Chapter 1
Why Are We Doing this Assessment?

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This introductory chapter provides relevant background information on the issue of Arctic mercury contamination, impacts on Arctic indigenous peoples, and the way in which the Arctic Council, AMAP, and indigenous peoples' organizations have responded to the issue through the publication of scientific assessments and engagement in international initiatives related to mercury in the environment. The chapter concludes with an outline of the report and provides a brief explanation as to the question-based chapter format. The outline makes use of a schematic illustration to provide the reader with a road-map to scientific information provided in the report.

1.1. Why is mercury a concern in the Arctic?

Mercury is a naturally occurring element that is ubiquitous in the global environment and can be measured in virtually all environmental media in proportions that, in the absence of anthropogenic influence, are defined by natural geochemical cycles. Until recently the natural release of mercury was generally in balance with the natural processes leading to its removal. Certain anthropogenic activities, however, extract mercury-containing materials from the Earth and process them to produce commercial goods, or in the case of fossil fuels, burn them to produce energy. Over time, and particularly since the Industrial Revolution, these types of industrial activity have mobilized vast quantities of mercury from a relatively inert state in the Earth's crust and redistributed it throughout the more biologically active and mobile compartments of the environment (surface soils, atmosphere, lakes, rivers, oceans). The increased amount of mercury now circulating in the global environment presents an increased risk to biological systems in which the highly toxic species, methylmercury, is biomagnified (AMAP, 2005). Increased mercury in the Arctic environment is of particular ecological concern because of its well-known ability to bioaccumulate and biomagnify in food webs. Despite a lack of major industrial sources within the Arctic, mercury concentrations can reach levels of toxicological significance in high trophic level species (AMAP, 2005). The ecological risks of mercury contamination in the Arctic are compounded by the presence of other contaminants, such as persistent organic pollutants (POPs), which add to the overall toxic burden on Arctic wildlife and human populations (AMAP, 2003, 2005, 2009b; Letcher et al., 2010). The potential threats from toxic contaminants must also be considered in the context of ecosystems and species that are already being subjected to the environmental stresses imposed by climate change (ACIA, 2005).

A substantial proportion of the mercury found in high trophic level Arctic species today is derived from anthropogenic sources (Dietz et al., 2009a; see Section 5.2). Elevated mercury concentrations in the Arctic environment, and especially in Arctic biota, can greatly affect Arctic indigenous peoples who rely on subsistence hunting and fishing for their nutritional, social and cultural well-being. Arctic indigenous peoples such as Inuit, Yupik, and Iñupiat consume marine mammals including seals, whales and polar bears that are high in the food web and which are known from previous assessments to be a major source of dietary mercury exposure. Mercury concentrations in most Arctic marine mammal species and some seabirds and predatory freshwater fish regularly exceed guidelines for consumption. This presents a significant exposure pathway to many indigenous communities for which marine mammals and fish such as lake trout and pike are important traditional/local foods. As a result, high levels of mercury have been measured in Arctic indigenous peoples (AMAP, 2009b; and summarized in Chapter 8). Results of blood monitoring surveys in Arctic communities have shown that a significant percentage of indigenous women from certain communities in Alaska, northern Canada, Greenland, and northern Russia still exceed the US Environmental Protection Agency and Health Canada guideline values. Although human blood levels in several communities have declined somewhat since the first AMAP assessment (AMAP, 1998, 2009b; see also Chapter 8), there are few indications of declining trends in mercury in wildlife in the corresponding areas (see Chapter 5). The reasons for the declining levels in humans are therefore complicated and involve additional factors, such as changes in dietary preferences (discussed in Chapter 8). Epidemiological studies have shown that infants born to mothers with elevated mercury exposure are at risk of neuro-developmental and behavioral effects. It has also been shown that elevated mercury exposure is associated with a higher incidence of cardiovascular disease, further demonstrating the unacceptable level of mercury-associated health risks to which some Arctic indigenous people are exposed (AMAP, 2009b).

The potential health effects of mercury have recently been discussed from an economic perspective (e.g., Hylander and Goodsite, 2006; Sundseth et al., 2010). Sundseth et al. (2010) estimated the annual global economic loss resulting from the impact of methylmercury exposure on IQ. The estimate, based on a forecasted 25% increase in global anthropogenic mercury emissions to air between 2005 and 2020, predicted an annual economic loss, associated only with diminished IQ due to ingestion of methylmercury, of USD 3.7 billion (2005 USD) in 2020. Conversely, scenarios under which global anthropogenic emissions to air were reduced by 50-60% were predicted to have a net economic benefit of between USD 1.2 and USD 1.8 billion (2005 USD). The study illustrates how the human health effects of methylmercury exposure could have global economic consequences and quantifies the potential economic advantages of reducing mercury emissions.

The presence of mercury and other contaminants in traditional/local foods contributes to increasing concern about food security for Arctic indigenous peoples. At the same time these foods are known to be important sources of energy and nutrients. This situation has led to what has been termed the 'Arctic Dilemma' (AMAP, 1997). Concern about contaminants in traditional/local foods can aggravate the ongoing nutritional transition in which indigenous peoples gradually and increasingly substitute their traditional diet with store-bought foods. High prices, low quality and limited availability of healthy store-bought food items have led to consumption of cheaper and less nutritious 'junk foods' that are high in sugar and saturated fats. Along with a more sedentary lifestyle, this diet increases the risks of developing obesity and related diseases, such as diabetes and coronary heart disease (see Chapter 8). Apart from its nutritional importance, traditional/local food is also an important part of cultural and social life for indigenous peoples in the Arctic as it reflects the connection with the land and traditional values such as sharing. It may be argued that the ability of indigenous communities to participate in traditional harvesting and sharing of local foods is one of the most important determinants of community health and cultural identity. Therefore, the importance of 'clean' local food for Arctic indigenous peoples cannot be overstated. Although reductions in mercury exposure in the short-term may be achieved through the development and implementation of appropriate dietary advice, a better long-term solution to mitigating the negative effects of mercury exposure among Arctic residents lies in reducing mercury concentrations in traditional/local foods.

The purpose of this assessment is to help better understand the sources, pathways, processes and effects of mercury in the Arctic. It is hoped that this improved understanding of the science will lead to improved policies on mercury emissions that will eventually lead to a decrease in Arctic mercury levels.

1.2. How has AMAP addressed mercury pollution?

The primary task assigned to AMAP by Ministers of the eight Arctic countries at the time of its establishment in 1991 was to prepare assessments of the 'state of the Arctic environment' with respect to defined pollution issues (AEPS, 1991). One of these priority pollution issues was heavy metals, including mercury. Through implementation of a circumpolar monitoring program based on national monitoring programs in the eight Arctic countries, and review of available information from monitoring and research activities, AMAP prepared its first assessment reports in 1997 (AMAP, 1997, 1998). These reports included international input from hundreds of Arctic scientists as well as from Arctic indigenous representatives and provided the first comprehensive picture of the contamination status of the Arctic region as a whole, and established an important baseline for further work. Mercury was found to be ubiquitous in Arctic abiotic media (air, snow/ice, sediments, water) and biota, due partly to long-range transport from source regions to the south, and partly to natural sources of mercury present in the Arctic and elsewhere. An important task of research since that time has been to determine the relative importance of each of these sources in various media and at various locations. Higher concentrations have been found in top predators due to bioaccumulation and biomagnification; in certain Arctic animals, levels were high enough to exceed thresholds associated with effects in laboratory animals, raising concerns about population and ecosystem health effects. Also, from previous AMAP assessments of mercury in the Arctic (AMAP, 1998, 2005) it became apparent that almost no mercury effects studies on relevant high trophic-level Arctic species had been conducted.

One of the findings highlighted when AMAP presented its first assessment results to Ministers in 1997, was that some Arctic human populations, in particular indigenous groups that utilized marine mammals as an important part of their traditional diet, received some of the highest exposures to mercury of any groups on Earth, raising concerns about possible human health effects (AMAP, 1997).

Between 1998 and 2002, AMAP prepared follow-up assessments, including an assessment of heavy metals, that built on the initial assessments, filling gaps in geographical coverage, and expanding the work to consider temporal trends in contaminant levels (relative to the ca. 1990-1995 baseline data compiled in the 1997 assessment report). As part of the assessment, AMAP also sponsored and contributed to the production of an updated global anthropogenic mercury emissions inventory, for use in modeling activities. A particular focus of attention in the 2002 AMAP assessment of heavy metals in the Arctic (AMAP, 2002, 2005) concerned new information on the potential of 'atmospheric mercury depletion events' to enhance deposition of mercury in the Arctic region. In both the 1997 and 2002 AMAP assessment rounds, human health effects of mercury were addressed in separate reports dealing specifically with the health effects of contaminants (AMAP, 1998, 2003).

This third AMAP assessment concerning metals in the Arctic differs from the assessments performed in 1997 and 2002, most importantly in that it focuses only on mercury, and does not include other heavy metals. This decision recognizes the fact that, although cadmium and lead in particular continue to be found in high levels in some Arctic wildlife and human populations, the associated issues are very different. In the case of cadmium, routes of exposure such as consumption of caribou/reindeer tissues and organs are relatively well-defined and have been covered adequately in previous AMAP assessments. Cigarette smoking remains the dominant route of cadmium exposure in most individuals that exhibit high blood cadmium levels (AMAP, 2003). In the case of lead, the introduction of lead-free gasoline has led to decreased deposition across the Arctic, although the continuing use of leaded petrol in Russia remains a potential area for action. Human exposure to lead has also been linked in the Arctic to the use of lead shot in hunting; this exposure pathway has been reduced by encouraging the use of lead-free ammunition (already mandatory in most countries) and communicating the risks associated with lead shot (Fontaine et al., 2008). Mercury, on the other hand, continues to present uncontrolled risks to Arctic wildlife and human populations with levels in at least some areas still increasing. Despite the continued concern, however, no global policy has been instituted to reduce emissions of mercury and, thereby, reduce human and

environmental exposure. Previous assessments also identified a number important gaps associated with environmental trends, pathways, processes and toxic effects (AMAP, 2005). Given the known complexity of the biogeochemical cycle of mercury, it has recently been recognized that climate change has the potential to significantly alter mercury pathways and processes of transformation (e.g., methylation). Presently, however, the role of climate change in the mercury cycle remains an inadequately explored area of study. Given the prevailing interest in mercury from a global policy context and the need for improved scientific understanding, mercury was identified as a continuing priority for assessment by AMAP.

The recommendations for mercury-related monitoring and research made in the 2002 AMAP assessment (AMAP, 2002)[1] are as follows:

- The Arctic Council should encourage expanded and accelerated research on critical aspects of the mercury cycle and budget in the Arctic. Such research should include long-range transport, mercury deposition mechanisms, processes leading to biological exposure and effects, and the influence of climate variability and change on these processes.
- The Arctic Council should promote efforts at global, regional, and national levels to quantify all sources of mercury and report results in a consistent and regular manner to improve emission inventories. Particular efforts should focus on measuring contributions made by the burning of coal for residential heating and small-scale power plants as well as by waste incineration.
- AMAP should be asked to continue temporal trend monitoring and the assessment of effects of mercury in key indicator media and biota. This will enable assessment of whether the measures taken in the LRTAP Protocol are being effective in driving down mercury levels in the Arctic.
- In view of the fact that reducing exposure to mercury can only be addressed by regional and global action to reduce worldwide emissions, and acknowledging the assessment for global action undertaken by UNEP and its resulting proposals, the Arctic Council should take appropriate steps to ensure that Arctic concerns are adequately addressed and to promote the development of regional and global actions.
- AMAP should be asked to further investigate how climate change and variability may influence the ways in which POPs, heavy metals, and radionuclides move with respect to the Arctic environment and accumulate in and affect biota. This will enable Arctic States to better undertake strategic planning when considering the potential effectiveness of present and possible future national, regional, and global actions concerning contaminants.

1 The recommendations listed in this box include the mercury-related recommendations from AMAP (2002) under the *Heavy Metals* subheading and the *Changing Pathways* subheading. They do not include the mercury-related recommendations under the *Human Health* subheading, since the present assessment does not follow up on the human health recommendations.

1.3. How can the AMAP assessment contribute to the development of global policies to reduce mercury impacts in the Arctic?

The linkage between the present assessment, the Arctic Council, and relevant international processes is shown in Figure 1.1.

The information on metals in the Arctic presented by AMAP in 1997 (AMAP, 1997) supported the negotiations that eventually led to the establishment of the Heavy Metals Protocol to the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP) that was adopted on 24 June 1998 in Aarhus (Denmark). This regional agreement aims to cut emissions from industrial sources, combustion processes and waste incineration, by suggesting best available techniques to limit emissions from stationary sources. The agreement also introduced measures to lower emissions from products, such as mercury in batteries, and proposed the introduction of management measures for other mercury-containing products, such as electrical components (thermostats, switches), measuring devices (thermometers, manometers, barometers), fluorescent lamps, dental amalgam, pesticides and paint. Under the 1998 Aarhus Protocol on Heavy Metals, parties are required to reduce their emissions below levels in 1990 (or an alternative year between 1985 and 1995) (*www.unece.org/env/lrtap/hm_h1.htm*). The Protocol entered into force on 29 December 2003, and (as of 1 March 2011) has been signed and ratified by all Arctic countries apart from Iceland (which has signed but not ratified), the Russian Federation (which has neither signed nor ratified), and the United States (which has 'accepted' but not ratified). The information on mercury in the Arctic which AMAP compiled in its 1997 and 2002 assessments, especially information concerning temporal trends in mercury levels, was summarized by AMAP in a special contribution to the first effectiveness and sufficiency review of the Heavy Metals Protocol in 2006.

In September 2000, as a contribution to the Second Ministerial Meeting of the Arctic Council, AMAP prepared an 'Update Report on Issues of Concern', including mercury in the Arctic (AMAP, 2000). On the basis of this report (and the 1997 assessment report; AMAP, 1997), and in addition to calling upon those Arctic countries that had not already done so to ratify the UNECE Heavy Metals Protocol, the Arctic Council Ministers: "*…called upon the United Nations Environment Programme to initiate a global assessment of mercury that could form the basis for appropriate international action in which the Arctic States would participate actively*" (Arctic Council, 2000).

This message was communicated to UNEP's Governing Council (GC), with the result that, at its 21st session in February 2001, the UNEP GC, specifically referring to the Barrow Declaration, agreed to initiate the UNEP Global Mercury Assessment (UNEP, 2002). This process effectively established the UNEP Mercury Programme (*www.chem.unep.ch/mercury/*).

Welcoming the UNEP initiative, the Arctic Council requested AMAP to continue to support the UNEP mercury process and the implementation of agreements such as the UNECE LRTAP Convention. In this context, AMAP was requested by the UNEP Chemicals Division in 2007 to coordinate the work to prepare a report on global atmospheric mercury emissions, in response to the UNEP GC's (2007)

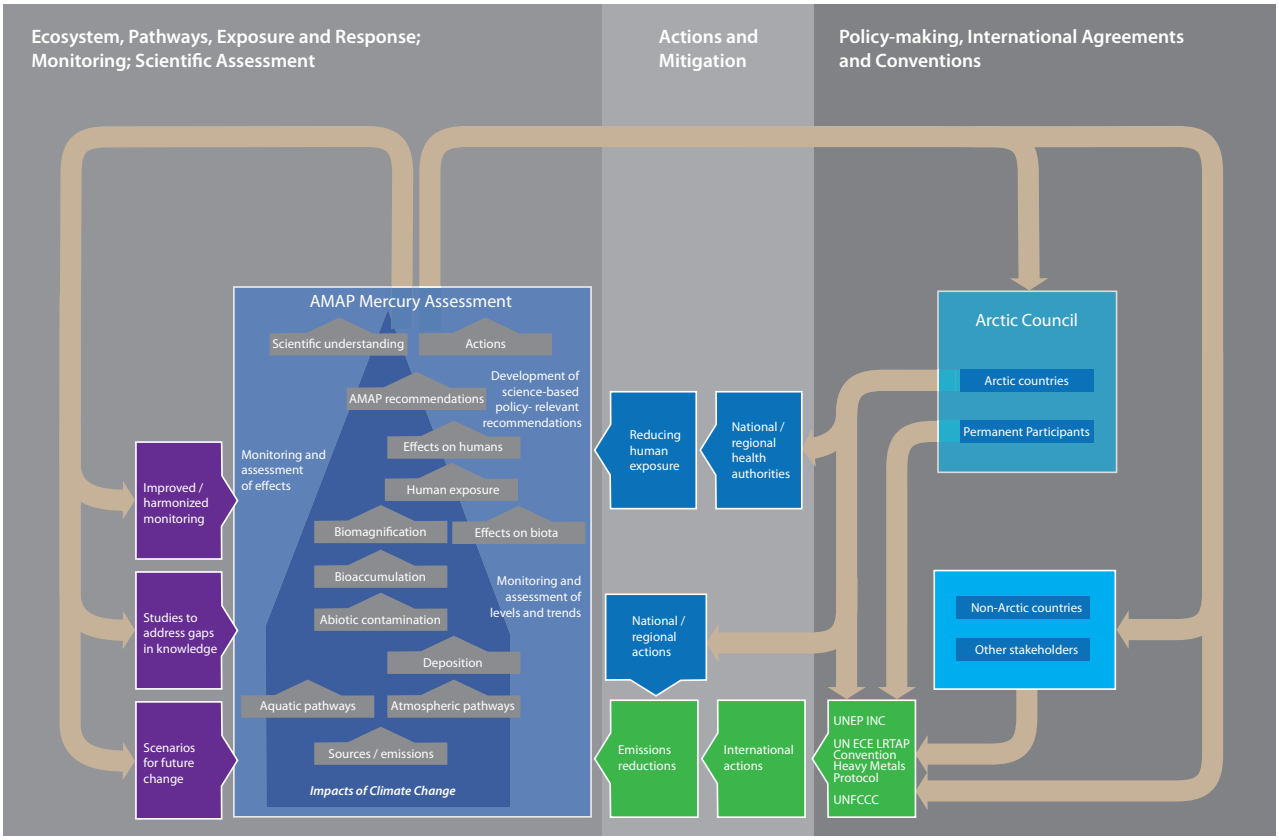

Figure 1.1. Linkage between the present AMAP assessment on mercury in the Arctic, the Arctic Council and relevant international processes.

decision 24/3 IV requesting preparation of a report addressing: *(a) Best available data on mercury atmospheric emissions* and *(b) Current results from modelling on a global scale and from other information sources*.

The resulting report (UNEP, 2008) is a summary for policymakers based on a technical report prepared by AMAP experts in association with UNEP Chemicals Branch (AMAP/UNEP, 2008). The information presented in this technical report also provided part of the basis for the AMAP 2011 assessment of mercury in the Arctic (this report). The UNEP Chemicals Branch *Global Atmospheric Mercury Assessment: Sources, Emissions and Transport* report (UNEP, 2008) was presented to the UNEP GC at its 25th meeting in 2009.

At its 22nd meeting in 2003, the UNEP GC had agreed that there was …*sufficient evidence of significant global adverse impacts from mercury and its compounds to warrant further international action to reduce the risks to human health and the environment from the release of mercury and its compounds to the environment*. Following their consideration of, among other things, the 2008 *Global Atmospheric Mercury Assessment* report, the UNEP GC further decided to initiate a process aimed at negotiating, by 2013, a legally-binding international agreement to limit emissions of mercury (*www.chem.unep.ch/MERCURY/mandates.htm*).

Such an agreement has the potential to significantly reduce Arctic mercury contamination, and it is anticipated that AMAP information, including the 2011 AMAP assessment of mercury in the Arctic (this report), will provide input to and be used in the international negotiating process that is currently underway.

Finally, at the regional level, AMAP information has spurred coordinated actions within the Arctic countries to address mercury contamination. From 2003 to 2008, the Arctic Council endorsed the Arctic Contaminants Action Program (ACAP) 'Mercury Project' called *Reduction of Atmospheric Mercury releases from Arctic States*. The project called for the identification of main source categories for mercury emissions within the Arctic region. Based on this information, the project then identified and prioritized source categories for possible reduction measures, and promoted development of action plans or strategies for reducing mercury emissions for those

Timeline of negotiations for a legally binding instrument on mercury

The meeting of the Ad Hoc Open-Ended Working Group on mercury was held in Bangkok, Thailand, 19-23 October 2009. Its purpose was to prepare for the upcoming meetings of the Intergovernmental Negotiating Committee (INC), where negotiations for a legally binding agreement on mercury will begin. Tentative timelines of INCs:
INC 1: 7 to 11 June 2010, Stockholm, Sweden
INC 2: 24 to 28 January 2011, Chiba, Japan
INC 3: 31 October to 4 November 2011, Nairobi, Kenya
INC 4: June 2012, Montevideo, Uruguay (to be confirmed)
INC 5: Early 2013, Brazil or Geneva, Switzerland (to be confirmed)
Diplomatic Conference: 2013, Japan.

countries or regions that did not have such plans. This involved the identification and proposal of cost effective measures at one or a few specific sources or plants where progress of reduction activities had been slow. Reduction measures were supported through fund raising, technology transfer and technical assistance.

AMAP human health assessment results concerning mercury have been utilized in various initiatives that aim to reduce mercury exposure, in particular among highly exposed critical groups. Development of health advisories has been effective in at least some areas in reducing such exposure, for example in reducing exposure to mercury of pregnant women in the Faroe Islands through limiting the consumption of pilot whale.

Future AMAP monitoring results on, for example, temporal trends of mercury in the environment are expected to constitute information necessary to evaluate the effectiveness of agreements such as the UNECE LRTAP Convention and an eventual UNEP agreement. The AMAP monitoring program was used, in connection with the Stockholm Convention on Persistent Organic Pollutants, as a model for the development of a global POPs monitoring program. The experience gained in implementing a monitoring program for mercury in the Arctic has potential lessons for such programs in other regions.

Following the successful cooperation between UNEP and AMAP on the recent preparation of the *Global Atmospheric Mercury Assessment*, it is anticipated that AMAP will play an important role in supporting the Intergovernmental Negotiating Committee (INC) process with up-to-date scientific information on mercury in the Arctic region. This assessment, also including information on biotic pathways, biomagnification, temporal trends and effects evaluation, etc., is intended to make a major contribution to that process, and could serve as a model for future development of components of a global mercury agreement implementation strategy.

1.4. How are Arctic indigenous peoples involved in national/international research, policy and decision-making processes?

Since Arctic indigenous peoples are greatly affected by high mercury/contaminant levels in the Arctic, the need for their involvement in policy and decision-making processes, as well as in research efforts, is well recognized by Arctic countries, as can be seen by statements in Arctic Council declarations. In particular, in the Salekhard Declaration (Arctic Council, 2006) the Arctic Council stressed …*the importance of enhancing well-being and eradicating poverty among the indigenous peoples and other Arctic residents, and the need for their inclusion in decision-making in relation to policy planning and implementation*, and in this context, the importance of facilitating closer cooperation at the regional and local level. In the Salekhard Declaration, the Arctic Council also stated that it wants to …*support the continued cooperation with indigenous peoples of the Arctic, welcome the contribution of their traditional knowledge of flora and fauna to the scientific research, and encourage further cooperation in the development of community-based monitoring of the Arctic's living resources*.

In the recent Tromsø Declaration (Arctic Council, 2009) the Arctic Council reiterated …*the engagement of indigenous peoples as being fundamental to addressing circumpolar challenges and opportunities*. The Arctic Council also acknowledged at the Tromsø Ministerial Meeting that more work needs to be done to engage indigenous peoples. It further requested that Arctic Council member states …*explore ways and means to enhance the participation of Permanent Participants in the activities of the Arctic Council*, and …*recognize the importance of providing adequate funding to Permanent Participants to support their preparations for, and participation in, the Arctic Council and its Working Groups*.

Within the Arctic Council, the category of the Permanent Participants allows for an active participation of, and full consultation with, Arctic indigenous peoples in all activities and meetings, including meetings of the Senior Arctic Officials, Ministerial meetings, and Regional meetings. Permanent Participants are also invited to participate in Arctic Council Working Group meetings and can be involved in any of the projects organized by the Working Groups. Within AMAP, Permanent Participants are active in Working Group and Expert Group meetings and in the development of assessment reports. This involvement is particularly important to indigenous groups, since AMAP assessment reports are utilized to inform and therefore influence international policy. Even though indigenous organizations may be present as observers at United Nation (UN) meetings, there is currently no formal process that ensures indigenous peoples' participation and consultation in international policy development at the UN level. The participation of Arctic indigenous peoples' organizations within Arctic Council Working Groups and with AMAP assessment reports is therefore crucial to allow for their input in the development of international policies which affect them. Permanent Participants to the Arctic Council include: the Inuit Circumpolar Council, the Saami Council, the Russian Association of Indigenous Peoples of the North, Siberia and the Far East, the Aleut International Association, the Arctic Athabaskan Council, and the Gwich'in Council International.

1.5. What are the structure and aims of this assessment?

In contrast to previous AMAP assessment reports, this report is structured around a series of key questions, which are aimed at discussing the most important current scientific issues concerning environmental mercury in the Arctic, and in a format that is likely to be most useful to policy-makers. The multi-disciplinary nature of many of the questions required considerable 'crossing of boundaries' between scientific disciplines, thereby encouraging more debate and synthesis of knowledge from disparate areas of science. Focusing this assessment on mercury alone, unlike previous heavy metals assessments, allows for a greater level of detail, including a higher degree of inter-disciplinary linkage, while also facilitating greater clarity in communicating messages to policy-makers and other relevant stakeholders.

The overall objective for the assessment is to provide the best possible scientific information in response to the questions: *What controls mercury levels in the Arctic and what*

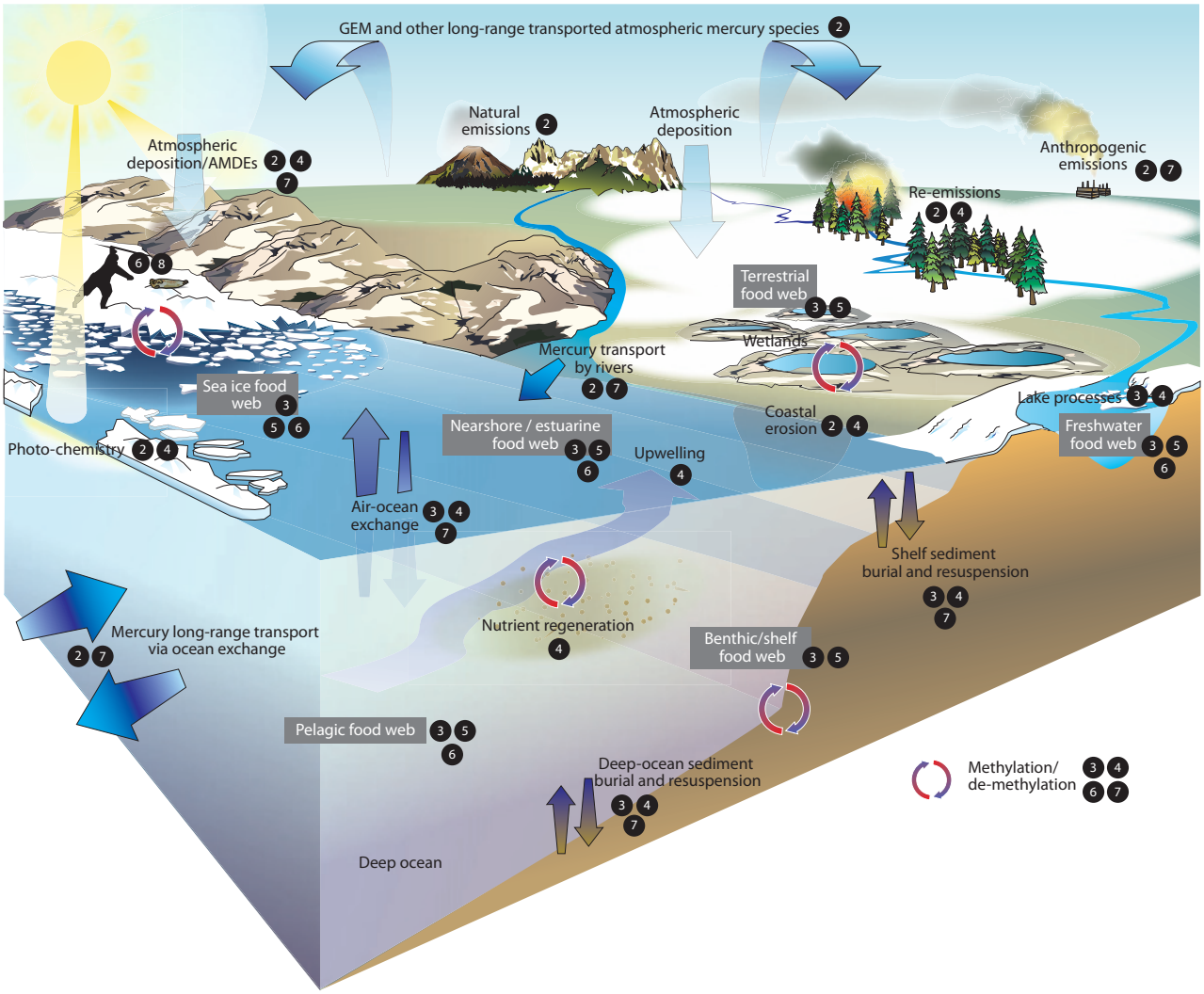

Figure 1.2. A simplified scheme showing the main components of the Arctic mercury cycle. The numbers indicate the chapters of this report in which the issue is addressed. For simplicity, the diagram does not show mercury speciation, however, this important property is discussed in detail throughout the rest of the assessment.

are the effects on Arctic biota? Each individual chapter of this assessment report centers around a key question; this in turn is answered through a more focused layer of additional questions. The questions were formulated and refined during and between two meetings of the AMAP Mercury Experts Group in November 2007 and December 2008. The report is written with the goal of providing as concise a response as possible, using the best available scientific data and information, while also describing the existing uncertainty and knowledge gaps.

The report presents information that contributes to an improved understanding of global mercury sources, pathways to the Arctic, and biogeochemical cycling and fate within the Arctic, including the uptake and accumulation of mercury in food webs and the associated ecological and human health risks. The mercury cycle within the Arctic is shown schematically in Figure 1.2, which also represents a 'road-map' for how information on various stages of the mercury cycle is distributed through different chapters of the report. Each sub-component in the diagram points the reader to the relevant chapter in this assessment report.

By way of an introduction, **Chapter 1** answers the question: *Why are we doing this assessment?* and in doing so provides important background information on Arctic mercury contamination, impacts on Arctic indigenous peoples, and the way in which the Arctic Council, AMAP, and indigenous peoples' organizations have responded to the issue through the publication of scientific assessments and engagement in international initiatives related to mercury in the environment.

Chapter 2 discusses global sources of mercury and describes how they are transported to the Arctic by addressing the question: *Where does mercury in the Arctic environment come from, and how does it get there?* The chapter covers natural and anthropogenic sources of mercury, different modes of long-range transportation and their relative importance to the delivery of mercury to the Arctic, the processes that influence transport, and models that have been used to describe mercury transport, deposition and distribution. Particular attention is paid to the importance of atmospheric mercury depletion events (AMDEs) as a means of delivering mercury to Arctic ecosystems.

Chapter 3 provides a detailed examination of the biogeochemical cycle of mercury in Arctic terrestrial, freshwater and marine ecosystems in response to the question: *What is the fate of mercury entering the arctic environment?* The chapter begins by examining what happens to mercury once it has been transported into the Arctic, how it moves from abiotic media into and then up the food chain, and ends with a discussion of mercury sequestration in natural archives. The environmental chemistry surrounding mercury speciation and the formation of methylmercury, and the importance of these processes for ecosystem uptake, are discussed.

Chapter 4 examines the question: *How does climate change influence arctic mercury?* Climate change is already having significant impacts on nearly all facets of the Arctic environment, from reductions in sea-ice cover and duration, coastal erosion, permafrost degradation, warming of air, water and soil, to changing biological communities. The chapter examines how these changes influence the various aspects of the mercury cycle described in Chapters 2 and 3, and discusses the impacts that these changes may have on mercury uptake and accumulation in Arctic ecosystems in the future.

Chapter 5 summarizes the latest data and information on temporal trends of mercury in Arctic biota in an answer to the question: *Are mercury levels in arctic biota increasing or decreasing, and why?* First, the long-term temporal trends of mercury in hard tissues of biota are assessed from pre-industrial times to the present day to establish the proportions of natural and anthropogenic mercury in modern Arctic biota. Recent decadal trends are then examined, based on monitoring programs of biological soft tissues and organs carried out over the past 10 to 30 years in various Arctic countries. Finally, the chapter discusses what may be driving the recent trends, and especially the relative role that anthropogenic sources and changing environmental processes might have played.

Chapter 6 provides an assessment of ecological risks associated with mercury in the Arctic by addressing the question: *What are the Toxicological Effects of Mercury in Arctic Biota?* The question is addressed through a combined assessment of recent toxicological studies on Arctic wildlife and a detailed comparison of mercury concentrations in wildlife with established thresholds for effects determined for other species. Different modes of mercury toxicity are examined and a discussion of thresholds and their relevance to Arctic wildlife is provided. The chapter concludes with a look to the future and the anticipated risks of mercury toxicity based on projections of temporal trends in biota.

Chapter 7 is entitled *To What Extent Will Projected Changes in Global Emissions Affect Mercury Levels in the Arctic Atmosphere and Ocean?* The chapter predicts how mercury concentrations in the Arctic atmosphere and ocean will respond under various possible scenarios of global emission reductions. The answer to this question is intended to provide policy makers with realistic expectations of how quickly environmental benefits may be achieved through actions taken to reduce global emissions.

Chapter 8, the final chapter of the report, presents a link between the rest of the assessment and the people of the Arctic by responding to the question: *What is the impact of mercury contamination on human health in the arctic?* The chapter provides a summary of mercury-related health effects information derived from AMAP human health assessment reports, and draws clear links between human health risks and mercury in the Arctic environment.