

Concentrations and Trends of Organochlorine Compounds and Polycyclic Aromatic Hydrocarbons in the Arctic Ocean (1996)

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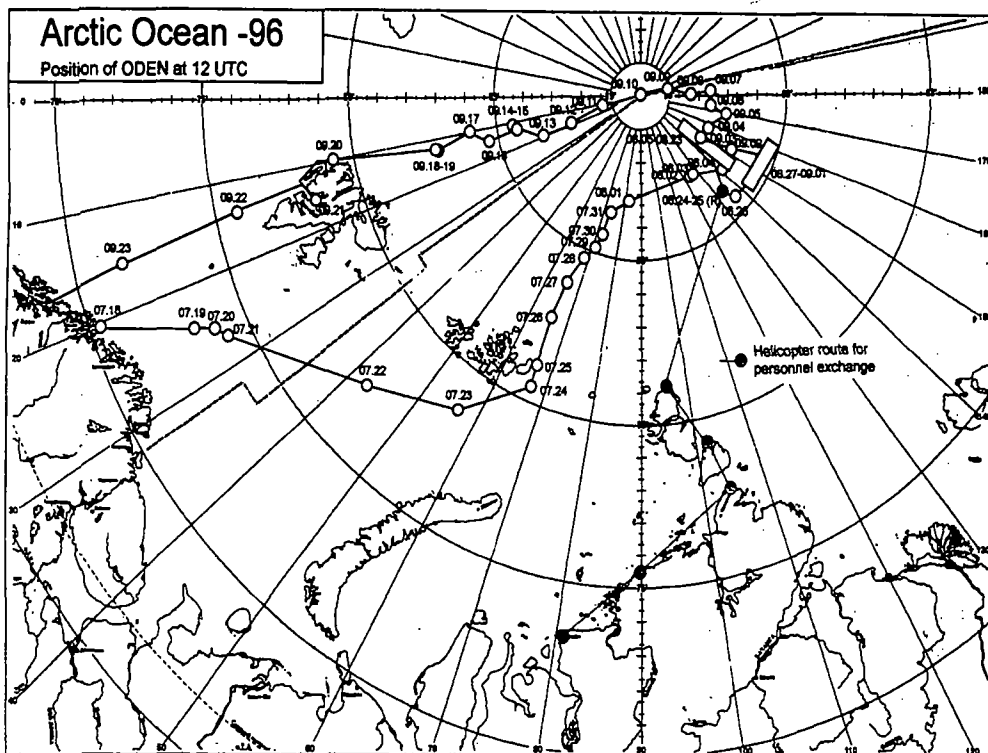
Introduction

During the summer of 1996, the Swedish Polar Research Program/Secretariat mounted an expedition to the Arctic region north of Russia. The icebreaker ODEN was used as the platform for the multi-disciplinary work and spent the period July 19 through September 22 in the region north of 75°N. A cruise track is presented as Figure 1; the circles represent the position of the ship at noon UTC for each day. For the investigations reported here, the track is divided into three portions -- a first leg south-to-north (07/24-08/01), a period of various activities at ca. 87°N between 120-170°W (08/02-09/05, and, a final leg (09/07-09/22). The first leg transect covered latitudes 75°N to 87°N and the final transect was over the range 88°N - 90° - 80°N.

Persistent organic pollutants (POPs) in the Arctic region have been identified as a major environmental problems (1,2). Such compounds most often refer to the organochlorine compounds found bioaccumulated in biota from this and other regions. Chemical information about levels of POPs in the surface and deeper waters is lacking. This expedition provided the opportunity to remedy some of this lack. Analytes investigated included: 20 organochlorine pesticides, 9 chlorobenzenes, 18 PAHs and 120 PCB congeners (including 13 coelutants). It is not possible to provide detail on all (not all were present in all samples) and a selection has been made from those occurring frequently and at more significant levels.

Sampling and Analysis

All stations reported here are for locations nominally covered with ice; occasional breaks in the ice were followed and were usually the locations for sampling. Water samples were collected in two ways at the stations indicated. During the first leg, surface water was pumped onboard from a depth of roughly 2 m and centrifuged to separate suspended solids from "dissolved". Deeper, whole water samples were collected with a teflon coated 100L GO-Flo bottle. In the middle and final legs, temperatures were such that the sea-water formed slush when stored on deck and centrifugation was not possible. After this time (08/25), all samples were



collected by GO-Flo bottle. For all surface samples, duplicates (ca. 80 L ea.) were placed in stainless steel "Pepsi" cans and pumped through XAD-2 columns (teflon); the resin was refrigerated for further onshore workup.

Snow samples were collected by clearing off a flat area well away from the ship and shovelling the semi-crystalline snow down to the ice surface into four pre-cleaned snow cases. These were allowed to warm to 15-20°C in the container laboratory and the snowmelt (ca. 40-50L/ duplicate sample) pumped through the XAD-2 columns and treated as for a water sample.

Analysis was by dichloromethane (DCM) extraction of the XAD-2 resin, solvent exchange, cleanup and fractionation on silica gel and analysis by GC/ECD for the chlorine-containing compounds and by GC/MSD for the PAHs. In the case of low level contaminants such as the PCB congeners, the chromatogram baselines were manually identified and quantified. Detection limits were approximately 0.001-0.002 ng/L.

Results and Discussions

Summarized results for selected compounds in surface samples are shown in the table; the variability for paired duplicates is also included there. Other analytes were less common than those reported and occurred at low levels (almost always below 0.01 ng/L for individual analyte).

Results for the three sampling legs indicate that the HCH isomers have increasing mean concentrations in the water remote from Eurasia including over the pole. This was also observed by others (3) in 1994; there were some expectations that Leg 1 would be highest with sites closer

Table: Concentrations of POPs in Surface Water and Snow from Ocean '96

	Surface Water				Snow			
	First Leg (5 pr.)	Middle Leg (6 pr.)	Final Leg (5 pr.)	Pair RSD	First Leg (1)	Middle Leg (3 pr.)	Final Leg (4 pr.)	Pair RSD
	----- ng/L -----			%	----- ng/L -----			%
a-HCH	0.54	0.86	1.20	10	0.06	0.040	0.048	22
Lindane	0.15	0.26	0.31	11	0.08	0.075	0.065	10
Dieldrin	0.008	0.006	0.000	50	0.000	0.008	0.000	36
t-DDT	0.006	0.002	0.000	47	0.000	0.025	0.000	226
HCB	0.007	0.009	0.009	10	0.017	0.016	0.017	10
Phenanthrene	0.45	0.43	0.31	45	5.92	3.63	2.68	12
Pyrene	0.12	0.12	0.09	40	1.31	0.52	0.80	75
BePyrene	0.02	0.02	0.01	37	0.06	0.07	0.22	148
Sum PAH	2.1	1.6	1.0	32	11.3	10.8	7.7	32
PCB31+28	0.007	0.006	0.006	143	0.228	0.149	0.107	79
PCB101	0.017	0.014	0.020	31	0.383	0.244	0.139	70
PCB138+163	0.005	0.005	0.007	36	0.094	0.122	0.124	56
Sum PCB	0.26	0.21	0.25	27	4.56	4.45	3.45	16

to Russia but this was not observed. Examination of the two north/south transects (Legs 1 and 3) indicates a distinct trend to higher northern levels, possibly the result of ice cover preventing volatilization losses. In the case of snow, observed levels are much lower than in water due to their long surface residence and re-volatilization. Similar losses from snow were observed at Alert and other Canadian Arctic stations (2).

The pesticide residues for dieldrin and DDT were both at very low levels which precluded any appearance of pattern in their residue concentrations. In the case of HCB, both the water and snow concentrations were uniform throughout the region with the snowmelt values being ca. 2X higher than those in the water. Low water values, relative to snow from which losses are expected, may suggest degassing from the leads in the icepack. Comparisons with air samples (also collected during the expedition) will be needed to determine whether this is the case.

Among the PAHs, no clear "Leg" pattern is apparent although water and snow values for

the two areas closer to Eurasia were higher than those for the third leg. Benz(e) pyrene is an exception to this. It is pointed out that phenanthrene and pyrene were also considerably higher (ca. 10X) in snowmelt than in the surface water. In the case of total PAH, naphthalene and phenanthrene form some 75% of the totals; the former is not presently included in these totals.

There is no pattern among the individual PCB congeners from the three legs. There is a high level of variance for the individual congeners -- more so than many of the other results -- despite the significant levels observed for the totals. For the Σ PCBs however, the difference between the water and snowmelt values is large (snowmelt ca. 15X water) and apparently significant. PCBs are reported to be lost in significant amounts from accumulated snow in the Canadian Arctic (2) and this snow represents a full season of deposition. These values are also 3-4X those found at the end of season in Alert over the winter 1994-95. Presuming that accumulated snow values reflect wintertime air movements (and losses over the season), the implications are that there are high air values arising from Russia. During 1993, however, air samples at Dunai (Lena R. area) did not differ greatly from values at Alert or further south and inland at Tagish (2).

At a total of 12 locations, 3-4 samples were collected and processed as described. When the concentration results were plotted against depth, no depth behaviour patterns were observed except for the HCHs. For α -HCH, surface values for individual locations ranged from 0.5-1.4 ng/L but deeper than 300m, all sites approached 0.3 ng/L. Similarly, for lindane the surface range was 0.1-0.4 with a deep value of 0.1 ng/L. At most locations, there was a ill-defined halocline and thermocline at roughly 200m. This deeper water is Atlantic layer water in the region (2) while the surface water reflects other sources. Earlier studies in the Bering and Chukchi Seas (1993) had higher levels of both analytes (4).

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References

1. Arctic Monitoring and Assessment Programme (AMAP); Arctic Pollution Issues: A State of the Arctic Environment Report. AMAP Secretariat, Oslo (<http://www.grida.no/amap>), 1997, 188 pp
2. Canadian Arctic Contaminants Assessment Report (CACAR), Chapter 2: Sources, Occurrences and Pathways. Northern Contaminants Programme. Dept. Indian and Northern Affairs, Ottawa, 25-182, 1997,
3. L. M. Jantunen, T. F. Bidleman; Air-water gas exchange of hexachlorocyclohexanes (HCHs) and the enantiomers of α -HCH in Arctic regions. *J. Geophys. Res.* 1996, 101: 28,837-46 and 1997, 102: 19,279-82.
4. W. M. J. Strachan, D. A. Burniston, M. Williamson and H. Bohdanowicz; Spatial differences in persistent organochlorine pollutant concentrations in the Bering and Chukchi Seas (1993). Special publication of the Russian Global Inst. Climate & Ecology and the U. S. Fish & Wildlife Service (in press, 1998)