	211	1	0,5
Copier	19	2	10,5
Strip light fittings	517	354	68,5
Oil burner	19	10	52,6
Radio/phono/others	89	3	3,4
Lawn-mower	13	0	0
Vacuum cleaner	55	1	1,8
Hood-type hair dryer	16	9	56,3
Washing machine	500	49	9,8
Laundry dryer	16	0	0
Commercial equipment	32	4	12,5
Other appliances	6	0	0
Total/Average	**2 365**	**462**	**19,5**

66. As in Belgium, it appears that small PCB containing capacitors are mainly still in use in strip light fittings in Germany.

67. For Germany, table 2.12 shows a PCB emission inventory estimated for the period 1994/95 by Ifeu (1998).

Table 2.12: CB emission inventory Germany (period 1994/95)

Source	PCB [kg]
open applications*	max. 16 000
Closed applications	max. 10 989
Diffuse land fill gas release	max. 5,9
Landfill gas incineration	0,02
Domestic waste incineration	0,32
Transport -diesel powered vehicles	0,26
sinter plants	92
Secondary steel production	206
fire places	789
Total:	30 894 kg
Source: Ifeu estimates (Ifeu, 1998) * only for PCB containing sealants	

68. The emissions of PCBs to air will ultimately end up in the soil or surface water through deposition. The PCBs in water will cling to the sediment because of the strong adsorption of these substances, which is why they can be found bound to soil particles. It can therefore be concluded that the emissions of PCBs will ultimately end up as a large-scale diffuse contamination of soil and sediments.

69. A summary of the assessment of PCB fluxes and inventories relevant to the OSPAR area is furthermore presented in Eurochlor, 1999, combining the information given in Axelman, 1997 and Ritter *et al*., 1996. It was estimated that the total amount of PCBs released to the environment in the Northern Hemisphere is about 100 000 tonnes, 75% having been released between 1955 and 1970. Current emissions are assumed to be between 10 and 100 tonnes per year both in the OSPAR area and in North America, the larger part of it coming from electrical equipment. A study carried out in Sweden indicated that in the OSPAR area, about 5 000 tonnes PCB could still be present in old buildings in the form of various surface coatings and sealant.

70. It was stated also in the Eurochlor report, 1999 that due to the persistent and semi-volatile character of PCBs "old emissions" are still present in the environment and are further spread via a distribution mechanism of deposition and volatilisation. The "new emissions" should then be considered in a global approach

71. In the following table 2.13 the results of Axelman (1997) are shown.

Table 2.13: PCB inventories and fluxes according to Axelman (1997; cited in Eurochlor, 1999)

	PCB #28	PCB#153
Emissions		
Total "old" emissions [t]	14 000	4 850
"New" emission [t/a]	6	0,6
Inventories		
in atmosphere [t]	62	17
in surface water [t]	6	7
in deep water [t]	45	54
in shelf sediment [t]	10	53
in soil [t]	917	760
in biomass and litter [t]	122	74
Total	**1 117**	**950**
Losses/degradation		
in atmosphere [t/a]	92	3,5
in sea water [t/a]	1	1,3
in sediment [t/a]	1	5
in soil and biomass [t/a]	0,3	0,2
Total [t/a]	**94,3**	**10**
Total [% inventory/a]	8	1

72. These results indicate that most of the existing PCBs are adsorbed to soil, litter and sediment. They are progressively volatilised to the atmosphere where the main but slow degradation takes place. The overall degradation process is however very slow, in particular for the highly chlorinated congeners. In this context the present emissions may act as a continuous supply to maintain constant atmospheric concentrations.

73. In the framework of an EU project on POP emissions in the Baltic region (Pacyna *et al*., 1999) the following estimates of emissions of PCBs are given.

74. The historic development of emissions of PCBs have been estimated with respect to national reduction measures and assumptions. Because there was only scarce information on measured emissions of PCBs, the emissions of PCBs in table 2.14 have therefore been calculated from statistical data on activity and population using default emission factors. For Germany for example, the estimates are higher than those presented by Ifeu. However, it is not possible to judge the reason for the difference between both emissions.

Table 2.14: Estimated PCB emissions [t/a] (Pacyna *et al*., 1999)

Year	BE	DK	FIN	FR	GER	LUX	NL	NOR	PT	SP	SWE	SWI	UK	Emission for Europe (including Eastern Europe)
1970	49,5	24,9	23,5	258,1	402,1	2,1	65,8	19,6	18,2	170,5	41,1	31,7	282,4	**1 729**
1975	40,3	20,5	19,3	214,8	323,8	1,8	55,1	16,2	17,9	143,6	33,7	25,9	228,0	**1 428**
1980	20,4	10,5	9,9	110,2	164,2	0,9	28,6	8,3	19,7	75,9	17,1	12,9	114,8	**757**
1985	20,2	10,4	9,9	111,7	160,1	0,9	29,2	8,4	20,1	77,7	16,9	13,2	114,7	**758**
1990	1,8	1,01	2,7	19,96	43,2	0,13	0,25	0,4	0,6	8,7	1,9	1,7	3,8	**116**
1995	1,8	1,02	2,7	20,4	42,4	0,13	0,25	0,4	0,6	8,7	2,0	1,7	3,7	**113**

2.3 Conclusions

75. Based on the above monitoring data and various data sources on remaining PCB sources and PCB emission estimates and also taking into account the uncertainty of these release estimates it can be concluded that the input into the environment has decreased significantly. A clear downward trend can be observed.

76. However, relevant emissions are estimated still to take place with regard to open and closed uncontrolled applications. For Belgium, the estimates show that these are of the same order as the ones from "controlled" applications (see table 2.15).

Table 2.15: Sum of all estimated emissions in Belgium

Applications		**Emissions in 2000 t/year**	
Small applications and products	Large applications	Small applications and products	Large applications (EMEP data)
Thiokol	-	0,38	-
PCC	-	0,2	-
Chlorinated rubber paint	-	0,86	-
vinyl chloride paint	-	0,28	-
latex paint	-	0,65	-
Capacitors in strip light fittings (indoors),	-	2,03	-
public lights on motorways and national roads, municipal roads	-	0,53	-
Capacitors in burners of CH installations	-	0,08	-
Capacitors in pump of CH installations	-	0,1	-
Capacitors in washing machines	-	0,224	-
Oil radiators	-	0,192	-
	Transformers & capacitors		5,2
Total		**5,52**	**5,2**

77. At this stage, we can observe that the emissions of PCBs from small, uncontrolled applications are still very important for 2000. They represent about a half of the total emissions from products in use.

78. It should be noted that, even for small uncontrolled applications, most emissions originate from the “end of life” applications (wastes).

79. With time, the “emissions from wastes” will predominate.

80. Although the above inventories give valuable information for the assessment of the emissions of PCBs and the size of the problem, one should be aware that estimates, thus far, remain very uncertain and often represent maximum levels based on a conservative approach.

81. As a conclusion it can be stressed that emissions of PCBs, on which law-makers and environmental authorities have focused for many years, still cannot be controlled comprehensively despite all abatement results. Since there is still a significant potential for emissions, further legal regulations containing binding specifications, in particular for waste disposal, may be required.

3. Existing legislative measures

3.1 International Agreements

82. OSPAR Decision 92/3 on the Phasing out of PCBs and Hazardous PCB Substitutes does not differentiate between “large” and “small” PCBs. Therefore, this Decision is understood to cover all applications of PCBs. The current round of implementation reporting provided an indication of the extent to which the Decision has been complied with and the problems which might have occurred. Because of the limited number of implementation reports submitted, only a short description of the information provided was possible. Nevertheless, from the information provided it may be concluded that in some Contracting Parties, intensified administrative action concerning safe disposal of e.g. small capacitors has taken place since the previous assessment carried out in 1997.

83. The HELCOM Recommendation 6.1 regarding the elimination of the use of PCBs and PCTs (1985) addresses the ban on the production and marketing of articles and equipment containing PCBs/PCTs from 1987 onwards. This Recommendation is complemented by a provision in the 1992 Helsinki Convention (Annex 1, part 2.2) banning all uses except in existing closed systems until the end of service life.

84. The UN-ECE Protocol on Persistent Organic Pollutants (POPs) requires ratifying countries (whose economies are not in transition) to destroy or decontaminate equipment containing more than 50 ppm PCBs (and liquid PCBs containing more than 50 ppm) by 2015. In the case of dioxins this Protocol also requires ratifying countries to reduce continually annual emissions (in relation to a specified base year), by the use of a number of measures outlined in the Protocol. These measures include the use of defined limit values (emission standards) and best available techniques. However, the Protocol acknowledges that the time may come when all such measures have been implemented and no further reductions can be achieved. It should also be mentioned that the UNEP Convention on Persistent Organic Pollutants includes, among others, a ban on PCB production and use as well as a requirement concerning the destruction of stockpiles and the handling of wastes.

85. Furthermore, it is worth mentioning some previous agreements:

- 1973 recommendation from OECD (control and restrict the flow of PCBs into the environment);
- 1976 WHO (discussing and evaluating the data available then on exposure level and effects of PCBs and PCTs on human health, and, to a lesser extent, on the environment;
- 1978 IARC (international agency for research on cancer);
- 1982 OECD (the 24 OECD member states have restricted the manufacture, sale, import, export, and use of PCBs, and established systems for these compounds).

3.1.1 EC Legislation

86. The use of PCBs in open applications such as printing inks and adhesives was banned in the European Community in 1976 under Council Directive 76/403/EEC.

87. The use of PCBs as a raw material or chemical intermediate has been banned in the EU since 1985 (Council Directive 85/467/EEC, 6^{th} amendment to Directive 76/769/EEC)

88. The disposal of PCBs and polychlorinated terphenyls (PCTs) has been regulated by Council Directive 96/59/EC. Key features of this Directive are:

- within 3 years of its adoption in 1996, EU Member States must submit an inventory and detailed plans for the disposal of the relevant PCB wastes and the decontamination/disposal of the relevant equipment. These will have to cover all equipment containing more than 5 litres of PCBs (see also paragraph 1.7).
- the year 2010 has been set as a deadline for complete disposal or decontamination of equipment containing PCBs (although OSPAR Contracting Parties should still be bound by the 1999 deadline set out in PARCOM Decision 92/3). The only exception is for transformers containing between 500 and 50 ppm of PCB, which are allowed to remain in service until their end of life.

89. With regard to national inventories within the framework of third Council Directive, it can be noted that many EU Member States appear to have difficulties in tackling and monitoring the remaining PCB containing equipment (see also paragraph 1.11).

3.1.2 National regulations

90. In all OSPAR Contracting Parties extensive regulations apply for the use of PCBs in open and closed systems. However, many countries have not taken their responsibilities regarding PCBs seriously enough. For example, Germany, Greece, Portugal, Spain and the UK are, or have been subject to legal action by the European Commission for failing to implement Council Directive 96/59/EC on the disposal of PCBs, which should have been transposed into national law by March 1998 at the latest.

91. In Germany an Executive Order implementing this Directive has been adopted (Executive Order of 26 June 2000, published BGBl. 2000 I, p. 932 - 936). A stricter cut off value of 1 litre instead of 5 litres with regard to liquid PCB waste has been set.

4. Identification of possible measures

4.1 Tackling the stock of PCB containing sediments

92. In Annema *et al*., (1995) the consequences for the PCB flux in the Netherlands were evaluated for the case that additional policy measures would be taken in the Netherlands with regard to:

- enhanced replacement of PCB containing equipment;
- elimination of upstream hot spots of contaminated river sediments through dredging; and
- dredging of the major downstream sedimentation areas.

93. Concerning the dredging of upstream hot spots it was recognised that the diffuse sources of PCB pollution are unknown (i.e. these hot spots are the result of past emissions and because of erosion in this area PCBs can be transported downstream to the Netherlands). It is therefore too difficult to reduce these PCB emissions by the development of additional measures in the Netherlands.

94. With regard to dredging the major downstream sedimentation areas with high PCB concentrations, it was stated that when disturbing the sediment layers from the 1960s and 70s, exposure may pose an acute risk, whilst otherwise the PCBs trapped in these layers appear to have only a limited impact. At locations with high levels in the top layers the risks of the presence of PCBs in the sediment would be significantly reduced by dredging and it was assumed that dredging the major sedimentation areas would result in a 20 % lower input into the North Sea.

95. With regard to the replacement of PCB-containing equipment it was estimated that in the Netherlands only slight changes in the fluxes of PCBs could be expected. It was therefore concluded in the Dutch report that a decrease in PCB fluxes could only be tackled with additional measures agreed at an international level, and by dredging the major sedimentation areas. Nevertheless, a 1998 report from the Netherlands to OSPAR on dumped dredged materials showed that the PCB content in the sediments that are annually dumped into the North Sea is rather low. The total input is less than 200 kg. Sediments are contaminated with PCBs and a lot of other hazardous substances. In theory it seems a good solution to remove and store contaminated sediments in landfills in order to stop the re-suspension of PCBs from sediments. However, it is not practicable in the Netherlands as the amount of sediment is so huge that it is physically (and also financially) impossible to store it all on land.

4.2 PCB re-introduction through recycling

96. Measures could also be taken in order to prevent the re-introduction of PCBs in applications via recycling. This appears to be of particular importance with regard to flame retardant cable sheathings that may contain significant amounts of PCBs. It could be envisaged that in this context the introduction of PCBs through recycling is controlled under the proposed Directive of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE).

97. In general terms, all equipment which needs electricity to work properly is either electrical or electronic. Each electrical or electronic product consists of a combination of several basic building blocks. The basic building blocks common to electrical and electronic equipment are among other things cables, plastics containing flame retardants and capacitors. The most environmentally problematic substances contained in these components are heavy metals, such as mercury, lead, cadmium and chromium, halogenated substances, such as chlorofluorocarbons (CFCs), polychlorinated biphenyls (PCBs), polyvinyl chloride (PVC) and brominated flame retardants as well as asbestos and arsenic.

98. Proposals for two Directives of the European Parliament and of the Council

- on waste electrical and electronic equipment and
- on the restriction of the use of certain hazardous substances in electrical and electronic equipment

are being developed by the European Commission and the EU Member States.

99. The first draft Directive includes provisions for the producer to bear the disposal costs. This is considered to contribute to an environmentally safe disposal which will also stimulate the producer to use less hazardous substances and those which are recyclable, and to construct long lasting electronic equipment. The aim of the second draft Directive is to restrict the use of hazardous substances in electrical and electronic equipment and to contribute to the environmentally sound recovery and disposal of waste electrical and electronic equipment.

100. In Sweden, a system will be introduced requiring dismantling of dangerous materials from electric and electronic wastes (E&E) by a certified operator before shredding, incineration or landfilling, and addresses producer responsibility for some types of E&E by 1 July 2001.

4.3 Stop feeding the waste stream – closed applications

111. A safe disposal of all PCB appliances is also advocated by Ifeu (1998). It was proposed that the crucial reduction measure consists of the elimination of capacitors containing PCBs via a separate controlled disposal route when disposing of equipment with such capacitors.

112. In the case of small electric appliances commonly found in domestic waste it should be ensured that these are not disposed of with domestic waste. A collection scheme for small electrical appliances is a prerequisite. Possible methods of achieving this include:

- possibility of delivering appliances to recycling centres/landfills sites;
- possibility of returning such appliances when bulky refuse is collected;
- possibility of returning such appliances in separate containers when bulky refuse is collected;
- collection on request;
- return to the retail trade.

113. It is assumed that in more than 200 of the altogether 500 waste collection areas in Germany small electric appliances are provided for by the local waste collection/delivery systems. Despite this, the main disposal path is still presumed to occur via household wastes. For the future it is considered to be necessary to adjust the collection schemes, where possible, and to increase public awareness and acceptance of the relevant collection schemes. With regard to closed applications it is suggested to have PCB-containing appliances separated, where possible, by the municipal scrap collection centres or by scrap merchants and the PCB-containing components removed.

114. The main problem with small electrical applications lies in the fact that it is very often too difficult to distinguish between small PCB-containing components and PCB-free ones. Therefore, it might be considered whether all small electrical equipment wastes collected should be destroyed by high temperature incineration (at the moment, they are directed towards normal household-waste incinerators).

4.4 Stop feeding the waste stream - open applications

115. For open applications it was stated in Ifeu, 1998 that PCBs are released via construction rubble or general scrap. The cost for separation is much higher than for closed applications and for practical reasons a safe disposal should be limited to suspected cases of PCBs. In such cases efforts should be made to separate the relevant components such as PCB-containing sealants prior to the demolition of the relevant building.

116. It might also be examined whether, before the demolition of buildings dating from the years 1950-1975, their different components should be analysed and decontaminated (concrete, “mastic”, paint).

117. In general it is concluded that in order to minimise emissions of PCBs, further logistic and educational measures among waste generators and recyclers, or further legal regulations containing binding specifications for dismantling should be developed.

118. In the construction sector, financial mechanisms could also be used by the governments to promote that employers communicate to the authorities on the existence of the applications of PCBs or waste which contains PCBs when they are confronted with this kind of material.

119. A program is running in Sweden for the identification of PCBs in buildings. A voluntary agreement for the replacement of material that poses a risk has been set up by the estate owners and the building industry.

4.5 Tackling wastes

120. Although important, this issue will not be tackled here because it is going far beyond the scope of this OSPAR background document. This problem concerns more substances than solely PCBs and merits a more horizontal "waste" approach. In this approach, amongst other things, tax legislation, rules on waste separation at source, rules on landfilling, detoxification of buildings and demolition wastes are elements that could be taken up and further refined, intensified and harmonised at EC level.

121. Eurochlor, 1999 considers that the rapid destruction of redundant PCBs should be mandatory at international level. In order to achieve this, environmentally sound technology should be applied.

4.6 Substitution of PCBs

122. For some applications or products, PCBs have been substituted by polyhalogenated biphenyl which are also substances of possible concern and short-chained chlorinated paraffins (SCCPs). SCCPs are on the OSPAR List of Chemicals for Priority Action. In the further development of the draft guidance document on substitution of hazardous chemical substances, attention should be paid to the application/product approach. In similarity with BAT, the consideration of BEP with regard to existing products might be a way forward.

4.7 PCBs as by-products

123. Enhanced or alternative production processes for new, bulky/high volume products might be explored to reduce the amount of PCBs occurring as by-product. This unintended annual production of around 100 tonnes/year of PCBs in the EU makes it one of the major sources of PCBs.

124. Furthermore, for PCBs in these bulk chlorinated chemicals (1 ppm), but even more in recycled products (recycled oils can contain up to 10 ppm), it might appear important to check the coherence between norms for PCBs in new and recycled products, if appropriate. This appears to be of particular importance with regard to flame retardant cable sheathings that may contain significant amounts of PCBs. Such sheathings should not be recycled it they contain more than 5 ppm PCBs (see also paragraph 4.6). The detection limit of current analysis methods will have to be taken into account when considering the setting up of limit values.

5. Choice for action / measures

125. PARCOM Decision 92/3 on the Phasing out of PCBs and Hazardous PCB Substitutes aims to prevent PCBs and hazardous PCB substitutes from entering the marine environment. Measures are to be taken to phase out, and to destroy in an environmentally safe manner, all identifiable PCBs as soon as possible with the aim of complete destruction, including the interim options of safe deep underground disposal in dry rock formation of capacitors and empty transformers.

126. Comparing the scope of the PARCOM Decision with that of Council Directive 96/59/EC, it is clear that the Council Directive does not cover the so-called uncontrolled PCB applications.

127. The findings of this background report suggest that the wording of PARCOM Decision 92/3 might have been too general in order to achieve optimal coverage of the problem. More specific measures should therefore be considered and should in particular address those areas where significant additional results could be achieved with reasonable effort. The measures that could be taken are outlined in Chapter 4.

128. At present the European Commission is preparing a Community Strategy to reduce the presence of dioxins and PCBs in the environment. The first informal expert meetings took place on 22 and 23 March 2001 in Brussels. At the meeting on 22 March, the question of sources of PCBs that are still relevant was stressed. It was recognised that by-product PCBs and PCBs in recycling processes may present a significant

source, that further data have to be compiled and that further measures may need to be taken with regard to these sources. Participants in these meetings were informed of the intention of the European Commission to publish, by September 2001, a Communication outlining this Dioxins and PCBs Strategy; they were also informed of the integrated nature of this strategy, linking public health and consumer safety with environment. The OSPAR lead countries Germany and Belgium encourage this integrated broader initiative.

5.1 Tackling the stock of PCB containing wastes & sediment

129. With regard to contaminated sediment as a relevant source, the present situation is that the level of PCBs in sediments is seldom the reason to remove the sediment and store it on land. As contaminated dredged materials are a secondary source of emissions, it is proposed to make dealing with the problems of combating the primary sources of PCB contamination the priority at this stage.

5.2 PCB introduction through recycling

130. The proposed Directives on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment and on Waste from Electric and Electronic Equipment (WEEE) will contribute to the reduction of emissions of PCBs. However,

> OSPAR Contracting Parties that are EU Member States should aim to include in the latter directive cut-off values for PCBs, such as 5 ppm for the purpose of recycling cable sheathings. However this value will be determined at a later stage pending the outcome of the development of a CEN standard for the analysis of PCB in products. This development should be supported by these states.

5.3 Stop feeding the waste stream – closed applications

131. As outlined in section 4.3, sufficient knowledge and administrative means should ensure a safe disposal for PCBs in closed applications.

5.4 Stop feeding the waste stream – open applications

132. As outlined in section 4.4, further logistic and educational measures should be adopted, and fiscal mechanisms introduced.

5.5 PCBs as by-products – redundant PCBs

133. PCBs that are by-products of bulky and high volume chemicals may represent a major source. In this background document, it is estimated that 100 tonnes/year may be released within the EU. BAT could be developed within the framework of the IPPC Directive to prevent this.

134. In order to reduce the releases derived from anthropogenic sources of PCBs with the goal of the continuing minimisation and, where feasible, ultimate cessation, the European Commission is currently developing a Community Strategy with regard to PCBs and foresees taking measures in accordance with the obligations of the UNEP POPs Convention.

135. In their present state, the discussions concerning the cooperation between OSPAR and the EC have stressed that the coordination of parallel programmes can be improved by, *inter alia*, “the EC utilising the work on programmes and measures, background documents and reports established in the framework of OSPAR”.

136. Therefore,

OSPAR should write to the European Commission in terms of a letter to be drafted by Belgium and Germany to bring this background document to the attention of the Members of the European Commission responsible for Environment and Public Health & Consumer Safety in order to contribute, in good time, (i) to the process of developing a Community strategy described above and (ii) to the inclusion of cut-off values for PCBs in the WEEE Directive.

137. It is recommended to OSPAR that Contracting Parties

continue to report on the implementation of PARCOM Decision 92/3 in the absence of more specific OSPAR measures.

138. To ensure that the information in this background document can be considered in the context of other international agreements which deal with hazardous substances and to which Contracting Parties are party,

OSPAR should send copies of this background document to the appropriate bodies dealing with those agreements and invite Contracting Parties who are common parties to OSPAR and those other agreements to promote action to take account of this background document by those other international bodies in a consistent manner.

139. PCBs are already covered by the Joint Assessment and Monitoring Programme and have been assessed extensively in the QSR 2000, which outlines the slow, but nevertheless clear, downward trend in the marine environment. Therefore,

it is recommended to OSPAR, in revising the Joint Assessment and Monitoring Programme,

(i) to agree:

- that monitoring should be carried out on a routine basis in sediments where PCB concentrations exceed the OSPAR ecotoxicological assessment criteria (EACs);
- on a less frequent surveillance for monitoring in the remaining areas.

  As within the programme for the Comprehensive Study on Riverine Inputs and Direct Discharges (RID) and in the Quality Status Report (QSR 2000) PCB concentrations have been below the detection limit in the water phase, it might be examined whether monitoring in the water phase should be restricted to suspended matter and sediments. Biota monitoring should also only be performed in areas where EACs in sediments have been exceeded;

(ii) to invite Belgium and Germany, on the basis of a survey of the available monitoring and research data, to identify any further gaps in knowledge and any monitoring and assessment tools that need to be developed, and to propose a monitoring strategy for PCBs based on the items in (i) above.

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Annex 1: Monitoring strategy for polychlorinated biphenyls

As part of the Joint Assessment and Monitoring Programme (*reference number 2003-22*), OSPAR 2004 adopted an Agreement on monitoring strategies for OSPAR Chemicals for Priority Chemicals (*reference number 2004-15*) to implement the following monitoring for tracking progress towards the objectives of the OSPAR Hazardous Substances Strategy (*reference number 2003-21*) with regard to polychlorinated biphenyls. The Monitoring Strategy for polychlorinated biphenyls will be updated as and when necessary, and redirected in the light of subsequent experience.

The potential sources of PCBs are known, but actual sources in all OSPAR countries are difficult to quantify.

OSPAR will seek to evaluate progress on the implementation of EC legislation and OSPAR measures addressing the phase out of PCBs and the cessation of further emissions and discharges from wastes and controlled applications, including information on the implementation of PARCOM Decision 92/3 on the phasing out of PCBs and hazardous PCB substitutes.

Disposal of waste containing PCBs is subject to a mandatory registration under Council Directive 96/59/EC, and therefore information on quantities of PCBs already disposed is available and the quantity at present in use can be estimated. The HARP-HAZ Guidance Document on PCBs as well as the OSPAR Background Document on PCBs provide an overview of all sources (closed application, open applications, new products) of PCB emissions to the environment, including an US-EPA study on the presence of PCBs in new products as unintended by-product. The EC strategy for dioxins, furans and polychlorinated biphenyls (COM(2001)593 final), which aims to reduce the presence of dioxins and PCBs, may provide additional data and includes the development of a PCB source inventory. In view of the available resources, developing a HARP-HAZ type inventory for all OSPAR countries would most probably be beyond OSPAR's capacities. Currently HARP-HAZ data on PCBs are available for Belgium only. Therefore, OSPAR will compile existing information, making use of the inventory to be prepared under the EC strategy, to develop an overview of amounts of PCBs from the various point and diffuse sources that may enter the environment.

OSPAR will continue to monitor inputs to the marine environment through CAMP and RID on a voluntary basis. CAMP measures the PCB-congeners 28, 52, 101, 118, 138, 153, 180 in precipitation and in air. RID measures the PCB-congeners 28, 52, 101, 118, 138, 153, 180. Since riverine input concentrations of PCBs in water are most often below detection limits, where monitoring is carried out under RID it should concentrate on suspended matter. OSPAR will also seek to make use of data on PCBs in the Arctic collected under the Arctic Monitoring and Assessment Programme.

OSPAR will continue to measure PCBs under the CEMP on a mandatory basis in biota (fish and mussels) and sediments for temporal trends and spatial distribution covering PCB-congeners 28, 52, 101, 118, 138, 153, 180. In the light of the assessment of CEMP data carried out in 2004/05 the coverage of PCBs by the CEMP will be reviewed, taking into account the current availability of data and the existing time series. The existing OSPAR dataset is much larger for biota than for sediments, and presently, time trend assessment is only possible for biota. The review should therefore consider whether it would be best to continue time series in biota, especially in areas with high concentrations. Less frequent surveillance monitoring or spatial surveys could be carried out in addition in sediment deposition areas (muddy sediments) like estuaries.

Background/Reference Concentrations have been established for PCB 153 and Σ PCB_7 in mussels and for individual congeners of PCBs in sediments of northern OSPAR sea regions. Ecotoxicological Assessment Criteria (EAC) have been derived for Σ PCB_7 in sediment, fish and mussels. It is not considered necessary to develop OSPAR EACs/BRCs as assessment tools further.

POLYCHLORINATED BIPHENYLS MONITORING STRATEGY	
Implementation of actions and measures	• Examination of progress in the implementation of regulations on marketing and/or use or emission and/or discharge which have been agreed, or are endorsed, by the Background Document
Emissions to air/Discharges and losses to water	• Compile overview of emissions, discharges and losses of PCBs from various point and diffuse sources in the Convention Area making use of the inventory to be prepared under the Community strategy for dioxins, furans and polychlorinated biphenyls
Atmospheric inputs	• Data will be used from the Arctic Monitoring and Assessment Programme (AMAP)
Riverine inputs	• Monitoring will continue under the RID study, as a voluntary determinand
Maritime area:	
Concentrations in sediments and biota	• Monitoring will continue under the CEMP

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