Risk Profile

and

Summary Report for

Short-chained Chlorinated Paraffins

(SCCPs)

Dossier prepared for the UNECE Convention on Long-range Transboundary Air Pollution, Protocol on Persistent Organic Pollutants

European Commission, DG Environment

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CONTENT

Executive summary ................................................................................................................ 3
Introduction ............................................................................................................................ 4

PART I – RISK PROFILE ......................................................................................................... 5
1 Chemical identity................................................................................................................. 5
   1.1 Names and registry numbers ................................................................................ 5
   1.2 Structure ................................................................................................................... 5
2 POP Characteristics............................................................................................................. 6
   2.1 Potential for long-range environmental transport......................................................... 6
      2.1.1 Vapour pressure and atmospheric half-life ............................................................ 6
      2.1.2 Monitoring data ..................................................................................................... 6
   2.2 Toxicity ....................................................................................................................... 8
      2.2.1 Environmental toxicity ........................................................................................ 8
      2.2.2 Human health toxicity ........................................................................................... 9
   2.3 Persistence .................................................................................................................. 10
      2.3.1 Abiotic degradation ............................................................................................. 10
      2.3.2 Biotic degradation ............................................................................................... 10
      2.3.3 Monitoring data ................................................................................................... 11
      2.3.4 Conclusion ........................................................................................................... 11
   2.4 Bioaccumulation ......................................................................................................... 11
      2.4.1 Log Kow .............................................................................................................. 11
      2.4.2 Bioconcentration factors ...................................................................................... 11
      2.4.3 Levels in biota ..................................................................................................... 11

PART II – SUMMARY REPORT ........................................................................................... 13
1 Extent of release to the environment ................................................................................. 13
   1.1 Production ................................................................................................................... 13
   1.2 Use .............................................................................................................................. 13
   1.3 Emissions and pathways to the environment .............................................................. 14
2 Environmental levels and bioavailability .......................................................................... 16
3 Socio-economic factors ..................................................................................................... 26
   3.1 National and International Regulation ........................................................................ 26
      3.1.1 European Union ................................................................................................... 26
      3.1.2 United States ......................................................................................................... 27
      3.1.3 Canada ................................................................................................................. 27
      3.1.4 International organisations .................................................................................. 27
   3.2 Alternatives / Substitutes ............................................................................................ 28
   3.3 Emission Control Techniques ..................................................................................... 28
   3.4 Costs and benefits of control ...................................................................................... 29
      3.4.1 Implications of Restrictions for Producers .......................................................... 29
      3.4.2 Implications of Restrictions for the Metalworking Sector .................................. 30
      3.4.3 Implications of Restrictions for the Leather Processing Sector .......................... 32
      3.4.4 Advantages and Drawbacks of Restrictions on SCCPs in Non-Emissive Applications ......................................................... 32

PART III – CONCLUSIONS ................................................................................................... 35

REFERENCES ..................................................................................................................... 36
Executive summary

Short chain chlorinated paraffins (SCCPs) are n-paraffins that have a carbon chain length of between 10 and 13 carbon atoms and a degree of chlorination of more than 48% by weight. These synthetic compounds are mainly used in metal working fluids, sealants, as flame retardants in rubbers and textiles, in leather processing and in paints and coatings.

The available data from remote areas show clearly contamination of biota and air by SCCPs. SCCPs are highly toxic to aquatic organisms. They do not break down naturally and tend to accumulate. Their persistence, bioaccumulation and toxicity mean that they may have damaging environmental effects at a global level. Overall, it can be considered that SCCPs fulfil the criteria of the Decision 1998/2 of the Executive Body (UNECE 1998) for persistence, potential to cause adverse effects, bioaccumulation and potential for long range environmental transport.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Meets the criterion (Yes/No)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential for long-range atmospheric transport</td>
<td>Yes</td>
<td>Vapour pressure &lt;1 Pa and estimated half-life in air 1.9 - 7.2 days; several monitoring studies from remote regions (incl. biota) suggesting significant long-range atmospheric transport.</td>
</tr>
<tr>
<td>Persistence</td>
<td>Yes</td>
<td>Not readily or inherently biodegradable. No simulation tests available; monitoring data from sediments suggest half-life &gt; 1 year.</td>
</tr>
<tr>
<td>Bioaccumulation</td>
<td>Yes</td>
<td>Log Kow 4.39 – 8.69; BCF in fish 1 173 – 7 816 and in mussels 5 785 – 40 900; high bioaccumulation potential supported by an in situ study and monitoring data.</td>
</tr>
<tr>
<td>Toxicity</td>
<td>Yes</td>
<td>Highly toxic to aquatic organisms; possible carcinogen in humans.</td>
</tr>
</tbody>
</table>

The most critical part of the assessment concerns persistence, due to the scarcity of experimental data. However, the available laboratory data together with monitoring results support the conclusion that SCCPs are persistent in the environment.
Introduction

Short chain chlorinated paraffins (SCCPs) are n-paraffins that have a carbon chain length of between 10 and 13 carbon atoms and a degree of chlorination of more than 48% by weight. These synthetic compounds are mainly used in metal working fluids, sealants, as flame retardants in rubbers and textiles, in leather processing and in paints and coatings. Due to the risks caused by the substance to the health and environment the marketing and use of these substances has been restricted in the European Union. There is a weight of evidence that SCCPs are persistent, bioaccumulating and toxic and have potential for long-range environmental transport.

This dossier is mainly based on the extensive EU Risk Assessment Report on SCCPs (European Commission 2000), which is publicly available at: http://ecb.jrc.it/existing-chemicals/. That report and its draft update (European Commission 2005) serve as important sources of detailed technical information on SCCPs. Therefore this dossier is only summarising the main information relevant to the POP review.

A large amount of other relevant summary reports and documents has been published on SCCPs in recent years and can be of value in the POP review. First and foremost, the final draft dossier prepared by Canada (UNECE 2003) is a comprehensive review of highly relevant information and should thus be used in parallel to this dossier. There are also other important summary reports such as the Environmental Health Criteria report on chlorinated paraffins (WHO 1996).
PART I – RISK PROFILE

1 Chemical identity

1.1 Names and registry numbers

Short chain chlorinated paraffins (SCCPs) are n-paraffins that have a carbon chain length of between 10 and 13 carbon atoms and a degree of chlorination of more than 48% by weight. There is a range of commercially available C\textsubscript{10-13} chlorinated paraffins and they are usually mixtures of different carbon chain lengths and different degrees of chlorination although all have a common structure in that no secondary carbon atom carries more than one chlorine.

Two other groups of chlorinated paraffins are made commercially. These are known as “mid, medium or intermediate chain length” (typically C\textsubscript{14-17}) and “long chain length” (typically C\textsubscript{20-30}). This dossier concerns only the short chain length (C\textsubscript{10-13}) chlorinated paraffins.

SCCPs are viscous, colorless or yellowish, dense oils. They are practically insoluble in water.

IUPAC Name: Alkanes, C\textsubscript{10-13}, chloro
CAS No: 85535-84-8
EINECS No: 287-476-5
Synonyms: alkanes, chlorinated; alkanes (C\textsubscript{10-13}), chloro-(50-70%); alkanes (C\textsubscript{10-13}), chloro-(60%); chlorinated alkanes, chlorinated paraffins; chloroalkanes; chlorocarbons; polychlorinated alkanes; paraffins chlorinated.

1.2 Structure

Molecular formula: C\textsubscript{x}H\textsubscript{2(2x-y+2)}Cl\textsubscript{y}, where x=10-13 and y=1-13
Molecular weight: 320-500

The structure of two example SCCP compounds (C\textsubscript{10}H\textsubscript{17}Cl\textsubscript{5} and C\textsubscript{13}H\textsubscript{22}Cl\textsubscript{6}) is shown below.
2 POP Characteristics

2.1 Potential for long-range environmental transport

According to the Decision 1998/2 of the Executive Body (UNECE 1998), potential for long-range transboundary atmospheric transport is determined by evidence that the substance has a vapour pressure below 1 000 Pa and an atmospheric half-life greater than two days. Alternatively, monitoring data showing that the substance is found in remote regions may be used as evidence.

2.1.1 Vapour pressure and atmospheric half-life

Drouillard et al. (1998) has determined vapour pressures for a range of SCCPs. They found that vapour pressure decreases with both increasing chain length and degree of chlorination. In the EU Risk Assessment Report (European Commission 2000), an assumed vapour pressure of a SCCP with chlorine content of approximately 50% of 0.0213 Pa at 40°C is used.

SCCPs are generally assumed to be photochemically stable. In the EU Risk Assessment Report (European Commission 2000), estimated atmospheric half-life is reported to be 1.9 - 7.2 days.

Both the estimated vapour pressure and the atmospheric half-life of SCCPs indicate that long-range environmental transport is a possibility according to the criteria of the Decision 1998/2 of the Executive Body (UNECE 1998).

2.1.2 Monitoring data

Concentrations of SCCPs have been measured in environmental samples from remote areas, far away from known sources, confirming that these substances have potential to be effectively transported over long distances.

The following information presents a summary of the relevant monitoring data from remote regions reviewed in the draft updated EU Risk Assessment Report (European Commission 2005):

Air

The levels of SCCPs in air have been determined in samples from a remote area in the Canadian Arctic (sampled between September and December 1992) (Peters et al., 1998). The analytical method used could determine chlorinated paraffins with chain lengths between C_{10} and C_{13} with between 5 and 9 chlorine atoms per molecule. The mean total (vapour + particulate phase) levels found were 20±32 pg/m$^3$ at the remote site.

Tomy (1997; as reported in Tomy, 1998) found that SCCPs (60-70% wt. Cl) were present in air from Egbert, Canada at a concentration of 65-924 pg/m$^3$ (mean 543 pg/m$^3$). The samples were 24-hour composite samples collected daily over a 4 month period during the summer of 1990. Muir et al. (2001) reported short chain chlorinated paraffins to be present at a concentration of 249 pg/m$^3$ in air overlying the west basin of Lake Ontario.
The levels of SCCPs in air from the Arctic have also been reported by Bidleman et al. (2001). The air samples were collected from January 1994 to January 1995. The concentrations of SCCPs in samples from Alert were found to be highest in the late summer months. The levels found ranged from 1.07 to 7.25 pg/m$^3$ and were dominated by the contributions from chlorodecanes (C$_{10}$ fractions).

The levels of SCCPs in Arctic air have also been investigated by Borgen et al. (2000). In this study samples (total volume 1,700-2,850 m$^3$) were collected during March to May 1999 at Mt. Zeppelin, Svalbard. The levels refer to the concentration in the vapour phase plus the particulate phase. The paper indicates that the levels found were of a similar order of magnitude to those in the field blank samples, but that the samples did contain higher amounts of the more volatile SCCPs than the blanks, indicating that transport of SCCPs by air may be occurring. The paper also indicated that the presence of contaminants such as phthalates may have caused some interference in the analysis, leading to an underestimate of the actual concentration of SCCPs.

A further study by Borgen et al. (2002) investigated the levels of SCCPs in ambient air from Bear Island in the Arctic. The samples (total volume sampled was 3 252 - 8 160 m$^3$) were collected during May to November 2000. The concentrations of SCCPS (with 5-10 chlorine atoms/molecule) found in samples varied from 1.8 to 10.6 ng/m$^3$. The levels again refer to the concentration in the vapour plus particulate phase.

Sediment

Tomy et al. (1997b and 1999) reported the following levels of SCCPs in surface sediments from the Canadian mid-latitude and Arctic regions: 176 µg/kg dry weight and 8 µg/kg dry weight in samples from Lake Winnipeg (south and north respectively), 257 µg/kg dry weight in samples from Fox Lake (Yukon), 18 µg/kg dry weight in samples from Lake Nipigon (northwest Ontario), 1.6 µg/kg dry weight in samples from Lake Ya Ya and 4.5 µg/kg dry weight in samples from Hazen Lake (Arctic). The chlorine content of the chlorinated paraffins found was in the range 60-70% wt. The concentrations of chlorinated paraffins in deeper layers were lower than found in the surface layers (the surface layer samples generally corresponded to around 1980-1992). Based on these data, the yearly surface flux of chlorinated paraffins to the Hazen Lake was estimated 0.89 µg/m$^2$. The flux was thought to be mainly as a result of atmospheric transport.

Stern (2003; as reported in UNECE, 2003) has investigated the levels of SCCPs in a lake sediment core taken from a lake on Devon Island, Nunavut, Canada. The levels of SCCPs in layers dating back to 1931 were low (<0.2 µg/kg dry weight), but were found to increase steadily in layers from 1943 onwards, reaching 0.8 µg/kg dry weight in the layer corresponding to 1956. The concentration was then found to decrease to <0.2 µg/kg dry weight between 1970 and 1980, but then showed an increasing trend up to 0.9 µg/kg dry weight in 1997 (the last year measured). These samples were taken from a very remote lake in the Arctic (75°34’N; 89°19’W) and provide evidence for transport to and deposition in the Arctic (UNECE 2003).
Levels of SCCPs in marine mammals from various regions of the Arctic have been reported (Stern et al 1997). The levels found were: beluga (western Greenland) 199 µg/kg wet wt; beluga (Mackenzie Delta) 206 µg/kg wet wt; seal (Ellesmere Island) 526 µg/kg wet wt; walrus (western Greenland) 426 µg/kg wet wt. Beluga from the St Lawrence River estuary had levels of 785 µg/kg wet wt. In the same study, short chain length chlorinated paraffins, at levels of 10.6-16.5 ng/g lipid (mean 12.8 ng/g lipid) were detected in three samples of breast milk taken from Inuit women living in settlements along the Hudson Strait.

Tomy (1997; as reported in Tomy, 1998) found SCCPs (60-70% wt. Cl) to be present in blubber from marine mammals from Canada and Greenland. The levels found were 370-1 363 µg/kg dry weight in Beluga from the St. Lawrence River, 106-253 µg/kg dry weight in Beluga from northwest Greenland, 178-302 µg/kg dry weight in Beluga from Hendrickson Island, 362-490 µg/kg dry weight in walrus from northwest Greenland and 374-767 µg/kg dry weight in ringed seal from southwest Ellesmere Island.

The levels of SCCPs in carp from Hamilton Harbour (western Lake Ontario), lake trout from Port Credit (northwestern Lake Ontario) and Niagara-on-the-Lake (south-western Lake Ontario) and beluga whale from the St. Lawrence River estuary and southeast Baffin Island in the Canadian Arctic have been determined by Muir et al. (2001).

**2.2 Toxicity**

According to Decision 1998/2 of the Executive Body (UNECE 1998), a substance may be considered as toxic if it has potential to adversely affect human health and/or the environment.

**2.2.1 Environmental toxicity**

Measurements of both short- and long term toxicity are available for fish, invertebrates and algae. These studies have been reviewed in the EU Risk Assessment Report (European Commission 2000) and its recent update. The following is a summary of the reviewed information.

SCCPs are of low acute toxicity to fish with 48- and 96-hour LC$_{50}$s in excess of the water solubility of the substance. Chronic toxicity values include a 60-day LC$_{50}$ of 0.34 mg/l for rainbow trout and no observed effect concentrations of <0.040 and 0.28 mg/l for rainbow trout and sheepshead minnow respectively.

For aquatic invertebrates, SCCPs are of high toxicity with 24-hour EC$_{50}$s with daphnids ranging from 0.3 to 11.1 mg/l and with acute NOECs ranging from 0.06 to 2 mg/l. In 21-day tests with daphnids, EC$_{50}$s ranged from 0.101 to 0.228 mg/l and NOECs ranged from 0.005-0.05 mg/l. For algae, 96-hour EC$_{50}$s ranged from 0.043 to 3.7 mg/l, with the marine alga *Skeletonema costatum* appearing to be more sensitive to SCCPs than the fresh water alga *Selenastrum capricornutum*. A NOEC of 0.012 mg/l was reported in the study with *S. costatum*. The toxic effects seen with the marine alga were transient, with no effects being seen at any concentration after seven days exposure.
In summary, the lowest “no observed effect concentration” from the available values is 5 µg/l for a 21 day multi-generation study on the water flea *Daphnia magna* using a 58% chlorinated C_{10-12} chloroalkane. (European Commission, 2000).

### 2.2.2 Human health toxicity

There is a reasonable database for SCCPs as a group from animal studies. The following is a brief summary of the relevant information reviewed in the EU Risk Assessment Report (European Commission, 2000).

The available animal data do not allow a direct comparison, for every toxicological endpoint, of the effects of SCCPs with differing chain length and degree of chlorination. However the information available from acute studies and skin irritation studies indicates that the intensity and nature of effects for these endpoints are independent of chain length and degree of chlorination. Assessment of the available data clearly indicates that SCCPs are of low acute toxicity in animals. Overall the evidence indicates that SCCPs are not mutagenic. No information is available on carcinogenicity studies in human populations potentially exposed to exclusively SCCPs. In rodent carcinogenicity studies, dose-related increases in the incidence of adenomas and carcinomas were observed in the liver, thyroid and kidney. Other cancers seen were dismissed as not significant. Consideration of the likely underlying mechanisms for these tumours suggests that they are not relevant to human health.

There are no data available in humans or animals on fertility although no changes were seen in the reproductive organs in rats and mice treated for 13 weeks with up to 5 000 and 2 000 mg/kg/day, respectively, of a SCCP. There are no data available on developmental effects in humans. A SCCP produced developmental effects in rats at a dose which also caused maternal toxicity (2 000 mg/kg), but no developmental effects at lower doses (500 mg/kg and below). No developmental effects were observed in a study in rabbits, although maternally toxic doses were not tested.

Overall, SCCPs are of low toxicity with the principal toxicological issue being for general non-specific toxicity following repeated exposure. NOAELs for general toxicity of 100 and 1 000 mg/kg/day were identified in rats and mice respectively.

The relevance of the finding that medium-chain length chlorinated paraffins can cause a severe effect (internal haemorrhaging leading to deaths) in suckling rat pups has been recently discussed (European Commission, 2005).

The current EU hazard classification for SCCPs is: Carc. Cat. 3; R40 - N; R50-53 (Risk Phrases: R40: Limited evidence of a carcinogenic effect; R50/53: Very toxic to aquatic organisms; may cause long-term adverse effects in the aquatic environment.). Also the International Agency for Research on Cancer (IARC) has designated SCCPs (as a group) as possible carcinogens.

Based on the available information, it can be considered that SCCPs fulfil the criteria of the Decision 1998/2 of the Executive Body (UNECE 1998) with regard to the potential for adverse effects on human health and the environment.
2.3 Persistence

According to Decision 1998/2 of the Executive Body (UNECE 1998), a substance may be considered as persistent if the substance’s half-life in water is greater than two months, or that its half-life in soils or sediments is greater than six months, or that there is alternative evidence that the substance is otherwise sufficiently persistent to be of concern.

2.3.1 Abiotic degradation

In the aqueous phase, rates of hydrolysis, photolysis with visible or near UV radiation, oxidation and volatilization are insignificant under ambient temperatures (Government of Canada 1993). Second order reaction rate constants have been calculated for C_{10-13}, 49-71% wt Cl, chlorinated paraffins as $2.2 \times 10^{-12}$ cm$^3$ molecule$^{-1}$ s$^{-1}$ for reaction with hydroxyl radicals. Assuming an atmospheric concentration of hydroxyl radicals of $5 \times 10^5$ molecules/cm$^3$, allows atmospheric half-lives of 1.9-7.2 days to be estimated (European Commission, 2000).

2.3.2 Biotic degradation

SCCPs are not readily or inherently biodegradable in standard tests. It can be concluded from the simulation tests that SCCPs with low chlorine contents (e.g. <50% wt Cl) may biodegrade slowly in the environment, particularly in the presence of adapted microorganisms. Certain bacteria have also been shown to dechlorinate SCCPs with high chlorine contents in a cometabolic process and so under certain conditions, biodegradation of these compounds might also be expected to occur slowly in the environment. No information on the anaerobic biodegradation of SCCPs is available (European Commission, 2000). In the EU, under the framework of Regulation 793/93, a simulation test for the determination of the half-life in the marine environment has been requested from the industry in April 2005. This test is meant to confirm whether SCCPs meet the criterion for persistence as laid down in the EU Technical Guidance Document for Risk Assessment.

In its opinion given in 2003 (CSTEE 2003), the EU Scientific Committee on Toxicity, Ecotoxicity and the Environment came to the conclusion that SCCPs are potentially persistent (P) and possibly very persistent (vP). The Committee emphasised the evidence that SCCPs are occurring in remote areas and were of the view that this is particularly important evidence that gives further support to the P/vP classification.

2.3.3 Monitoring data

SCCP residues have been detected in sediment cores dating back to the 1920s and 1930s at these locations. SCCPs were not manufactured in Canada until the 1940s but the residues observed in slices dated earlier can be explained by diffusion of residues vertically through the sediment core or contamination as an artefact of core sampling. Weight of evidence indicates that the half-life of SCCPs in sediment is greater than 1 year (UNECE 2003).

Furthermore, it should be noted that SCCPs have been detected in the remote Arctic and in marine biota (including top predators such as seals and whales) (see chapter 2.1), indicating that the substance is sufficiently persistent to reach the remote areas and accumulate to biota.
2.3.4 Conclusion

Even if half-life values are not available for water, sediment or soil, the above evidence can be considered as indicating that SCCPs are persistent in water and sediment, pursuant to Decision 1998/2 Paragraph 1(c) of the Executive Body (UNECE 1998).

2.4 Bioaccumulation

According to the Decision 1998/2 of the Executive Body (UNECE 1998), a substance may be considered as bioaccumulative if the bioconcentration factor (BCF) or bioaccumulation factor (BAF) for the substance is greater than 5 000 or the log Kow is greater than 5.

2.4.1 Log Kow

Reported log Kow of different SCCPs range from 4.39 to 8.69 indicating a high potential for bioaccumulation (European Commission 2000).

2.4.2 Bioconcentration factors

High bioconcentration factors in fish have been reported in the scientific literature (European Commission 2000). In one of the key studies, whole body bioconcentration factors (BCFs) of 1 173-7 816 were determined based on radioactivity measurements in the fish and BCFs of 574-7 273 were determined based on the parent compound analysis (Madeley and Maddock 1983a). Chlorinated paraffins were taken up rapidly; uptake may be slower at the higher end of the chlorination range.

Depuration half-lives in different fish tissues have been reported in Madeley and Maddock (1983b): liver 9.9-11.6 days; viscera 23.1-23.9 days; flesh 16.5-17.3 days; and whole body 18.7-19.8 days. It has been suggested that more rapid depuration from the liver, as compared to whole body, is indicative of metabolism and excretion. Other studies suggest that 71% or 69% chlorinated compounds may be retained longer (European Commission, 2000).

In addition to these experimental values from laboratory studies, BCF values have been estimated in situ for lake trout (Salvelinus namaycush) in western Lake Ontario. The overall BCF for SCCPs (C₁₀–₁₃) in lake trout from western Lake Ontario was 36 500 (UNECE 2003).

Bioconcentration in mussels has also been assessed with reported whole body BCFs ranging from 5 785 to 40 900 (European Commission 2000).

2.4.3 Levels in biota
Levels in biota from remote areas are reported in chapter 2.1. This part only summarises some relevant findings in other areas.

SCCPs have been found present in a wide range of aquatic organisms, including fish and marine mammals at locations both close to industrial sources and from more remote locations. The levels found are generally up to a few mg/kg. Moreover, SCCPs are present in various terrestrial mammals, bird livers and muscle, in various foodstuffs and in human breast milk samples. (European Commission 2005)

Concerning the levels of SCCPs in breast milk, mean levels of 12-20 µg/kg (lipid) have been reported in a recent study (Thomas and Jones 2002, Thomas et al. 2003) in the United Kingdom. These levels seem to be similar to those found in an earlier study (Tomy 1997, as reported in Tomy, 1998) in northern Canada (mean level 13 µg/kg lipid) but slightly higher than levels found earlier in Germany (mean level 3 µg/kg lipid) (European Commission 2000).

Based on the BCFs found in fish and mussels, reported log K_{ow} ranging from 4.39 to 8.69, and findings of SCCPs in biota it is concluded that SCCPs are bioaccumulating substances according to the criteria stipulated in Decision 1998/2 of Paragraph 1(d) of the Executive Body (UNECE 1998).
PART II – SUMMARY REPORT

1 Extent of release to the environment

1.1 Production

According to the EU Risk Assessment Report, in 1994 C{sub}10-13 chloroalkanes were manufactured by two producers within the EU, and with a total production of < 15 000 tonnes/year (European Commission 2000). According to the updated draft Risk Assessment Report (European Commission 2005), SCCPs are still produced in the EU but the quantities cannot be made available for confidentiality reasons. According to the same report, chlorinated paraffins are also manufactured in Asia and North America.

For comparison, the total production of SCCPs, MCCPs and LCCPs in China in 1997 was about 100 000 tonnes (OSPAR 2001).

In the context of the UNECE POP Expert Group, a questionnaire concerning SCCPs was sent to all UNECE countries. The results are summarised in the Canadian draft dossier on SCCPs (UNECE 2003) and they cover both historical and current production of SCCPs. Countries confirming historical production of SCCPs were Germany, Slovakia, the UK and USA. Current production of SCCPs was confirmed by the Czech Republic, the UK and USA (20 000 metric tones/year).

The UNECE questionnaire also covered import information. Belgium, Canada, Denmark, Finland, Germany, Norway, Spain, Sweden, Switzerland and USA indicated historical imports. Except for Germany, Spain, and Norway the same countries also confirmed current imports. Annual import quantities ranged from 10 tonnes per year to 5 500 metric tones per year.

1.2 Use

The main uses of SCCPs have been in metal working fluids, as plasticiser in paints, coatings and sealants, as flame retardant in rubbers and textiles, and in leather processing (fat liquoring).

Table 1 provides the use distribution within the EU in 1998. This data shows that the use of SCCPs has been reduced from 13 000 tonnes in 1994 to 4 000 tonnes in 1998 (OSPAR, 2001). The main use in 1998 was still in metal working fluids, in spite of a considerable reduction of 7 362 tonnes. Overall there has been a reduction of nearly 70% over the period 1994 to 1998.
Table 1: Use of SCCPs in Europe (OSPAR 2001).

<table>
<thead>
<tr>
<th>Application</th>
<th>tonnes/year in 1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal working fluids</td>
<td>2 018 (49.5%)</td>
</tr>
<tr>
<td>Paints, coatings and sealants</td>
<td>726 (17.8%)</td>
</tr>
<tr>
<td>Rubber/flame retardants/</td>
<td>638 (15.7%)</td>
</tr>
<tr>
<td>Leather fat liquors</td>
<td>45 (1.1%)</td>
</tr>
<tr>
<td>Other</td>
<td>648 (15.9%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4 075</strong></td>
</tr>
</tbody>
</table>

Due to the implementation of EU Directive 2002/45/EC, the use of SCCPs in Europe has been rapidly decreasing. The draft updated EU Risk Assessment Report (European Commission 2005) refers to information that there has been a further decrease in the use of SCCPs in all applications since 2001. The EU consumption in textiles and rubber had decreased by a factor of three in 2003 compared to the 2001 level. The consumption in paints and sealants/adhesives also decreased by a factor of two over the same time period. Some use in metal working fluids was still occurring in 2003, but this use was expected to cease by 2004. The overall amount of SCCPs used in the remaining applications in 2003 was less than 1 000 tonnes.

The results of the UNECE questionnaire (UNECE 2003) indicate historical uses of SCCPs in Belgium, Canada, Czech Republic, Denmark, Finland, Georgia, Germany, Netherlands, Norway, Spain, Sweden, Switzerland, UK and USA. Except for Norway and Spain, SCCPs were also reported to be currently in use in the same countries. Uses reported were mainly those listed in Table 1. In addition, Georgia reported minor uses for laboratory purposes or other non-commercial small scale uses, Belgium reported use in softener for PVC and Finland in dye additives. Annual quantities used ranged from 10 tonnes per year to the USA’s 25 500 metric tonnes/year which assumed that all domestically manufactured and imported quantities were used in the USA. In Canada, 1995 surveys indicated that SCCPs were used primarily as lubricants in the metal working industry, with other uses including rubber, sealants and flame retardants for rubber and soft plastics (UNECE 2003).

Further information on types and amounts of uses can be found in the EU Risk Assessment Report (European Commission 2000).

1.3 Emissions and pathways to the environment

The Environmental Health Criteria report (WHO 1996) contains a general description of environmental losses of chlorinated paraffins. These substances are not known to occur naturally in the environment. Since chlorinated paraffins are produced without contact with water, the possibility of leakage into the environment by direct water discharge is low. After chlorination the solvent is removed and residual amounts of chlorine gas and hydrogen chloride are removed by blowing air or other gases through the product. This could possibly
lead to some loss into the air, but since the chlorine gas and hydrochloric acid are recovered and the volatility of chlorinated paraffins is very low, the loss is likely to be very low.

Some loss into the environment could be expected during transport and storage. If the drums which are used for the transport of chlorinated paraffins are cleaned for further use environmental release might occur. Soil could be contaminated if empty drums are dumped at landfills. Spills may occur, but clean-up using an adsorbent material is easy. The adsorbent material would probably be deposited in a landfill, which in turn could lead to possible environmental contamination.

WHO (1996) concludes that the uses of chlorinated paraffins probably provide the major source of environmental contamination. When chlorinated paraffins are used as plasticizers or additives in coatings, they are effectively dissolved in the polymers and will therefore leak into the environment only very slowly. However, polymers containing chlorinated paraffins will act as sources of chlorinated paraffins for centuries after disposal. A more likely route of leakage of chlorinated paraffins into the environment would be the improper disposal of oils containing chlorinated paraffins. Loss of chlorinated paraffins by removal from paints and coatings may also contribute to environmental contamination.

Disposal of wastes containing chlorinated paraffins occurs through resource recovery, destructive incineration or landfill, usually on disposal sites for special wastes and in compliance with local regulations. Owing to their thermal instability, chlorinated paraffins are expected to be degraded by incineration at low temperatures and thus would not be expected to volatilize in exhaust gases from an incinerator. Chlorinated paraffins are not expected to be formed de novo. The disposal of chlorinated paraffins in landfills may give rise to leaching into water, but owing to the low water solubility and strong adsorption onto solids the amounts reaching water are likely to be low.

The EU risk assessment (European Commission 2000) and its update contains a number of release estimates, made by using various models and assumptions and on the basis of SCCP uses in Europe.

**Table 2: Summary of release estimates (European Commission 2000).**

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount Released in EU</th>
<th>Main compartment to which release occurs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production - default</td>
<td>45 000 kg/year or &lt;36.6 kg/year</td>
<td>Water</td>
</tr>
<tr>
<td>Production - site specific information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal working - formulation</td>
<td>23 450 kg/year</td>
<td>Water</td>
</tr>
<tr>
<td>Metal working - use</td>
<td>1 688 tonnes/year</td>
<td>Water</td>
</tr>
<tr>
<td>Rubber formulations</td>
<td>&lt;12 kg/year</td>
<td>Air/soil/water</td>
</tr>
<tr>
<td>Paints and sealing Compounds</td>
<td>negligible</td>
<td></td>
</tr>
<tr>
<td>Leather formulation</td>
<td>3.9 kg/year 7 800 kg/year</td>
<td>Air  Water</td>
</tr>
<tr>
<td>Leather use</td>
<td>390 kg/year 19 500 kg/year</td>
<td>Air  Water</td>
</tr>
<tr>
<td>Textile applications</td>
<td>negligible</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>393.9 kg/year 1 784 tonnes/year</td>
<td>Air  Water</td>
</tr>
</tbody>
</table>
There are no figures on amounts of imported SCCPs and hence, no estimates of releases from such uses. These could, however, contribute considerably to emissions to the environment. An example is given by CSTEE (1998) on estimated emissions of nine tonnes on a yearly European scale from surfaces with paint containing SCCPs. Other sources, which could contribute to emissions mentioned, are articles, containing SCCPs like rubber, textiles, sealants and polymers. This can be the case during production and use, and when the articles become waste and are sent to landfill.

In the EU risk assessment, emissions from articles are discussed very briefly. Elaborated methods to estimate this are lacking in the EC Technical Guidance Document (TGD) on Risk Assessment of New and Existing Substances (1996). However, reported data on emissions from surfaces with a paint containing SCCPs could indicate that such emissions can be significant (CSTEE 1998).

The EU risk assessment has recently been updated (European Commission 2005) and it provides data on emissions for the current production and uses in the EU after the implementation of the Directive 2002/45/EC of the European Parliament and of the Council. The assessment considers emissions from the production of SCCPs and formulation and use in rubber (and polymers), paints, sealants and adhesives and textiles. The total worst case EU emissions of SCCPs from these processes based on 2001 consumption data are estimated to be around 3 000-11 000 kg/year to air, 37 000-97 300 kg/year to waste water treatment plants, 20 100-45 900 kg/year direct to surface water and 32 800-64 900 kg/year to urban/industrial soil. These estimates include emissions from articles during their service life and on disposal.

Concerning the environmental fate, the major characteristics of SCCPs relevant for the exposure assessment are:
- no hydrolysis in water;
- not readily or inherently biodegradable;
- high log Kow;
- an estimated atmospheric half-life of 1.9-7.2 days.

The high log Kow values imply a high potential for bioaccumulation, strong sorption to sewage sludge, soils and sediments and very low mobility in soils. High BCF values have been reported with a variety of freshwater and marine organisms. SCCPs are taken up rapidly, although most studies report moderate loss of bioaccumulated material on return to clean water.

It has been estimated that in sewage treatment plants 93% of any discharged SCCPs will be absorbed onto sludge, and the remaining will remain in water based on the results of a coupled Units Test. Despite the high adsorption potential of the substance onto soil and sediment, a small but not insignificant fraction is predicted to distribute into water and air. This means that SCCPs may be slightly mobile in the environment and so small fraction of the release may be transported over a wide area away from sources of release (European Commission 2000).

2 Environmental levels and bioavailability

There is a wealth of monitoring data on environmental levels of SCCPs, including biota. It can be generally that bioavailability of SCCPs has been demonstrated by the measured levels
in biota, including human breast milk. Information on environmental levels in air and biota especially in remote areas is summarized already in Part I (chapters 2.1 and 2.4).

The draft updated EU Risk Assessment Report (European Commission 2005) reviews available data on measured concentrations. The following is an extract of the final draft report which is yet not publicly available.

**Air**

The levels of SCCPs in air have been determined in samples from a semi-rural site in the United Kingdom (sampled between May 1997 and January 1998), a semi-rural site in southern Ontario, Canada (sampled during summer 1990), and a remote area in the Canadian Arctic (sampled between September and December 1992) (Peters et al. 1998). The analytical method used could determine chlorinated paraffins with chain lengths between C\(_{10}\) and C\(_{13}\) with between 5 and 9 chlorine atoms per molecule. The mean total (vapour + particulate phase) levels found were 99±101 pg/m\(^3\) at the semi-rural site in the United Kingdom, 543±318 pg/m\(^3\) at the semi-rural site in southern Ontario and 20±32 pg/m\(^3\) at the remote site. Peters et al. (2000) determined the level of short-chain chlorinated paraffin in air at a semi-rural site in United Kingdom, over a 12-month period (samples taken at 2-weekly intervals). The arithmetic and geometric means found were 320±320 pg/m\(^3\) and 160 pg/m\(^3\), respectively. Around 95% of the SCCPs found were associated with the gaseous phase.

Greenpeace (2003) have carried out a survey of the levels of SCCPs in dust samples collected from around 70 households in the United Kingdom. The samples were collected between the 30\(^{th}\) October and 8\(^{th}\) November 2002 from ten regional areas, and pooled samples (from 7 households in each region) were analysed for the presence of short-chain chlorinated paraffin. The substance was found to be present in eight out of ten pooled samples at a concentration of 1.9 to 13 mg/kg (ppm), with a mean value of 4.3 mg/kg (the analytical method used was considered to be only semi-quantitative for SCCPs due to the highly complex nature of the products and so the reported concentrations are only approximate; the detection limit of the method was around 0.12 mg/kg). In addition, a single dust sample from a household in Denmark and a single dust sample from a household in Finland were found to contain SCCPs at a concentration of 5.1 and 9.6 mg/kg respectively, which is similar to the range found in the United Kingdom. The results showed that SCCPs are widespread contaminants of the indoor environment.

SFT (2002b) determined the concentrations of SCCPs in three samples of moss from Norway. The samples were taken from Valvik (67.38°N, 14.64°E), Molde (62.73°N, 07.00°E) and Narbuvoll (62.38°N, 11.47°E). The samples were collected in forest areas not closer than 300 m to the nearest road or building/house. The distance of each sampling site from the nearest village/town was at least 10 km. The concentration found was in the range 3-100 µg/kg wet weight. The report suggested that the presence in moss was indicative of transport of SCCPs via the atmosphere.

**Water**

Levels of C\(_{10-17}\) chlorinated paraffins in the effluent from a chlorinated paraffin production plant in Canada have been reported to be around 12.7 µg/l, but they were not detected in sediments downstream of the plant (Metcalfe-Smith et al., 1995; as reported in Tomy, 1998).

Further levels of SCCPs in final effluent from municipal waste water treatment plants in Canada have been reported by Muir et al. (2001). The waste water treatment plants were all
Table 3. Concentrations of SCCPs in municipal waste water treatment plant effluent (Muir et al. 2001).

<table>
<thead>
<tr>
<th>Location</th>
<th>Concentration (µg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamilton</td>
<td>0.448</td>
</tr>
<tr>
<td>Burlington</td>
<td>0.068</td>
</tr>
<tr>
<td>Niagara Falls</td>
<td>0.082</td>
</tr>
<tr>
<td>St. Catherines treatment plant 1</td>
<td>0.110</td>
</tr>
<tr>
<td>St. Catherines treatment plant 2</td>
<td>0.080</td>
</tr>
<tr>
<td>Niagara-on-the-Lake</td>
<td>0.060</td>
</tr>
</tbody>
</table>

Tomy (1997; as reported in Tomy, 1998) found C_{10-13} chlorinated paraffins to be present in Red River, downstream of Winnipeg in Canada, at levels of around 0.02-0.05 µg/l.

An in-depth study of the levels of short- and medium-chain chlorinated paraffins in industrial areas of the United Kingdom has been carried out (CEFAS 1999, Nicholls 2001). The main purpose of the study was to determine the concentrations of chlorinated paraffins in surface water, sediment, biota and soil associated with their industrial use. The sampling sites were chosen with regards to their proximity to known sources/users of short- or medium-chain chlorinated paraffins such as polymer product manufacturing sites, rubber product manufacturing sites, metal working sites, lubricant blending sites, sealant and adhesive manufacturing sites, chlorinated paraffin manufacturing sites, paint manufacturing sites, PVC product manufacturing sites, leather finishing chemicals formulation sites and leather finishing sites. In this study, no short- or medium-chain chlorinated paraffins were detected (detection limit around 0.1 µg/l) in any of the surface water samples taken except in some samples from a site near to engineering (metal working) activity. These were identified as being SCCPs and the concentration found was 0.2-1.7 µg/l.

Sediments

Tomy et al. (1997a) reported that SCCPs were present at a concentration of around 245 µg/kg dry weight in sediments from the mouth of the Detroit River at Lake Erie and Middle Sister Island in western Lake Erie. The samples were collected in August 1995.

Muir et al. (2001) determined the levels of SCCPs in surface sediment samples from harbour areas in western Lake Ontario. The samples were collected in 1996. The levels found were 24-27 µg/kg dry weight at Toronto inner harbour, 5.9 µg/kg dry weight at Humber River mouth (Toronto), 7.3 µg/kg dry weight at Port Credit Harbour, 27-41 µg/kg dry weight at Hamilton west harbour, 290 µg/kg dry weight at Hamilton Windemere Basin and 81 µg/kg dry weight at northwest Hamilton. The highest levels were present at the most industrialised site sampled (Windemere Basin).

CSTEE (2002a) indicates that Marvin et al. (2002) reported that SCCPs were generally relatively evenly distributed in sediments from Lake Ontario and estimated that the average
concentration was around 36 µg/kg dry weight. Muir et al. (2002) give the mean value for Lake Ontario in 1998 as 49 µg/kg dry weight for total short chain chlorinated paraffins (the mean values were 11.8 µg/kg dry weight for C\textsubscript{10}-chlorinated paraffins, 17.2 µg/kg dry weight for C\textsubscript{11}-chlorinated paraffins, 16.7 µg/kg dry weight for C\textsubscript{12}-chlorinated paraffins and 3.2 µg/kg dry weight for C\textsubscript{13}-chlorinated paraffins).

Tomy et al. (1997b and 1999) reported the following levels of short-chain chlorinated paraffins in surface sediments from the Canadian mid-latitude and Arctic regions: 176 µg/kg dry weight and 8 µg/kg dry weight in samples from Lake Winnipeg (south and north respectively), 257 µg/kg dry weight in samples from Fox Lake (Yukon), 18 µg/kg dry weight in samples from Lake Nipigon (northwest Ontario), 1.6 µg/kg dry weight in samples from Lake Ya Ya and 4.5 µg/kg dry weight in samples from Hazen Lake (Arctic). The chlorine content of the chlorinated paraffins found was in the range 60-70% wt. The concentrations of chlorinated paraffins in deeper layers were lower than found in the surface layers (the surface layer samples generally corresponded to around 1980-1992). Based on these data, the yearly surface flux of chlorinated paraffins to the lakes was estimated as 147 µg/m\textsuperscript{2} and 3.99 µg/m\textsuperscript{2} for Lake Winnipeg (south and north respectively), 34.1 µg/m\textsuperscript{2} for Fox Lake, 2.66 µg/m\textsuperscript{2} for Lake Nipigon, 0.45 µg/m\textsuperscript{2} for Lake Ya Ya and 0.89 µg/m\textsuperscript{2} for Hazen Lake. Local industrial sources (use in cutting oils and paints and plastics) were thought to contribute significantly to the flux to Fox Lake and the southern basin of Lake Winnipeg, but the flux to the other lakes was thought to be mainly as a result of atmospheric transport. Analysis of the sediment cores obtained in Fox Lake indicated that the relative contribution of the C\textsubscript{10}, C\textsubscript{11}, C\textsubscript{12} and C\textsubscript{13} congeners to the total chlorinated paraffin present appeared to change with depth, indicating that microbial transformation may be occurring in the aerobic surface layers with the congeners persisting in the lower anaerobic layers. However, only very slight differences in relative contribution with depth was seen in the sediment cores from the southern basin of Lake Winnipeg.

An in-depth study of the levels of short- and medium-chain chlorinated paraffins in industrial areas of the United Kingdom has been carried out (CEFAS 1999, Nicholls 2001). The main purpose of the study was to determine the concentrations of chlorinated paraffins in surface water, sediment, biota and soil associated with their industrial use. The sampling sites were chosen with regards to their proximity to known sources/users of medium-chain chlorinated paraffins. SCCPs were found to dominate in only a few of the samples. For most samples medium-chain chlorinated paraffins were identified as the dominant chlorinated paraffin present, but it is also possible that some SCCPs could also have been present in these samples. SCCPs were identified to be present in sediment close to a chlorinated paraffin production site (up to 24.2 mg/kg wet weight (mixture of short- and medium-chain chlorinated paraffins)) and a PVC and/or paint manufacturing site (up to 8.1 mg/kg wet weight (mixture of short- and medium-chain chlorinated paraffins)).

A sediment core taken in 1988 from the western basin of Lake Ontario (43°26'01''N, 79°24'00''W; the sample was taken approximately 40 km from the nearest sewage treatment plant) showed a maximum concentration of short-chain chlorinated paraffin of around 800 µg/kg dry weight (Environment Canada 2003). The maximum concentration was found in the sediment layer corresponding to the 1970s but had fallen to around 390 µg/kg dry weight in the layer corresponding to 1996. SCCPs could be determined in the layers dating back to 1913 (as SCCPs were not manufactured in Canada until the 1940s, the occurrence in the older layers was thought to be as a result of diffusion of residues through the sediment core or an artefact of sampling).
SFT (2002) carried out a screening study for the concentrations of short-chain chlorinated paraffins in sediments associated with the effluents from waste dumps in Norway. In all, samples from five locations were analysed and short-chain chlorinated paraffins were found to be present in all five samples at a concentration of 0.33-19.4 mg/kg wet weight.

**Aquatic biota**

Tomy et al. (1997a) reported that SCCPs (60-70% wt. Cl) were present at a concentration of around 1 010 µg/kg wet weight (also reported as 1 148 µg/kg dry weight in Tomy, 1998) in yellow perch and 241 µg/kg wet weight (also reported as 305 µg/kg dry weight in Tomy, 1998) in catfish from the mouth of the Detroit River at Lake Erie and 651 µg/kg wet weight (also reported as 1 205 µg/kg dry weight in Tomy, 1998) in zebra mussels from Middle Sister Island in western Lake Erie. The samples were collected in August 1995 and were taken from an industrialised area.

Metcalfe-Smith et al. (1995; as reported in Tomy, 1998) reported that the level of SCCPs (60-70% wt. Cl) in white suckers from the St. Lawrence River, downstream of a chlorinated paraffin manufacturing plant, was <3 500 µg/kg dry weight.

Tomy (1997; as reported in Tomy, 1998) found SCCPs (60-70% wt. Cl) to be present in blubber from marine mammals from Canada and Greenland. The levels found were 370-1 363 µg/kg dry weight in Beluga from the St. Lawrence River, 106-253 µg/kg dry weight in Beluga from northwest Greenland, 178-302 µg/kg dry weight in Beluga from Hendrickson Island, 362-490 µg/kg dry weight in walrus from northwest Greenland and 374-767 µg/kg dry weight in ringed seal from southwest Ellesmere Island.

The levels of SCCPs in carp from Hamilton Harbour (western Lake Ontario), lake trout from Port Credit (north-western Lake Ontario) and Niagara-on-the-Lake (south-western Lake Ontario) and beluga whale from the St. Lawrence River estuary and southeast Baffin Island in the Canadian Arctic have been determined by Muir et al. (2001). The fish were collected in 1996 and the beluga samples were collected in 1988-1991 and 1995. The levels found are shown in table 4.

**Table 4. Levels of SCCPs in biota from Canada (Muir et al. 2001).**

<table>
<thead>
<tr>
<th>Species</th>
<th>Sample</th>
<th>Mean concentration of short-chain chlorinated paraffin (mg/kg wet wt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beluga whale</td>
<td>9 Female blubber samples from St. Lawrence Estuary, 1988-1991.</td>
<td>0.94±0.48</td>
</tr>
<tr>
<td>(Delphinapterus leucas)</td>
<td>3 Male blubber samples from St. Lawrence Estuary, 1988-1991.</td>
<td>0.85±0.56</td>
</tr>
<tr>
<td></td>
<td>3 Female blubber samples from South East Baffin Island, 1995.</td>
<td>0.116±0.052</td>
</tr>
<tr>
<td></td>
<td>3 Male blubber samples from South East Baffin Island, 1995.</td>
<td>0.168±0.035</td>
</tr>
<tr>
<td>Carp (Cyprinus carpio)</td>
<td>3 Samples from Hamilton Harbour, 1996.</td>
<td>2.63±2.56</td>
</tr>
<tr>
<td>Lake trout</td>
<td>5 Samples from Niagara-on-the-Lake, 1996.</td>
<td>0.059±0.051</td>
</tr>
<tr>
<td>(Salvelinus namaycush)</td>
<td>5 Samples from Port Credit, 1996.</td>
<td>0.073±0.047</td>
</tr>
</tbody>
</table>
Data on the levels of SCCPs in beluga whale, rainbow trout and carp from Canada have also been reported by Bennie et al. (2000). For the whale, 37 blubber samples and 6 liver samples from 25 individuals were analysed for C_{10-13} chlorinated paraffins. The samples were taken from dead animals from the St. Lawrence River between 1987 and 1991. The fish samples were all taken from Lake Ontario in 1996 and three carp and ten trout were analysed (whole body homogenates). Some of these samples appear to have been the same as those analysed by Muir et al. (2001) discussed above. The area sampled was near to a chlorinated paraffin production site. The levels are shown in table 5. The authors indicated that the method used (involving low resolution mass spectrometry) may be more subject to analytical interferences from other organohalogen compounds than some of the methods used in other analyses, and that the levels found in beluga whale in this study are one or two orders of magnitude higher than the levels found by Muir et al. (2001) when analysing the same sample extracts. Therefore the results of this study should be treated with caution.

Table 5. Levels of short-chain chlorinated paraffins in biota from Canada (Bennie et al., 2000).

<table>
<thead>
<tr>
<th>Species</th>
<th>Sample</th>
<th>Lipid content</th>
<th>Concentration of SCCPs (mg/kg wet wt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beluga whale</td>
<td>Blubber samples from 15 females taken from mid depth of the subcutaneous fat</td>
<td>81-91% range, 86.2% mean</td>
<td>4.60-60.7 range, 25.9 mean</td>
</tr>
<tr>
<td></td>
<td>Blubber samples from 10 males taken from mid depth of the subcutaneous fat</td>
<td>68-96% range, 83.5% mean</td>
<td>27.6-85.6 range, 46.1 mean</td>
</tr>
<tr>
<td></td>
<td>Liver samples from 3 females</td>
<td>11-32% range, 16% mean</td>
<td>0.54-38.5 range, 0.50 mean</td>
</tr>
<tr>
<td></td>
<td>Liver samples from 3 males</td>
<td>20-52% range, 16% mean</td>
<td>4.61-8.52 range, 0.50 mean</td>
</tr>
<tr>
<td>Carp</td>
<td>Whole body homogenates from 3 individuals</td>
<td>12-19% range, 16% mean</td>
<td>0.12-1.25 range, 0.50 mean</td>
</tr>
<tr>
<td>Trout</td>
<td>Whole body homogenates from 10 individuals</td>
<td>18-30% range, 24% mean</td>
<td>0.45-5.33 range, 1.47 mean</td>
</tr>
</tbody>
</table>

An in-depth study of the levels of short- and medium-chain chlorinated paraffins in industrial areas of the United Kingdom has been carried out (CEFAS 1999, Nicholls 2001). The sampling sites were chosen with regards to their proximity to known sources/users of chlorinated paraffins. Samples were collected during early summer 1998. The levels found in biota are shown in table 6. The actual identity of the chlorinated paraffin (short- or medium-chain) was difficult to assign reliably in this study.

Table 6. Levels of short- and medium-chain chlorinated paraffins in fish and benthos in the United Kingdom, related to sources (CEFAS, 1999).

<table>
<thead>
<tr>
<th>Industry</th>
<th>Comment/ tentative identification$^a$</th>
<th>Sample</th>
<th>Concentration of chlorinated paraffin (mg/kg fresh weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymers/ tarpaulins</td>
<td></td>
<td>Fish: roach muscle</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>Synthetic rubber</td>
<td></td>
<td>Fish: perch muscle</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>manufacture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal working</td>
<td></td>
<td>Fish: flounder muscle</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Industry</td>
<td>Comment/ tentative identification</td>
<td>Sample</td>
<td>Concentration of chlorinated paraffin (mg/kg fresh weight)</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------</td>
<td>--------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>Lubricant blending/ metal working</td>
<td>Possibly medium-chain - levels could not be accurately quantified owing to interferences.</td>
<td>Benthos: 90% Hindinidae + Lymnaeidae Fish: roach muscle Fish: eel muscle Fish: pike liver</td>
<td>0.3 0.6 0.7 2.8</td>
</tr>
<tr>
<td>Sealant and adhesive manufacture</td>
<td>Possibly short-chain.</td>
<td>Benthos: 25% Spaeridae, 13% Hindinidae, 9% Gammanidae, 25% Asellidae, 17% Planorbidae, 9% Valvatidae, 2% Sialidae Fish: roach muscle</td>
<td>0.3 &lt;0.1</td>
</tr>
<tr>
<td>Rubber product manufacturer</td>
<td>Possibly medium-chain.</td>
<td>Benthos: 2% Vivilparidae, 16% Lymnaeidae, 5% Gammanidae, 16% Asellidae, 3% Zygoptera, 5% Corixidae, 16% Chironomidae, 8% Caddis, 3% Beetle, 16% Hindinidae, 8% Hydrobiidae Fish: roach muscle Fish: eel liver</td>
<td>0.1 &lt;0.1</td>
</tr>
<tr>
<td>Manufacturer of building sealants/ lubricant blending</td>
<td></td>
<td>Fish: roach muscle</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Manufacturer of chlorinated paraffins</td>
<td>Possibly mixture of short- and medium-chain</td>
<td>Benthos: 90% Chironomidae, 8% Gammanidae, 2% Lymnaeidae Fish: eel liver</td>
<td>0.1 0.2</td>
</tr>
<tr>
<td>Control site - no known uses.</td>
<td>Possibly medium-chain</td>
<td>Benthos: 18% Chironomidae, 71% Lymnaeidae, 7% Asellidae, 4% Sphaeridae Fish: carp muscle</td>
<td>0.5</td>
</tr>
<tr>
<td>Lubricant manufacturer(and other industries)</td>
<td>Possibly short-chain.</td>
<td>Benthos: 95% Gammanidae, 5% Chironomidae Fish: carp muscle</td>
<td>0.1</td>
</tr>
<tr>
<td>PVC cable manufacturer</td>
<td>Possibly medium-chain.</td>
<td>Benthos: 90% Spaeridae, 5% Lymnaeidae, 5% Hirudinidae</td>
<td>0.8</td>
</tr>
<tr>
<td>Metal working/ leather finishing</td>
<td>Possibly mixture of short- and medium-chain.</td>
<td>Benthos: 50% Asellidae, 40% Chironomidae, 5% Tipulidae, 4% Hirudinidae, 1% Lymnaeidae</td>
<td>0.5</td>
</tr>
<tr>
<td>Metal working sites</td>
<td>Possibly short-chain.</td>
<td>Benthos: 60% Oligochaetes, 20% Chironomidae, 16% Lymnaeidae, 4% Sphaeridae. Fish: whole, Stone Loach</td>
<td>&lt;0.05 5.2</td>
</tr>
<tr>
<td>PVC production/ paint manufacture</td>
<td>Possibly mixture of short- and medium chain.</td>
<td>Benthos: 95% Asellidae, 5% Oligochaetes Fish: eel muscle</td>
<td>0.7</td>
</tr>
<tr>
<td>Leather finishing chemicals formulation site</td>
<td></td>
<td>Benthos: 65% Sphaeridae, 265 Lymnaeidae, 3% Planorbidae, 2% Corixidae, 2% Sialidae, 2% Hindinidae, 2% Valvatidae Fish: roach muscle Fish: eel muscle</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Background site</td>
<td></td>
<td>Fish: eel muscle</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Note a) The actual identity of the residues present were difficult to assign owing to the high concentration of co-extracted lipid-soluble material. Tentative identity based on the chlorinated paraffins found in sediment in the area.
Borgen et al. (2001) determined the levels of SCCPs (with 5-10 chlorine atoms/molecule) in freshwater fish from various locations in Norway. The results are summarised in table 7.

Table 7. Levels of short-chain chlorinated paraffins in fish from Norway (Borgen et al. 2001).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Location</th>
<th>Concentration (µg/kg lipid)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trout muscle</td>
<td>Takvatn</td>
<td>172</td>
</tr>
<tr>
<td></td>
<td>Fjellfrøsvatnet</td>
<td>545</td>
</tr>
<tr>
<td></td>
<td>Grunnvatnet</td>
<td>1 692</td>
</tr>
<tr>
<td></td>
<td>Store Raudvannet</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td>Selbusjøen</td>
<td>436</td>
</tr>
<tr>
<td></td>
<td>Breimsvatn</td>
<td>923</td>
</tr>
<tr>
<td></td>
<td>Bøgøvatnet</td>
<td>1 414</td>
</tr>
<tr>
<td></td>
<td>Kalsjøen</td>
<td>178</td>
</tr>
<tr>
<td></td>
<td>Kalandsvatn</td>
<td>254</td>
</tr>
<tr>
<td></td>
<td>Vegår</td>
<td>263</td>
</tr>
<tr>
<td></td>
<td>Mårvann</td>
<td>256</td>
</tr>
<tr>
<td></td>
<td>Grindheimsvatn</td>
<td>733</td>
</tr>
<tr>
<td></td>
<td>Lygne</td>
<td>408</td>
</tr>
<tr>
<td>Arctic char muscle</td>
<td>Ellasjøen&lt;sup&gt;a&lt;/sup&gt;</td>
<td>592</td>
</tr>
<tr>
<td></td>
<td>Velmunden</td>
<td>500</td>
</tr>
<tr>
<td>Burbot liver</td>
<td>Grensefoss</td>
<td>741</td>
</tr>
<tr>
<td></td>
<td>Selbusjøen</td>
<td>226</td>
</tr>
<tr>
<td></td>
<td>Røgden</td>
<td>787</td>
</tr>
<tr>
<td></td>
<td>Øgderen</td>
<td>695</td>
</tr>
<tr>
<td></td>
<td>Femsjøen</td>
<td>3 700</td>
</tr>
</tbody>
</table>

Note:  a) This location is at Bear Island at a latitude of 74°N and is considered to be a remote Arctic site.

SFT (2002) have recently determined the concentrations of short-chain chlorinated paraffins present in blue mussel and cod livers from Norway. Short-chain chlorinated paraffins were found to be present in all samples analysed and the concentrations found were 18-130 µg/kg wet weight in two samples of blue mussel from Oslofjord, 14 µg/kg wet weight in a sample of mussel from Risøy and 23-750 µg/kg wet weight in four samples of cod liver from Oslofjord. Cod liver samples from inner Oslofjord were found to have the highest concentrations and indicated that a local emission source may be present.

**Terrestrial environment**

A monitoring survey of concentrations of short- and medium-chain chlorinated paraffins in sewage sludge, soil and earthworms associated with some uses of chlorinated paraffins in the United Kingdom has been carried out (CEFAS 1999, Nicholls, 2001) and the results are summarised in Table 8. The samples used in the study were collected in the early summer of 1998.
Table 8. Levels of short- and medium-chain chlorinated paraffins in sewage sludge, agricultural land and earthworms from the United Kingdom (CEFAS, 1999).

<table>
<thead>
<tr>
<th>Location</th>
<th>Comment</th>
<th>Sample type</th>
<th>Concentration(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South West</td>
<td>Sewage treatment plant associated with polymers/tarpaulin industry. Soil received repeated application of fertiliser made from sludge.</td>
<td>Digested sewage sludge</td>
<td>2.9 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dried digested sewage sludge (fertiliser)</td>
<td>27.7 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil receiving fertiliser</td>
<td>&lt;0.1 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Earthworms</td>
<td>&lt;0.1 mg/kg fresh weight</td>
</tr>
<tr>
<td>South East</td>
<td>Sewage treatment plant associated with synthetic rubber and other varied industries. Digested sewage frequently applied to soil.</td>
<td>Digested sewage sludge</td>
<td>12.1 mg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil receiving sewage sludge</td>
<td>&lt;0.1 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Earthworms</td>
<td>0.7 mg/kg fresh weight</td>
</tr>
<tr>
<td>Wales</td>
<td>Sewage treatment plants associated with formulation and use of metal working fluids. Digested sewage applied to soil January 1998. Tentatively identified as short-chain(^*_a).</td>
<td>Digested sewage sludge</td>
<td>11.8 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil receiving sewage sludge</td>
<td>&lt;0.1 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Earthworms</td>
<td>&lt;0.1 mg/kg fresh weight</td>
</tr>
<tr>
<td>West Midlands</td>
<td>Sewage treatment plant associated with formulation and use of metal working fluids. Digested sewage frequently applied to soil. Known to have been applied January 1998.</td>
<td>Digested sewage sludge</td>
<td>17.1 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil receiving sewage sludge</td>
<td>&lt;0.1 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Earthworms</td>
<td>0.3 mg/kg fresh weight</td>
</tr>
<tr>
<td>East Midlands</td>
<td>Sewage treatment plant associated with rubber production. Several applications of sludge made during February 1998.</td>
<td>Digested sewage sludge</td>
<td>3.4 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil receiving sewage sludge</td>
<td>&lt;0.1 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Earthworms</td>
<td>&lt;0.1 mg/kg fresh weight</td>
</tr>
<tr>
<td>East Anglia</td>
<td>Industry source unknown. Digested sewage frequently applied to soil.</td>
<td>Digested sewage sludge</td>
<td>1.8 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil receiving sewage sludge</td>
<td>&lt;0.1 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Earthworms</td>
<td>0.5 mg/kg fresh weight</td>
</tr>
<tr>
<td>North West</td>
<td>Sewage treatment plant associated with formulation and use of metal working fluids, and other industries. Digested sewage frequently applied to soil. Several applications made during 1997/1998</td>
<td>Digested sewage sludge</td>
<td>6.7 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil receiving sewage sludge</td>
<td>&lt;0.1 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Earthworms</td>
<td>&lt;0.1 mg/kg fresh weight</td>
</tr>
<tr>
<td>North East</td>
<td>Sewage treatment plant associated with PVC/other industries. Digested sewage frequently applied to soil.</td>
<td>Digested sewage sludge</td>
<td>93.1 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soil receiving sewage sludge</td>
<td>&lt;0.1 mg/kg dry weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Earthworms</td>
<td>1.7 mg/kg fresh weight</td>
</tr>
</tbody>
</table>

Note: a) The actual identity of the residues present (i.e. medium-chain or short-chain chlorinated paraffin) was difficult to assign owing to the high concentration of co-extracted lipid-soluble material.
The levels found in digested sewage sludge prior to application onto soil were in the range 2.9-93 mg/kg dry weight and the levels found in soil where the sludge was applied were generally not detected (<0.1 mg/kg dry weight which is equivalent to <0.088 mg/kg on a wet weight basis). In general it was not possible to identify exactly what type (short- or medium-chain) was present in the samples.

The levels of SCCPs in further sewage sludge samples from the United Kingdom have recently been determined (Stevens et al. 2002). Samples of digested sludge from 14 waste water treatment plants from domestic and/or urban and/or industrial areas were analysed. The total concentration of SCCPs found ranged between 6.9 and 200 mg/kg dry weight (mean level found was 42 mg/kg dry weight). The report concluded that theses findings were indicative of there being numerous ongoing diffuse sources of the substance.

Junk and Meisch (1993) reported that SCCPs (~56% wt. Cl) were present at a concentration of 582 mg/kg in paving stones collected outside a metal working plant in Germany.

Terrestrial organisms

A recent study has found SCCPs to be present in human breast milk samples from the United Kingdom (Thomas and Jones 2002). In all, 22 breast milk samples were analysed (8 from Lancaster and 14 from London, randomly chosen from a limited number of samples collected for a different study). SCCPs were found at concentrations of 4.6-110 µg/kg lipid in five out of eight samples from Lancaster and at concentrations of 4.5-43 µg/kg lipid in seven out of 14 samples from London. No SCCPs were found in the remaining samples (the detection limit of the method used varied with sample size but was in the range 1.6-15 µg/kg lipid). Although not calculated in the original paper, it is possible to estimate that the mean level found in breast milk was around 20±30 µg/kg lipid (based on the positive findings alone) or 12±23 µg/kg lipid (assuming that not detected = half the detection limit).

In addition to human breast milk, Thomas and Jones (2002) also determined the levels of SCCPs in a sample of cow’s milk from Lancaster and single butter samples from various regions of Europe (Denmark, Wales, Normandy, Bavaria, Ireland, and southern and northern Italy). SCCPs were not detected in the cow’s milk sample (detection limit <1.2 µg/kg lipid) but were found in the butter samples from Denmark at 1.2 µg/kg and Ireland at 2.7 µg/kg. The detection limit for the butter samples ranged between 0.72 and 1.1 µg/kg.

Thomas et al. (2003) carried out a follow-up study on the levels of SCCPs in breast milk samples from the United Kingdom using a more sensitive analytical procedure. In this study relatively large samples of human milk-fat were collected from the London (twenty samples) and Lancaster (five samples) areas of the United Kingdom between late 2001 and June 2002. SCCPs were detected in all samples from Lancaster and in sixteen out of the twenty samples from London. The median and the 95th percentile levels found were 180 and 680 µg/kg lipid and the range of concentrations found was between 49 and 820 µg/kg lipid. No significant difference was found between the concentrations in the samples from Lancaster and those from London. The more detailed analysis of the types of chlorinated paraffins present indicated that, in general, the pattern of chain-lengths found for SCCPs were very similar to that in the commercial product used as analytical standard.
Chlorinated paraffins have been found to be present in the biodegradable fraction of household waste from Sweden in 1995 (Nilsson et al., 2001). The concentration found in one sample was around 4.2-5.5 mg/kg dry matter (some of the other samples appeared to contain no chlorinated paraffin) but the actual type of chlorinated paraffin found is not clear from the paper (it may have been a medium-chain chlorinated paraffin).

3 Socio-economic factors

3.1 National and International Regulation

3.1.1 European Union

SCCPs have been identified as a group of priority substances for risk assessment under Regulation 793/93/EEC. The United Kingdom was responsible for assessment of risks associated with SCCPs. The risk assessment was completed in 2000, leading to a conclusion that the use of SCCPs in the metalworking and leather processing industries posed a risk to the environment and there was a need for risk reduction.


In addition, The European Commission had also carried out a study assessing the risks and benefits of the use of SCCPs in the metalworking industry and in leather processing, and a study on potential derogations to marketing and use restrictions to prohibit or limit the use of SCCPs in these applications (ERM, 1999).

As a result of the EU risk assessment and risk reduction processes, Directive 2002/45/EC of the European Parliament and of the Council was adopted 25 June 2002 (http://europa.eu.int/eur-lex/pri/en/oj/dat/2002/l_177/l_17720020706en00210022.pdf). This Directive came into force in January 2003 and was to be implemented by the Member States January 2004. According to the Directive, SCCPs may not be marketed or used in concentrations greater than 1% for metalworking and leather finishing. Furthermore, the Directive states that all remaining uses of SCCPs were to be reviewed by the European Commission, in cooperation with the Member States and the OSPAR Commission, in the light of any relevant new scientific data on risks posed by SCCPs to health and the environment. The United Kingdom has recentlyfinalised a draft updated Risk Assessment Report.

SCCPs have also been identified as priority hazardous substances in the field of water policy under the Water Framework Directive (Directive 2000/60/EC of 23 October 2000). These substances will be subject to cessation or phasing out of discharges, emissions and losses within an appropriate timetable that shall not exceed 20 years.
A number of uses (including some former uses) of SCCPs are covered under the Integrated Pollution Prevention of Control Directive (Directive 1996/61/EC). These include (depending on the size of operation) production of short-chain chlorinated paraffins, metal working (though only large companies in the ferrous and non-ferrous metals sectors), some plastics compounding/conversion sites and leather processing sites (larger sites only) (Entec, 2004).

3.1.2 United States

According to available information, there have been no specific regulatory actions on SCCPs in the United States. The only specific federal environmental regulation is an annual requirement that requires certain facilities to report environmental releases of SCCPs under the Toxic Release Inventory (TRI).

3.1.3 Canada

In 1993, Environment Canada classified SCCPs as "toxic" under the Canadian Environmental Protection Act (CEPA). Environment Canada is finalising a domestic follow-up report on all chlorinated paraffins for the Canadian Priority Substances Assessment Program. The Draft Follow-up Report prepared by Environment Canada proposes that short, medium, and certain long chain chlorinated paraffins are toxic to the environment, as defined under Canadian Environmental Protection Act, 1999, and would be proposed as candidates for virtual elimination.

Similar to the US TRI requirement, in 1999, Environment Canada added SCCPs to the list of chemicals subject to reporting pursuant to the Canadian National Pollutant Release Inventory (NPRI). Environment Canada is currently assessing the data gathered as a result of its November 2002 Reporting Rule for chlorinated paraffins. The rule required all Canadian companies that manufactured, imported, exported, distributed or sold chlorinated paraffins or products formulated with chlorinated paraffins in 2000 and/or 2001 to report information by February 2003.

3.1.4 International organisations

*International Agency for Research on Cancer (IARC)*

In 1989, as a result of laboratory testing in animals, SCCPs were classified as a Group 2B carcinogen by the International Agency for Research on Cancer (IARC).

*OSPAR Commission*

OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic has adopted a decision on SCCPs in 1995 (PARCOM Decision 95/1). This established a ban on the use of SCCPs all areas of application: as a fluid additive in the metal working industry; as a fat liquoring agent in the leather finishing industry; as a plasticiser in paints and coatings; as a plasticiser in sealants; and as a flame retardant in rubber, textiles and plastics. Under this
Decision, the sale and use of SCCPs should be prohibited by the end of 1999. Exemptions will allow the use of SCCPs in dam sealants and underground mine conveyor belts until 2004.

**Helsinki Commission (HELCOM)**

Similarly to OSPAR, also the Baltic Marine Environment Protection Commission (HELCOM) has included SCCPs on their list of harmful substances. According to available information no recommendations have yet been taken on SCCPs.

### 3.2 Alternatives / Substitutes

Summary of alternatives for SCCPs is provided for in a recent HELCOM draft guidance document on SCCPs (HELCOM 2002):

The medium-chain chlorinated paraffins (MCCPs) \((C_{14}-C_{17})\) may have similar uses as SCCPs and they are used as replacements for SCCP as extreme pressure additives in metal working fluids, as plasticisers in paint, and as additives in sealants. Based on a UK draft risk assessment on MCCPs it is understood that some risk reduction measures may be required for uses in the production of PVC, in some process formulations of metal cutting fluids, in emulsifiable metal cutting/working fluids where the spent fluid is discharged to waste water, in leather fat liquors and in carbonless copy paper during recycling. The risk from use in oil-based metal cutting fluids may also be of concern.

The long chained chlorinated paraffins (LCCPs) have, at least in Sweden, been used in some demanding applications in metal working fluids instead of SCCP. LCCP is also suggested as replacements to SCCP in the leather industry as well as in paint and coatings, in sealants and rubber.

Alkyl phosphate esters and sulfonated fatty acid esters may function as replacements for SCCPs as extreme pressure additives in metal working fluids. Natural animal and vegetable oils are alternatives to in the leather industry. In paint and coatings, phthalate esters, polycrylic esters, disobutyrate as well as phosphate and boron containing compounds are suggested as replacements. Phthalates esters are alternatives for use in sealants. Alternatives as flame retardant in rubber, textiles and PVC are antimony trioxide, aluminium hydroxide, acrylic polymers and phosphate containing compounds. These substances are by Sweden considered as less harmful than chlorinated paraffins. Still, there might be uses for which these alternatives do not fulfil all technical and security demands. Neither may cost for substitution be proportional to health and environmental advantages for all types of applications.

### 3.3 Emission Control Techniques

No specific studies on SCCPs’ emission control techniques are available. General emission control techniques for the industry sectors involved (metal, leather and textile working etc.) can be found i.a. from the best available techniques reference documents (BREFs) (see: [http://eippcb.jrc.es/pages/FActivities.htm](http://eippcb.jrc.es/pages/FActivities.htm)).
3.4 Costs and benefits of control

As indicated in chapter 3.1 “National and international regulation” on the section dealing with the European Union, the European Commission and the UK have prepared a Risk Reduction Strategy and analysis of advantages and drawbacks of possible measures to reduce the risks identified for the aquatic environment through the EU risk assessment procedure.

The European Commission report (ERM 1999) constitutes a good summary of all the studies carried out on costs and benefit of control and deals mainly with the advantages and drawbacks of the bans of some uses. As this report is not publicly available, the following subchapters report the main conclusions drawn from this study.

The approach taken in the ERM study was to conduct an initial rapid review of information from previous studies on SCCPs. Specifically, this included information provided by the European Commission, and the UK Government. This information was supplemented through extensive consultation with the two remaining producers of SCCPs (ICI, Caffaro) and a number of key EU industry associations, including the European Chemical Industry Council (CEFIC), EuroChlor Chlorinated Paraffins Sector Group, as well as associations and companies at Member State level. At Member State level, research focused on those countries which were using, or had historically used, the largest quantities of SCCPs (Italy, France, UK, Germany, Spain).

It is noted in the study that in many cases, it is difficult to make estimates of the economic impacts of restrictions at a European level due to lack of robust cost data from companies and widespread lack of understanding amongst users, many of whom recognise the brand names of metalworking and leather processing fluids which they are using, but do not know about the constituents of these fluids (eg. SCCPs, Medium CCPs).

3.4.1 Implications of Restrictions for Producers

Information on the likely impacts for the producers of a ban on the use of SCCPs include:

- due to the fact that production is a batch process, the technical/conversion costs of the transition from SCCPs to MCCPs (the major alternative) is limited;

- producers have been instrumental in moving customers away from SCCPs since the PARCOM Decision 95/1, and so half or more (based on discussion with ICI) of the costs of conversion were already been borne by the producers;

- the unit cost of MCCPs is lower by around 25% per tonne, which will reduce the value of sales for producers (but will also reduce the input costs for users);

- as SCCPs cannot be substituted by other chlorinated paraffins in all applications, there will be some ‘drop out’ of customers for the existing producers;

- there is no indication that a ban would lead to a loss of employment in the producing companies.
3.4.2 Implications of Restrictions for the Metalworking Sector

Short-chain chlorinated paraffins are used as EP (extreme pressure) additives in metalworking fluids, particularly for processes involving very high pressure, temperature and/or with high shearing forces. They perform lubrication, cooling and swarf (metal debris/fragments) clearing roles, and are used as cutting and drawing liquids (metal forming).

With the reduction in use of SCCPs, they are now mostly retained for the most arduous metalworking tasks on exotic metals such as stainless steel, titanium and nickel chrome alloys. In these applications, SCCPs with high chlorine content are particularly effective, providing maximum lubrication, with a wide working temperature range.

It is the understanding of the authors of the report, that there would be a minimal impact on formulators of metalworking fluids, as a move towards medium- or long-chain chlorinated paraffins, or non-chlorinated products was well under way and expected to be complete by the end of 1999. Transitional costs due to the need for reformulation, e.g. laboratory testing, were expected to be in the order of 50 000 Euros per formulator. Despite some concerns from users over availability and efficacy of alternatives, indications were that any increased costs involved in reformulation would not be passed on to users, with equivalent or improved performance claimed. There might, however, be some issues concerning tool-life and surface finish for which a cost estimate was not available. Some non-chlorinated alternatives were likely to be slightly more expensive.

Previous consultation with industry had indicated that formulators would experience cost increases of around 20% when moving to chlorine-free alternatives, as their development requires reformulation of the base-oil. It had been suggested that such costs would be passed onto the customer. At that time, chlorine-free products cost approximately 25 to 33% more than SCCP-based fluids. This consultation went on to suggest that impacts of restrictions on the use of SCCPs in metalworking would appear to be minor, especially in those countries which have been phasing out SCCPs for sometime. Price increases of no more than 5% were estimated when switching from SCCPs to MCCPs. Formulators indicated that these costs would most likely be absorbed by themselves, rather than being passed onto the users.

The costs of moving towards MCCPs or chlorine-free alternatives had been previously estimated as set out in table 9 below.

<table>
<thead>
<tr>
<th>Member State</th>
<th>Move to MCCPs</th>
<th>Move to Chlorine-Free</th>
<th>% European Sales of MWFs</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>790,000</td>
<td>4.5 million</td>
<td>25%</td>
</tr>
<tr>
<td>Germany</td>
<td>1 million</td>
<td>6 million</td>
<td>32%</td>
</tr>
<tr>
<td>UK</td>
<td>3.5 million</td>
<td>19.5 million</td>
<td>13%</td>
</tr>
</tbody>
</table>

Note: Information available only for France, Germany and the UK. - based on 1995 data.

Based on the consultation with formulators and users, it was believed that a large part of these costs had already been borne by the majority of users - as there had been a significant drop in the quantity of SCCPs used in metalworking fluids since 1995, the year on which previous calculations were based.
For those companies yet to move to other longer chain chlorinated paraffins, the costs of reformulation were expected to be met by the formulators and not passed on to users - as reported in previous work. However, cost increases in relation to non-chlorinated alternatives are likely to be more expensive - for one sulphur-based alternative, up to 130%.

Although alternatives do appear to be available for those processes suggested as previously requiring SCCPs, there still does not appear to be a real consensus over their degree of efficacy. In particular, one supplier claimed there were a number of applications for which no completely effective alternative to chlorinated paraffins was available, for example broaching and deep-hole boring in stainless steel and nickel chrome alloys. It was suggested that the basic problem concerned difficulties in obtaining MCCPs with a low enough viscosity similar to SCCPs. However, this may not be the case due to the current availability of a wide range of new medium- and long-chain chlorinated paraffins, with differing viscosities. Whilst some users have made a complete switch to MCCPs without difficulties, others have yet to make the switch - the main barrier being the increased cost of alternatives where there is a move away from chlorinated products.

Through consultation with industry, there appeared to be a number of areas where substitution of SCCPs was found difficult. In terms of metalworking processes these related to the following extreme pressure processes:

- deformation (e.g deep drawing);
- deep hole boring;
- broaching (‘fir-tree’); and
- gear cutting.

Difficulties may be particularly relevant to certain types of metal, such as: stainless steel; nickel chrome alloys; titanium; and molybdenum.

There might also be some difficulties in moving over to non-chlorinated alternatives, such as sulphur. These may not be suitable in certain areas of industry where SCCPs are particularly suited (e.g. nuclear power engineering industry), and where the surface finish of metals is a problem.

The RPM study summarised that there is a clear difference of opinion on the subject of whether derogations are required. Whilst some of those companies consulted had already switched to use of substitutes for applications such as gear cutting, deformation/deep drawing, others claim that this was not yet possible. The only direct calls for derogations were from the aerospace industry in France, and from one manufacturer of components for metered-dose inhalers (MDIs) in the UK. Although the nuclear power engineering industry was suggested as requiring SCCPs, no evidence was found to support this.

The report states that should derogation be necessary for the MDI component manufacturer, the likely environmental impact would be small. No information was available from producers, formulators or users on the quantity of SCCPs used in metalworking fluids by the French aerospace industry and thus it was not possible to estimate the environmental impact of derogation on this application.
3.4.3 Implications of Restrictions for the Leather Processing Sector

SCCPs are used as relatively cheap bulking agents in the leather industry to increase the product volume of fat-liquors (processing agents). However, SCCPs are reported not to offer any improved performance as they do not convey any fat-liquoring properties - the replacement of oils lost during the tanning process - they are merely odour-free and ‘cost-effective’ in comparison to current alternatives. SCCPs may comprise around 20% of the fat-liquoring mix, with approximately 1-5% of SCCPs used found in the waste washings.

The Confederation of National Associations of Tanners and Dressers of the European Community (COTANCE) has also indicated that SCCPs do not appear to be crucial to leather processing, used only in ‘lower grade’ fat-liquoring agents.

The EuroChlor Chlorinated Paraffins Sector Group has reported that actual consumption of SCCPs in the leather industry was around 390 tonnes in 1994, falling to 45 tonnes in 1998. This represented a reduction in use of nearly 90% (based on 1994 figures).

Despite claims of price increases by a number of industry associations representing tanneries around Europe, consultation with the key formulator indicated that any costs would not be passed on to tanners, as much of the transition has already been made. Given that only 45 tonnes of SCCPs were used in leather processing in 1998, very small economic impacts were expected. No calls for derogations by the leather industry had been presented.

3.4.4 Advantages and Drawbacks of Restrictions on SCCPs in Non-Emissive Applications

Applications and Quantities Used

SCCPs are used in a range of non-emissive applications: as a plasticiser in paints and coatings; as a plasticiser in sealants; and as a flame retardant in rubber, textiles and plastics. Total consumption in non-emissive applications fell significantly in the 1990’s, from 3,438 tonnes in 1994 to 1,999 tonnes in 1998.

Technical & Economic Implications of Restrictions for Users

Plasticiser in Paints/Coatings

SCCPs are used as a plasticiser for paint resins. They are considered too brittle to be used by themselves. There appeared to be considerable confusion within the industry of the exact application of these SCCP-based paint resins; ERM received many contradictory reports from different suppliers, formulators and users.

One key contact stated that these resins are intended for use as exterior marine coatings and protective systems for steel-work exposed to aggressive industrial environments. Another contact (a major resin manufacturer) claims that current and future requirements for SCCPs is in non-aromatic solvent-based acrylic paints for both interior and exterior use. Traditionally, LCCPs have been used in these paints, but a growing trend throughout the EU paint industry has been to move towards these new, non-aggressive paints based on low toxicity, non-aromatic solvents. SCCPs are considered the most cost-effective plasticiser soluble in such
paints. This trend was assumed to be likely to continue, extending to all categories of solvent-based acrylic paints. This would lead to a two- to three-fold increase in demand for SCCPs for use in paint resins over the next 2-5 years. A ban on SCCPs might lead to a 7% increase in the cost of acrylic paints. However, it has not been possible to corroborate this information.

**Plasticiser in Sealants/Adhesives**

SCCPs and MCCPs are used as inert plasticisers in a wide range of sealants and mastics for use in construction, automotive and industrial applications (e.g. polysulphide sealants and polyurethane-based resins). They are also used in adhesives as a plasticiser or flame retardant additive.

The majority of polysulphide sealants were produced in the UK for use in the construction industry. Most other Member States have moved away from these products. Consultation with UK industry revealed mixed opinions over the need for SCCPs. Some of the UK producers stated that they would need up to 2 years to find and test alternatives and that costs to end users may increase by 5%. However, other companies had substituted SCCPs with MCCPs and report no apparent loss in performance or increase in cost.

SCCPs were also used in the production of polyurethane foam sealants (eg. by a major Dutch producer), but had been largely substituted by MCCPs, with no significant difficulties.

**Flame Retardant in Rubber, Textiles and PVC**

Short-chain chlorinated paraffins ($C_{10-C_{13}}$) or long-chained, with 70-72% chlorine, are used as flame retardant additives in synthetic rubber and flexible PVC. They are often used in combination with antimony trioxide and other substances to improve flame resistance. Their main application is in inflammable conveyor belts, hoses and tubes in underground mining applications, where use of SCCPs has been justified on grounds of the high flame resistance required for safety reasons.

Under the PARCOM Decision 95/1, exemptions were allowed for the use of SCCPs in dam sealants and underground mine conveyor belts until 2004. SCCPs were still being used in production of mine conveyor belts in several Member States.

Whilst alternatives appeared to be available (longer chained chlorinated paraffins, and non-chlorinated alternatives) they were substantially more expensive than SCCPs (required in greater quantities to achieve desired chlorine level, or up to 4 or 5 times as costly). Reformulation costs were assumed to be in the order of 75 000 Euros per producer, and re-approval costs could be in the order of 1.5 million Euros for the larger producers. This was estimated to lead to a rise in cost of finished products of 15-20% if SCCPs were banned and to possible losses of jobs.

The use of SCCPs in textiles and PVC was very limited. MCCPs were preferred as a flame retardant and plasticiser in PVC. It was expected that the impact of a ban on SCCPs in these applications would be minimal.
Summary of Advantages and Drawbacks of Restrictions

In summary, the advantages of restrictions were assessed to be small, given that the risks from use of SCCPs in these applications had been assessed as being low. However, the risks from most of the major alternatives (MCCPs, LCCPs, phthalates) were assumed to be lower than those from SCCPs.

The disadvantages of restrictions were mainly economic because alternatives which provide equivalent performance were available for most, if not all, applications. A rise in the cost of end products for users was estimated to be caused by the need for reformulation and re-approval (transitional costs which will fall on producers, who will require some time to make the transition away from SCCPs) and the ongoing higher input costs of alternatives to SCCPs. In the case of rubber products for the mining industry, the costs were estimated to be significant and there was also a risk of consequent loss of employment.
PART III – CONCLUSIONS

SCCPs are highly toxic to aquatic organisms. They do not break down naturally and tend to accumulate. The available data from remote areas show clearly contamination of environment and biota by SCCPs. Their persistence, bioaccumulation and toxicity mean that they may have damaging environmental effects at a global level. Overall, it can be considered that SCCPs fulfil the criteria of the Decision 1998/2 of the Executive Body (UNECE 1998) for persistence, potential to cause adverse effects, bioaccumulation and potential for long range environmental transport.

Production and use of SCCPs has been restricted over the last years in the European Union but no total prohibition has yet been foreseen. On the other hand, production and use of SCCPs continues unrestricted in many other countries. As SCCPs can move in the atmosphere far from its sources, single countries or groups of countries alone cannot abate the pollution caused by it. Due to the harmful POP properties and risks related to its widespread production and use, international action is warranted to control this pollution.
REFERENCES


Environment Canada (2003). Follow-up report on a PSL1 Substance for which there was insufficient information to conclude whether the substance constitutes a danger to the


