Interdisciplinary Workshop for Research on Mercury in Polar Regions

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Sponsored by:

AMAP Arctic Monitoring and Assessment Programme

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The Interdisciplinary Workshop for Research on Mercury in Polar Regions was held in Toronto August 29-31, 2005. The workshop was hosted by Environment Canada's Air Quality Research Branch (AQRB) and co-sponsored by Environment Canada, the Arctic Monitoring and Assessment Programme (AMAP) and the Canadian Northern Contaminants Program (NCP).

In 2002, 40 scientists from 8 different countries gathered in Toronto for the Arctic Atmospheric Mercury Research workshop hosted by Environment Canada's AQRB to discuss the state of research on atmospheric mercury in the Polar Regions. The focus of this workshop was to increase the understanding of the chemistry and cycling of atmospheric mercury depletion events recently discovered in both the Arctic and Antarctic. From this workshop gaps of knowledge were identified and the needs for future research on atmospheric mercury in Polar Regions were put forward. The recommendations were published in Atmospheric Environment in 2003[1].

Since this time, significant research on mercury contamination in Polar Regions has been undertaken in many different disciplines. It is well known that the behaviour of mercury throughout polar ecosystems is complex and its movement between media and its impacts on the environment are poorly understood. The International Polar Year (IPY) is fast approaching and several international research programs are being planned. Therefore, it was decided that this meeting was an opportune time to discuss the state of mercury research in Polar Regions and to take advantage of upcoming research programs.

At the meeting held in August 2005 the progress and research issues relating to the behaviour of mercury in Polar Regions were discussed with an **interdisciplinary** approach. The 3-day meeting was attended by 60 researchers from 6 different countries (participant list in Annex 1) to discuss the following topics about mercury (Hg):

1. Transport of Hg and atmospheric processing of Hg in Polar Regions.
2. Air/surface exchange and processing of Hg in and around the ocean.
3. Mercury in vegetation and wildlife.
4. Impacts of Hg on human health and health processes.

The goals for this workshop included:

- Gather (and introduce) researchers from different disciplines to encourage complementary research pertaining to Hg in polar regions
- Establish which research/knowledge goals and gaps previously identified have been addressed and/or met
- Identify new issues for mercury research in <u>all disciplines</u>
- Establish what issues need to be addressed (with possible time frames)
- Ascertain how to approach and integrate current results and future research goals

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[1] Summary report: first international Arctic atmospheric mercury research workshop. Schroeder, WH, Steffen, A, Scott, K, Bender,T, Prestbo, E, Ebinghaus, R, Lu, J, and Lindberg, S. (2003) Atmos Environ; 37(18), 2551-2555.

- Discuss current IPY plans and develop an interdisciplinary strategy for IPY for mercury (potentially through currently organized programs)
- Plan the next AMAP assessment for mercury in the Arctic

Several overarching questions were presented to the participants along with more specific questions within each topic. These questions (shown below) were discussed and debated with the aim of producing a cohesive plan for future research as a result of this meeting.

1. What does the science tell us about risks to human health and the environment posed by mercury in Polar Regions?
2. What are the impacts of recent scientific discoveries (e.g. mercury depletion events) on our understanding of the behaviour of mercury in Polar Regions?
3. Are the current models sufficient to understand and predict the behaviour of mercury in the environment? What further information is needed to improve the models?
4. What have we learned since the last meeting held in 2002?
5. How can research in Polar Regions help us know if actions to reduce mercury releases are being effective?

After 3 days of meeting the participants identified the following main points in regards to gaps in scientific knowledge and recommendations for areas where future research should be focused:

1. More interdiciplinary measurements of mercury need to be undertaken.

2. Cycling of mercury in the whole Arctic environment is still not well understood. In order to understand this cycling, interdisciplinary and whole-system projects need to be undertaken.

3. Time trends of mercury levels in the atmosphere, sediments, wildlife and humans are not consistent. There are no clear trends indicating a decline in mercury concentrations in the Arctic environment. The reasons for these complex results are not known.

4. Both process and trend reaearch must be continued in combination to understand the relevance of the other.

5. The relationship and possible impacts between behaviour of mercury in the Arctic and climate change needs to be established. Climate change can impact the temperature in the Arctic which may impact the methylation rate of mercury, increase snow melt (and release more Hg to the environment), increase open ocean and drive more deposition chemistry. These factors need to be properly understood in order to ascertain the impact of a changing environment on the deposition of mercury to Polar Regions.

6. The role of the ocean in mercury cycling in the Arctic has been neglected and must be better understood.

7. The impact of interactions between the atmosphere-sea ice snowpack, chemical physical, biological, marine ecosystem exchanges at open leads need to be better understood because this is a draw for biota.

8. What is the source of elevated levels of methyl mercury in the snow pack; how does mercury methylate in this environment and what changes methylation rates are key questions that need to be answered?

9. How Hg enters the Arctic environment needs to be understood.

10. What parameters are important for the uptake of Hg to the Arctic environment?

11. Understanding risk/benefit factors for human health and consumption of country foods.

12. What are the links of Hg to cardiovascular diesease?

13. Understanding what species of mercury are in food items and the need to monitor the foods that are consumed were identified.

14. Understanding metabolic interactions with other pollutants and nutrients.

15. Who are our communities of interest and what social and economic changes are they undergoing and what kind of human monitoring is needed to assure public health were put forward?

A full list of participants is found in Annex 1. The abstracts are attached in Annex 2. The final agenda is found in Annex 3.

Acknowledgements:

I would like to thank all who participated in this workshop! I enjoyed meeting many of you for the first time and as well reconnecting with many familiar faces. The efforts that the speakers put into preparing for this meeting as well as the discussions in which the group participated demonstrate that the scientific mercury community can team up from many different disciplines and work together effectively.

I would especially like to thank those people who took excellent notes of the discussions throughout the meeting that were used in this summary including Tina Scherz, Steve Brooks, Lyle Lockhart, Cathy Banic, Alan Penn, Grace Howland, Jason Stow, Christian Temme and Simon Wilson. I would like to thank Cathy Banic for leading most of the discussions on Day 2 and for making the morning summaries of the work from the previous day's discussions.

I would like to also thank Annette Mediati and Wendy Gerecht for helping organize before and during the meeting.

Finally, many thanks to The Northern Contaminants Program, the Arctic Monitoring and Assessment Program and the Air Quality Research Branch for funding this workshop. I would also like to personally thank Simon Wilson and Russell Shearer for their input and enthusiasm to get this meeting off the ground.

I hope you enjoyed the workshop and I look forward to working together on mercury science in Polar Regions for many years to come!

Sincerely,

Sandy Steffen
Workshop organizer

DAY 1 – AUGUST 29, 2005. PRESENTATIONS OF THE PARTICIPANTS

The first day of the workshop comprised of 29 short talks presenting the state of mercury research in Polar Regions. Abstracts of these talks are attached as Annex 2. Below are the highlights and the key messages from each presentation.

Alexandra Steffen: Annual median gaseous elemental mercury concentrations (GEM) at Alert, Canada do not show a temporal trend from 1995 to 2002. Seasonal variation is evident with a slight decrease in the summer median concentrations between 1995 and 2002.

Torunn Berg: Higher variability was found for GEM at sea level than at 474m asl at Ny Ålesund, Svalbard. There is evidence of long range transport of mercury depleted air at Svalbard.

Cathy Banic: Processes observed to deplete air of GEM and add GEM to the air are occurring near the surface. Mercury from the global atmospheric pool is circulating aloft and meteorology appears to control the exchange.

Steve Brooks: High concentrations of reactive gaseous mercury (RGM) and particulate mercury (PM) were observed in the Antarctic, as compared with what is commonly measured in the Arctic. Higher values of RGM/PM are observed when there is more mixing in the lower atmosphere.

Ashu Dastoor: Listed the knowledge gaps for the mercury models. These gaps include levels of natural emissions and re-emission of mercury. Showed the transport of mercury from source regions to the Arctic and estimated the amount of mercury deposited there. Anthropogenic emissions of mercury have increased by about 10% from 1990 to 2000; distribution of anthropogenic emissions has changed with more emissions now from Asia and Africa

Christian Temme: Observations made from the Polarstern from 62^{o}N to 84^{o}N over the north Atlantic during the summer show that the mean concentration of dissolved gaseous mercury (DGM) in seawater increases from south to north and concentrations of GEM and DGM increase with increased extent of sea-ice cover.

Henrik Skov: Model shows an annual estimate of 208 tonnes of mercury deposited in the Arctic during depletion events. His model showed higher deposition in the eastern Arctic.

Parisa Ariya: Mercury in the Arctic is a complex system. Models for atmospheric mercury in arctic regions must consider secondary reactions and transient species. In addition, the fate of mercury species post-deposition must be considered

Marc Amyot: GEM is released from the snow by action of solar radiation. The reactivity of the mercury in snow changes with season. There is more mercury in snow in coastal areas and most of this mercury is bound to particles.

Joel Blum: Seeks to understand the role of sea ice, leads and frost flowers. Recently deposited crystals have highest mercury concentrations near the leads. Mercury concentrations are high in hoar frost and frost flowers. Scavenging of mercury from the atmosphere and deposition to the surface can be rapid. Surface snow has the highest concentration of mercury compared with other levels in the snow pack.

Frank Cobbett/ Bill Van Heyst: Surface fluxes of GEM and concentrations of mercury species in the air and snow were measured at Alert from full dark to full sun over 6 months in 2005. Results are forthcoming.

Enno Bahlman: The concentration of total mercury in ice cores is correlated to dust concentration. Concentration of methyl mercury can be high in ice cores from 450,000 years ago which includes 4 climatic cycles.

Peter Outridge: Mercury is stable in lake sediments and the mercury flux to lake sediments in the Arctic has been increasing since 1970. Increased algal activity leads to increased mercury concentration and flux in lakes. See increased diatom concentrations in Arctic lakes compared with sub-arctic lakes.

James Zheng: Can collect ice core samples for metals but currently does not include mercury; seeking funding for ice core mercury record.

Vince St. Louis: The total concentration of mercury in the snow pack decreases as you move away from open water. Methyl mercury seems to be reduced in the snow pack. What are the sources of methyl mercury in the snow pack? The deposited mercury is photo-reduced quickly at the snow surface.

David Lean: If methyl mercury is formed by sulphate-reducing bacteria, what happens at $4^{o}C$? What is the role of hydrogen peroxide or snow pH on the increase or decrease of mercury in the snowpack?

Rune Dietz: Measurements made in Greenland show the following: increased concentration of mercury in ringed seal from 1985 to 2004, increased concentration of mercury in polar bears and birds in West Greenland.

A high fraction of birds of prey have levels of mercury which exceed effects levels.

Derek Muir: There may be a decrease or slight leveling-off of mercury in lake sediments. This does not agree with trends observed for mercury in land-locked char. When looking at lake sediments there is an increase in biological activity in the eastern Arctic Togwell Jackson sees shifts in mercury isotope rations as you go up the food web.

Michael Kwan: Monitoring mercury levels in ringed seal, char, shellfish, beluga and lake trout throughout the Canadian Arctic. Levels of Hg in seal liver are higher in the western Arctic. Char samples showed low levels of Hg in Nunavik and Labrador. In all the muktuk and muscle samples examined, total mercury concentrations exceeded the Health Canada's mercury guideline for subsistence consumption and about 80% of the total mercury in these two tissues is organic mercury. Total mercury concentration was positively correlated with age for all beluga tissues examined. Age also has a significant effect on the speciation of mercury accumulated in the liver and the kidney.

Birgit Braune: The eggs in three species of seas birds show increasing trends in mercury concentration since 1975. Can this be explained by changes in their diet?

Steven Christopher: Monitoring sea bird eggs over large spatial scale in Alaska for organic and inorganic contaminants.

Lyle Lockhart: Looking at relationship between lake bedrock and mercury levels in fish. There is no strong conclusion regarding time trends of mercury in fish. There are differences in mercury levels by species. Sea run char and whitefish have low levels of mercury and lake trout show high levels of mercury.

Jay Van Oostdam: Monitoring of arctic Canadians has found that Inuit peoples have significantly higher levels of mercury. The traditional foods of Inuit peoples are the source of this increased exposure. Recently research has linked mercury levels to various risk factors for cardiovascular disease which may have great relevance to all arctic populations. Further studies are planned underway to assess trends in northern populations and their diets.

Jens Hansen: Is methyl mercury a risk factor for cardiovascular disease? In Greenland 100% of the population exceed the blood concentration of 4.2 microgram/l corresponding to a daily intake at the US-EPA RfD mercury levels; effects on population are expected to occur at these levels. The expectation that changes in diet would lead to a decrease in mercury concentration in the population, but the concentration is increasing. Are there alternative exposure routes which are currently not being considered? A positive correlation between mercury levels in blood and pulse pressure show that there seems not to be a lower limit for this effect.

Alexei Konoplev: Mercury levels in maternal cord blood are higher in central and eastern Russian Arctic but are lower than in Nunavik, Greenland, eastern Nunavut and Alaska.

Tom Clair: Through a multi-disciplinary database of work conducted on mercury in mid-latitudes, scientists were willing to share data and collaborate to produce 21 publications. It's very important to have a common data base for all data. The cost of collecting such a multi-disciplinary data set for a region of North America and the synthesis of the data is about $300K (Canadian) over 3 years.

Frank Schaedlich: Mercury measurement techniques are under refinement and development. Presented new updates to atmospheric mercury sampling and analysis.

Xinjie Song: Work in progress on the development of a calibration source for the quantification of different mercury species in air.

Gary Stern: Mercury depletion events have a potential to alter the mercury loadings to marine systems. Foraging by large animals such as belugas is organized so as to reduce energy expended during feeding, thus regions of higher food concentrations are likely to be sought. Oceanic fronts show higher concentrations of food and both total and methyl mercury in zooplankton and arctic cod.

DAY 2 - AUGUST 30, 2005. SCIENTIFIC DISCUSSIONS

Four general topics of discussion were suggested and distributed prior to the meeting addressing scientific questions about each discipline in order to focus the scientific discussions. The following is a summary of the discussion sessions from DAY 2 of the workshop.

Topic #1: Transport of Hg to Polar Regions (PRs) and atmospheric processing of mercury (Hg) in PRs

- How can we relate emissions of Hg to Hg in PRs?
- What are the temporal and spatial trends of atmospheric Hg in Arctic and non-Arctic sites? Is this consistent with our knowledge of emissions and environmental processing?
- What is the lifetime of Hg (0) in the troposphere and what are the products of the reactions during mercury depletion events (MDEs)?
- To what extent are MDEs occurring and how do MDEs vary between regions?
- Can we identify the products of MDEs, is the technology there? How far are we away from this technology?
- Are we sampling the "chemistry" at our field locations or simply advected air?

Discussion summary Topic #1:

The direct relationship between MDEs and elevated levels of mercury in the Arctic environment is still unresolved. A range of views were expressed regarding the implications of the transformation of inorganic mercury from the atmosphere during depletion events to its transfer to the marine and terrestrial ecosystems. Currently, there is no defined pathway for the process moving atmospheric mercury to biota. The question still remains **"Can we link what happens in the atmosphere to what is seen in the biota and wildlife?"**

The need for more emission inventories was expressed. Atmospheric trends of mercury indicate no significant increases or decreases of mercury in the high Arctic despite decreasing emissions in North America and Europe. This, however, may be a reflection of recent increases in coal burning in China. Measurements aloft have shown more mercury in air in Asia than in Europe. Concern was expressed that such large-scale continental atmospheric sources may be entering into the Arctic environment. The simple question of "what will happen to mercury in the Arctic if anthropogenic emissions are reduced?" was posed. No clear answer to this question is currently available. The significance and levels of natural or background sources of mercury have been neglected and should be considered in processes research and modeling. What is the change of these natural sources with time?

Current atmospheric models show that the Arctic is a sink for mercury. Many additional processes need to be incorporated into the Arctic component of global models. Even though information from various components is available and a multi-compartmental model is being undertaken there are still many gaps of information.

The fate of Hg deposited to the snow and ice surfaces from the atmosphere was highly debated. While some scientists believe that <u>the majority of</u> the Hg deposited during these MDEs is returned to the atmosphere, others feel that <u>a portion</u> of the deposited mercury is returned to the atmosphere while a portion remains unaccounted for or is released into the ecosystem. Speciation of mercury was a large part of the discussion in the 2002 meeting and unfortunately not much progress has been made in regards to identifying the species of mercury in the atmosphere during depletion events (either in the gas phase or associated to particles). Elucidation and proper calibration of Reactive Gaseous Mercury (RGM) and Hg associated to particles (PHg) must be done. The processes involved in photo-reduction and re-evasion of mercury need to be better identified in order to go to the next step in understanding the cycling of mercury. Bromine radicals and not bromine contribute to the atmospheric photo-chemical processes causing MDEs. Altitudinal measurement gradients have shown that depletion events are restricted to within the boundary layer.

Understanding where the MDE chemistry occurs is still unknown. Research should focus more on what happens around polynyas and open leads over the ocean to understand the source of halogens for the photochemistry and the mercury cycling around the ocean.

It was stressed by many that processes research is essential in order understand the trend data; the 2 approaches to research must **both** continue. NOAA has closed its Arctic research office as well as the ongoing atmospheric measurements at Barrow, Alaska. Currently, there are no atmospheric measurements being collected within the western North American Arctic. This gap of information is significant as this is a key location to measure air masses entering the Arctic from Asia. As well, there is a lack of atmospheric mercury data from Siberia.

Summary of the gaps in knowledge for Topic #1:

-Identification of atmospheric species of mercury involved in MDEs
-Need more emissions data
-There is a lack of measurements being collected in Western North American Arctic and Siberia.
-More information on the processes of mercury in the atmosphere during MDEs is warranted.
-More long term trend information is needed. Alert and Ny Alesund are the only sites where there is commitment for long term atmospheric measurements.
-Need to establish the contribution of natural Hg to the Arctic and the changes in these natural sources with time.
-A standardization of sampling methods is required.
-There is a lack of input from those who hold historical records.

Topic #2: Air/surface exchange and processing of Hg in and around the ocean

- What is the influence of MDEs on the total amount of Hg deposited in PRs? What is the fate of this deposited Hg?
- Does the chemistry of Hg itself affect any other polar chemical cycles?
- What is the source of methyl-Hg in the snow?
- What fraction of atmospherically deposited Hg is bio-available? Are there other sources of mercury to the snow surface?
- What is the potential uptake by biota of mercury deposited to the surface?
- What is the role of the ocean in the cycling of Hg in PRs?
- How will climate change alter the influence of the oceans on the Hg cycle in PRs?
- What is the distribution of mercury fractions in Arctic marine waters?

- How much mercury is transported to the sediments and potentially converted to other forms of Hg by benthic bacteria?
- Where is bio-available mercury found? How does it enter the marine biosphere?

Discussion summary Topic #2:
We are still no further at understanding the fate of the deposited mercury as a result of MDEs because it is more complex than initially thought. More current work has been focused on processes of Hg occurring at the surface.

Methyl mercury (MeHg) was identified as an important parameter to investigate because of its toxic implications to wildlife and eventually to humans. Understanding the origin, pathways and relationship of MeHg to ecological processes needs to be addressed. Elevated concentration levels of MeHg have been found in some certain packs over the sea ice in the Arctic during springtime, suggesting a marine source of the MeHg. In addition, results presented showed that MeHg concentration increases with increasing water depth and closely follows primary productivity in the water column. The water/sediment interface may play an important role in this MeHg generation and should be investigated further. The source of these elevated MeHg levels and what controls methylation rates are still unknown. Levels of MeHg have been shown to increase in ocean water around the time of snowmelt. The effect of snowmelt on the distribution of mercury has begun to be investigated but more research is necessary. Different forms of MeHg will bind and have different uptake and thus the form of MeHg being measured makes a significant difference in the bio-availability of Hg. Therefore, it was cautioned that using the general term MeHg should not be done and more specific species be discussed and used.

Snow and ice surface processes are thought to be very important but are not understood and almost no work has been done near leads. The snow pack does play a role in MDEs. Processes of Hg cycling at the snow surfaces are still not fully understood. Estimates of mercury that are available for deposition in the springtime, based on observations of mercury in the atmosphere, do not balance with mercury levels found in the snow pack. The role of biological surfaces in the cycling of mercury in the Arctic has also been neglected and should be investigated. The impact of deposition of Hg from MDEs is challenging because the surface changes regularly. Snow blows, sublimates, drifts, gets buried and melts; all of which need to be considered for net deposition to the Arctic from the atmosphere. Concentration levels of mercury species in snow melt are important to investigate because the Hg contained in the melt water may be more reactive than Hg in the snow and thus may be more likely to contribute to bioaccumulation. It was suggested that the elevated levels of mercury in marine mammals may not only be caused by atmospheric processes but may be a result of oceanic processes. The oceans were considered to be a neglected area of study for mercury cycling in the Arctic area. Understanding surface processes is a critical step in pursuing mass balance calculations for the Arctic.

Both mercury pollution and climate change are global issues. Since the Arctic is such a vulnerable environment to both these issues, the effect of climate change on mercury processing is now an Arctic issue. The impacts of climate change on many aspects of mercury behaviour in the Arctic were discussed. Potential impacts discussed include the effects of increased temperatures on parameters such as open leads (availability of halogens to initiate mercury oxidation), methylation rates of mercury and snow melt. A change in pH will alter the bio-availability of MeHg. The role the ocean plays in respect to mercury trends and climate change needs to be investigated. We know that MDEs happen at the snow surface, what happens when that surface changes? Recent studies showed that there was a potential relationship between the concentration of dissolved gaseous mercury in the North Atlantic and the quantity of sea ice demonstrating that concentrations of Hg may be sensitive to changes in the amount of available sea ice. The levels of mercury in the snow pack are impacted by MDEs – if conditions change to increase the amount of Hg deposited through MDEs then this has a direct relationship with levels in the snow pack.

Summary of the GAPS of knowledge for discussion topic #2:

- **What is the origin of MeHg?**
- **What drives the production of MeHg?**
- **The role of the oceans is neglected in current research.**
- **What is role of the snow pack and subsequent melting? How will climate change affect that role?**
- **What are the interactions of Hg at the air/snow/melt water/lakes/ice/ocean?**
- **How do the different Hg species transfer between media?**
- **What are the certain impacts on Hg processing in Polar Regions from climate change?**
- **What is the role of the deposited Hg from the atmosphere? Are there other sources besides the atmosphere that cause elevated Hg levels in Polar Regions?**
- **The speciation of mercury in water is still not known! What are the species of mercury in water in polar environments?**

Topic #3: Mercury in vegetation and wildlife

- What are the mechanisms of mercury/biota interactions? What are the uptakes of Hg by algae and under what conditions would they occur?
- How does Hg travel up the food chain and how is it biomagnified?
- What are the spatial and temporal trends of Hg in wildlife?
- What are the differences of Hg levels in marine, lake and terrestrial wildlife?
- Do we see a relationship between MDEs and levels of Hg in vegetation and wildlife? Are there data gaps to answer this question?
- Can we correlate trends of Hg in wildlife with atmospheric concentrations?

Discussion summary Topic #3:

Concentrations in biota suggest that the Arctic is probably a sink for mercury. Even though the proportion of mercury that remains in the snow pack following atmospheric deposition is unclear, the fact that this toxic pollutant is deposited to the ecosystem is considered significant. What organism initially takes up the mercury from these sources has yet to be identified. The concentration of MeHg in mirrors the concentration of primary productivity the water column. Thus, pulses of Hg from atmospheric deposition may impact this primary productivity. Pulses of mercury have been detected in zooplankton (up to 3 times higher after snow melt) so seasonal pulses such as MDEs are seen at these lower trophic levels but are not as evident higher up in the food chain because they are muted by other factors. Investigating parameters such as eggs or blood for Hg concentration levels may be helpful for looking at the uptake of seasonal inputs. There is no change in Hg concentrations in coastal lakes but high concentrations observed in marine environments invites the question: what is the effect of MDEs and/or snowmelt on the uptake of Hg? Stable isotopes are subject to fractionation in the environment. Adding stable isotopes to the snow pack and following them into the biota was a suggested idea for studying the transport of Hg.

There appears to be no great Hg contamination problem in terrestrial animals but the Hg concentration in fish in freshwater is higher than ocean fish. Hg concentrations are the highest in <u>marine</u> mammals but not in marine fish. It has also been shown that marine mammals detoxify MeHg by binding it to Se.

Although the temporal trends of Hg in biota over the past 20-30 years are inconsistent (i.e. some animal populations exhibited significant increases in Hg whereas others did not), there have been no significant decreases in Hg noted, which is not consistent with what the trends of Hg in air (no change/decreasing) are telling us. Additionally, temporal trends of mercury concentration found in some wildlife are not consistent with atmospheric measurements. There is clear evidence of increases from historical times to current times but, for current trends, we may be looking for too small a change in concentration over too few years. For trend research, maybe the question needs to be reformulated from: "Are levels increasing or decreasing" to "Is there strong evidence that Hg levels are decreasing?" Differences in diet and foraging behaviour of beluga in the north western arctic are being studied and related to levels of Hg concentration.

There is a strong need to standardize how biotic samples are collected and how mercury levels are reported so that results can be comparable across the board. There is a need to measure other variables which may confound the results. There is a critical need to differentiate between organic and inorganic mercury in biota. While MeHg is commonly seen as the species to investigate, inorganic mercury is the major species of mercury found in marine mammals. These mammals take it in as methyl mercury but it's the total mercury concentrations in the animals that are exceeding the guidelines. Therefore, inorganic mercury levels in mammals should not be neglected.

In order to make sense of apparent geographical gradients/patterns in the exposure of mercury to the wildlife, the abiotic research should be focused on where wildlife is concentrated. For example, collect samples where birds and mammals feed near open leads as this is a draw for biota. Interdisciplinary research should be congregated at these locations. This approach may be helpful in starting to link the biotic and abiotic environments. Because the Hg that biota bio-accumulate may not follow inorganic mercury trends, there is a need for speciation data in biota. Hg in food is measured as total Hg not as bioavailable Hg. Also, there is little connection between what the scientists investigate for Hg and what the northerners eat. Research is focused, at times, on the health of the animal (samples from the liver, kidney or eggs) whereas northerners are interested in how much mercury is consumed by the people (usually the flesh of the animal –which does contain MeHg, as well). So, investigating the processes by which Hg gets into the whole system is different from investigating what is consumed by northerners. This message is, at times, difficult to disseminate. Wild life and human health researchers need to work together to ensure that the correct or relevant information is collected to answer the appropriate question.

Summary of the GAPS of knowledge for Topic #3:

- **Standardization of analysis and/or reporting methods is needed.**
- **Better statistical analysis needs to be done (careful when thinking about throwing out outliers).**
- **Biota and wildlife sampling and processes research need undertaken at ice edges.**
- **More collaboration is necessary to connect the abiotic and biotic processes.**
- **Abiotic scientists asked the biotic scientists: what data do you need from us to better your research?**
- **In locations where there are elevated levels of Hg in wildlife, make abiotic measurements (e.g. air and snow concentrations).**
- **Bioaccumulation rates may be overestimated and need to be better identified.**
- **Cannot confirm or deny correlation between atmospheric deposition and increased levels in marine wildlife – a direct correlation may be too simple an answer.**
- **Need more time trend data, times from available data are too short to address current questions.**
- **Need an assessment to determine temporal and spatial trends and effects on exposed species.**
- **Must focus on the fate of deposited mercury to the marine environment (how it enters the food chain and how it works its way up).**

Topic #4: Impacts of Hg on human health and health processes

- What are the current impacts of mercury exposure on humans in PRs?
- What are the health implications if Hg levels remain the same or continue to increase in PRs?
- Are there spatial and temporal trends of Hg concentration levels in humans?
- Can we correlate trends of Hg concentrations in the atmosphere and wildlife with levels in humans?

Discussion summary Topic #4:

The human health dimension is challenging to address if there are still so many questions about the origin and fate of Hg in the environment. Currently, we do not definitively know the effects of Hg on the Arctic population. We should not associate mercury exposure in the Arctic to the likes of Minimata; it is more complex than that and we look at Hg as one of many risk factors. Issues such as diet, communication, tradition, changing lifestyles and balance must be considered when addressing the impacts of mercury on the health of people living in the Arctic.

A clear assessment (dietary survey) of what northerners are eating in terms of mercury-contaminated food and non-traditional food is essential. The link between what humans are consuming combined with geophysical data must be made in order to begin to entertain a cause and effect relationship between traditional foods and elevated levels of mercury in northerners. More monitoring of consumed wildlife tissue needs to be undertaken. Greenlanders have higher Hg concentrations in hair than in pre-industrial times despite increases in consumption of non-traditional food. Arctic people consume both marine and terrestrial wildlife which differs from other regions but foods have changed over time and consumption of western (processed) food is on the rise. There needs to be an assessed balance of benefits and risks to eating traditional foods.

Identifying the species of mercury that are consumed is important for human health. Some foods (e.g. seal liver) are high in total mercury (in which a large portion is inorganic mercury) but nearly all inorganic mercury has little effect on human health. Thus, more information about the distribution and bioavailability of MeHg in food stuff is warranted. Additionally, the metabolic interactions with other contaminants must be fully understood. For example, research on the benefits of Se binding with Hg in humans and subsequently limiting neurological damage must be undertaken. The people whom advisories mostly affect are women of child bearing age although there is some evidence that MeHg can cause brain injury in all adults. Human blood and hair are studied in health studies but this is not comparable to the samples collected and measured in wildlife. Communication and collaboration between disciplines must be increased to fully benefit from research results. While links between MeHg exposure and cardio-vascular disease generated some discussion, diet and lifestyle were attributed as more significant risks for this disease; however, MeHg exposure may act as an aggravating co-factor.

Communicating research results to northerners is challenging as there are cultural and linguistic boundaries. This should be done by communication specialists and not scientists. The risks and benefits to food advisories regarding traditional foods must be considered. Capacity building within communities to convey accurate messages is warranted. Currently, there are very few means to follow up with knowing the effects of Hg contamination on people in later life. This will be key when risk/benefit analyses are undertaken.

Summary of the GAPS of knowledge for Topic #4:
- **A risk/benefit assessment on consumption of country foods is critical.**
- **Proper communication of this risk/benefit must be done.**
- **Better quality dietary surveys are needed (what are northerners eating?).**
- **Increased understanding the speciation of mercury in consumed foods is required.**
- **What are the interactions of mercury with other contaminants and nutrients?**
- **Understanding the links between wildlife exposure to Hg and human food consumption?**
- **There is need to understand demethylation processes within organisms.**
- **The toxicology of organic and inorganic mercury needs to be assessed in relation to the consumption of marine mammals.**
- **There must be more follow up information on people investigated once past childhood and child-bearing years.**
- **Are there toxic effects of Hg to adults?**

- **Are there other sources of Hg to humans other than through food consumption?**
- **What do we need to know to further protect human fetus?**
- **There is a need to assess the current impacts of mercury exposure on northerners.**
- **Further work on the link between Hg exposure and cardiovascular disease needs to be done.**

EXECUTIVE SUMMARY OF GAPS IN CURRENT SCIENTIFIC KNOWLEDGE AND RECOMMENDATIONS FOR AREAS WHERE FUTURE RESEARCH SHOULD BE FOCUSED:

1. More interdiciplinary measurements of mercury need to be undertaken.

2. Cycling of mercury in the Arctic environment. In order to understand this cycling, interdisciplinary and whole-system projects need to be undertaken.
3. Time trends of mercury levels in the atmosphere, sediments, wildlife and humans are not consistent. There are no clear trends indicating a decline in mercury concentrations in the Arctic environment. The reasons for these complex results are not known.

4. Both process and trend reaearch must be continued in combination to understand the relevance of the other.

5. The role of the ocean in mercury cycling in the Arctic has been neglected and must be better understood.

6. The impact of interactions between the atmosphere-sea ice snowpack, chemical physical, biological, marine ecosystem exchanges at open leads need to be better understood because this is a draw for biota.

7. What is the source of elevated levels of methyl mercury in the snow pack; how does mercury methylate in this environment and what changes methylation rates are key questions that need to be answered?

8. The relationship and possible impacts between behaviour of mercury in the Arctic and climate change needs to be established. Climate change can impact the temperature in the Arctic which may impact the methylation rate of mercury, increase snow melt (and release more Hg to the environment), increase open ocean and drive more deposition chemistry. These factors need to be properly understood in order to ascertain the impact of a changing environment on the deposition of mercury to Polar Regions.

9. How Hg enters the Arctic environment needs to be understood.

10. What parameters are important for the uptake of Hg to the Arctic environment?

11. Understanding risk/benefit factors for human health and consumption of country foods.

12. What are the links of Hg to cardiovascular diesease?

13. Understanding what species of mercury are in food items and the need to monitor the foods that are consumed were identified.

14. Understanding metabolic interactions with other pollutants and nutrients.

15. Who are our communities of interest and what social and economic changes are they undergoing and what kind of human monitoring is needed to assure public health were put forward?

DAY 3: INTERNATIONAL POLAR YEAR DISCUSSIONS AND AMAP ASSESSMENT REPORT DISCUSSIONS

Proposed discussion items for the International Polar Year session:

- What programs are currently being proposed for IPY?
- How does this mercury work fit into the strategic plans for IPY?
- What can we accomplish in a full year of field work for IPY
- What infrastructure can be set up for future research as an IPY legacy?
- Can we come up with a comprehensive/interdisciplinary strategy for mercury in PRs that addresses the overarching questions for implementation during IPY?

1. Ocean Atmosphere Sea Ice Snow pack Interactions (OASIS)

Presentation by Jan Bottenheim

The mission statement of OASIS is to determine the importance of *OASIS* (Ocean-Atmosphere-Sea Ice Snow pack) chemical, physical and biological *exchange processes* on tropospheric chemistry, the cryosphere, and the marine environment, and their *feedback mechanisms* in the context of a *changing climate*.

There are several overarching questions that will be addressed in this study:

1. What is the nature of feedback loops between OASIS exchange processes and global climate change?
2. What are the fundamental physical, chemical, and biologically-mediated chemical exchange processes involving halogens, DMS, NOx, O_3, VOCs, POPs, Hg, S-constituents, particulate matter and CO_2 in the Polar Regions?
3. What are the impacts of OASIS exchange processes on a) the marine cryosphere (ice/snow) and the underlying Polar ocean?, and b) the chemistry, physics and biology of airborne gaseous and aerosol particles and cloud/snow formation?
4. Environmental pollution: what is the impact on, and by, OASIS exchange and the role of long term changes?

The following implementation plan is proposed in order address these issues and questions listed above:

Experimental Fieldwork

- Arctic Ocean Chemical Measurement Buoys will be developed and deployed in an Arctic Ocean wide surface network.
- Icebreakers and Associated Ice camps: An extended ice camp study will be conducted from an ice breaker that will be frozen well removed from the coastal zone in the Arctic ice sheet at a location yet to be determined.
- Aircraft and other airborne platforms: Airborne platforms of various sizes and capabilities can play critical roles during OASIS.
- Remote sensing platforms (e.g. buoys)

Laboratory Studies and Modeling Activities

- OASIS modeling / lab workshop September 2005 in Toronto

It was shown that mercury fits very well into the objectives of the OASIS program. Researchers (including oceanographers and biologists NOT only participation from atmospheric scientists is expected) were invited to participate in any aspect of the OASIS research program and, if interested, were encouraged to contact the organizers of the project for more information: www.OASIShome.net

The coordinator is Dr. Harry Beine, CNR Italy harry@iia.cnr.it,

(39) 06.906.72.262, fax (39) 06.906.72.660

or Contact Dr. Jan Botttenheim, Environment Canada, Canada
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2. SYNSCOPE: Synoptic Studies of Contaminants in Polar Environments
Presentation by Torunn Berg for Jesse Ford

SYNSCOPE will establish an international circumpolar network to document contaminant deposition to terrestrial Arctic/Antarctic environments using the moss/lichen monitoring approach coupled with passive POPs samplers. Faunal compartments are important in order to understand potential contaminants status of subsistence foods, but are not well-suited to understanding deposition issues such as 1) bioaccumulation; 2) species-specific degradation pathways; 3) require sex/age/length adjustments and 4) mobile/migratory patterns

Locations for this study are based on related IPY projects, AMAP air monitoring stations, and circumpolar networks of national field stations. There will be co-location of some sites with existing Arctic/Antarctic atmospheric/precipitation stations. In addition, passive sampler deployment will link to global but spatially sparse network of passive POPs samplers. Analytical work will be done at national laboratories; some North American labs have expressed willingness to handle more than Canadian and US samples if needed, funding permitting. In addition, there will be community-based sampling and K-12 education.

How best to link this program with the Hg community? Air/surface exchange of vegetation is one form of a “passive sampler” for collecting and studying mercury. Vegetation is the missing link between atmosphere and wildlife and should be more thoroughly investigated. Spatial patterns of Hg deposition inferred not characterized (particularly marine/inland).

Timeline for SYNSCOPE:
Phase I (2006): ID sampling sites, logistics, field QA/QC protocols, laboratories, education/outreach and website launch.

Phase II (2007): Lab protocols, intercalibrations, data management system, cross-training of field personnel, pilot studies, student-teacher teams

Phase III (2008): Synoptic sampling
Phase IV (2009-2010): Complete sample analysis, data analysis, modeling to discern source-receptor relationships and interpolate among sites

It proposed to fit mercury into the objectives of the SYNSCOPE program. Researchers were invited to participate in SYNSCOPE, if interested, were encouraged to contact the organizers of the project for more information.

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3. IPY Update

Presentation by Russell Shearer

Russell presented an overview of the International Polar Year 2007-2008. This is the largest-ever program of coordinated interdisciplinary research and observations focussed on the Polar Regions. IPY presents a tremendous opportunity for the international science community to:

- undertake collaborative scientific research in polar regions
- enhance capacity for polar science through: observational systems, facilities, infrastructure and research networks and strengthened capacity in the North
- train and develop the next generation of polar scientists, engineers and logistics experts
- provide unprecedented access to data and information
- capture the interest of the public and showcase science & technology

How do contaminants and mercury fit into IPY as it appears to be a climate change driven program? Mercury is a major human health issue and would fall under that stream including processes related to mercury contamination. It also fits under the climate change stream given that the changes in contaminants and exposure are unknown but expected with climate change. It was Russell's opinion that **mercury fits very well into the IPY mandate**.

Proposals for IPY research should be submitted through national and international committees. At the time of this meeting, the funding commitment of the Canadian government was publicly unknown. It is anticipated that once Canada announces its financial contribution to IPY that other countries will follow. It has since been announced that $150 million dollars have been provided over six years to carry out an innovative, interdisciplinary program for International Polar Year (IPY) along with our international partners (http://www.ainc-inac.gc.ca/nr/prs/s-d2005/2-02709_e.html). Canadian IPY proposals will be submitted in March 2006 as separate proposals and will go through a rigorous, transparent competitive process. They will be evaluated against criteria and relevancy.

The research themes for IPY include:

- State of the polar environment
- Change in the polar regions
- Polar-global linkages
- New frontiers
- Polar regions as vantage points
- Human dimension

Legacy expectations include:

- Research Infrastructure
- Research Capacity
- New generation of scientists
- Data
- Communication

IPY timelines:

Phase I: Build up to IPY (2005, 2006)
Collaboration & Partnership Building
Infrastructure Enhancement
Logistics Enhancement
Research Program Begins

Phase II: IPY Activities (2007, 2008)
"The Research Program"
Education and Communication, Training
Data systems development
Ensure safety & security during period of increased international activity in North

Phase III: Legacy of IPY (2009, 2010+)
Data interpretation, integration, management and access
Unprecedented access to data and information
Education/Training/Communication
Reporting and research/knowledge translation

For more information:
www.ipy.org; www.ipy-api.ca/; www.ualberta.ca/~ipy/

IPY Discussion:

The discussion began by a roundtable dialogue of research plans by the participants for IPY. They are included in Table 1 below.

Table 1: Summary of intended/anticipated work by participants during IPY

Participant	IPY intended activities
Peter Outridge	Gather more long term trend data in biota Work with Danish to examine Hg and climate trends in biota
Christian Temme	Activities on Polarstern (frost flowers) OASIS Lab work to generate frost flowers and study in wind tunnel
James Zheng	Ice cores on Devon Island
Steve Brooks	Examine land locked vs ocean-side locations (Barrow) Comparison of Arctic and Antarctic work
Rune Dietz	Sample polar bears (POPs and Hg) Global ring seal plan (add to existing data) Add to long term trend project with P. Outridge
Alexandra Steffen	Atmospheric work on OASIS Near open lead sampling, over ocean (over year) speciation sampling, intense 6 weeks on icebreaker with other Hg scientists
Jay Van Oostdam	Meetings planned for 2007/08 -Results symposium planned from a mostly human health perspective -AMAP related meeting (hh focus) Drawing attention to capacity building in the north
Henrik Skov	Sea ice field study planned with Hg group for OASIS
Ashu Dastoor	Attempt to identify gaps got models Concentrate efforts where field studies are happening to understand fluxes, surface exchange etc.
Jan Bottenheim	OASIS – processes work to connect between how Hg gets into the snow (collaboration with A. Steffen)
Enno Bahlman	LGGE will participate in OASIS – surface/ atmospheric exchange
Gary Stern	Physical/biological Hg coupling at open leads in oceans
Birgit Braune	DFO Lancaster Sound marine ecology/wildlife sample collection Collect zooplankton, fish, birds to add to historical data Netherlands project: comparison between Arctic and Antarctic by examining food web and effects of contaminants north vs south
David Lean	Working at more southern Arctic locations to investigate deposition and reemission rates MeHg sources, formation and behaviour
Gary Stern	Participation in frozen in Amundsen to look at the physical Circumpolar flow lead to study biological coupling in the ocean
Parisa Ariya	Understand post depletion fate of Hg in the Arctic Continue work in Resolute and northern Quebec OASIS participation on Hg

Marc Amyot	Establish trance element laboratory in Resolute
Alexei Konoplev	SYNSCOPE participation – collecting and analysis of vegetation More measuring of atmospheric Hg other than Amderma
Torunn Berg	OASIS SYNSCOPE

From this discussion it was shown that there are many opportunities to collaborate with scientists from different disciplines for the activities taking place during IPY. Some of these possibilities mentioned (as well as OASIS and SYNCOPE) are shown below. The participants are invited to contact each other and work together to reduce the gaps of information identified the previous day.

Opportunities for collaboration and/or sample collection for IPY:

- The Polarstern will be in the Antarctic Aug – Oct, 2006; opportunity for sample collection (Christian Temme)
- Ice core samples from Devon Island – need collaborators for analysis of Hg; can be linked with climate change interests (James Zheng)
- Additional data sought for Hg global circulation model (Ahsu Dastoor)
- Amundsen frozen in – possible samples can be collected (Gary Stern)
- Lancaster Sound marine ecology project lead by DFO – opportunity for interdisciplinary sampling (Birgit Braune)
- Seeking funding and collaboration for sites around Russia to sample atmospheric Hg (Alexei Konoplev)
- National Wildlife Monitoring Plan (NIST) access to tissue banks – interested in collaboration on time trends (Steven Christopher)
- Looking for interest in developing a program in Iqaluit (David Lean)
- OASIS Hg group seeking interested parties for 6 week intensive on the frozen in icebreaker pertaining to water/snow/ ice/ air exchange of Hg (Alexandra Steffen)
- Snow samples requested for studies of snow surface exchanges (Enno Bahlman)
- CANE project on Louis St. Laurent looking at biological coupling in the ocean.

It was felt that IPY was an excellent opportunity to undertake intensive field processes work on Hg in Polar Regions as applied in the **research themes** 1) State of the polar environment and 2) Change in the Polar Regions. In addition, trend measurements MUST be continued, in ALL ARCTIC countries, as **legacy** building work for collecting ongoing data. **The Americans are encouraged to restart continuous monitoring of Hg at Barrow, Alaska and the Russians are encouraged to start new sites in the far east of Russia.** Participants are encouraged to contact fellow researchers from this meeting and use the opportunities mentioned above to gain access to increased sampling and knowledge of Hg behaviour in the polar environment.

Session on AMAP-related Issues

In connection with the 'Interdisciplinary Workshop for Research on Mercury in Polar Regions' a special session was convened to allow the participants to present their views on some questions relating to future AMAP assessments of mercury and related issues.

Experts present were asked to consider the following questions:

- The Need for an Update AMAP Assessment of Mercury in the Arctic
- Proposals for practical arrangements for an AMAP (Metals) Expert Group
- Needs for Updating the AMAP Monitoring Programme for Heavy Metals

The following is a summary of the main conclusions from the discussions on the above matters.

<u>Need for Updated Mercury Assessment</u>

The last comprehensive circumpolar AMAP assessment of heavy metals (including mercury) in the Arctic was completed in 2002. Were AMAP to continue to work on a five-yearly assessment cycle the next update would be due in 2007.

Most of the experts present, including the 5-6 participants who had contributed as key experts/authors to the 2002 assessment, felt that a new comprehensive AMAP assessment on mercury in the Arctic would be premature within the next 1-2 years.

A considerable amount of new information has become available since the 2002 AMAP assessment, and progress has been made in a number of fields of research, however many of the main outstanding questions (including some identified in 2002 or earlier) cannot yet be answered. These questions include:

- Are levels of mercury going up in the Arctic, and if so where?
- Are changes in Arctic mercury levels related to natural processes including climate-induced changes?
- How long after reductions in anthropogenic emissions will responses be seen in the Arctic and what is the magnitude of the response that can be expected?
- What is the spatial extent of mercury delivery to the Arctic related to MDEs (is this correctly reflected in models)?
- Do MDEs result in a net input of mercury to Arctic terrestrial/aquatic environments, and if so how much?
- Where is the methyl-mercury coming from?
- Are we missing/ignoring other important routes of mercury transport to the Arctic (e.g. oceans vs. MDEs on different time scales)
- How best can we reduce modeling uncertainty (e.g., process studies to improve the parameterization of key transformations in models)

The mercury projects proposed for the IPY can be expected to provide a lot of new information to answer some of these questions and the experts considered that it would be appropriate to wait until information from these activities is available before preparing a new comprehensive mercury assessment, which should then represent a major step in knowledge concerning mercury in the Arctic.

It was therefore recommended that the next full AMAP assessment report on mercury in the Arctic be scheduled for delivery in 2010.

Notwithstanding this recommendation, the experts did consider that an interim activity on mercury was warranted in order to:

- keep the attention of the Ministers directed towards the mercury issue
- update the Ministers on new information relating to mercury and human health
- address standardization of protocols for mercury temporal trend monitoring studies (current interpretation of trend patterns is confused by the fact that some trend studies generate high quality datasets that are amenable to rigorous trend interpretation whilst others are of lesser quality)
- maintain an active network of mercury (and heavy metals) experts to address questions from AMAP

It was therefore thought that in the interim period a series of update reports dealing with specific aspects of the mercury issue might be produced.

One such product might be a short communication to Ministers highlighting new important messages, and in this context a number of proposals were made (see recommendations, below)

A second category of reports that was considered feasible to produce on a 1-2 year timeframe was a series of reports of a more restricted nature dealing with particular aspects of the (Arctic) mercury problem. These reports would summarize new scientific knowledge on specific issues where progress had been made. The reports could serve a similar purpose to the Canadian Northern Contaminants Programme 'Synopsis Reports'. Such products would be potentially useful to AMAP to track progress, etc., and could serve as a basis for an eventual comprehensive assessment report, but would probably be of lesser interest for Ministers and policy-makers. This type of product could also be readily adapted for publication in the scientific literature, and thus represent one way to encourage the involvement of experts in their production. The recommendations below list some of the 'subject reports' that might be considered for production within the next 1-2 years.

Another type of 'status report' that was suggested was the type of product that could be provided to, e.g., the UN ECE as a contribution to its review of the LRTAP Metals Protocol that is due to be completed in 2006/2007 (dealing with mercury and also other heavy metals).

In relation to the issue of climate and contaminants, several experts supported the idea that this issue be addressed in relation to contaminants in general, as the effects are not specific to mercury. A combined assessment could be useful for interpreting information on both POPs and mercury. However, it was also pointed out that mercury, unlike most POPs, has both anthropogenic and natural sources and this is a factor that should be taken into account. Another reservation expressed was that in products that might be aimed for delivery to e.g. the Stockholm Convention, it was not desirable to see Hg combined with POPs.

AMAP (Metals) Expert Group

Birgit Braune summarized the outcome of discussions that took place during an AMAP POPs expert group meeting the previous week which also considered how best to involve and organize experts in the future AMAP assessment work.

Most participants supported the idea that AMAP mercury/metals assessments could be organized around an extended network of experts that could be asked to address relevant questions from AMAP in the period between the major assessments.

The idea of a combined metals/POPs group was also generally supported, especially since the main future metals assessments are likely to focus on mercury rather than all heavy metals – other metals could probably be covered on an ad hoc basis as an update was required. Several experts routinely work on both metals (mercury) and POPs and find the distinction artificial especially when they become associated with one assessment process and not the other.

One disadvantage of a multi-contaminant group might be that 'single contaminant' specialists might be put off attending meetings if they considered that they might not be able to contribute to much of the discussions. However, it was noted that if the group could call upon a large 'network of experts', the composition at any given meeting could be varied depending on the topics needing to be addressed.

It was however pointed out that, in order to be effective, such a group would need a stable core group of experts who could rely on support from their countries to undertake tasks and attend regular meetings. The concept of national representatives as the core to such an expert group, as is the case in the human health and radioactivity groups, could provide a model. However, in the contaminants field (whether POPs, metals or combined) it may be difficult to identify a single individual who could act effectively as a national focal point for experts in all related scientific disciplines (POPs vs. metals, atmospheric vs. ocean, abiotic vs. biotic, trends vs. effects, etc.). In addition to 'national representation', therefore, a 'balance in disciplines' would need to be ensured in any core group of experts that might meet regularly and coordinate (inter)national input.

Apart from scientific expertise and support from countries/managers, a high degree of enthusiasm for the work of AMAP would be a criterion for membership of the core group.

Considering how involvement of experts from observer countries in AMAP assessment work might be improved, lack of support (including financial support) from relevant national agencies is a barrier that needs to be overcome – especially if regular meeting participation is desirable. One option to involve a greater number of experts from observing countries in some of the work might be to see if observing countries could host some of the expert meetings.

Update of the AMAP Monitoring Programme for Heavy Metals

Time constraints and lack of familiarity of most of the experts with the detailed AMAP monitoring programme guidelines meant that the discussions on the need to update the AMAP Trends and Effects Programme were limited to general aspects. The points noted included the following:

- the programme should be developed with the objective of obtaining more comprehensive and consistent information on diet and mercury in consumed foodstuffs as the PTS project has demonstrated the importance of this for the human health assessment process
- The monitoring programme should be refined/expanded to give a greater emphasis to measurements of methyl-mercury as opposed to total mercury (in both abiotic and biotic systems), since it is methyl-mercury that biomagnifies and is the toxic form. Measurements of total mercury do not always provide meaningful information for the types of assessment question being addressed by AMAP.
- Some experts consider that the emphasis on atmospheric mercury depletion chemistry over recent years may have led to a situation where other important aspects, such as ocean transport of mercury to the Arctic, have been neglected. This matter needs to be further investigated and if necessary the AMAP monitoring (and assessment) programme might need to be refocused to provide necessary information on other aspects of mercury transport and delivery to the Arctic and/or routes of mercury exposure.
- The monitoring and research studies need to be better integrated to investigate the connection between mercury occurrence and migration between different environmental media.

Updating of the AMAP monitoring programme should be an ongoing task for the AMAP metals/mercury/contaminants/human health expert group(s). In recent years the components of the programme dealing with metals (and POPs) have received less attention than those dealing with human health monitoring. This partly reflects the fact that, until recently, the POPs/metals expert groups have only convened in order to produce assessments whereas the human health expert group meets regularly and can accommodate other tasks. This is being addressed in future plans for meetings of the AMAP metals/mercury and POPs expert groups.

Recommendations:

(1) The next comprehensive circumpolar AMAP assessment of mercury will be provisionally scheduled for 2010.

(2) AMAP should consider producing a short (<5 page) update report for the 2006 Ministerial meeting, to include

- a possible communication updating Ministers about new information on the link between mercury and cardiovascular disease, and mercury effects on the developing fetus, and possible implications for Arctic communities
- a message to highlight the importance of climate change in relation to mercury transport and fate (both in the Arctic and in a wider context)
- a message concerning the need to support research to answer some of the key scientific questions raised at this workshop

(3) AMAP should consider the production of a series of assessment reports on restricted (mercury-related) subjects over the coming 1-3 years to summarize the state of the scientific

knowledge, and also investigate possibilities to link these to publication in the scientific literature. Specific proposal included:

- a detailed re-evaluation/assessment of Arctic mercury time series datasets, aiming to clarify the issue of mercury temporal trends, establish protocols for handling such datasets, and providing products that might contribute to the review of the effectiveness of the UN ECE LRTAP Metals Protocol
- an update report on 'mercury depletion events' summarizing new information that has been gained from research into these events and re-evaluating their importance for delivery of mercury to the Arctic and its uptake in Arctic food webs. These subjects represent a 'work in progress, but a considerable amount of new information is now available.
- An update report on mercury and human health (the human health group are not planning a comprehensive update assessment on human health in the Arctic within the coming years, but were also considering reports of more limited scope and would consider this at the next AMAP HHAG meeting)

(4) AMAP should consider how best to address the very important issue of climate change influence on mercury, including the question of whether this issue should be addressed within the context of a mercury assessment or a more general AMAP assessment of 'climate and contaminants'.

(5) Linked to the above, AMAP might consider initiating new modeling work to investigate both climate and emission scenarios.

(6) AMAP should consider initiating new work to look into mercury transport to the Arctic via ocean pathways.

(7) Updating of the AMAP monitoring programme should be an ongoing task for the AMAP expert group(s)

(8) AMAP should consider establishing a combined group of metals/mercury and POPs experts, with a core group of experts who are willing to coordinate the input from a wider network of (identified) experts. This core group should have the necessary national support to contribute to both production of AMAP assessment reports and also ad hoc requests from AMAP. This group should meet regularly, possibly include national focal points but also ensure that necessary contacts with experts in all disciplines can be maintained.

Organization of work:

If AMAP were to request an update report on MDEs, several of the relevant experts will be participating in the International Conference for Mercury as a Global Pollutant (Wisconsin, August 2006) what would present an opportunity for arranging a drafting meeting, or an AMAP mercury expert's group meeting. Steve Brooks indicated that he may be able to volunteer to co-author such as report and several other experts volunteered to contribute (see below).

If AMAP were to request an update report on temporal trends, an efficient mechanism to support this would be to convene a workshop including relevant statisticians and individuals who could bring appropriate time series to the meeting (including all detailed data necessary to address normalization issues). These datasets should be pre-compiled in advance of the meeting. Several experts expressed their interest in participating in such a workshop and producing standardized products (synopsis report) that could be delivered to AMAP and other potential customers (e.g. UN ECE), however, it was noted that producing a report akin to the metals chapter in the 2002 AMAP metals assessment represented a different level of commitment and this may require either financial support or some other incentive (e.g. the aim of producing a paper for the scientific literature). A workshop early in 2006 or late in 2006 is preferable, avoiding the summer field season and taking note of possible commitments to IPY deadlines/projects.

Nomination of experts:

The following individuals who have been involved in previous AMAP assessments confirmed that (subject to support) they would be willing to contribute to future AMAP assessment activities:

Peter Outridge (temporal trend assessment activities)

Birgit Braune (POPs and metals assessments, temporal trends and effects)

Rune Dietz (mercury levels and effects in biota)

Alexandra (Sandy) Steffen (atmospheric trends and MDEs as a contributing expert)

Torunn Berg (atmospheric trends and MDEs)

Steve Brooks (MDE update, including possibilities to author report)

Gary Stern (ocean transport of mercury)

Ashu Dashtoor (atmospheric mercury transport modeling)

Henrik Skov (MDEs)

Most other participants indicated that they would also be interested in contributing or joining an eventual AMAP 'network' of mercury experts.

ANNEX 1: LIST OF PARTICIPANTS

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ANNEX 2: ABSTRACTS OF THE PRESENTATION IN A SEPARATE FILE *(ATTACHED)*

ANNEX 3: FINAL AGENDA

Final Agenda for the Interdisciplinary Workshop for Research on Mercury in Polar Regions

August 29, 2005   Environment Canada, McTaggart Auditorium

9:00 – 9:45
Introductory Remarks and Welcome
Keith Puckett – Director of the Air Quality Research Branch, Environment Canada
Jason Stow – Northern Contaminants Program
Simon Wilson – Arctic Monitoring and Assessment Programme
Cheryl Heathwood – Transboundary Air Issues Branch, Environment Canada
Sandy Steffen – Air Quality Research Branch
Cathy Banic – Chief Air Quality Processes Research and moderator of the workshop

9:45 – 10:00 ***COFFEE BREAK***

10:00 – 10:10 *Sandy Steffen*
Long term Atmospheric Measurements of Mercury in the Canadian High Arctic

10:10 – 10:20 *Torunn Berg*
Five Years of Mercury at Ny-Alesund

10:20 – 10:30 *Cathy Banic*
Mercury Aloft

10:30 – 10:40 *Steve Brooks*
Atmospheric Hg (II) Deposition to Antarctic Polar Plateau: A Case for Stratospheric Mercury Subsidence

10:40 – 10:50 *Ashu Dastoor*
Transport of Mercury to Polar Regions

10:50 – 11:00 *Christian Temme*
Air/water exchange of mercury in the north Atlantic Ocean during the Arctic Summer

11:00 – 11:10 *Henrik Skov*
FOMA, Atmosphere

11:10 – 11:20 *Parisa Ariya*
Arctic: A sink for Hg

11:20 – 11:30 **10 minute leg stretch**

11:30 – 11:40 *Marc Amyot*
Reactivity, bioavailability, and trophic transfer of newly deposited Hg in the Arctic

11:40 – 11:50 *Joel Blum*
Deposition and fate of mercury in the Barrow environmental observatory

11:50 – 12:00 *Frank Cobbett / Bill Van Heyst*
Arctic atmospheric mercury: Six months of continuous GEM flux measurements above the Arctic snow pack in Alert and a snow and water sampling program to better describe Arctic surface exchange

12:00 – 12:10 *Enno Bahlmann*
Process Studies on the air/ snow exchange of mercury

12:10 – 12:20 Peter Outridge
Recent Arctic Research at the Geological Survey of Canada

12:20 – 12:30 *James Zheng*
A plan to retrieve a ice core for Hg studies from Prince of Wales, Nunavut, Canada"

12:40 – 13:30 **Group LUNCH Served in the Environment Canada Cafeteria**

13:40 – 13:50 *Vince St Louis*
What is the net springtime deposition of Hg (II) and methyl Hg to Arctic regions?

13:50 – 14:00 *David Lean*
Where does all the methyl mercury come from?

14:00 – 14:10 *Rune Dietz*
The Hg time trends in the Greenland biota

14:10 – 14:30 *Derek Muir*
To be determined

14:30 – 14:40 *Michael Kwan*
An overview of the monitoring works on spatial and temporal trends of mercury in wildlife at the Nunavik Research Centre

14:40 – 14:50 *Birgit Braune*
Mercury in Canadian Arctic Seabirds

14:50 – 15:00 *Steven Christopher*
Monitoring Mercury in Alaskan Seabirds through STAMP, the Seabird Tissue Archival Monitoring Project

15:00 – 15:20 **COFFEE BREAK**

15:20 – 15:30 *Lyle Lockhart*
To be determined

15:30 – 15:40 *Jay Van Oostdam*
Mercury - human tissue levels in Arctic Canada, effects, future directions

15:40 – 15:50 *Jens Hansen*
Human exposure to mercury in Greenland. Current Status

15:50 – 16:00 *Alexei Konoplev*
Hg in blood of indigenous people of Russian North

16:00 – 16:10 *Gary Stern* *
SHEBA, CASES and ArcticNet: results and a brief overview of on going mercury studies
16:10 – 16:20 *Gary Stern* *

16:20 – 16:30 *Tom Clair*
Building a database for assessing mercury distribution in northeastern North America

16:30 – 16:40 *Frank Schaedlich*
Recent improvements in the Model 1130/35 Mercury Speciation Units

16:40 – 16:50 *Xinjie Song*
Improvement of a diffusion type device for generating gaseous Hg (II) species

16: 50	**END of DAY 1**
August 30, 2005	***St. Michaels College, Father Hall (in Carr Hall)***
9:00 – 9:15	*Cathy Banic* - Welcome and agenda for the day
9:15 – 10:30	***Discussion Topic #1*** Transport of Hg to polar regions and atmospheric processing of Hg in polar regions
10:30 – 11:00	**COFFEE BREAK**
11:00 – 12:30	***Discussion Topic #2*** Air/surface exchange and processing of Hg in and around the ocean
12:30 – 13:30	**LUNCH in the Chabonnel Lounge**
13:30 – 15:00	**Discussion Topic #3** Mercury in vegetation and wildlife
15:00 – 15:30	**COFFEE BREAK**
15:30 – 17:00	***Discussion Topic #4***

Impacts of Hg on human health and health processes

17:00 END OF DAY 2

19:15 – 21:00 Cocktail Reception at the Boiler House

August 31, 2005 St. Michaels College, Father Hall (in Carr Hall)

9:00 – 9:15 *Cathy Banic* - Welcome and agenda for the day

9:15 -9:45 Overview of previous day discussions

International Polar Year (IPY)

9:45 – 9:55 *Jan Bottenheim*
OASIS planned Program for IPY

9:55 – 10:05 *Torunn Berg*
SYNSCOPE

10:05 – 10:30 ***IPY Discussion***

- Current proposals
- Identify gaps in mercury research in polar regions
- What needs to be done to enhance these proposals

10:30 – 11:00 **COFFEE BREAK**

11:00 – 12:30 ***IPY Discussion continued…***

- Identified gaps: which should be addressed through IPY
- Linkages for interdisciplinary work

12:30 – 13:30 **LUNCH in the Chabonnel Lounge**

13:30 – 15:00 **AMAP Mercury Assessment Report**
Led by Simon Wilson

15:00 – 15:30 COFFEE BREAK

15:30 – 16:30 **Wrap up and future plans**