Setting the Stage

Environmental contaminants are a global problem. Their presence and role in the Arctic reflects the physical, biological, and social characteristics of the region, as well as the way the Arctic interacts with the rest of the world. Current concern about Arctic contaminants began with discoveries of high levels of persistent organic pollutants (POPs) in some indigenous inhabitants of the Arctic. Subsequent research confirmed that Arctic animals have elevated levels, posing a threat not only to the people who eat them but also to the animals themselves, and their ecosystems.

In 1997 and 1998, the Arctic Monitoring and Assessment Programme (AMAP) published a comprehensive assessment of what was then known about contaminants in the Arctic. In light of recent discoveries and new information, AMAP has prepared five new scientific assessments, covering persistent organic pollutants, heavy metals, radioactivity, human health, and changing pathways. In addition, this volume presents a plain-language summary of each of the scientific assessments. To set the stage, this chapter describes the previous assessment and what it led to, provides an overview of the Arctic and its special characteristics, and outlines the contents of the rest of the volume.

AMAP Phase I

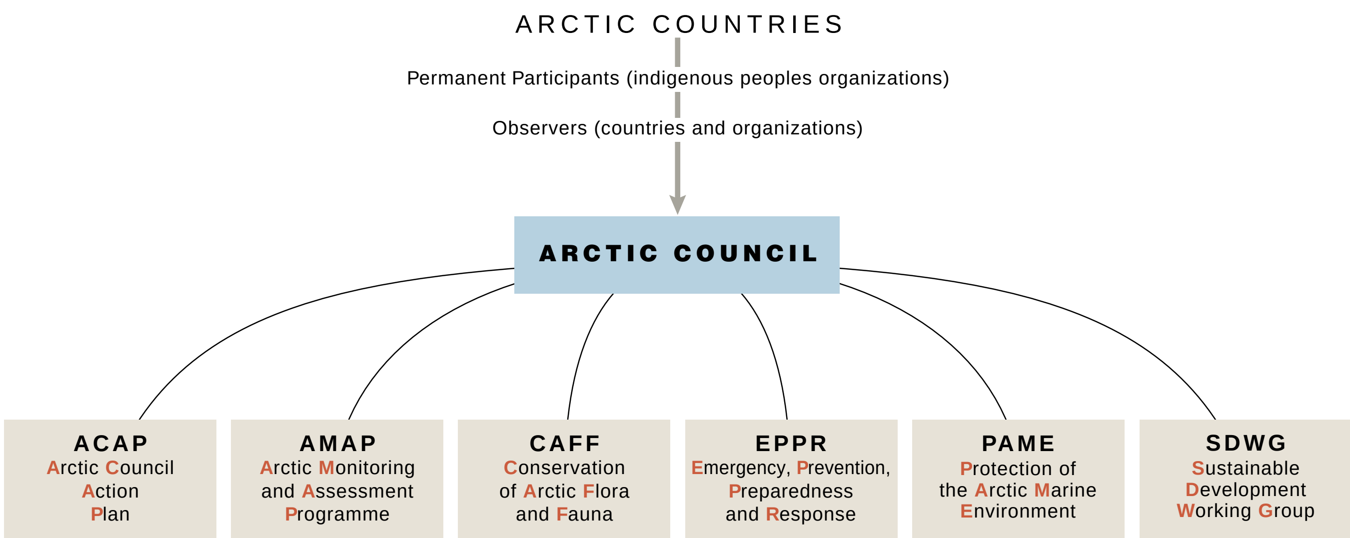
In 1991, the eight Arctic countries – Canada, Denmark, Finland, Iceland, Norway, Sweden, Russia, and the United States – initiated the Arctic Environmental Protection Strategy. Under this framework, the countries pledged to work together on issues of common concern. Recognizing the importance of the environment to the indigenous communities of the Arctic, the countries at that time included three indigenous organizations in their cooperative programs. In 1996, the eight Arctic countries created the Arctic Council, incorporating the Arctic Environmental Protection Strategy and expanding it to include sustainable development issues. They have also included three more indigenous organizations for a total of six permanent participants.

One of the programs created under the Arctic Environmental Protection Strategy and continued under the Arctic Council is the Arctic Monitoring and Assessment Programme. AMAP was designed to address environmental contaminants and related topics, such as climate change and ozone depletion, including their impacts on human health. Its specific task in Phase I of its existence was to prepare a comprehensive scientific assessment on these matters.

The 1998 scientific assessment

The AMAP Assessment Report: Arctic Pollution Issues, published in 1998, was the result of collaboration between over 400 scientists and administrators from all eight Arctic countries plus several non-Arctic countries and international programs. Its conclusions and recommendations were adopted by consensus of the eight Arctic countries.

The assessment described the geography, ecology, and people of the Arctic. It then re-



viewed the state of knowledge about pathways of contaminants; their levels, trends, and effects; human exposure; and potential threats. Its extensive recommendations addressed future research and monitoring, the need for remedial action, and the need for international agreements to reduce emissions of contaminants.

Overall, AMAP concluded that the Arctic remains a clean environment compared with most regions of the world. Nonetheless, the assessment warned that for certain contaminants, Arctic residents are among the most exposed populations in the world. This is especially true for Arctic indigenous people, whose traditional diets place them at the top of Arctic food webs. Through their dietary exposure, some groups are exposed to levels above national and international guidelines for daily intakes. The health risk was considered greatest for newborns and infants. Concerns were also raised about the potential effects on some wildlife populations.

Results from AMAP Phase I

The conclusions and recommendations from the first scientific assessment led to substantial progress in addressing the problem of contaminants. They raised the profile of environmental contamination in the Arctic as a public policy issue, and helped in the preparation of dietary guidelines in several countries.

At the time AMAP began its work, the United Nations Economic Commission for Europe (UN ECE) Convention on Long-range Transboundary Air Pollution was already considering whether it should take action on POPs and heavy metals. The data compiled by AMAP over the next several years established a strong case for restricting or eliminating several POPs. In 1998, a protocol to the Convention covering 16 POPs was adopted, as was a protocol on heavy metals.

As the protocols were being completed, the United Nations Environment Programme (UNEP) began negotiations for addressing 12 POPs worldwide. Here, too, Arctic data and Arctic countries were instrumental in promoting, negotiating, and concluding, in 2001, the Stockholm Convention on Persistent Organic Pollutants. Arctic indigenous organizations also played a significant role in the negotiations. They were able to do so in part because they had learned much from AMAP concerning transboundary contaminants in the Arctic. Indeed, the preamble to the Stockholm Convention explicitly recognizes the risks POPs pose to Arctic ecosystems and indigenous health and well-being.

The findings of the first AMAP assessment also led the Arctic Council in 2000 to ask UNEP to take action on mercury. As a result, UNEP is currently conducting a global study on mercury and is also tackling the issue of lead in gasoline.

The Arctic Council also decided to take cooperative actions to reduce pollution of the Arctic. In 1998, the Regional Programme of Action to Prevent Pollution of the Arctic Marine Environment from Land-Based Activities was adopted. As a direct follow-up of the AMAP scientific assessment, the Arctic Council Action Plan to Eliminate Pollution of the Arctic was created to address sources identified by AMAP. This plan was approved in 2000 and several projects have begun.

The assessment had made it clear that there was a general lack of data about contaminant levels in the Russian Arctic. A special project, *Persistent Toxic Substances, Food Security, and Indigenous Peoples of the Russian North*, was initiated to fill this gap. The work is sponsored by the Global Environmental Facility, Arctic countries, and others and is being coordinated by the AMAP Secretariat and the Russian Association of Indigenous Peoples of the North. Some of the first results are presented in the updated AMAP assessment.

In addition to its recommendations on contaminants, the AMAP assessment recommended further work on climate change and ultraviolet radiation. In 2000, the Arctic Council approved the Arctic Climate Impact Assessment, overseen by AMAP, its sister working group on Conservation of Arctic Flora and Fauna, and the International Arctic Science Committee. This impact assessment will deliver a report to the Arctic Council in 2004.

The Arctic

The behavior of environmental contaminants depends in part on the characteristics of the environment they are in. Several physical, biological, and cultural features of the Arctic are distinct from those of lower latitudes, with significant implications for contaminants. The previous AMAP reports contain general background chapters on geography, ecology, people, and pathways. The information in these chapters is still relevant. A brief summary is provided here for readers new to these topics.

Geography

The Arctic covers the northern part of the Earth; it has been given various boundaries (see map on top of the opposite page). Key characteristics, especially of the High Arctic, are dry and cold air, prolonged darkness in winter contrasting with continuous daylight in summer, permafrost over much of the land, and seasonal sea ice over much of the ocean.

The Arctic climate is variable both from place to place and from year to year. The ocean is a moderating influence, reducing seasonal temperature variation along the coast. Inland areas can experience annual ranges in temperature as great as 100°C. The extreme variability in climate and weather means that Arctic species must be prepared for a variety of conditions, or have the ability to wait several years to grow or reproduce.

The Arctic landscapes and seascapes include mountains and lowlands, wetlands and deserts, deep basins and shallow continental shelves, rivers and ponds, isolated islands and vast landmasses. Geologically, it includes the still-forming land of Iceland, and some of the oldest rocks in the world in Greenland. Across this diversity, snow and ice dominate the land and waters of the Arctic, shaping all that lives there.

Pathways

Air, water, and ice carry contaminants great distances, to, from, and within the Arctic. In the global climate system, the Arctic cools the air and water warmed in lower latitudes. Cooler air can hold less moisture, and thus the Arctic is dry. As the cooling air releases rain and snow, contaminants are deposited as well. These contaminants end up on the ground, in meltwater in rivers, and in the top layer of the ocean, where biological productivity is highest. Sea ice can carry contaminants across the Arctic and release them in the productive melting zone of the North Atlantic (see map right).

Ocean currents are a slow but important pathway for contaminants to, within, and from the Arctic. The significance of ocean pathways appears higher than once realized. For radionuclides in particular, it is a major route from coastal sites outside the Arctic to marine food webs in the Arctic.

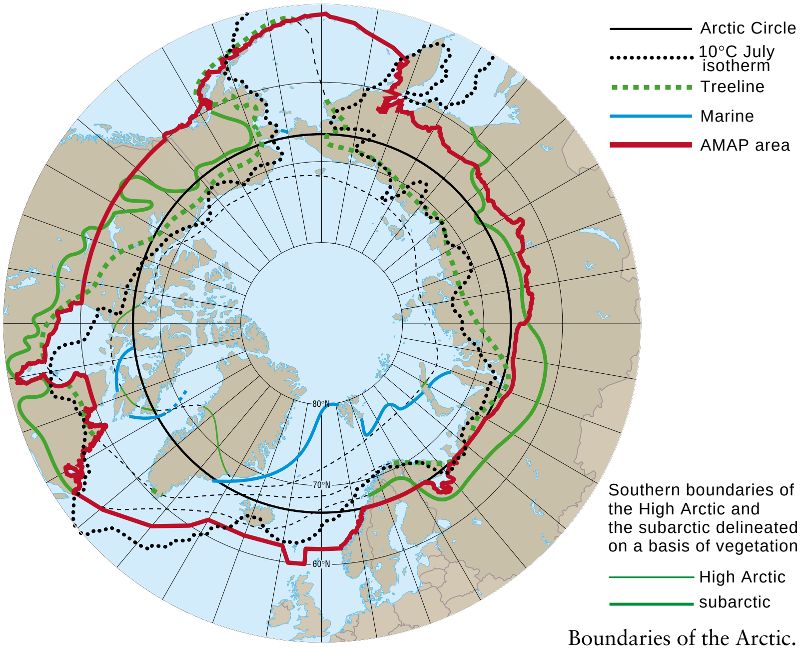
Rivers carry contaminants and process them through sedimentation and resuspension of particles. Lakes, deltas, and estuaries serve as sinks for contaminants in sediment.

The transport and deposition of contaminants follow seasonal patterns. In winter, the Arctic is home to a stable zone of high pressure centered over the Arctic Ocean and reaching far to the south (see map at bottom of page). This polar air mass becomes a trap for airborne contaminants, especially those generated in the industrial areas of Eurasia that are within the stable zone. In spring and summer, the energy from sunlight breaks up this system, causing greater mixing with air from lower latitudes.

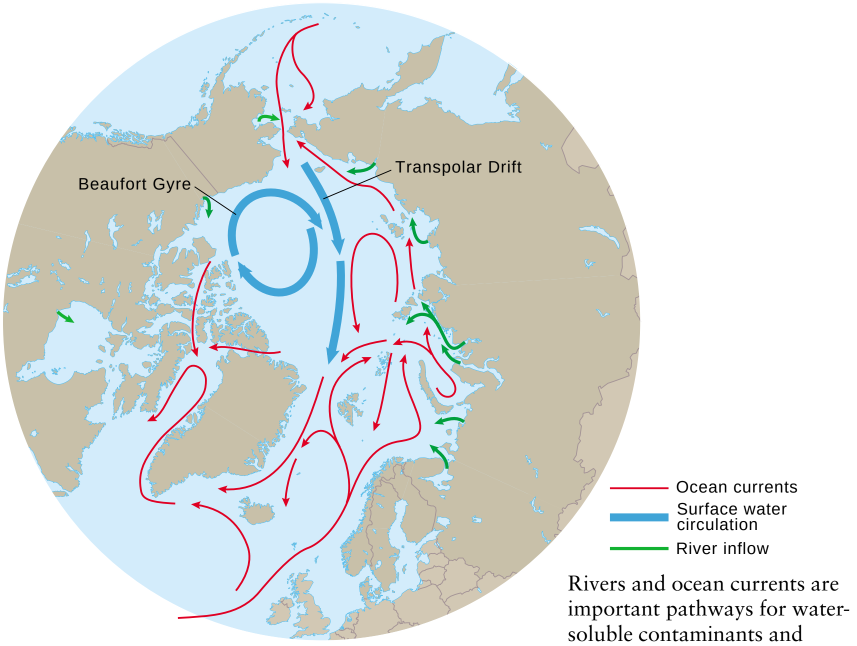
Ecology

In terrestrial, freshwater, and marine ecosystems, Arctic plants and animals have developed many strategies for coping with Arctic conditions. These include long periods of inactivity, the storage of nutrients and fat, the ability to grow and reproduce quickly when conditions are good, and flexibility in behavior. Arctic plants and animals also tend to be long-lived.

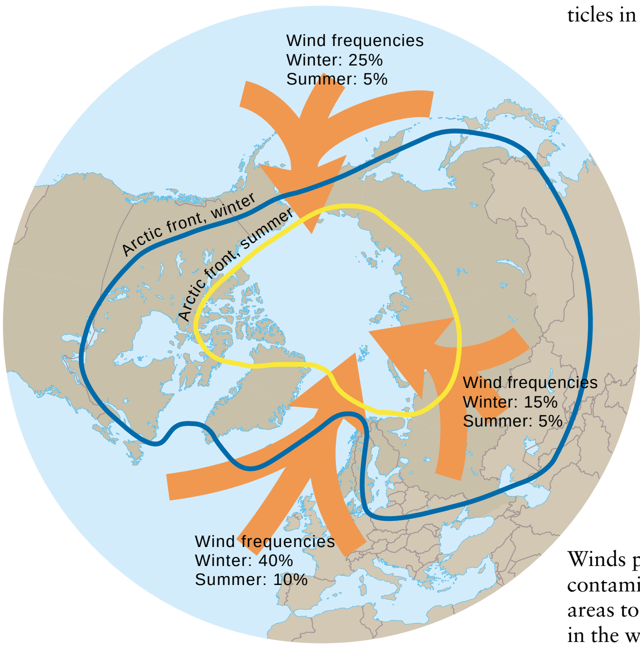
These characteristics, combined with the geography of the region, have a great influence on the uptake of contaminants in food webs.



Boundaries of the Arctic.



Rivers and ocean currents are important pathways for water-soluble contaminants and those that are attached to particles in the water.



Winds provide a fast route for contaminants from industrial areas to the Arctic, especially in the winter.

Indigenous peoples of the Arctic and their affiliations with the six permanent participants of the Arctic Council.

The ability to store fat is critical to many species, and predators tend to prefer fatty tissues for their great energy content. Many contaminants, especially among POPs, dissolve in fat, and thus become concentrated in Arctic animals. Moving up the food web, these concentrations increase in a process called biomagnification. This is especially prominent in the long, fat-dominated marine food webs.

Some contaminants are difficult for animals to excrete. Long-lived species can accumulate these substances throughout their lives, so that old animals have much higher levels than young ones. This process is called bioaccumulation. Scavengers can bring these contaminants back into the food web, keeping them available for long periods even without additional inputs.

Rapid bursts of productivity accompany the onset of favorable conditions, such as snowmelt in spring. When contaminants have been deposited in snow and ice, this burst can result in the uptake of contaminants available in meltwater. At other times, nutrient shortages may cause plants and animals to take up contaminants that have similar chemical properties to the unavailable nutrient elements.

When animals are inactive for long periods, they lose weight, thereby concentrating the contaminants that remain in their bodies. In extreme cases, contaminant concentrations in fatty tissues can increase greatly in marine mammals that fast for months at a time, such as pregnant polar bears. In that case, the problem is made worse as the mother bear nurses her cubs, injecting them with a heavy dose of contaminants dissolved in the fats of her milk.

People

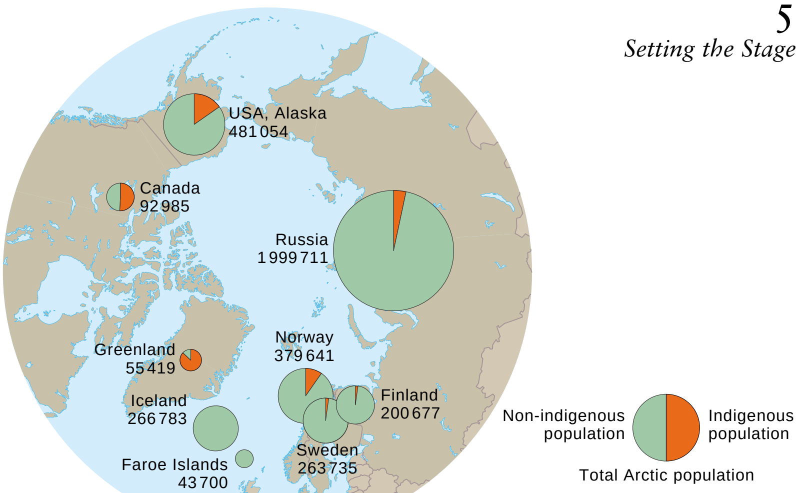
There are great economic, social, cultural, and demographic variations around the Arctic. These variations reflect not only geography and climate, but also national conditions and policies, as in Russia where economic hardship has caused many people to move south. The proportion of the population that is indigenous varies from 85% Inuit in Canada's Nunavut Territory, to 2.5% in the Saami region of Fennoscandia and the Kola Peninsula, Russia, to 0% in Iceland and the Faroe Islands.

Historical factors are significant, too, including the rush to exploit whales, gold, fur, oil, fish, seabird eggs and down, and other natural resources around much of the Arctic. As large numbers of people moved into the region, they spread disease and caused social dislocation and competition for land and resources. At the same time, modernization brought benefits to Arctic communities.

Despite these challenges, Arctic indigenous people retain distinct cultures with long-standing traditions of land occupancy and resource use. Their hunting, fishing, trapping, herding and gathering take place over vast areas of land and sea. They also retain their close and complex relationship with the environment, including a wealth of detailed ecological knowledge and a powerful spiritual connection with the animals and places surrounding them. Traits and customs vary from group to group, but practices such as the sharing of foods are found throughout the Arctic, reflecting the need for a communal approach to survival in a harsh climate.

Today's Arctic residents range from urban dwellers in large cities to isolated families and small villages largely dependent on their local environment. Traditional hunting and fishing contrast with large-scale commercial fishing. The development of oil, gas, and minerals provides wealth, attracts new residents, and threatens landscapes supporting reindeer herders and others.

Contaminants enter this picture as another threat to the integrity of the Arctic way of life. The discovery that contaminants were present in breast milk was an unwelcome surprise. The fact that living one's life in the traditional manner and with a traditional diet posed a risk to one's children was deeply shocking. The traditional foods that had been a mark of cultural stability were turned into a pathway for toxic contaminants. For indigenous people, this problem raises fundamental questions of cultural survival, for it threatens to drive a wedge of fear between people and the land that sustains them. In response, Arctic indigenous groups have staunchly supported AMAP and related research, and have pushed hard for national and international action to combat the problem.



Total and indigenous populations of the Arctic in the early 1990s, by Arctic area of each country.

HENRY HUNTINGTON

Iñupiat, Anaktuvuk Pass, Alaska.

GNWT/NWT ARCHIVES

Dene, Midway Lake, NWT, Canada.

STAFFAN WIDSTRAND

Saami, Kautokeino, Norway.

PTS PROJECT

Chukchi, Kanchalan, Russia.

PTS PROJECT

Samples were taken from a gray whale in the Lavrentiya Bay during the *Persistent Toxic Substances* project in Russia.

Special concerns about interpreting data

The different contaminants found in the Arctic have substantial differences in sources, pathways, trends, and effects. Nonetheless, a few general points apply to the data presented in the subsequent chapters of this report.

First, identifying spatial trends is often complicated by a lack of standardization. This is particularly true for samples from plants and animals. Not only must collection and analytical methods and techniques be comparable, but researchers must take into account sex, age, and food-web structure. Although these requirements pose a problem for quantifying the differences from place to place, it is possible to identify general trends.

Second, determining temporal trends is also complex, particularly when other environmental changes have been occurring at the same time. The climatic regime of the Arctic has shifted dramatically from the conditions that prevailed during most of the 1970s and 1980s to those that prevailed during the 1990s, and these changes may have had significant effects on contaminant pathways. This period is exactly the time covered by most of the data available for the assessment of recent temporal trends. This raises the question of the extent to which observed trends may reflect changes in pathways as opposed to changes in, for example, emissions. As discussed in the chapter *Changing Pathways*, shifts in climate and weather can greatly alter contaminants pathways to and within the Arctic.

Third, there is still little information on effects of contaminants on Arctic biota. This is especially true for the effects of low-level, chronic exposures, which may result in subtle effects such as stress responses or reduction in overall fitness. Risk assessments often have to rely on comparisons between levels in the Arctic and threshold levels for effects that have been determined in other parts of the world, sometimes using other species. This may be more or less valid depending on the species and the contaminant of concern. Effects thresholds for Arctic animals are largely unknown.

The structure of this volume

Five scientific reports have been prepared for delivery to the Arctic Council in 2002 presenting the results of AMAP's second phase.* The main findings of the reports and the recommendations of the AMAP Working Group are contained in the Executive Summary. Each of the scientific reports is summarized by a chapter in this volume:

Persistent Organic Pollutants describes new findings in trends, levels, and effects of POPs, including several contaminants that have recently been detected in the Arctic. The implications of POPs for people are addressed in the chapter *Human Health*.

Heavy Metals reviews recent data and discoveries concerning mercury, lead, and cadmium. It also looks at the localized impacts of smelters in the Russian Arctic. As with the previous chapter, the implications of metals for people are addressed in the chapter *Human Health*.

Radioactivity covers the sources, pathways, uptake, and effects of radionuclides. Emphasis is on the behavior of radionuclides in ecosystems and on hazards connected with potential sources. In contrast to POPs and heavy metals, human health implications of radioactivity are addressed in this chapter.

Human Health examines what has been learned recently concerning Arctic people and the ways in which contaminants affect them. It describes the basic health parameters of Arctic populations as a basis for considering the potential impacts of contaminants.

Changing Pathways discusses the potential impacts of climate change on the ways in which contaminants are carried to the Arctic and taken up in Arctic food webs. The anticipated changes may greatly alter the distribution and trends of many contaminants throughout the Arctic.

The inside front cover has a circumpolar map, a list of species with their scientific names, and a list of units. The inside back cover has a list of contaminants with their abbreviations.

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* *AMAP Assessment 2002: Human Health in the Arctic.* ISBN 82-7971-016-7

AMAP Assessment 2002: The Influence of Global Change on Arctic Contaminant Pathways. ISBN 82-7971-020-5

AMAP Assessment 2002: Persistent Organic Pollutants in the Arctic. ISBN 82-7971-019-1

AMAP Assessment 2002: Heavy Metals in the Arctic. ISBN 82-7971-018-3

AMAP Assessment 2002: Radioactivity in the Arctic. ISBN 82-7971-017-5