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PCBs in Svalbard

Status of knowledge and management

April 2008

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Summary
PCBs have long been well-known pollutants in the Arctic environment. Since the early 1990s, several studies have been conducted on PCBs in Svalbard. The report provides a summary of knowledge on PCBs in Svalbard, particularly research and management status, presented at a multidisciplinary seminar in Trondheim from the 9th - 11th January 2008. The seminar was arranged by the Geological Survey of Norway on behalf of the Governor of Svalbard and the Norwegian Pollution Control Authority. The purpose of the seminar was to collate existing documentation related to PCBs and prepare a combined report on PCBs in and around Svalbard. The report documents the need for, and provides proposals for, specific research and management activities.

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- PCB
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Keywords English
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Front page image
From the Monaco glacier in Liefdefjorden and polar bear on Phippsøya. Photo: Halvard R. Pedersen

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1. Introduction

1.1. *Purpose of the seminar*

PCBs have long been well-known pollutants in the Arctic environment. Since the early 1990s, several studies have been conducted on PCBs in Svalbard. The Governor of Svalbard has initiated a project to reduce as much as possible of the local sources of PCBs. In this connection representatives from a number of organisations that have worked on pollutants in Svalbard were invited to a working seminar related to PCBs.

The objectives of the seminar have been:

1. to collate existing documentation related to PCBs and prepare a combined report on PCBs in and around Svalbard (air, precipitation, water/snow, soil, contaminated areas, landfills, sediments, products, seals, gulls, polar bears etc.)
2. to examine and estimate the extent of local use of PCBs in Svalbard (Primary sources: capacitors, transformers, hydraulic oils, paint and secondary sources (soil)
3. to examine conditions connected to the relation between long-range and local PCB sources
4. to examine the effects of PCBs on the ecosystem
5. to make recommendations for further work primarily connected with the significance of local sources

Norway has a high level of ambition for environmental management in the Arctic and in Svalbard. Legislation creating the framework for such management includes Report no. 9 (1999-2000) to the Storting, Svalbard, Report no. 12 (2001-2002) to the Storting, Protecting the Riches of the Seas (incl. regional action plans) and the National action plan for reduced PCB emissions. Svalbard is to be one of the best managed wilderness areas in the world.

In its report on the management of Svalbard no. 3:8 (2006-2007), the Office of the Auditor General of Norway (OAG) found inadequate environmental monitoring resulting in an inadequate basis for decision-making. The work to systematize PCB efforts in Svalbard can be seen as an example of action taken to follow up the comments made by the OAG.

Seminar participants

- Rolf Tore Ottesen, Geological Survey of Norway (NGU)
- Tore Volden, NGU
- Morten Jartun, NGU/NTNU
- Ola Eggen, NGU
- Anders Ruus, Norwegian Institute for Water Research (NIVA)
- Halvard R. Pedersen, Governor of Svalbard
- Geir Wing Gabrielsen, Norwegian Polar Institute (NP)
- Anita Evenset, Akvaplan-niva
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- Hans Jørund Hansen, SFT
- Roland Kallenborn, University Centre in Svalbard (UNIS) and Norwegian Institute for Air Research (NILU)
- Janneche Utne Skåre, National Veterinary Institute/Norwegian School of Veterinary Science
- Bjørn Munro Jenssen, Norwegian University of Science and Technology (NTNU)

- Søren Jensen, Stockholm University (guest speaker on the topic of how PCBs were discovered to be pollutants at the end of the 1960s).

Contributions to chapter 3.2.3 Snow/ice were received from Elisabeth Isaksson (Norwegian Polar Institute) and Mark Hermanson (Univ. of Pennsylvania) after the seminar.

1.2. *PCBs*

PCBs do not degrade readily and are highly fat-soluble. These properties mean that PCBs build up (bioaccumulate) in parts of organisms rich in fat and increase in concentration in food chains (biomagnify). PCBs are passed on to the next generation in eggs, via the uterus to the foetus as well as via the mother's milk. PCBs are acutely poisonous for marine organisms. Acute toxicity for mammals is relatively low. Even in small concentrations PCBs have chronic toxic effects on both land and water-based organisms. For example, PCBs are often seen to cause reproductive defects in sea mammals. In addition PCBs can weaken immunity levels, thereby increasing susceptibility to infections and diseases. Different PCB compounds can damage the nervous system, cause liver cancer and reproduction problems as well as damage the foetus. PCBs have also been shown to have a negative effect on development and the ability to learn in humans.

More information about PCBs can be found at www.miljostatus.no and on websites of the participating institutions, includingwww.sft.no.

1.3. *Method requirements, sampling, analyses etc.*

When evaluating research and environmental monitoring reports it must be noted that PCBs are reported in many different ways, not all of which are directly comparable. Here are some examples:

- $\sum PCB_7$, $\sum PCB_{33}$, etc.
- Representing wet weight and dry weight or lipide weight (most common in animals)

An important purpose of monitoring levels of pollutants is to establish trends. This objective should be so clearly formulated that the scale of trends that the monitoring is designed to establish can be quantified. This will be of major significance in the choice of monitoring strategy; for example the number of samples to be taken and their frequency. This problem is illustrated by a statistical analysis the Norwegian Polar Institute carried out on samples of pollutants in polar bears collected over an eight-year period. The samples were taken from blood, fatty tissue and milk and initially showed no periodic trends due to the large variations in the data. The first task was therefore to find out in which tissue there was the least variance. This was found to be in blood serum. Thereafter all samples in serum were analysed to find any reasons other than pollution levels that could explain the variation between years. It was found that the animals' state of nutrition, reproductive status as well as the time and location of sample collection all played a part. It was not until material was obtained that was standardised for these factors, that it was possible to establish a trend – incidentally the first time series of contamination in polar bears. Yet no more than around half the samples collected were required for this. This clearly demonstrated how important it is to standardise sample collection in the future.

This type of analysis is an example of how it is possible to proceed in order to have less natural variance in the sample material and more realistic expectations of the kind of trend analyses that monitoring can produce. Such statistical analyses should be included in all monitoring. However more research efforts are needed to improve methods of monitoring.

The PCB content in various samples from Svalbard has been determined in many different laboratories and over many years. The likelihood of "batch problems" is an issue that should be clarified. Sample collection, locations, analysis methodology and equipment can influence the result.

ACTION

- Initiate collaboration on problems connected to checmical analyses of PCB, need for re-analyses and level adjustment? Different sample types, different laboratories, in a laboratory: batch-problems, how to deal with time series?

2. Sources and pathways for PCBs

2.1. *General*

Understanding and predicting the distribution and effects of PCBs in Svalbard is an extremely complex task; one reason being the large seasonal variations in supply. Local topography and meteorological conditions also have a major influence on the amount of long distance environmentally transported pollution that is deposited on the ground or in the water. Furthermore the different congeners can act in different ways and have different environmental effects.

2.2. *Global transport*

PCBs in Svalbard come from several sources; many have been verified as long range air-transported (evaporation from contaminated soil and unintentionalle formed PCBs from sources such as forest fires) and oceanic currents.

PCBs in the atmosphere can originate from:

1) Primary anthropogenic emissions as a direct consequence of earlier production of PCBs ((Breivik et al., 2002a,b).
2) Emission due to the unintentional formation (*de novo synthesis*) of different PCB congeners in combustion processes (e.g. Brown et al., 1995). One example is forest fires in boreal areas.
3) The re-emission[1] of PCBs from various media in contact with the air, such as water and soil (e.g. Jeremiason et al., 1994; Agrell et al., 1999).

It is estimated that around 45% of long distance environmentally transported PCBs reach Svalbard through direct and continuous transportation in the air, 30% directly from oceanic currents and 25% through ice transport (particles in ice floes) and the annual smelting in the marginal smelting zones in Framstredet and around Svalbard and Bjørnøya. It is most likely that PCBs that are transported through ice movements originated from a fresh water supply through the East Arctic rivers, atmospheric deposition and intake in the ice through exchange processes in the sea water/ice boundary (Arctic Monitoring and Assessment Programme, AMAP 2004; Carroll et al. 2008). NGU is taking part in a large-scale IPY project that includes the transport of PCBs in rivers in areas including Russia (The International Polar Year Project 317: "Flux of sediment-associated chemical elements in rivers draining to the Arctic Ocean").

[1] PCBs and similar components have the potential for reversible atmospheric deposition based on accepted theories and models concerning global fractation / the grasshopper effect (see Wania & Mackay, 1996).

PCBs are also transported to the Svalbard area by fauna that migrate or gather food from outside the area and pick up pollutants en route. Supply through migrating marine organisms is deemed to be of less significance, despite being important in certain areas.

The transportation of PCBs to Svalbard depends upon the physical and chemical properties of the PCB congeners and different environmental conditions such as the weather, hydrology and geology etc. Variations in transport throughout the year and regionally have been found for certain PCB types in both water and air samples from the Zeppelin station in Ny-Ålesund (MOSJ and AMAP 2004, various SFT reports).

The background level in the atmospheric samples of Σ PCB $_{33}$ was 15-20 pg/m^3 at the Zeppelin station during the period 2000-2006 and 40-50 pg/m^3 at Bjørnøya in the period 2000-2003. Data from Bjørnøya reflects a significant contribution from the surrounding areas (evaporation from the sea, PCBs connected to particles from guano or similar) compared with data from the Zeppelin station where measurements showed mainly long distance environmentally transported PCBs in the air (Kallenborn et al. 2007).

ACTION

- ☐ Initiate collaboration on the reduction of PCB emissions with countries that contribute to PCB pollution in Svalbard via air and oceanic currents. For countries that have ratified the Stockholm convention, this can for example be turned into a joint activity for following up the convention:
  - SFT's collaboration with countries such as China and Poland
  - AMAP and the bilateral environmental cooperation with Russia (including providing input to PCB projects in the bilateral Russia work for the 2008-2010 programme
  - Collaboration on cleaning up PCB contamination in Frantz Josef land

2.3. *Local and regional sources*

There is no available information on the quantity of equipment and oil containing PCBs that has been brought to Svalbard. The technical properties of PCB oil made it widely used in the mining industry, amongst others. Its uses included that of an insulating and cooling agent in electrical equipment (capacitors and transformers) and in hydraulic oils. PCBs have also been used in construction supplies.

PCB compounds have been dispersed into the environment through equipment breakdowns, in the destruction of equipment etc. as well as in the depositing of oils and equipment containing PCBs in waste landfill sites. PCB compounds can be re-emitted. It is likely that contaminated sediments are a source of continued environmental dispersion. PCBs can also be unintentionally created in and mobilized in combustion processes.

Several reports from the period from 1998-2007 document contaminated soil and landfill sites in Svalbard that can contain PCBs. In addition, there are large quantities of waste potentially containing PCBs spread throughout the settlements. A number of surveys have been carried out that indicate that PCBs and other pollutants have leaked into the marine environment, where these can be absorbed by organisms and introduced into food chains; see chapter 3.2.

ACTION

- ☐ Collate all survey results, divided into marine environment, terrestrial environment and sediment-dwelling organisms, for example. This can help in also making externally

sourced reports/non-public environmental surveys available for use (e.g from Store Norske and Bydrift Longyearbyen).

- ☐ Examine and estimate the amounts of PCBs in pristine areas; on land, in fresh water and in the ocean (background levels/long range environmental transportation aggregated effect).

3. PCB contamination status in Svalbard

3.1. *Atmospheric*

Analyses of PCBs in air samples collected during the period from 2000-2004 indicate that the distribution of PCBs in air masses over Svalbard varies according to the time of year. It is likely that one reason for this is increased evaporation from the ocean surface during the summer months. Increased PCB concentrations have been particularly visible during the years 2001-2002 while in 2003 no definite maximum level of PCBs was observed during the summer months - see the figure below. This is probably due to the weather situation and low average temperature in the ocean around Svalbard.

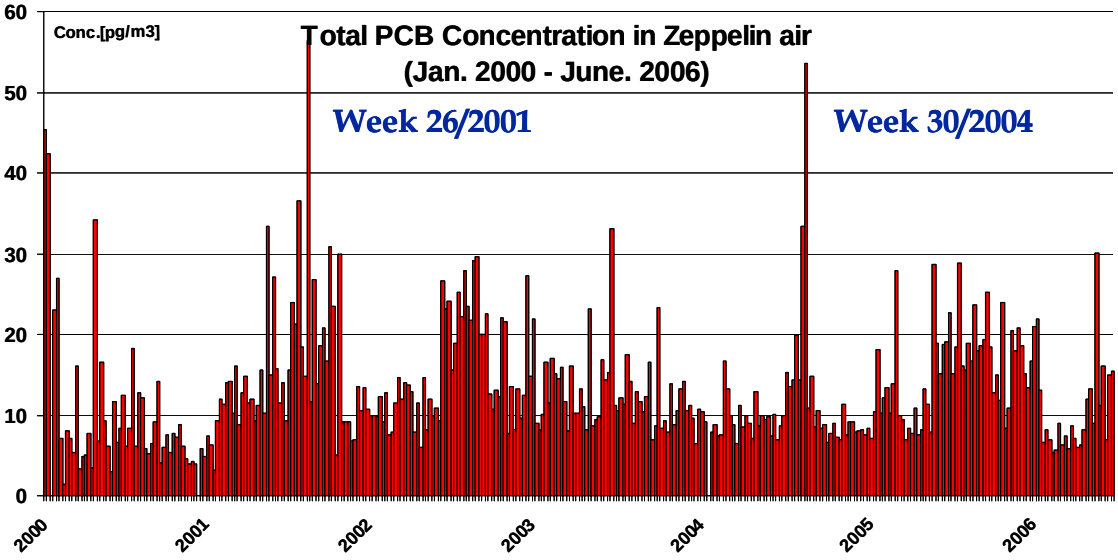

Figure 3.1-1. PCB levels in air samples from Zeppelin station in Ny-Ålesund 2000-2006.

As a part of an AMAP network of air monitoring stations, the Zeppelin station plays an important international role in the long-term monitoring of persistent organic pollutants. A comparison of PCB levels in air from six arctic atmospheric monitoring stations shows that the PCB concentrations in the air from Zeppelin station are the highest. The Canadian Alert station reports a declining trend for PCBs in air. Such a tendency cannot be confirmed at Zeppelin station (Berg et. al. 2004).

ACTION

- ☐ Pilot project with a more close-knit station network in Svalbard for a limited period (PCB/POP in Svalbard air) to investigate local/regional differences in dispersion and exposure patterns. Pass on experiences from Bjørnøya.
- ☐ Pilot project with the collection of dust (dust buckets) in the settlements as the basis for the estimation of its contribution to human exposure.
- ☐ Overview map of Svalbard that shows the distribution and long distance environmental transportation of PCBs to Svalbard (air, ocean, ice and biological pathways, with indication of relative quantities.

- Overview map of Svalbard that shows the geographical distribution of estimated potential local pathways (soil contaminated with PCBs, condition classes of the fjord bed outside the settlements, PCBs on land).
- Verification measurements of emissions from combustion in coal power stations are viewed in conjunction with the summer evaporation of PCBs (differentiate local sources and long distance environmentally transported PCBs).
- Contribute to further research in the Barents Sea by carrying out uniform environmental monitoring at the different measurement locations.

3.2. *Terrestrial*

3.2.1. Soil (surface soil in the settlements, contaminated soil, landfills)

Local sources on land

Results from marine environment monitoring in 2005 and previous years indicate that there are active local sources of PCB pollution in the settlements in Svalbard (Akvaplan-niva). PCB sources could be waste containing PCBs (e.g. old capacitors and scaling from painted surfaces), buildings (e.g. the mortar used in cement and paint containing PCBs in the Russian and the Norwegian settlements) and contaminated soil. Contaminated sediments may also be a source of PCBs for marine organisms (through re-suspension).

15 locations in Svalbard are registered in SFT's national database on potentially contaminated and contaminated sites as either having been found or likely to be contaminated with PCBs. These locations were in Longyearbyen, Ny-Ålesund, Barentsburg and Pyramiden (SFT 1998, NGI reports). The database primarily covers landfills, and data was not collected from workshops or around the actual settlements in Barentsburg og Pyramiden, for example.

Follow-up surveys carried out by NGI found PCBs in these locations:

- Ny-Ålesund: areas 6003 (Thiisbukta), 6013 (shaft 6) and 6014 (shaft 7) where small amounts of PCBs drain into the Tvillingvatn). A later survey found no PCBs in Thiisbukta.
- Sveagruva: 0003 closed landfill at Svea (small amounts of PCBs).
- Barentsburg 0080 Kapp Heer, 0066 barges in Colesbukta, and low levels of PCBs at area 0075 fuel tanks and 0079 landfill site after the mines between Kapp Heer and the town limits.

NGU report 2007.075 shows low concentrations of PCBs in the surface soil in Longyearbyen (number of samples, N=30). Concentrations of PCBs up to 29 mg/kg were found in the surface soil from the Russian settlements in Barentsburg (N=22) and Pyramiden (N=31), with median values of 0,27 and 0,17 mg/kg respectively. Simple calculations based on arithmetic average content suggest that there may be over 2,500 kg of pure PCBs in the soil around the buildings in Barentsburg. Figure 3.2.1-1 shows the cumulative frequency distribution diagram from the three settlements. These concentrations are much higher than those reported in similar tests from towns in mainland Norway; see table 3.2-1. NGU report 2007.075 concludes that it is highly likely that PCBs have spread to the marine environment through fluvial and eolian erosion.

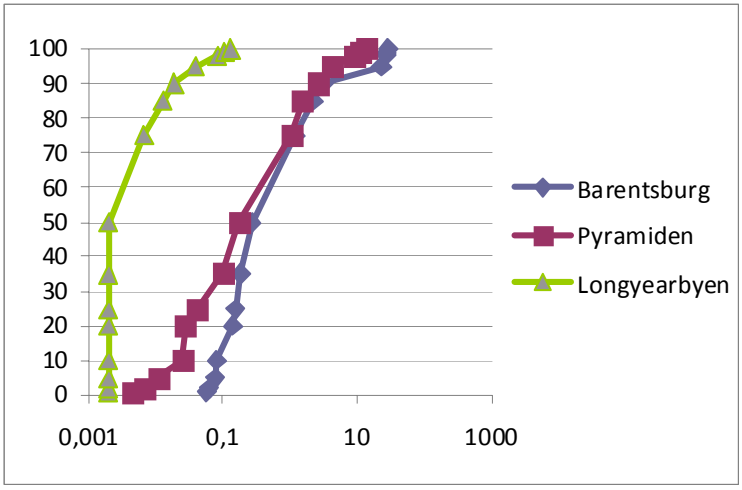

Figure 3.2.1-1: Cumulative frequency distribution for concentrations of PCB_7 in surface soil from Barentsburg, Pyramiden and Longyearbyen. Concentrations in the Russian settlements are far higher than in Longyearbyen, and also exceed the results of previous surveys in towns on the mainland.

Table 3.2.1-1. Overview of PCB_7 concentrations in soil and paint from Svalbard compared with data from Norwegian towns on the mainland. The rows in grey are from Svalbard. The surveys in the remaining towns were also carried out by NGU.
Outline of PCB_7 concentrations in soil and paint from other studies carried out by NGU.

mg/kg	Location	No. of samples	Median (50 %)	Range		Reference
Soil	All	83	0,068	< 0,004 -	28,7	x
	Barentsburg	22	0,268	0,052 -	28,7	x
	Pyramiden	31	0,172	< 0,004 -	13,9	x
	Longyearbyen	30	< 0,004	< 0,004 -	0,131	x
	Harstad (2006)	39	0,007	< 0,004 -	0,078	Jartun and Volden (2006)
	Tromsø (2003)	52	< 0,004	< 0,004 -	2,40	Tromsø (2003)
	Oslo (2006)	6876	< 0,004	< 0,004 -	9,00	e.g. Eggen et al., 2007 ; Haugland et al., 2005 ; Haugland et al., 2006
	Trondheim (2000)	262	< 0,004	< 0,004 -	0,420	Ottesen et al. (2000)
	Bergen (1999)	20	0,007	< 0,004 -	0,950	Ottesen and Volden (1999)
Soil (specific sampling)*	Bergen (2002)	43	0,150	< 0,004 -	320	Andersson et al. (2002)
	Bergen playgrounds (2003)	39	0,038	< 0,004 -	28,0	Andersson et al. (2003a)
	Tromsø (2002)	4	0,099	< 0,004 -	0,60	Andersson et al. (2002)
	Oslo (2003)	56	0,008	< 0,004 -	1,40	Andersson et al. (2003b)
Paint	All	27	0,236	< 0,004 -	3520	x
	Barentsburg	13	0,601	0,0201 -	3520	x
	Pyramiden	7	0,0421	< 0,004 -	1290	x
	Longyearbyen	7	0,0655	0,0048 -	0,695	x
	Longyearbyen (2006)	10	< 0.004	< 0,004 -	0,176	NGU, unpublished
	Bergen (2006)	69	0,246	< 0,004 -	3390	NGU, unpublished

*Soil adjacent to facades of buildings from 1950-70.

Old landfill sites in Sveagruva are followed up by Store Norske, and land-based activity there is not expected to generate significant emissions of pollutants based on procedures regarding and current requirements for waste treatment, including hazardous waste (everything is sent to the mainland).

ACTION

- ☐ Overview map showing local pathways (soil contaminated with PCBs, condition classes of the seabed outside the settlements, PCBs on land (estimated), estimated amounts in the Svalbard environment in total and geographically distributed.
- ☐ Further sampling in Barentsburg and Pyramiden to demarcate polluted areas.
- ☐ PCB sampling in Colesbukta, Grumant, Isfjord radio, Sveagruva and Ny Ålesund (soil samples and products).
- ☐ Soil water monitoring from an area containing PCB contaminated soil in Barentsburg.
- ☐ More detailed PCB analyses from erosion-prone areas below PCB sources in Pyramiden can show PCB transportation from relevant sources.
- ☐ Follow-up work on contaminated sites in local area planning and handling of PCB contaminated soil in the event of demolition/renovating/new building work in the settlements.
- ☐ Review of SFT's contaminated sites database and evaluation of whether new contaminated areas from NGU's documentation work in 2007 should be included (NGU report 2007.075).

3.2.2. Fluvial sediments

A flood sediment profile has been prepared for Adventdalen by Norwegian Water Resources and Energy Directorate (NVE). As of January 2008 the samples have been sent for chemical analysis to determine PCB content. In addition NGU has 650 samples of fluvial sediments from all of Svalbard in its sample store. Selected samples from this collection can be used to determine the contribution made by long distance environmentally transported pollution to PCBs in the soil in Svalbard. Data material from this process will be included in the new geochemical atlas for Svalbard to be published in 2008.

NVE runs a measurement station in Adventdalen. The station measures water flow and mass flow. Sediment flux is determined. Data from the station can be used to calculate the supply and coverage of PCBs from the settlements and other known land-based sources to the marine environment.

ACTION

- ☐ Include PCB in the new geochemical atlas for Svalbard.
- ☐ Calculations of PCB flux and sedimentation (Akvaplan-niva+NVE).
- ☐ Selected samples NGU's collection of fluvial sediments to be analysed to determine the contribution made by long distance environmentally transported pollution to PCBs in the soil in Svalbard.

3.2.3. Snow/ice

NP has carried out PCB analyses of winter snow from several glaciers (Lomonosovfonna, Holtedahlfonna, Austfonna, Linnebreen) over several years. This has been carried out to gain an indication of variability around Svalbard. Ice taken from the ice core from Lomonosovfonna (taken in 2000) has been analysed and a time series for PCBs has been established (Hermanson et al. 2005). The maximum PCB concentration (> 100 cogenes) was 748 pg L^{-1}.

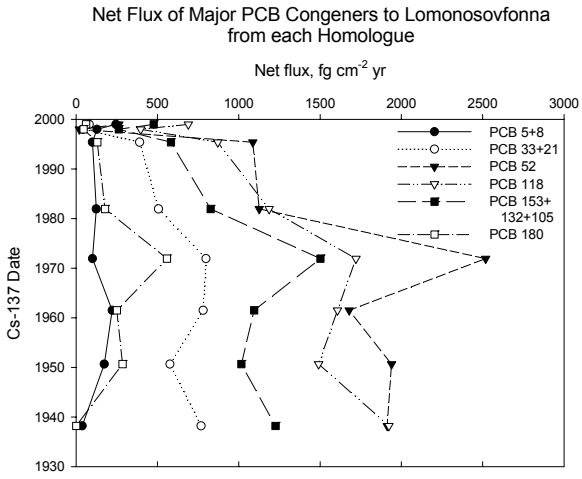

Figure 3.2.3-1. PCB measurement in ice from Lomonosovfonna

Analyses of the ice cores show a clear reduction in the supply of PCBs via air streams after 1970. The congener composition shows little change which indicates an effective "atmospheric distillation process" over Svalbard. An analysis of spring snow taken in 2001 in ny-Ålesund showed a PCB content of 742 pg L^{-1}. Studies support the observations that PCB congeners with a low molecular weight can remain present in the gas phase under the climatic conditions found in Svalbard.

Snow samples that were collected in the study of precipitation-borne PCBs at Bjørnøya have been analysed. (Evenset et al. 2002).

3.2.4. Humans

It is not known whether there are any measurements of PCBs in humans.

3.2.5. Plants

Moss samples from Ny-Ålesund and from Bjørnøya have been analysed for substances including PCBs (Tveter 2005). The levels in moss were lower in Ny-Ålesund than in moss from Bjørnøya, but the basis data was more limited and more samples should be analysed before final conclusions can be drawn. Russian data should be available from lichen in the area around Barentsburg (see chapter 4.2).

ACTION

- □ Studies of PCBs in flora.

3.2.6. Herbivores

The Svalbard reindeer is a distinct subspecies of the 7 remaining subspecies of Arctic reindeer and is local to Svalbard. Some individual animals also seem to have adapted to living conditions and pasture in the settlements. These could absorb PCBs and other pollutants from local sources through particular paint containing PCBs (via the wind dispersion of the substrate that attaches itself to the vegetation). Analyses of samples from reindeer in 1993 showed minimal values at a level that makes it difficult to detect intake from local sources (NP 1995). There is a need to update this information with new samples and analyses to monitor whether the situation is still the same.

PCB analyses have not been carried out on the the Sibling mouse, which is found in the areas of Grumant, Adventfjorden and Longyearbyen. At times, but very rarely, there have been invasions by rats in the settlements, and in 2007 the problem occurred again in Longyearbyen. Potentially these animals could accumulate PCBs, and rats, due to their diet, are probably more likely to do so. This could then lead to further bioaccumulation at the higher predator levels. The Sibling mouse is a pure herbivore and unlikely to be a good indicator.

ACTION

- □ Surveys of possible PCBs in game as a possible source of PCBs in humans in Svalbard (hunting reindeer, grouse and seals, fishing for arctic char).
- □ Analyses of planned samples of rats in Longyearbyen also to include pollutants.

3.2.7. Birds

The Svalbard grouse is found all over Svalbard and is common in and near the settlements. During the nesting season it generally keeps to its home territory. There is therefore a hypothetical possibility that this too can accumulate PCBs and pollutants from local sources in

sand/gravel and from plant material. NP has examined PCB and heavy metal levels in grouse from Longyearbyen and Ny Ålesund. The levels were very low and in all probability not suitable for the detection of pollution from local sources.

A species that can probably be used to trace further dispersion in biota of local PCB pollution is the glaucous gull. The glaucous gull is found all over Svalbard and sometimes throughout the whole year. Despite not having undertaken detailed investigation it is assumed that certain individual birds live in or close to the settlements, at least outside of the nesting season. Foraging for fish with regard to marine recipients beyond local land sources can therefore be deemed a potential dispersion pathway. It is possible to trace any uptake of local PCBs and differentiate this from long distance environmentally transported PCBs as the analyses differentiate between the various types of PCBs (congener profile).

ACTION

- ☐ Investigations of possible methods to identify local sources by studying the concentration of PCBs in birds local to a given area.
- ☐ Surveys of possible PCBs in game as a possible source of PCBs in humans in Svalbard (hunting reindeer, grouse and seals, fishing for arctic char).

3.2.8. Arctic fox

The arctic fox is the only carnivorous land mammal in Svalbard. The species is found all over the archipelago, but only periodically on islands without sufficient ice connections through the summer and autumn seasons. The arctic fox also normally lives in the settlements and is practically an omnivore (opportunist). The uptake of pollutants (including PCBs) of most relevance to the arctic fox is assumed to be long distance environmentally transported pollution. This is due to the fact that a significant proportion of the population live on sea birds and eggs from the colonies and on the carcasses of seals caught by polar bears. The proportion of the population living close to any local PCB sources is relatively small. Samples taken from the arctic fox were analysed in the 80s and 90s in Svalbard (AMAP 2004). No samples taken from arctic foxes from the settlements have been analysed. NP has collected samples after 2002, but this material has not been analysed. Samples from arctic foxes from Adventdalen will be analysed in the near future. It is hoped that this will show the extent to which the arctic fox can be an indicator in tracing dispersion from local sources.

In addition to the samples mentioned above data on PCB levels in fat and liver samples taken from arctic foxes collected in the periods 1973-74, 1983-84, 1991-92 and 1998-99 is available. The PCB levels found are up to 40% higher than the levels measured in the polar bear. This provides grounds to assume that this pollution may have an effect on the immune and reproductive system of the arctic fox.

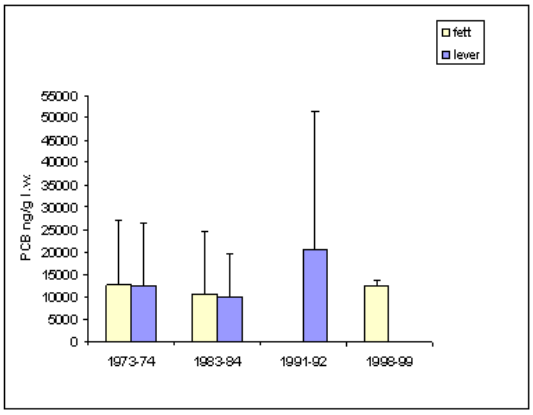

Figure 3.2.7-1: Average level of total PCBs in ng/g fat weight over time in the liver and fat of arctic foxes in Svalbard. The levels of the environmental pollutant polychlorinated biphenyl congeners (PCBs) have been measured in the arctic fox in Svalbard over four periods. PCB levels measured in the liver of arctic foxed were twice as high in 1991-92 compared with 1973-74 and 1983-84, while the values measured in fat in 1998-99 were back to the 1973-74 and 1983-84 level. A similar time trend was found in the polar bear from Svalbard and Øst-Grønland. In 1998-99 PCBs made up 60% of the total effects caused by pollutants in the arctic fox in Svalbard (source: MOSJ).

ACTION

- ☐ Investigations of possible methods to identify local sources by studying the concentration of PCBs in arctic foxes in the settlements

3.3. *Freshwater*

3.3.1. Water

Water samples from Ellasjøen and Øyangen in Bjørnøya have been analysed for PCBs. The concentrations were highest in Ellasjøen: 129 x 10^{-12} g/l compared with 23 x 10^{-12} g/l, total of 11 congeners (see Evenset et al. 2007). Russian data may be available on freshwater in the area around Barentsburg (see chapter 4.2).

ACTION

- ☐ Examine PCB levels in lakes in Svalbard

3.3.2. Lacustrine sediments

Sediments from Ellasjøen in Bjørnøya and Barentsvannet in Barentsøya were analysed for POPs as a part of AMAP's documentation of pollutants in freshwater carried out in 1997 (Skotvold et al. 1997). Very high concentrations of PCBs were found in the sediment from Ellasjøen. This was later confirmed through further analyses including analyses of the sediment from the area (see Evenset et al. 2006). The levels in the sediment from Barentsvannet were relatively low, and at the same level as in sediment from Northern Norway.

Akvaplan-niva and NIVA are currently running a follow-up lake survey on behalf of SFT/AMAP. Analyses of sediment from Ellasjøen, Richardvatn, Kongressvatn and Arresjøen are included in this survey. The results will be available early in 2008 (Christensen et al. in prep.).

Supply

Variations in the supply of PCBs to sediment have been determined in Ellasjøen in Bjørnøya. The results showed that supply was at its highest in the period from 1960-1972; see the figure below (Evenset et al. 2007).

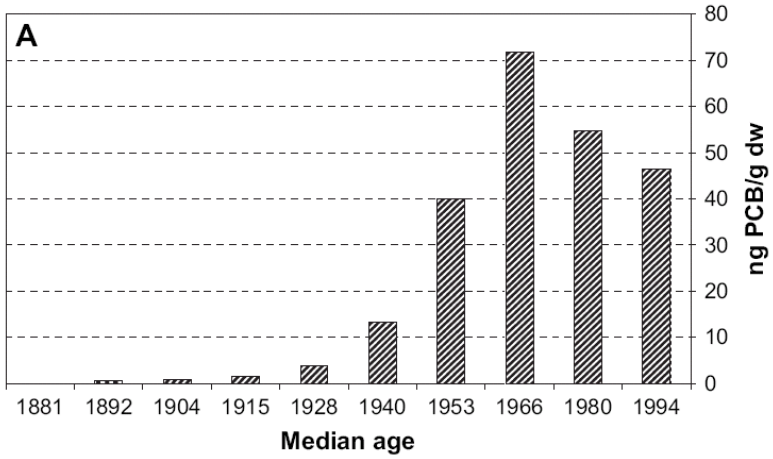

Figure 3.3.2-1. Concentrations of PCBs in a dated sediment core from Ellasjøen in Bjørnøya (from Evenset et al. 2006).

Akvaplan-niva has sediment cores from some of the other lakes in Svalbard. These can be used in studying time trends for PCBs and other pollutants, as well as estimating background values.

3.3.3. Arctic char

Arctic char have been included in AMAP's surveys in Bjørnøya and Svalbard. Skotvold et al. (1997) found extremely high PCB concentrations in arctic char from Ellasjøen. This has later been confirmed through further surveys of arctic char from this lake (Evenset et al. 2004; 2005; 2007). In the case of fish from the lakes of Diesetvannet, Richardvatn and Hornsundet Skotvold et al. (1997) reported generally lower levels of PCBs, whilst for fish from Linnèvann and Kongressvatn somewhat higher concentrations were found.

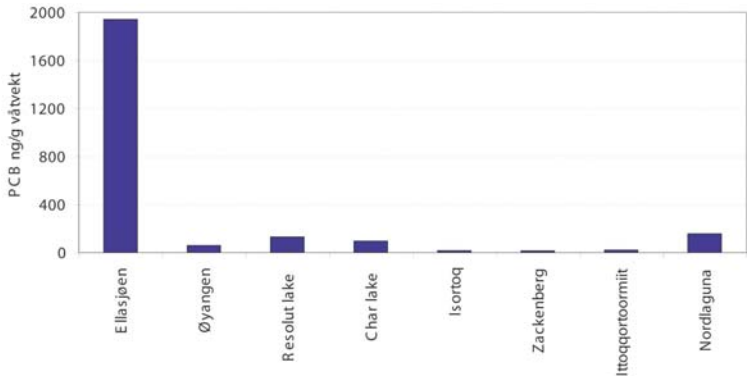

Figure 3.3.3-1. Concentrations of PCBs in arctic char from Bjørnøya (from Evenset et al. 2004,2005,2007).

In AMAP's most recent lake survey (Christensen et al. in prep) fish from Ellasjøen, Kongressvatn, Richardvatn and Åsøvatn were analysed for POPs, including PCBs. The results will be available in early 2008.

ACTION

- ☐ Surveys of PCBs in arctic char, with special focus on lakes where fishing is carried out or where special, local conditions can lead to increased concentrations of PCBs.

3.4. *Marine*

3.4.1. Seawater

Some studies have been carried out (AMAP/Olsson 2002). The levels in seawater collected in Bjørnøya were reported by Evenset et al. (2002). Otherwise no data for PCBs in seawater from Svalbard has been found. The COPOL project (see chapter 4.5) will generate new data from Kongsfjorden and Rijpfjorden. Due to low levels a major element of uncertainty applies to the measurements of PCBs in seawater and results from different laboratories vary widely. Analyses of seawater will not therefore be particularly suited to revealing local sources.

3.4.2. Sea ice

It is estimated that 25% of long distance environmentally transported PCB contamination reaching Svalbard comes with sea ice, in the transport of frozen contamination from the major Russian rivers over the Pole to the West Arctic region. NP has data for ice movements in the ocean areas of the Arctic. NGU, NVE and Moscow State University have data for the level of pollutants and the flux of particle-bound contamination in S. Dvina and Pechora. . Akvaplan-niva has calculated the flux of pollutants from Ob and Yenisey (Carroll et al. 2008).

3.4.3. Marine sediments

Supply of pollutants (Flux of particle-bound contamination)

The reservoir of pollutants in sediment depends on two factors. 1) concentrations of pollutants in the sediment and 2) sedimentation speed. By observing the combined significance of these factors in dated sediment data it is possible to obtain an integrated picture of trends in environmental pollutant effects in both time and space.

Cochrane et al. (2001) calculated the supply of different pollutants, including PCBs, to the sediments in Forlandssundet, Grønfjorden, Billefjorden and Isfjorden. The sedimentation speed was highest in Barentsburg, followed by Isfjorden, Pyramiden and Forlandsundet. The supply of pollutants to the seabed was highest in the area outside Barentsburg, as a result of a relatively high sedimentation speed as well as high concentrations of environmental pollutant in the sediments; see figure 3.4.3-1. A comparison between the areas shows that the supply of chloroorganic compounds in the period from 1988-1998 was 3-5 times higher to the area outside Barentsburg than to the areas outside Pyramiden, Isfjorden and Forlandsundet. This indicates an active PCB source. The flux calculations also indicate that local sources are important outside the settlements.

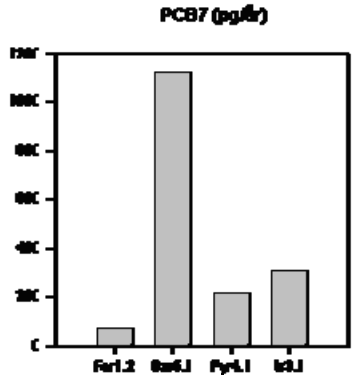

Figure 3.4.3-1. Supply of $\sum PCB_7$ to bed sediments in Forlandsundet, Barentsburg, Pyramiden and Isfjorden in the period from 1988-1998.

Braganzavågen and Van Mijenfjorden are also distinguished by large-scale mass transportation and sedimentation.

If the contamination sources on land are removed, this will lead to the more rapid coverage of the contaminated marine sediments with clean material.

Marine environmental surveys

Several marine environmental surveys have been carried out in the fjords in Svalbard and in the waters around the archipelago. This covers surveys of sediment in Kongsfjorden, the marine recipients outside the waste landfills in Barentsburg and Longyearbyen, environmental pollutants and benthic fauna outside the settlements of Longyearbyen, Barentsburg and Pyramiden, pollutants in seabed-dwelling organisms from the fjords outside the same settlements plus Ny-Ålesund, follow-up sediment surveys outside the settlements in Isfjorden and the marine sediments in Colesbukta (Skei 1993, Holte et al 1994, Cochrane et al 2001, Hop et al 2001, Evenset et al 2006).

The results from Skei's survey (Skei 1993) showed that the concentration of heavy metals in the sediment from Kongsfjorden (outside Ny-Ålesund) generally had not increased with regard to the background level. There were low concentrations of PCBs and HCBs, but these were slightly higher near Kullhamna (Thiis-bukta). In Grønfjorden high values of PCBs were also registered in the sediments (Holte et al 1994). Cochrane *et al* (2001) concluded that the levels of pollutants in sediment collected outside the settlements in Longyearbyen, Barentsburg and Pyramiden – with certain exceptions – were low compared to industrial areas in mainland Norway. However, the levels of PCBs outside the settlements were higher than in open sea areas outside Svalbard. The sediments outside Longyearbyen and Barentsburg were less affected, while the effect was higher outside Pyramiden.

Hop *et al* (2001) documented local contamination by PCBs outside the settlements in Isfjorden through measurements taken from seabed-dwellling marine organisms. The concentrations were generally relatively low. Since the concentrations in benthic fauna were higher in areas near the settlements than in areas further out into the fjords, the conclusion was drawn that local sources were more important than long distance environmentally transported sources for these compounds.

Evenset et al. (2006) concluded that the area outside Barentsburg (Grønfjorden) was the most affected of the areas surveyed, and the fjord had slightly higher concentrations of PCBs (from condition class I : Insignificant/little contamination, to condition class III: Markedly polluted; in accordance with SFT's guidelines for the classification of environmental quality in Norwegian fjords and coastal waters, Molvær et al. 1997)). The area outside Pyramiden was also affected by PCBs (from condition class II: moderately polluted, to condition class III: Markedly polluted). The concentrations here were higher in 2005 than in 1998, indicating the presence of an active PCB source in the area.

In general the surveys of the marine sediments show that the levels of organic pollutants are higher outside the settlements that in other areas in Svalbard. This indicated that the marine environment in these areas is affected by local sources, including PCBs, to a certain extent.

Akvaplan-niva has surveyed the PCB content in sediments in Colesbukta in 2005 (Evenset et al. 2006). Samples were taken at 3 stations, and the levels were low. There is insufficient or no documentation of the environmental pollutant content in the sediments in Van Mijenfjorden and Grumant. Here there are landfill sites with greater or lesser potential of being sources of pollution, cf. SFT's soil contamination database.

On behalf of Store norske Spitsbergen Kullkompani (SNSK), Akvaplan-niva are carrying out a survey of the marine environment in Van Mijenfjorden in 2007/2008 (Akvaplan-niva/Velvin et al. in prep). The documentation of pollutants is included for a limited number of stations. The results will probably be available from SNSK.

ACTION

- ☐ Surveys of bioaccessibility of PCBs in the sediments and the possibility of further distribution in the food chains through analyses of benthic fauna collected outside the Norwegian and Russian settlements (comparison of levels and congener profiles).
- ☐ Monitor developments in marine sediments outside the settlements with sample collection every 5 years (2010, 2015…), including new sample collection points (outside the burning coal waste rock dumps in Barentsburg).
- ☐ Documentation of environmental pollutant content in the sediments from Sveagruva, Colesbukta and Grumant.
- ☐ Surveys to find any active sources in Barentsburg.
- ☐ Calculate the dispersion of PCBs from sources on land to the marine environment (see terrestrial).
- ☐ Analyse existing core samples (flood diameter and marine sediments) to examine changes in the supply of pollutants from 1950-2008. When were most PCBs supplied to the different areas?
- ☐ Contact SNSK to gain access to PCB surveys, including with regard to Van Mijenfjorden.

3.4.4. Marine invertebrates

Sediment-dwelling invertebrates are exposed to the bioaccessible part of pollutants in the sediments. As prey for organisms higher up the food chain they can therefore act as a link in the transfer of PCBs between sediment and animals higher up the food chain. Since invertebrates are low down the food chain and the majority have a limited ability to metabolise PCB compunds, this group of organisms can be useful in evaluating the significance of contaminated sediment, and they can be used to trace local sources. Hop et al. (2001) examined POPs in marine macrobenthos (7 species) and fish near Norwegian and Russian settlements in

Svalbard. Probable local supplies of PCBs were indicated. The distribution patterns of different PCB congeners were different from fjord to fjord. The biggest differences were found to be between the areas near the Norwegian settlements and the areas near the Russian settlements. The characteristic congener-patterns probably occurred due to local contamination from these settlements.

ACTION

- Surveys of bioaccessibility of PCBs in the sediments and the possibility of further distribution in the food chains through analyses of benthic fauna collected outside the Norwegian and Russian settlements (comparison of levels and congener profiles).

3.4.5. Fish

The Marine Research Institute has measured environmental pollutant levels in zooplankton and fish in the pelagic ecosystem in the Barents Sea. Herring, capelin and arctic cod are important plankton-eating fish, with raudåte as their meal of choice. The levels in the fish are 3 to 45 times higher than in the prey. Plankton-eating fish are eaten by other fish including cod and haddock. The relative levels in their livers increase from 13 to 57 times above crustaceans.

The measurements were used to make some simple estimates of how much contamination is found in these species in the entire Barents Sea and the Norwegian Sea. For example, the amount of PCBs was estimated at around 6kg in all zooplankton and 14kg in all cod. Although this only indicates an order of magnitude, it does illustrate that on the whole there are small quantities in fish. All the same, the concentrations are high enough to enable damaging effects to occur when the substances are further enriched in species that directly or indirectly live off fish.

The National Institute for nutritional and seafood research carries out monitoring of fish from the Barents Sea.

The COPOL project (see chapter 4.5) will generate data on PCBs in different species of fish from Svalbard. Sculpin and Arctic staghorn sculpin from different fjords in Svalbard, close to potential sources (settlements) have been analysed for PCBs (Hop et al. 2001). In general low concentrations were found, but the concentrations were higher than those observed in the area at Bjørnøya (that is known to have increased background levels of PCBs).

3.4.6. Seabirds

A number of chloro-organic and other compounds have been found in blood samples, tissue and eggs from glaucous gulls from Svalbard and Bjørnøya. These substances are alike in the fact that they do not degrade readily and their levels increase as they climb the food chain. This means that animals at the top, such as the glaucous gull, are exposed to the highest levels. In addition to PCBs a number of compunds and their metablolites have been found in glaucous gulls (Gabrielsen and Henriksen 2001; Gabrielsen 2007). Despite finding new types of enviromental pollutants (bromided flame retardants and fluoride compounds), as well as metabolites, PCBs continue to dominate in glaucous gulls and makes up almost 75% of total environmental pollutant effect. Pesticides (DDE, chlordan and HCBs) make up less than 20%, while metabolites make up less than 1% of pollutants effect on glaucous gulls.

There are major variations in the levels of organic pollutants in glaucous gulls. Individual animals that eat the eggs and offspring of other species of seabird have twice as high levels of pollutants as those that eat fish. This is due to the fact that fish are on a lower level of the food chain than fish-eating seabirds such as the kittiwake and guillemot. Other factors that influence

the level of pollutants in glaucous gulls are their ability to break down pollutants, as well as their gender. glaucous gulls are poor at breaking down pollutants. This is due to the fact that glaucous gulls have a relatively low activity of enzymes that convert pollutants. The male of the species on Bjørnøya has levels that are twice as high as the female. This is primarily due to the fact that the female lays eggs and thereby transfers pollutants from its own body fat to the eggs (Gabrielsen 2007**)**. Like other species of seabird glaucous gulls experience major changes in body weight throughout the year. The laying of eggs, breeding and growth period for offspring demand a lot of energy, and result in body weight being burned off. Fat-soluble organic pollutants bound to the body fat are released and end up in the bloodstream. This again leads to the levels increasing in sensitive tissue, for example the brain.

Dead glaucous gulls from Svalbard and Bjørnøya, that were found in the nesting period, had 10 to 100 times higher levels of PCBs in the liver and brain respectively compared with healthy birds (Gabrielsen et al. 1994; Knudsen et al. 2006). Trend studies of glaucous gulls from Bjørnøya show that PCB concentration has decreased from the middle of the 1990s (Verreault et al. 2006).

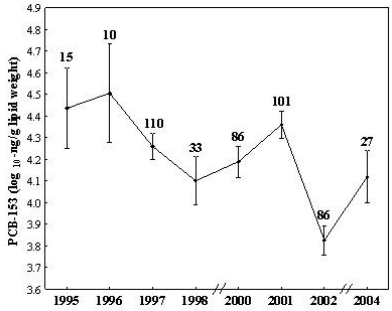

Figure 3.4.6-1: Despite significant variations between years, the graph for the period 1995-2004 shows a general downward trend in the concentration of PCB-153 in blood samples from glaucous gulls. In addition to changes in the PCB level in the Arctic ecosystem, the major variations are probably also due to different rates of exposures in the various colonies (source: MOSJ).

ACTION

- ☐ Documenting pollutants in eggs from the kittiwake in Barentsburg can provide insight into local influence on nesting birds (NP/NTNU)
- ☐ Habitation use by glaucous gulls (distribution in time and space with the help of GPS satellite tracking), potential PCB intake (and other pollutants) and effects from local sources, through the collection and analysis of tissue samples (blood) and stomach content. Analysis to clarify any absorption from local sources (pattern variation). The survey should be compared with the red list status for the species (Svalbard) and its position as the top predator in the ”Arctic food chain”.

3.4.7. Seals

The level of pollutants from samples from several species of seal collected in the Svalbard area was only 2-10% of the concentrations reported in seals from the Baltic Sea and the North Sea. The average PCB concentration in ring seals, Greenland seals, bearded seals and walrus was 1-5 µg per gram (w.w.). The level of PCBs in ring seals was much lower than in samples of Greenland seals collected in the Svalbard area. The ring seal from Svalbard is stationary and shows little variation in environmental pollutant levels. The Greenland seal shows more variation that is related to where the seals live during the casting period. In Greenland seals from the Eastern Ice (from Kvitsjøen) the total level of PCBs in biopsy samples from fatty tissue were three times higher than samples from the Western Ice (from the Jan Mayen area)(de Wit et al. 2004; Gabrielsen and Henriksen 2001; Gabrielsen 2007).

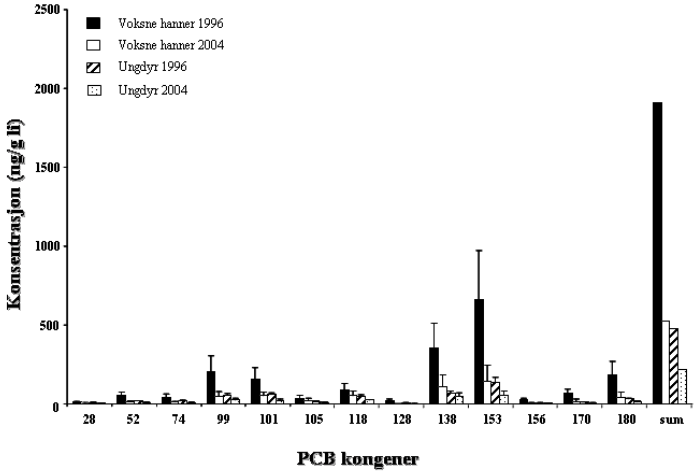

Figure 3.4.7-1: Significant differences in the levels of PCB concentrations (all congeners) have been registered in both offspring and adult male ring seals in 1996 and 2004, with dramatically lower levels found in 2004. This indicates that the species is exposed to lower PCB levels than before.
(Source: MOSJ).

ACTION

- Surveys of possible PCBs in game as a possible source of PCBs in humans in Svalbard (hunting reindeer, grouse and seals, fishing for arctic char)

3.4.8. Whales

Samples taken from whales in the Svalbard area show lower levels of pollutants than whale samples collected from southern ocean areas. The concentration of PCBs in fat samples from fish-eating whale species (beluga whale, porpoise whale and narwhale) range from 5-6 µg per gram (w.w.). This is twice as high (2-4 µg per gram (w.w.) in mink whales that eat krill and amphipods. The level of pollutants in whales increases with age and is higher in males than in females. Blubber samples from narwhale from the Svalbard area show higher PCB levels than samples from Canada and Greenland. The level of pollutants in many species of whale increases from west to east.

The highest concentrations of pollutants in whales were found in fat samples from porpoise and killer whales collected in the Lofoten area. The level found in these species from this area was compared with samples from whales collected in the Baltic Sea and North Sea.
Trend studies of both whales and seals from Canada and the European Arctic show a decline from the 1990s to 2005 (de Wit et al. 2004; Gabrielsen and Henriksen 2001; Gabrielsen 2007; Wolkers et al. 2007).

3.4.9. Polar bears

The polar bear is a top predator in the marine food chain. It mainly lives on seal and is often content to eat just the blubber. This has accumulated a relatively high level of PCBs and in this manner the polar bear builds up a high level of PCBs. Levels increase with age and are higher in adult males than females because the female effectively transfer PCBs to their offspring via mothers milk. The PCB levels are higher in the body fat of the offspring than in the mother (Bernhoft et al. 2007, Lie et al. 2000). The concentrations in blood samples from polar bears are around 100 times higher than in Norwegian women (Skaare et al. 2000). Polar bears are good at disposing foreign substances and the PCB pattern is therefore extremely species-specific. There is a major individual variation in the PCB level, and reasons for this include gender, age, birth selection, reproduction status, nutritional status and diffusion. There is a tendency indicating that PCB concentrations declined from 1990-1998, but flatten out after this (Bernhoft et al. 2001; Henriksen et al. 2001, Verreault et al.2005).

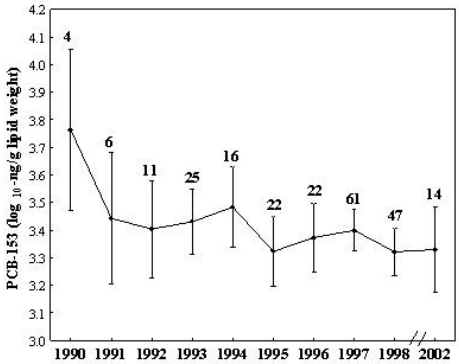

Figure 3.4.9-1: The figure shows a falling trend in concentrations of PCB-153 in polar bears from Svalbard in the period from 1990-2002, but with a weaker trend during the last part of the period (1995-2002). This indicates that the PCB level in polar bears is now in keeping with the global spread of PCBs. A further reduction in the PCB level is expected to be slower. (Source: MOSJ).

3.5. *Biological effects of PCBs*

3.5.1. Degradation products of PCBs

Many PCBs congeners are converted in the body to hydroxyl and methyl sulphon metabolites. Data about the toxic and biological effects of these products and their interaction with other PCB congeners and other pollutants is very limited.

ACTION

- Research the effects of degradation products from PCBs

3.5.2. Effects on polar bears

High PCB levels are associated with reduced levels of metabolic hormones (thyroid hormones) and vitamin A (retinol) in the blood in polar bears. Effects have also been found on the most important antibody against infection, IgG. Due to these findings an experimental study was carried out on wild polar bears in which the effects on the immune system and endocrine system were examined. The effects were found when the levels of PCBs exceeded 25-89 ng/g blood. It was also found that polar bears with a high level of PCBs had a reduced level of metabolic hormones (thyroid hormones) and sex hormones in male (testosterone) and female (progesterone) polar bears. The conclusion was that the endocrine system and resistance to infection were reduced and that this can have a negative effect on the popoulation status (Haave et al. 2003, Oskam et al. 2003; 2004; Skaare et al. 2001; Braathen et al. 2004; Berhoft et al. 2001; Lie et al. 2004, 2005; Steindahl et al. 2006; Skaare et al. 2002; de Wit et al 2004).

3.5.3. Effects on glaucous gulls

A number of biological effects of pollutants were found in glaucous gulls from Bjørnøya. These effects are related to a change of behaviour (in the breeding season), effects on egg quality, effects on hormones, metabolism, immune system, sex distribution as well as offspring and adult survival (see Gabrielsen and Henriksen 2001; Gabrielsen 2007). The conclusion was that locally these effects can have negative consequences for the population status (de Wit et al. 2004; Gabrielsen 2007). It has been found that the glaucous gull population on Bjørnøya has decreased by around 60% since the 1980s. It can be assumed that the combined effects will have consequences for the development of the population on Bjørnøya, but an important factor that has to be considered is the proportion of the population that are exposed to high levels of environmental pollution. An interesting finding from Glaucous gulls in Bjørnøya is that the majority of effects are not closely connected to the most common pollutants such as PCBs or DDT, but to substances that make up just 3-4% of the total amount of pollutants, namely oxychlordan and HCB. These two substances are known to be extremely poisonous (Gabrielsen and Bustnes 2004; Gabrielsen 2007).

4. Other important work related to PCBs

4.1. *PCBs in buildings and technical equipment*

PCBs have been found in samples of paint and surface soil in Longyearbyen, but in significantly lower concentrations than in the Russian settlements. High concentrations of PCBs in paint and electrical components are deemed to be the most important sources of local PCB contamination in these areas. High PCB content in samples taken on land in Pyramiden can suggest that these are possible sources of the increased PCB content measured in the sediments in 2005. There are large amounts of electrical and construction waste containing PCBs on open land in both Barentsburg and Pyramiden, see picture 4.1-1.

The PCB content in electrical capacitors from Barentsburg and Pyramiden is high, reaching 11 % $\sum PCB_7$. The $\sum PCB_7$-profiles (congener pattern) from these capacitors show a dominance of low-chlorinated PCB congeners. These could be the largest local sources of PCB contamination in Svalbard unless a controlled decommissioning is initiated.

PCBs have not been found in samples from capacitors from Longyearbyen.

Enforcement
Several PCB inspection programmes have been carried out (2005-2007) in all the settlements in Svalbard. To summarise these programmes the decommissioning and handling of products containing PCBs is now under control, with the exception of the Russian settlements. PCB capacitors have been phased out, double-glazing containing PCBs has been marked and waste containing PCBs is delivered to and treated in accordance with the regulations and delivered to the Waste Site in Longyearbyen. An analysis of a capacitors from a Russian lighting fixture was found to contain PCBs.

Picture 4.1-1. There are large amounts of electrical waste, building remains and scrap metal lying in the open, particularly in the Russian settlements. A large proportion of this waste contains PCBs.

ACTION

- ☐ Input for practical guidelines with regard to the new regulations concerning BA waste.
- ☐ Prepare a simple handbook for identifying Russian electrical equipment containing PCBs (with photos and possible analysis documentation).
- ☐ Removal of electrical equipment containing PCBs in Barentsburg and abandoned settlements such as Pyramiden.
- ☐ Decommissioning of capacitors and other electrical equipment containing PCBs in Barentsburg and abandoned settlements such as Pyramiden.
- ☐ Surveys of the bioavailability of Russian paint containing PCBs.
- ☐ Collection of samples of paint in buildings from other locations in Svalbard.
- ☐ Inspection to ensure the completion of PCB decommissioning in the Norwegian settlements (2008-2010).
- ☐ Use experience gained from decommissioning work in Barentsburg for extended bilateral PCB collaboration with Russia

4.2. *Russian environmental surveys in Svalbard*

Russia has a national environmental monitoring programme (soil, water and air) that also covers Svalbard. Sample collection and analyses have been carried out in the Russian settlements (2006 and 2007 and a new one is planned for 2008). It is not known whether the analysis results are available as public documentation.

The Governor has an environmental monitoring report in its archive from the State Institution Regional Center "Monitoring of the Arctic" of Roshydromet (case no. 2001/00201, doc. no. 20). The report is entitled “Review of environmental pollution in the area of Barentsburg settlement on the Spitsbergen archipelago based on the results of baseline ecological monitoring in 2002” and includes documentation of PCB levels in freshwater (Lake Bienda), soil and lichen.

ACTION

- ☐ Seek collaboration with the Russians for joint analysis and intercalibration of available material from the respective country’s sample collection in 2007.
- ☐ Seek collaboration with the Russians on a joint sample collection project (soil, water and air) in 2008.
- ☐ Collaborate with Russia to establish PCB profiles for PCBs produced during the Soviet era.
- ☐ Provide input regarding pollutants/PCBs as a topic for the next Norway/Russia conference in Svanhovd in June 2008.

4.3. *New formation of PCBs (de novo synthesis)*

With certain preconditions PCBs can be formed in combustion processes (smelting plant, incineration plant and similar). Data is only available for PCB emissions in Norway for new formation from industrial sources, incineration and heating plants, motorised traffic and fires. Some passive and active air sample collection has been carried out in Svalbard close to the burning rock tipper in Barentsburg in 2007 (Kallenborn, NILU personal communication). Otherwise no data is known to exist for Svalbard. Sources of potential new formation of PCBs in Svalbard are:

- Power plants that burn coal (Longyearbyen and Barentsburg). SFT has set requirements for verification measurements of any PCB formation in the licensing procedure for the Longyearbyen Energy Board.
- Fires in ore landfills and stone tips
- Combustion engines (scooters, cars, shipping)

4.4. *Models for supply and dispersion*

Models could be used to:

- Identify sources and pathways
- Complement existing monitoring data and provide a better overview of the geographical distribution of pollutants, distribution in food chains and time development
- Provide the basis for the calculation of exposure and effects
- Give a continuous picture of the physical and biochemical situation in Svalbard
- Contribute to focus further monitoring and research

Models can be a tool to demonstrate the relative significance of long distance environmentally transported PCB contamination in specific areas in Svalbard. Organic pollutants in the food chain in the Barents Sea have been modelled (Borgå & Di Guardo, 2005). Models from the mainland are also available (for Grenland and Oslo; developed at NIVA and NILU, e.g Saloranta et al. 2008), that can be adapted to this purpose. The SedFlex model was developed (NIVA) to be easily modified to suit new locations/ecosystems. The significance of contamination connected to sediment (e.g. established contamination in specific locations) on concentrations in local, marine biota can be modelled. In the same way it is possible to provide estimates for future concentrations in biota after a reduction in sediment concentrations. If local supplies to the sediment cease, over time sedimentation will lead to lower concentrations. Data on sedimentation is therefore of interest in such a context. Carbon dating of sediment cores (parallel to PCB analyses in sediment sections) will be able to show when the sediment contamination was greatest and provide a timeframe for this (see chapter 3.4.3 on marine sediments).

ACTION

- ☐ Adaptation of existing models for the supply and distribution of long distance environmentally transported contamination to Svalbard.
- ☐ Adaptation of the model for the evaluation of the significance of locally-contaminated sediment for concentrations in local biota.
- ☐ Collection of sediment cores in relevant areas for carbon dating and PCB analyses in sediment sections, to examine whether net flux to sediment (from local land-based sources) continues to occur.

4.5. *Environmental monitoring programmes and other sources of information*

Monitoring how contamination is distributed geographically and how concentrations and effects change over time will show the effectiveness of actions that have been taken.

AMAP is an important data source for environmental effects around Svalbard.
Svalbard and Jan Mayen Environmental Monitoring (MOSJ) is built up around a series of indicators, where the level of PCBs is included as a parameter in contamination indicators such as air in Ny-Ålesund, polar bears, arctic foxes, ring seals, glaucous gulls, Brünnich's guillemot, arctic cod, cod and arctic char. Together the indicators give a picture of the environmental conditions and create the basis for evaluating whether the government's environmental targets for the area are met. An overview of MOSJ and the indicators can be found at www.mosj.npolar.no. A complete evaluation of the selected indicators in MOSJ is currently underway. The new set of indicators will be ready during the first quarter of 2008.

The "Supply project" is included as a part of the work on management plans for the maritime zones. The supply project shall calculate and monitor supplies to, emissions in and the levels of environmental substances, oil and similar. The measuring points are to be included in an integrated monitoring program for the coast and ocean.

As part of the management plan for the Barents Sea (Integrated Management of the Marine Environment of the Barents Sea and the Sea Areas off the Lofoten Islands), coordinated monitoring of the areas round Svalbard (east) is to be carried out. Originally (October 2005) 17 types of indicator were proposed in which the contamination levels would be measured, and PCBs were included in the majority. This list is still being adapted by the monitoring advisory group for the Barents Sea that was established as part of the new management regime. The Norwegian Sea management plan is to cover the areas on the western side of Svalbard.

COPOL (Contaminants in Polar Regions: Dynamic Range of Contaminants in Polar Marine Ecosystems) is a project as part of the International Polar Year (IPY), with the main goal of getting closer to an understanding of the scope of the dynamic of human-created pollutants in marine ecosystems in arctic areas. The project is a collaboration between the Norwegian Polar Institute, NIVA, Akvaplan-niva, NILU, NTNU and NINA. Furthermore the aim of the project is to enable better prediction of how possible climate-related changes in the marine food web are reflected in the levels and effects at higher trophic levels. This goal is to be approached through four integrated work packages; food web exposure and flux (1), trophic transfer and potential effects (2), chemical analyses and "screening" (3), as well as synthesis and integration (4) The COPOL project is aimed at the Arctic and the primary focus is on Kongsfjorden. This fjord has been identified as being particularly suited to this purpose, due to the distance to important sources and influence of climatic processes (in the relationship between the inflow of Atlantic water and NOA, "North Atlantic Oscillation"). Samples were collected in 2007 and these were analysed for PCBs. More collections will be made in 2008 and 2009.

Biotrans and several SFT projects cover the documentation of old and new pollutants in the Svalbard area.

SFT's emissions licence for coal operations in Sveagruva contains requirements for a recipient survey (and with analysis for PCBs) with a focus on Braganzavågen and Kapp Amsterdam every 5 years, first survey in 2007. According to plan surveys of marine sediments outside the settlements in Isfjorden from 1998 and 2005 shall be followed up with monitoring every 5 years, i.e. 2010, 2015 etc.

ACTION

- Propose Ellasjøen and a reference lake as the model for trend monitoring (also for other pollutants, early indication of supply of new pollutants). If accepted this should be included in MOSJ.
- Propose potential stationary measurement points for monitoring any leakages of PCBs from local sources on land into the ocean. If accepted this should be included in MOSJ and the "Supply project".

5. Summary

5.1. *Challenges*

5.1.1. Endangered animal species

Certain animal species from some areas (glaucous gulls and polar bears) have a PCB level exceeding effect values. This level can endanger the ability to survive for both the individual animal and the local population. Despite finding new types of environmental pollutants (bromide flame retardants and fluoride compounds), as well as metabolites, PCBs continue to dominate in glaucous gulls and makes up almost 75% of total environmental pollutant effect.

5.1.2. Waste, materials and products with potentially PCB content

Waste containing PCBs (electrical and construction waste) lies on open land and in landfill sites. Products containing PCBs such as paint and capacitors in fixtures are still found in Barentsburg and abandoned Russian settlements. These could be the largest local sources of PCB contamination in Svalbard unless a controlled decommissioning is initiated.

5.1.3. Contaminated land, soil and sediments

There is an element of uncertainty with regard to how bioavailable PCB contamination in sediments and contaminated land is but the concentrations of PCBs in benthic fauna are higher in the areas near the settlements than in areas further out in the fjords. This indicates that local PCB sources are more important than long distance environmentally transported PCBs. The flux calculations also indicate that local sources are important outside the settlements. Sculpin and Arctic staghorn sculpin from different fjords in Svalbard have low concentrations of PCBs, but the concentrations were higher than those observed in the area of Bjørnøya.

Notified climate changes could result in increased supply of polluting masses (from for example waste disposal sites and surface soil) to the marine environment.

High concentrations of PCBs in surface soil have been found in Barentsburg and the abandoned Russian settlement Pyramiden. Environmental surveys indicate an active PCB source.

5.1.4. Long distance environmentally transported PCBs

In quantitative terms long distance environmentally transported PCB contamination is probably the main source of the PCBs found in Svalbard. It is beyond the possibilities available to the Governor to reduce the "import" of such contamination.

5.1.5. PCBs and other pollutants

After many years of research, environmental monitoring and active management work in Svalbard there are still gaps in knowledge and a need for research and action against PCB contamination and effects on the individual, population and ecosystem levels.

PCBs are just one of many pollutants. The effect of pollutants alone, working together with others and metabolites as one of many effects on individuals and populations is mostly unknown.

An evaluation of the research and environmental monitoring reports is complicated by factors including the natural variance in the sample material and uncertainty connected to methodology, sample collection and analysis.

5.2. *Conclusions*

Svalbard is increasingly being formed into a platform for international research and as a tourism destination. Local pollution must be reduced. Increased activity and a focus on tourism, also in the Russian settlement, will help towards a change in the local contamination situation for pollutants in the future. This should be seen in relation to the fact that Svalbard is to be one of the world's best managed wilderness areas.

PCBs are a high priority environmental pollutant that to a great extent is associated with the Arctic and Svalbard after much documentation showing that the pollutant is found in the local and regional natural environment and in fish, birds, mammals and humans. The most important way to reduce PCBs in Svalbard is secure international phasing-out (following up the Stockholm Convention). However it is also vital to initiate action to limit the supply of PCBs in particular as well as other pollutants from local and regional sources.

PCBs reach Svalbard via major air and oceanic currents; much of this is "international" contamination. Norway should actively assist countries contributing to long distance environmentally transported PCB contamination in Svalbard reducing their emissions and as

far as possible securely phasing out equipment containing PCBs. Environmental management must work to promote active collaboration, bilaterally and internationally, that can assist in actual reduced emissions of PCBs.

Follow-up work on contaminated soil areas in local area planning and handling of PCB contaminated substances in the event of demolition/renovating/new building work in the settlements is important in the future. If the contamination sources on land are removed, this will also lead to the more rapid coverage of the contaminated marine sediments with clean material.

Local PCB sources have also caused contamination, and there are still active and potential sources that can cause dispersion to the marine environment far into the future. Spills from and uncontrolled decommissioning of potential PCB products in buildings and factories will move quickly. Experience suggest that some of this PCB waste may go astray. There is sufficient knowledge of the negative properties of PCBs to make it clear that the pre-emptive decommissioning of equipment and products should be carried out. The extent to which local sources may also contribute to the concentration measures in the air in Svalbard should be examined further. Action to reduce or stop further PCB contamination from local sources (contaminated soil and landfill sites) should be considered. Assuming that strong reactivation does not take place, the remediation of deposited marine masses in the fjords should not be undertaken.

The process leading up to this report has thrown light upon a number of gaps in available knowledge and the need for research and action against PCB contamination and effects. The action proposed will thus contribute to increased and more uniform understanding about PCBs and reduced supply from potential sources of contamination in Svalbard.

It is expected that climate changes that have been notified for the future will contribute to increased supply of long distance environmentally transported PCBs in the region.

5.3. *Recommendations for further work (actions and need for further information)*

A summary of action proposed and recommended further surveys and efforts detailed in chapters 2-4, divided by topic:

Sources and pathways for PCBs

- ☐ Collaboration on the reduction of emissions with countries that contribute to PCB pollution in Svalbard via air and oceanic currents.
- ☐ Documentation and characterisation of diffuse sources around Svalbard.
- ☐ Climatic influence on the remobilisation of secondary PCB sources.
- ☐ Collate all survey results (including those acquired externally), divided into marine environment, terrestrial environment and sediment-dwelling organisms, for example.
- ☐ Examine and estimate the amounts of PCBs in pristine areas; on land, in fresh water and in the ocean (background levels/long range environmental aggregated effect).

PCB contamination status

- ☐ Pilot project with a more close-knit station network in Svalbard for a limited period (PCB/POP in Svalbard air) to investigate local/regional differences in dispersion and exposure patterns.
- ☐ Pilot project with the collection of dust (dust buckets) in the settlements as the basis for the estimation of its contribution to human exposure.
- ☐ Overview map of Svalbard that shows the distribution and long distance environmental transportation of PCBs to Svalbard (air, ocean, ice and biological pathways, with indication of relative quantities).
- ☐ Overview map of Svalbard that shows the geographical distribution of estimated potential local pathways (soil contaminated with PCBs, condition classes of the fjord bed outside the settlements, PCBs on land).
- ☐ Verification measurements of emissions from combustion in coal power stations are viewed in conjunction with the summer evaporation of PCBs (differentiate local sources and long distance environmentally transported PCBs).
- ☐ Contribute to better research in the Barents Sea by carrying out uniform environmental monitoring at the different measurement locations.

Terrestrial

- ☐ Studies of PCBs in flora.
- ☐ Examine PCB levels in lakes in Svalbard
- ☐ Further sampling in Barentsburg and Pyramiden to demarcate polluted areas.
- ☐ PCB sampling in Colesbukta, Grumant, Isfjord radio, Sveagruva and Ny Ålesund (soil samples and products).
- ☐ Soil water monitoring from an area containing PCB contaminated soil in Barentsburg.
- ☐ More detailed PCB analyses from erosion-prone areas below PCB sources in Pyramiden can show PCB transportation from relevant sources.
- ☐ Follow-up work on contaminated sites s in local area planning and handling of PCB contaminated soil in the event of demolition/renovating/new building work in the settlements.
- ☐ Review of SFT's contaminated sites database and evaluation of whether new contaminated areas from NGU's documentation work in 2007 should be included (NGU report 2007.075).

Fluvial sediments

- ☐ Include PCBs in the new geochemical atlas for Svalbard.
- ☐ Calculations of PCB flux and sedimentation (Akvaplan-niva+NVE).
- ☐ Surveys of PCBs in arctic char, with special focus on lakes where fishing is carried out or where special, local conditions can lead to increased concentrations of PCBs.

Marine sediments/marine environment

- ☐ Monitor developments in marine sediments outside the settlements with sample collection every 5 years (2010, 2015…), including new sample collection points (outside the burning coal waste rock dumps in Barentsburg).
- ☐ Documentation of environmental pollutant content in the sediments from Sveagruva, Colesbukta and Grumant.
- ☐ Surveys to find any active sources in Barentsburg.
- ☐ Calculate the dispersion of PCBs from sources on land to the marine environment (see terrestrial).
- ☐ Analyse existing core samples (flood diameter and marine sediments) to examine changes in the supply of pollutants from 1950-2008.
- ☐ Surveys of bioaccessibility of PCBs in the sediments and the possibility of further distribution in the food chains.
- ☐ Contact SNSK to gain access to PCB surveys, including with regard to Van Mijenfjorden.

Plant and animal life

- ☐ Surveys of bioaccessibility of PCBs in the sediments and the possibility of further distribution in the food chains through analyses of benthic fauna collected outside the Norwegian and Russian settlements (comparison of levels and congener profiles).
- ☐ Investigations of possible methods to identify local sources by studying the concentration of PCBs in birds and fish local to a given area.
- ☐ Investigations of possible methods to identify local sources by studying the concentration of PCBs in arctic foxes in the settlements
- ☐ Surveys of possible PCBs in game as a possible source of PCBs in humans in Svalbard (hunting reindeer, grouse and seals, fishing for arctic char).
- ☐ Analyses of planned samples of rats in Longyearbyen also to include pollutants.
- ☐ Documenting pollutants in eggs from the kittiwake in Barentsburg can provide insight into local influence on nesting birds at the location (NP/NTNU)
- ☐ Habitation use by glaucous gulls (distribution in time and space with the help of GPS satellite tracking), potential PCB intake (and other pollutants) and effects from local sources, through the collection and analysis of tissue samples (blood) and stomach content. Analyses to clarify any intake from local sources (pattern variation). The survey should be compared with the red list status for the species (Svalbard) and its position as the top predator in the ”Arctic food chain”.

Biological effects of PCBs

- ☐ Research the effects of degradation products from PCBs

Other work on PCBs

PCBs in buildings and technical equipment

- ☐ Input for practical guidelines with regard to the new regulations concerning BA waste
- ☐ Prepare a simple handbook for identifying Russian electrical equipment containing PCBs (with photos and possible analysis documentation)
- ☐ Removal of electrical equipment containing PCBs in Barentsburg and abandoned settlements such as Pyramiden.
- ☐ Decommissioning of capacitors and other electrical equipment containing PCBs in Barentsburg and abandoned settlements such as Pyramiden.
- ☐ Surveys of the bioavailability of Russian paint containing PCBs.
- ☐ Collection of samples of paint in buildings from other locations in Svalbard.
- ☐ Inspection to ensure the completion of PCB decommissioning in the Norwegian settlements (2008-2010).
- ☐ Use experience gained from decommissioning work in Barentsburg for extended bilateral PCB collaboration with Russia

Russian environmental surveys in Svalbard and Norwegian-Russian collaboration

- ☐ Seek collaboration with the Russians for joint analysis and intercalibration of available material from the respective country’s sample collection in 2007.
- ☐ Seek collaboration with the Russians on joint sample collection (soil, water and air) in 2008.
- ☐ Collaborate with Russia to establish PCB profiles for PCBs produced during the Soviet era.
- ☐ Provide input regarding pollutants/PCBs as a topic for the next Norway/Russia conference in Svanhovd in June 2008.

Models for supply and dispersion

- ☐ Adaptation of existing models for the supply and distribution of long distance environmentally transported contamination to Svalbard.
- ☐ Adaptation of the model for the evaluation of the significance of locally-contaminated sediment for concentrations in local biota.
- ☐ Collection of sediment cores in relevant areas for carbon dating and PCB analyses in sediment sections, to examine whether net flux to sediment (from local land-based sources) continues to occur.

Environmental monitoring programmes

- ☐ Propose Ellasjøen and a reference lake as the model for trend monitoring (also for other pollutants, early indication of supply of new pollutants). If accepted this should be included in MOSJ.
- ☐ Propose potential stationary measurement points for monitoring any leakages of PCBs from local sources on land into the ocean. If accepted this should be included in MOSJ and the "Supply project".

6. Summary of reports from localised environmental surveys

This table provides an overview of surveys of PCBs and pollutants carried out in geographically limited areas on land and in sediments in Svalbard, with results and possible follow-up (Governor of Svalbard 2008).

Year	Inst./reference	Result/Condition	Substances/ sources	Summary and follow-up
Longyearbyen/Adventfjorden				
2007	NGU/ Jartun et.al. 2007	PCB analyses of surface soil, paint, cement, oils and capacitors. Low level of PCB contamination in soil (condition class I and II) found in paint and in soil around huts in Nybyen and in paint from Gruve 3.	PCBs in oil, paint, cement, soil and capacitors	Local supply of pollutants to Adventtfjorden was found, but generally low values (condition class I-II). Possible sources in contaminated soil evaluated by NGI, and recommended action has been followed up earlier and was reviewed by SFT/SMS in 2008. Possible action on PCBs in paint and in surface soil in Nybyen and Gruve 3 must be considered. The source situation in the drainage system is expected to be better than before the 1990s due to stricter regulations on use of the various compounds. New cleaning action will be evaluated after new measurements taken by 2009. Will be necessary to carry out follow-up surveys to monitor status. Overview of decommissioned PCB fixtures at SMS. The Energy Board company has been required to construct a new waste disposal site that over time will reduce wash-outs along the fjord where currently ash is dumped, even though the supply of pollutants and heavy metals from soil water has been found to be minimal.
2006	SMS 2006	Inspection of all buildings with the building owners covering decommissioning of PCB light fixtures, marking of PCB double-glazing and treatment of hazardous waste. All capacitors are to be phased out during 2007, all windows must be marked.	PCBs in Light fixtures and double-glazed glass.	
2005	Akvaplan-niva/Velvin et al. 2006	Marine recipient survey at Longyearbyen, Svalbard 2005. Soft-bed survey in Adventfjorden for Svalbard Samfunnsdrift.		
2005	Akvaplan-niva/ Evenset 2006	Environmental survey of marine sediments outside the settlements in Isfjorden. PCBs found in the sediment in Adventfjorden are within condition class I.		
2002	Akvaplan-niva/Evenset 2002	Environmental pollutants in Adventfjorden: Related to emissions from Longyear Energi? On behalf of Longyear Energi.		
2001	Akvaplan-niva/ Evenset 2002	Follow-up of DDT and toxaphene findings in two stations from Cochrane et al. 2001. Significantly lower DDT values (class I) and with a relatively higher proportion of DDE and DDD than in 1998. Local emissions of DDT at the end of the 1990 cannot be ruled out. Toxaphene was not found again. Possible errors in the toxaphene analysis from 1998 must be considered.	PCB/HCB: drain system, old landfill sites PAH: Coal fired power plant, shipping, oil contamination, coal particles (natural and from coal power operation) DDT: Not known	
1999	Akvaplan-niva/ Savinova et al. 1999.	Biological effects of POPs on glaucous gulls.		
1999	NP/ Hop et.al. 2001	POPs in marine macrobenthos. An insignificantly higher level of contamination was found in the material (class I).		
1998	Akvaplan-niva/ Cochrane et.al. 2001	All stations in PAH, class II. PCB class I in the majority of stations, one station class II. For HCBs the stations were in class I-II. DDT: one station class IV, others class I-II. High proportion of DDT in relation to DDD/DDE indicated "fresh" supply. Low values for metals (class I).		
1992	Akvaplan-niva/ Holte et.al. 1994	All stations: PAH in class III. PCBs under detection limit (< 0,2 µg/kg). HCB in class III-IV. Low DDT values. Low values for metals (class I).		
Grønfjorden/Barentsburg				
2007	NGU/ Jartun et.al. 2007	PCB analyses of surface soil, paint, cement, oils and capacitors. Over 11% PCBs in Russian capacitors. Soil from the Russian settlements was markedly contaminated with PCBs (condition class II-V for both), higher PCB content than previously found in mainland Norway. This is due to extremely high concentrations of PCBs in paint from Barentsburg and Pyramiden, PCBs also found in cement in Barentsburg.	PCBs in oil, paint, cement, soil and capacitors	Local supply of pollutants found, and Grønfjorden outside Barentsburg is today the most affected of the areas (condition class I-III). Possible sources in contaminated soil evaluated by NGI, and recommended action to be followed up. *(see next page)*

Year	Inst./reference	Result/Condition	Substances/ sources	Summary and follow-up
2005	Akvaplan-niva/ Evenset 2006	Environmental survey of marine sediments outside the settlements in Isfjorden. Concentrations in Grønfjorden outside Barentsburg were in condition class II.		The source situation in the drainage system is expected to be better than before the 1990s due to stricter regulations on use of the various compounds. The effect of this in the Russian settlements is uncertain. Follow-up surveys necessary to monitor status and implementation of inspections. Norwegian authorities have notified equal treatment of Trust Arktikugol with regard to environmental requirements for the company.
1999	Norsk Polarinst./ Hop et.al. 2001	POPs in marine macrobenthos. An insignificantly higher level of contamination was found in the material, i.e. mainly class I with the exception of PAH class II.	PAH: Coal fired power plant, shipping, oil contamination, coal particles (natural and from coal power operation) PCB/HCB: drain system, old landfill sites	
1998	Akvaplan-niva/ Cochrane et.al. 2001	PAH in class II and PCBs in class I for all stations. HCB in class I-II. DDT: one station class III, others class I-II. Low values for metals (class I).		
2001	Akvaplan-niva/Savinov et al. 2001.	Contaminant levels in glaucous Gulls from Barentsburg, 2001		
1992	Akvaplan-niva/ Holte et.al. 1994	All stations: PAH in class III. PCBs one station class III, three stations class II, two stations class I. For HCB the stations were in class III-IV. Low DDT values. Low values for metals (class I).		

Billefjorden/Pyramiden

2007	NGU/ Jartun et.al. 2007	PCB analyses of surface soil, paint, cement, oils and capacitors. Over 11% PCBs in Russian capacitors. Soil from the Russian settlements was markedly contaminated with PCBs (condition class II-V for both), higher PCB content than previously found in mainland Norway.	PCBs in oil, paint, cement, soil and capacitors.	Local supply of pollutants found in sediments (class II-III). Higher levels of PCBs in 2005 than 1998 indicate an active source. High PCB levels in paint/cement, Disused equipment containing PCBs. Possible sources in contaminated soil evaluated by NGI. Big storage room for oil cleaned up in 2006. May have leaked oil. Operations closed down in 1998, discharge ceased. Wash-out of contaminated soil can increase over time as the river erodes the town. Clearing up of waste containing PCBs and action on PCBs in paint and surface soil must be considered. Follow-up surveys should be carried out.
2005	Akvaplan-niva/ Evenset 2006	Environmental survey of marine sediments outside the settlements in Isfjorden. The highest concentrations of PCBs were found outside Pyramiden (condition class III).	PCBs from possible active source on land.	
1999	Norsk Polarinst./ Hop et.al. 2001	POPs in marine macrobenthos. An insignificantly higher level of contamination was found in the material (class I)	PAH: Coal fired power plant, oils, coal particles (natural and from coal power operation) PCB/HCB/DDT: drain system, old landfill sites	
1998	Akvaplan-niva/ Cochrane et.al. 2001	The majority of stations had PAH in class II, PCB class I, HCB in class I, DDT class I-II. Low values for metals (class I-II, natural)		

Kongsfjorden/Ny-Ålesund

1999	Norsk Polarinst./ Hop et.al. 2001	POPs in marine macrobenthos. An insignificantly higher level of contamination was found in the material (class I).	PAH: Oil contamination, coal particles (natural and from coal power operation) PCBs: old landfill site	Action on various sources (waste disposal and tank site) was carried out in 2003. When the location is shut down it is necessary to determine monitoring requirements. Implementation of inspection.
1997	Akvaplan-niva/ Olsson et.al. 1998	PAH class II in Kongsfjorden. Concentrations on same level as other stations in the survey in areas without local sources.		
1991/ -92	NIVA/ Skei 1993	Sediment survey. Increased values of PCBs – class I - at the waste disposal site in Kullhamna. PAH class V at thewaste disposal site in Kullhamna and class III right outside Ny-Å. The waste disposal site and oil contamination from the tank site (leakage in 1985) can be possible sources. PAH has not otherwise been detected in the fjord in concentrations necessitating follow-up. Pesticides and PCBs mainly at background level or under detection limit in Kongsfjorden. Metals generally at background level.		
1988	NGU	Metals in soil	Naturally increased content	Gold, Arsen deposit

Isfjorden

1999	Norsk Polarinst./ Hop et.al. 2001	POPs in marine macrobenthos (west of outlet from Linnèvatnet). An insignificantly higher level of contamination was found in the material, i.e. mainly class I with the exception of PAH class II.	Natural leakage of oil from seabed, coal (natural and from mining operations) and combustion remains from coal power plant and shipping.	Can be necessary to include measurement points from these surveys in follow-up surveys of sediments outside settlements in Isfjorden planned in 2015 to follow developments in the large fjord system and monitor status.
1998	Akvaplan-niva/ Cochrane et.al. 2001	PAH class II in Svensksunddjupet furthest out in the fjord. POPs and metal do not show significantly higher values (class I-II).		
1992	Akvaplan-niva/ Killie et.al. 1997	PAH class III in Svensksunddjupet furthest out in the fjord. Other POPs and metal do not show significantly higher values (class I-II).		

Year	Inst./reference	Result/Condition	Substances/ sources	Summary and follow-up
Colesbukta				
2001	NGI 2002		Diesel in free phase by barges.	Obligatory action requirement to be assessed by SFT/SMS in 2008.
2005	Akvaplan-niva/Evenset et al. 2006	Environmental survey of marine sediments outside the settlements in Isfjorden. Low concentrations of PCBs (condition class I).	PCB pattern indicates long distance environmental transportation as source.	
Forlandsundet				
1998	Akvaplan-niva/ Cochrane et.al. 2001	PAH class II south of Poolepynten in Forlandssundet. Other POPs and metal do not show significantly higher values (class I-II), lower values than in Isfjorden, and in accordance with “background values” around Svalbard.		Follow-up not necessary.
Sveagruva				
2008	Akvaplan-niva/Velvin et al. In prep.	Environmental pollutants in sediment from VanMijenfjorden. On behalf of Store Norske Spitsbergen kullkompani.		
Grumant				
-		PCB surveys necessary. Major sedimentation and significant fjord currents, but necessary to carry out fjord surveys as part of sample collection in the next sediment survey in 2010.		
Freshwater				
1997	Akvaplan-niva/ Skotvold et al. 1997.	Heavy metals and persistent organic pollutants in sediment and fish from lakes in Northern Norway and in Svalbard.	PCBs measured in sediment	PCBs measured in sediment from Ellasjøen and Barentsvann. High levels in Ellasjøen. Relatively low levels in Barentsvann. Fish from Ellasjøen, Diesetvannet, Richardvatn, Hornsundet and Kongressvatn analysed for POPs.
2008	Akvaplan-niva/ Christensen et al. In prep.	Coordinated, national sediment surveys. Part III: Status of metals and organic pollutants in sediments and fish from selected lakes within the Norwegian AMAP area	POPs and metals measured in sediment.	Sediment from Ellaqsjøen, Kongressvatn, Arresjøen and Richardvatn analysed for POPs and metals. Fish from Ellasjøen, Richardvatn, Åsøvatn and Arresjøen analysed for POPs and Hg.
Various areas				
1994 1992	Akvaplan-niva/ Olsson et.al. 1998 Killie et.al. 1997	Measurement of long distance environmentally transported contamination level in Hinlopen, Storfjorden, Erik Eriksenstretet and other locations.		Follow-up not necessary.
1987	NGU, Ottesen et al	Geochemical documentation of 50 elements.		Sample material archived in NGUs sample bank.

7. 7. References

References are sorted by the following subjects:

1. *Contaminated soil and PCB surveys on land*
2. *Sediment surveys*
3. *Mammals*
4. *Birds*
5. *Fish*
6. *Bjørnøya (Bear island)*
7. *Other*

1. Contaminated soil and PCB surveys on land

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Transport and effects programme (1998-2004)

The transport and effects programme was a research programme on the transport of pollutants in the northern marine zones (Barents Sea etc.) and the effects on marine ecosystems. The purpose was to gather knowledge necessary to evaluate the environmental status and design programmes for monitoring pollutants in the area. The program received NOK 13 million from the Ministry of Foreign Affairs and the Ministry of the Environment. It was managed by the Norwegian Polar Institute together with the Directorate for Nature Management, Norwegian Pollution Control Authority and the Norwegian Radiation Protection Authority. The funds were allocated to 21 projects that were carried out from 1999 to 2004, many of which were implemented in collaboration with Russian researchers.

Further reading

All background documents and final reports are available at: http://npolar.no/transeff/. Two factsheets were created that popularise the results: 1) Effects of pollutants in the Arctic 2) Recommendations on monitoring. See also State of the Environment Norway http://miljostatus.no/ under “Polar regions/pollution” and “Hazardous checmical”, as well as Arctic Monitoring and Assessment programme (AMAP) http://www.amap.no/

8. Appendix: Programme for multidisciplinary working meeting on the PCB status in Svalbard

NGU/Trondheim, 9th-11th January 2008

Wednesday 9th January 2008		
1000-1020	Opening and presentation of participants and relevant problems	Rolf Tore Ottesen, Halvard Pedersen and Qno Lundkvist
1020-1050	PCB – a major environmental challenge	Søren Jensen
1050-1100	Questions	
1100-1130	Problems related to chemical analyses of PCBs - need for re-analyses and level adjustments?	Rolf Tore Ottesen
1130-1230	Lunch	
1: Long distance environmentally transported and local sources of PCBs in the Svalbard environment		
1300-1320	Long distance environmentally transported air-borne PCBs – source areas	Roland Kallenborn
1320-1340	Significance of ocean currents for PCB source areas	Anders Ruus
1340-1400	Waste disposal sites nad contaminated land	Hans Jørun Hansen
1400-1420	Products (capacitors, paint, cement) and soil	Morten Jartun
1420-1440	Marine sediments	Anders Ruus
1440-1500	Coffe and fruit	
1520-1700	Group work: Local sources	
1520-1700	Group work: Long distance environmentally transported PCBs	
1700-1745	Light meal at NGU	
1745-1900	Joint actvity: *Collation of the report section "Supplies of PCBs"*	

Thursday 10th January 2008		
2: Effects of PCBs on the environment and ecosystems		
0830	Coffee	
0900-0920	NP PCBs in seabirds	Geir Wing Gabrielsen
0920-0940	AkvaplanNiva PCBs in marine organisms	Anita Evenset
0940-1000	Veterinary Institute	Janneke Utne Skåre
1000-1020	NTNU	Bjørn Munro Jenssen
1020-1040	DN	Reidar Hindrum/ Morten Ekker
1040-1100	Short break and coffee	
PERIOD 3 Preparation of a combined updates report on PCBs in the Svalbard environment		
1100-1130	Discussion on the construction of the seminar report – table of contents	Joint activity:
1130-1230	Lunch	
1230-1400	PCBs in Svalbard - Information 199x-2007(Multidisciplinary collation, trends and similar)	Joint activity
1430-1500	Coffe and fruit	
1500-1700	PCBx in Svalbard 2008-201x Challenges, future requiements, holes in knowledge, coordination requirements, existing environmental monitoring program for Svalbard/Jan Mayen ……	Joint activity
1700-1800	Collation of draft report	NGU/SFT/SMS
1900-	Dinner	

Friday 11th January 2008		
4: Report from multidisciplinary seminar on PCBs in the Svalbard environment		
0900-1100	Review of draft seminar report	Joint activity
1100-1130	Summary and closing	Rolf Tore Ottesen, Halvard Pedersen and Qno Lundkvist
1130-1230	Lunch	