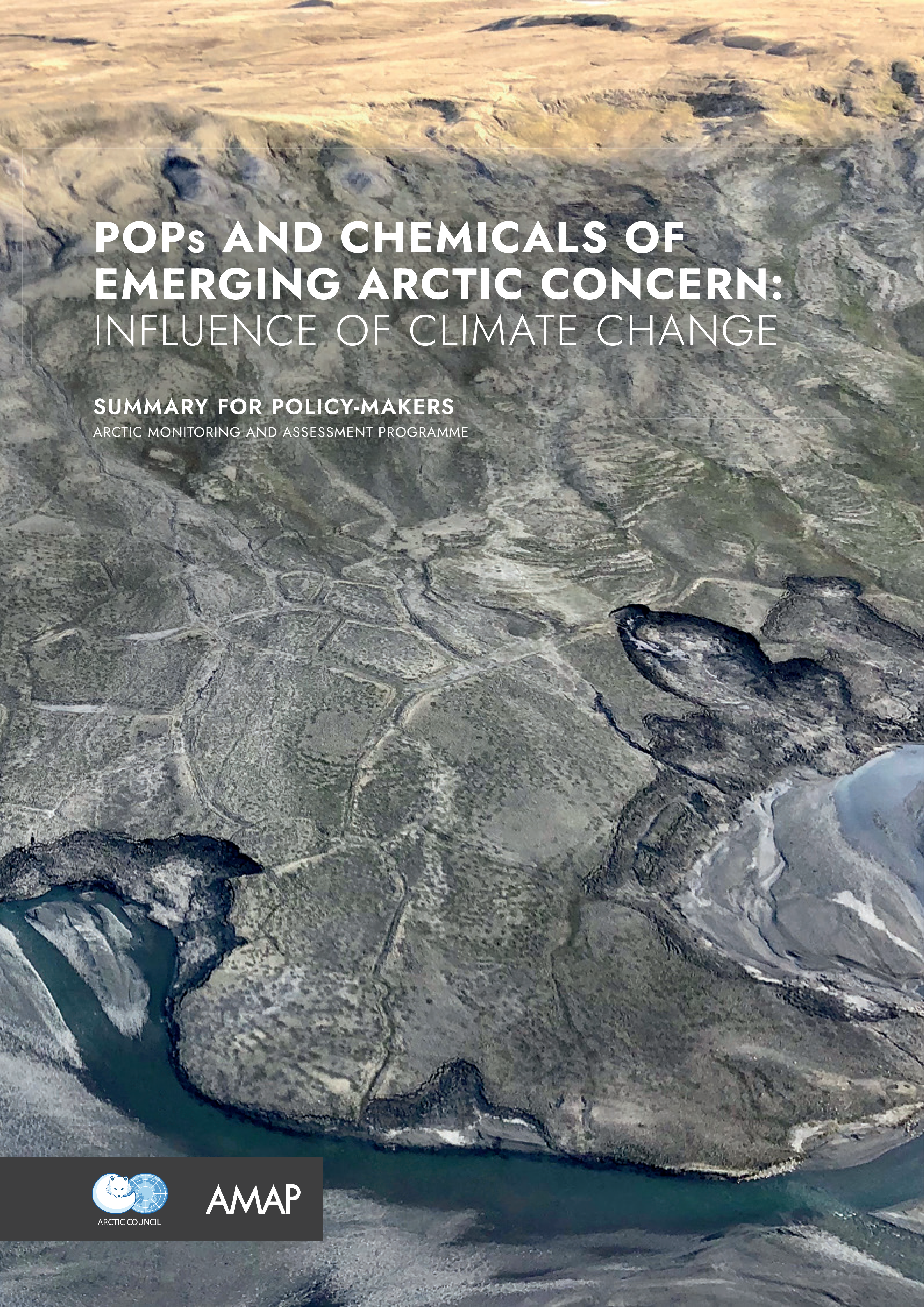


POPs AND CHEMICALS OF EMERGING ARCTIC CONCERN: INFLUENCE OF CLIMATE CHANGE

SUMMARY FOR POLICY-MAKERS

ARCTIC MONITORING AND ASSESSMENT PROGRAMME

ARCTIC COUNCIL

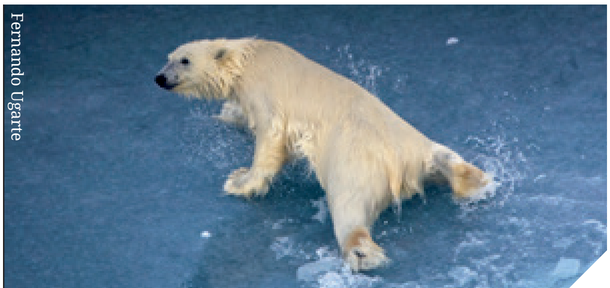
AMAP

KEY FINDINGS AT A GLANCE

Climate change is directly and indirectly impacting the sources, transport pathways, and fate of persistent organic pollutants (POPs) and chemicals of emerging Arctic concern (CEACs), which, in turn is influencing the exposure to, and potentially the effects of, these contaminants on Arctic wildlife and other biota, as well as people.

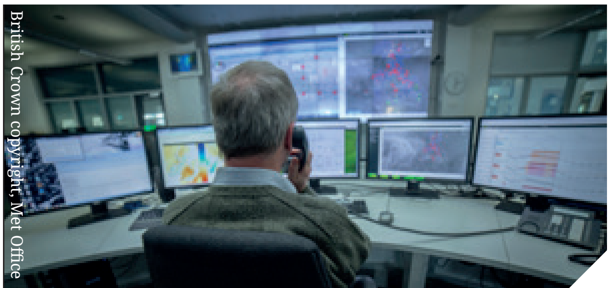
1

Recent studies confirm that some earlier predictions of climate change impacts on POP sources, pathways, and fate in the Arctic are actually occurring. New observations include the warming-induced release of previously accumulated POPs from permafrost, snow and ice melt and the redistribution of POPs among water, sediments, snow, and air. However, to date these findings stem from a limited number of studies of a few, specific Arctic locations, and it is not yet known whether these impacts are widespread throughout the region.



2

Climate-associated changes in Arctic food webs are influencing the exposure of top predators, such as polar bears and certain seabirds to POPs. These changes include the northward movement of species into and within the Arctic, and dietary and food web shifts associated with, for example, the loss of sea ice. However, the degree and direction of such changes on contaminant exposures cannot be generalized due to differences between pollutants, species, and locations.



3

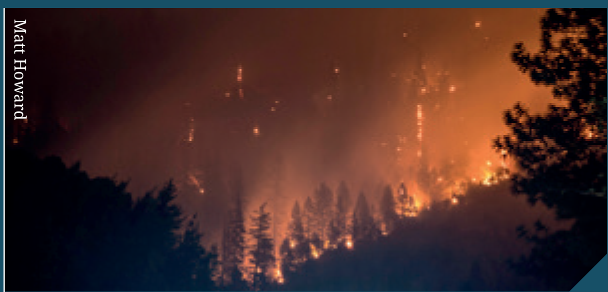
Based on climate and emissions modelling projections, levels in the Arctic of most POPs included under the Stockholm Convention will continue to be influenced mainly by global emissions from primary sources rather than by climate change effects on secondary sources such as (re)emissions from soils, glaciers or permafrost.

4

Climate change may be contributing to observations that levels of some POPs, including polychlorinated biphenyls (PCBs), are no longer declining in the Arctic to the extent that would be expected given known decreases in their primary source emissions. Trends of POPs have generally been decreasing in the Arctic due to measures introduced both before and since the establishment of the Stockholm Convention to reduce emissions and releases; however, some are levelling off, and even showing upward trends in air and biota in recent years, and climate change may be part of the reason.

5

Studies of POPs in Arctic air and biota have revealed associations between temporal trends observed at specific locations and climate-related parameters. This information can be useful for processes that use time trends data to assess the effectiveness of regulatory measures to reduce POPs emissions and releases, such as the Stockholm Convention effectiveness evaluation.



6

Many knowledge gaps remain regarding the current and projected impacts of climate change on POPs and CEACs in the Arctic. These include the extent to which primary sources of these contaminants within the Arctic, as well as secondary effects of climate change will contribute to local and regional contamination. The potential for climate change to influence pathways and fate of some CEACs can be inferred from their physical-chemical properties but field and modelling studies are needed, in particular for CEACs that may be considered for listing under the Stockholm Convention. Knowledge is also lacking about the potential changes to Arctic ecosystems and food-webs that may alter pathways of wildlife and human exposure to contaminants.

KEY TO SYMBOLS:

- OBSERVED
- PROJECTED
- NEW FINDING
- UPDATED FINDING
- KNOWLEDGE GAP
- REINFORCING MESSAGE

CONTEXT & SCOPE: UNDERSTANDING CONTAMINANT FATE IN A RAPIDLY CHANGING ARCTIC

Arctic landscapes and ecosystems are being rapidly transformed by climate change. The loss of snow and sea ice, increase in sea water temperature, thawing of permafrost, and occurrence of wildfires and extreme weather events continue to intensify, and in some cases are accelerating. Changes in the physical environment are driving shifts in the abundance, distribution, and behavior of Arctic biota, altering food webs, and leading to increased human activity in the region. While significant in their own right, these climate-related changes also have the potential to alter the sources, transport, and fate of anthropogenic contaminants, many of which are associated with effects on wildlife and human health.

POLICY RELEVANCE – WHY THIS IS IMPORTANT

Climate-related changes in contaminant transport and fate have potential consequences for the exposure and health of Arctic wildlife and human populations, particularly, Arctic Indigenous Peoples and Local Communities. Understanding such changes is thus critical for predicting future risks to wildlife and human health so that such risks may be addressed through national, multi-lateral or global policy actions.

Previous AMAP assessments[1] and joint work with the United Nations Environment Programme[2] examined the potential influences of climate change on the long-range transport and fate of POPs in the Arctic, highlighting its relevance to the Stockholm Convention on Persistent Organic Pollutants (POPs). New scientific information is providing increasing evidence that predicted impacts of climate changes on Arctic contaminant levels and trends are indeed taking place and need to be taken into account in some policy- and decision-making.

POPs AND CEACs: CHARACTERISTICS & INFLUENCES OF CLIMATE CHANGE

The outcome of interactions between climate and contaminants depends not only on the type and magnitude of environmental changes, but also on the sources, properties, and regulatory status of the chemicals. Two broad groups of environmental contaminants are referred to in this assessment:

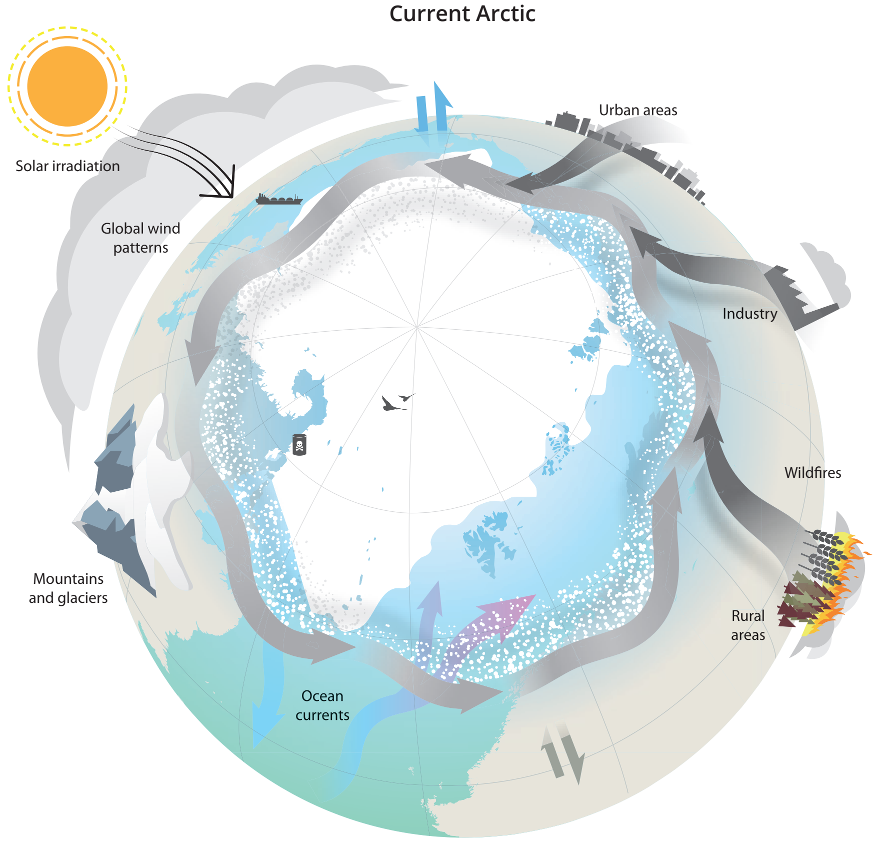
Persistent Organic Pollutants (POPs): Chemicals that are listed under the Stockholm Convention based on evidence of their environmental persistence, bioaccumulation, long-range transport, and toxicity. Their presence in the Arctic to date mainly stems from long-range transport. Resulting from restrictions on their production and use, levels of many, but not all POPs are declining in the Arctic. However, as a consequence of past use, repositories of POPs may exist in environmental reservoirs, such as Arctic glaciers and sea ice that could be re-released in a rapidly warming Arctic. Examples include pesticides (e.g., DDT) and industrial chemicals such as PCBs, flame retardant chemicals (e.g., PBDEs) or fluorinated surface protectants (PFOS, PFOA).

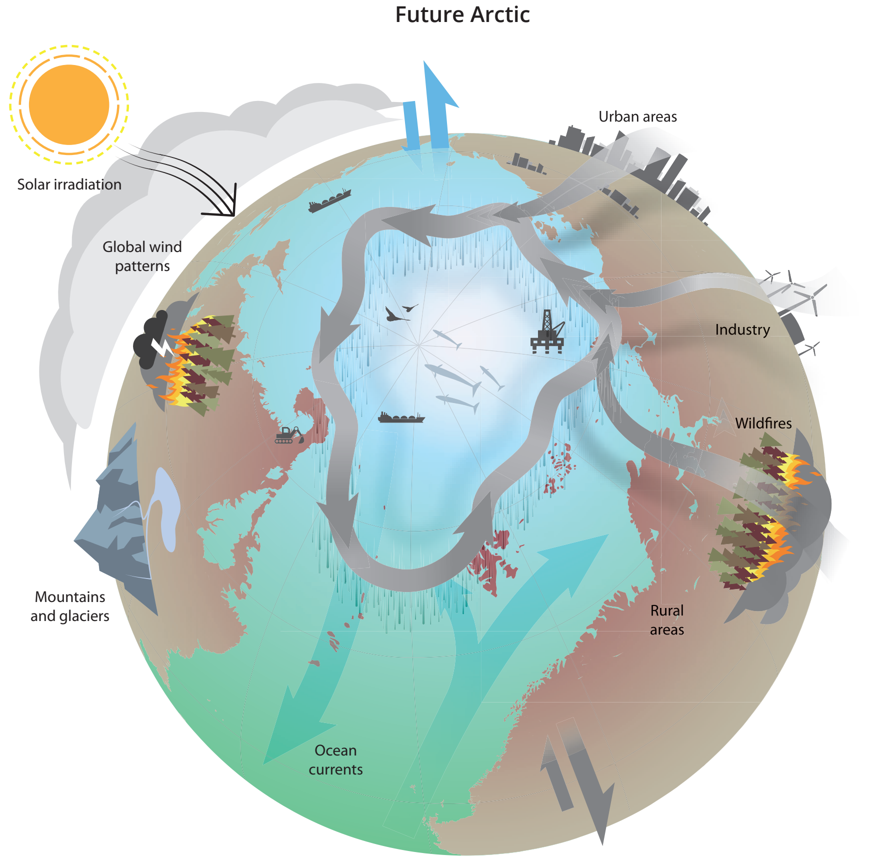
Chemicals of Emerging Arctic Concern (CEACs): Chemicals that are not presently (as of 2020) listed under the Stockholm Convention but have been recognized as a potential concern based on their documented occurrence in Arctic ecosystems[4]. Most are current-use chemicals that are largely unregulated, and some are alternatives for banned chemicals and possible candidates for nomination under the Stockholm Convention. Some are found in consumer products and their presence in the Arctic is likely to originate from both long-range transport and local sources within the Arctic. Less information exists for CEACs and the projected impact of climate change on their fate in Arctic ecosystems. Examples include per- and polyfluoroalkyl substances (PFASs) not already listed under the Stockholm Convention, current-use pesticides (CUPs), and organophosphate esters (OPEs).

Knowledge of the influences of climate change on Arctic contaminants is important for evaluating past and informing future actions of the Stockholm Convention and other chemical regulatory bodies.

The presence of chemical contaminants in the remote Arctic presents a unique opportunity to provide evidence of environmental persistence and long-range transport, both of which can be used to evaluate chemicals for potential management under the Stockholm Convention. Climate change also has the potential to influence long-term contaminant temporal trends used in processes to track the efficacy of chemical restrictions and bans, such as the Stockholm Convention effectiveness evaluation.

The AMAP assessment[3] summarized here reviews the current state of knowledge on climate-related impacts on the fate of POPs and CEACs. The assessment findings provide insight into where to direct research and policy efforts for understanding future changes in Arctic pollution, informing regulatory decisions, and protecting the health of Arctic wildlife and people. These findings are the basis for the recommendations of the AMAP working group given later in this document.





Under future climate change conditions the Arctic will be subject to numerous changes including loss of ice, snow, and permafrost, increasing human activity and development, and changes in wind and ocean circulation patterns – all of which could alter the sources, pathways, distribution and fate of contaminants.

1. AMAP Assessment 2002: The Influence of Global Change on Contaminant Pathways to, within, and from the Arctic. Arctic Monitoring and Assessment Programme (AMAP).

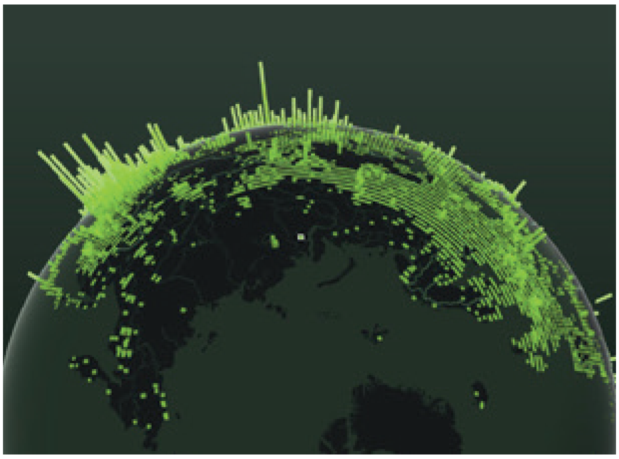
2. Report of the UNEP/ AMAP Expert Group 2011: Climate Change and POPs: Predicting the Impacts. United Nations Environment Programme (UNEP) and Arctic Monitoring and Assessment Programme (AMAP).

3. AMAP Assessment 2020: POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change. Arctic Monitoring and Assessment Programme (AMAP).

4. AMAP Assessment 2016: Chemicals of Emerging Arctic Concern. Arctic Monitoring and Assessment Programme (AMAP).

IMPACTS OF CLIMATE CHANGE ON CONTAMINANT PRIMARY SOURCES & PATHWAYS TO THE ARCTIC

Contaminants found in the Arctic originate from various sources. Some substances, such as pesticides and industrial chemicals, are predominantly released during production and use at lower latitudes and carried to the Arctic via atmospheric and oceanic currents. Other substances, such as flame retardants and PFASs, are present in materials and products that are imported, used, and disposed of locally within the Arctic.



Quantifying the impacts of climate change on contaminant sources and pathways is challenging; therefore, models based on available chemical emissions and environmental monitoring data are often employed to derive estimations of current and future impacts.

How is climate change affecting primary sources of contaminants to the Arctic?

Although environmental phenomena and human activities that are known primary sources of contaminants are expected to intensify in the Arctic as climate warms, few studies that directly link these changes with contaminant levels are available. Wildfires are projected to increase in the Arctic and are sources of POPs and CEACs, including polycyclic aromatic hydrocarbons (PAHs). Predicted shifts in the geographic range or numbers of agricultural pests and insect disease vectors may eventually increase use of pesticides. Human activities in northern latitudes are also expected to increase as climate warms, and as populations and economic activity grow in the region, primary sources of contaminants are expected to be brought closer, or even into the Arctic.

Is climate change altering contaminant long-range transport pathways to the Arctic?

Model-based studies suggest climate change will affect contaminant transport pathways to the Arctic. Changes in temperature and large-scale climate patterns have the potential to increase chemical volatilization, enhance degradation, and alter long-range transport pathways, and will impact chemicals differently depending on their primary method of transport to the Arctic. However, the effects of climate change on contaminant transport to the region as projected by modelling studies to date are small compared to the expected effects of global regulatory efforts on reducing contaminants emissions. Model projections for the year 2100 estimated that climate change could contribute up to a four-fold increase in concentrations of some POPs in Arctic air and water, whereas global emissions reductions could drive concentration declines greater than 1000-fold.

How will local sources compare to long-range transport sources of contaminants under future climate change scenarios?

Climate change is expected to lead to an increase in human populations, activities and developments in northern regions that are likely to be accompanied by an increased presence of CEACs. Therefore, primary sources of contaminants within the Arctic are likely to increase in the future as well. Previous AMAP assessments concluded that long-range transport was the predominant contributor to current contaminant levels in the Arctic region; however, the relative contribution of long-range transport and local releases to Arctic contamination may change for certain chemicals at local-scales, especially for areas in close vicinity to sources.

Mihajlo Maricic / Alamy Stock Photo

HUMAN ACTIVITIES & DEVELOPMENT: POTENTIAL PRIMARY SOURCES OF CONTAMINANTS WITHIN THE ARCTIC

An expanding human footprint in the Arctic is expected to directly as well as indirectly contribute to local releases of chemical contaminants. Contaminant releases from new primary sources within the Arctic may also be compounded by climate-related environmental changes, such as increasing precipitation, meltwater run-off and permafrost thaw, contributing to the discharge of contaminants to local and coastal waterways. Arctic shipping, tourism, fishing and mineral resource exploitation are economic activities that are associated with potential for local contamination. Elevated levels of flame retardants and PAHs have already been detected in the vicinity of Arctic communities, buildings and airports. Many household and commercial products contain CEACs that may be released into the environment after their disposal. Arctic communities, especially remote communities, have limited possibilities for waste management which may include open incineration of waste and discharge of liquid waste in sewage lagoons. As climate warms, the permafrost underneath sewage lagoons and waste dumpsites may degrade and no longer prevent contamination of adjacent soil, aquifers and water courses. Any increases in local releases would occur alongside the continued input of long-range transported pollutants from distantly located sources.

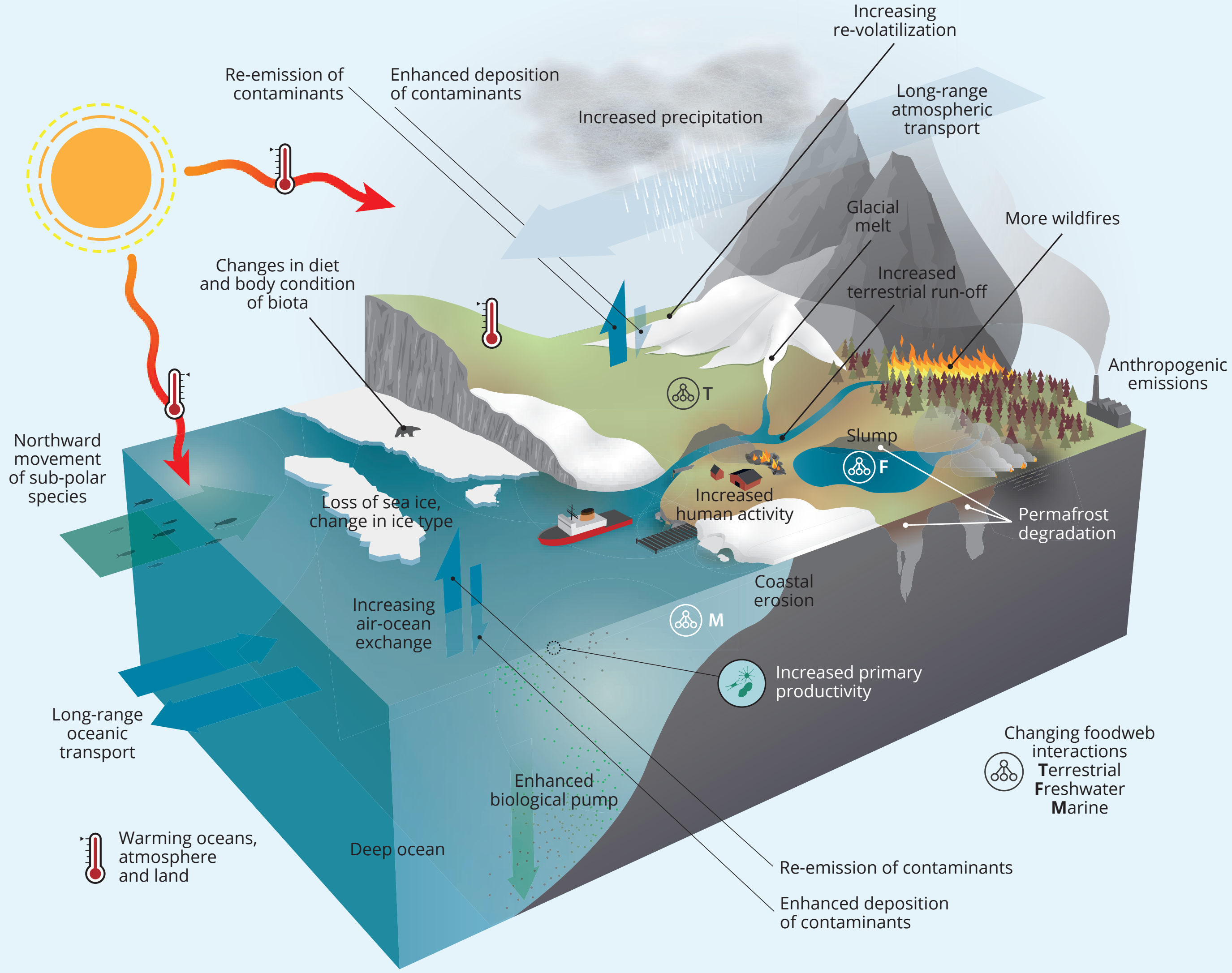
A number of PFASs are found in fire-fighting foams – one potential local source of CEACs within the Arctic

INFLUENCE OF CLIMATE CHANGE ON CONTAMINANTS IN ARCTIC ECOSYSTEMS & WILDLIFE

The Arctic is a large region that encompasses diverse ecosystems and species connected through complex biogeochemical and ecological pathways – many of which also mediate the transport and bioaccumulation of POPs. As climate change alters ecosystem structures and connections between species, levels and trends of contaminants in the environment and biota are also being affected.

What are the key climate-related changes influencing contaminant levels and fate in Arctic ecosystems?

Numerous climate-related changes to Arctic environments and ecosystems are occurring with both observed and projected effects on contaminant movement and distribution within the region. Confidence in the linkages between climate change and effects on contaminants varies depending on availability and frequency of observations.



Key climate-related changes influencing contaminant levels and fate in Arctic ecosystems

OBSERVATIONS OF CLIMATE CHANGE-RELATED EFFECTS ON ARCTIC CONTAMINANTS

Recent observations indicate that climate change is transforming Arctic ecosystems in ways that are influencing the movement and accumulation of contaminants. Although such ecosystem changes are likely occurring throughout the region, evidence to date of climate-related effects on contaminants comes from a relatively small number of studies conducted at only a few locations.

SHIFTING SEASONS

Altered timing of seasonal changes, such as snow melt and sea ice break-up, affect the timing of ecosystem responses, such as phytoplankton blooms, migration, and food availability, with indirect effects on contaminant exposure. Shorter sea-ice seasons are associated with declining POPs in seals in West Greenland and the Canadian Arctic Archipelago and Hudson Bay.

For seabirds, POP levels at summer Arctic breeding grounds reflected higher exposures from their southern wintering grounds, therefore, changes in the time spent at winter and breeding grounds could affect POP exposure.

PERMAFROST DEGRADATION AND THAW

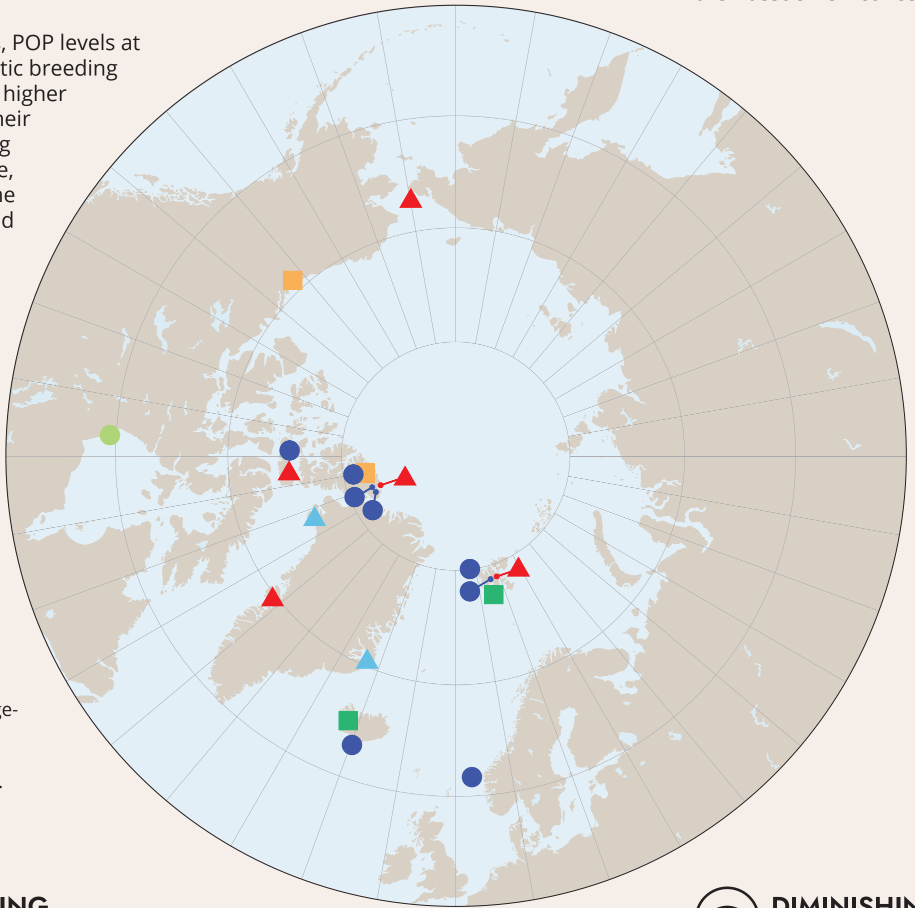
Thaw and erosion of permafrost surrounding Arctic lakes remobilizes stored contaminants into freshwater watersheds.

In the Canadian Arctic, permafrost thaw has been linked to increased POP concentrations in freshwater, benthic invertebrates and Arctic char.

ALTERED ECOLOGICAL COMMUNITIES AND FOOD-WEBS

Changes in the abundance, distribution and seasonal movements of Arctic species are creating new ecological communities and relationships that alter contaminant exposure pathways and levels in wildlife.

Dietary shifts of polar bears associated with diminishing sea ice have been linked with changes in their tissue POP concentrations.



Examples of studies where climate change-related effects on Arctic contaminants have been observed.

CHANGING CLIMATE PATTERNS

Altered global and regional climate patterns can influence the distribution and movement of chemicals to and within the Arctic. Statistical associations have been reported between contaminant levels in biota and climate parameters, including precipitation, sea ice conditions, and variations in regional climate patterns.

Associations between climate oscillation indices and POPs have been observed for Arctic air, seawater, and biota.

NORTHWARD MOVEMENT OF SUB-ARCTIC SPECIES

The increasing presence in the Arctic of biota from more contaminated regions at lower latitudes may introduce higher levels of contaminants into the Arctic food web.

In the Canadian Arctic, sub-Arctic capelin showed higher POP concentrations than Arctic cod.

DIMINISHING CRYOSPHERE

Sea ice loss, glacier retreat and reduced snow cover remobilizes previously deposited contaminants to air, rivers, lakes, and seawater, and alters the behavior of ice-dependent wildlife, with consequences for their diet and contaminant exposure.

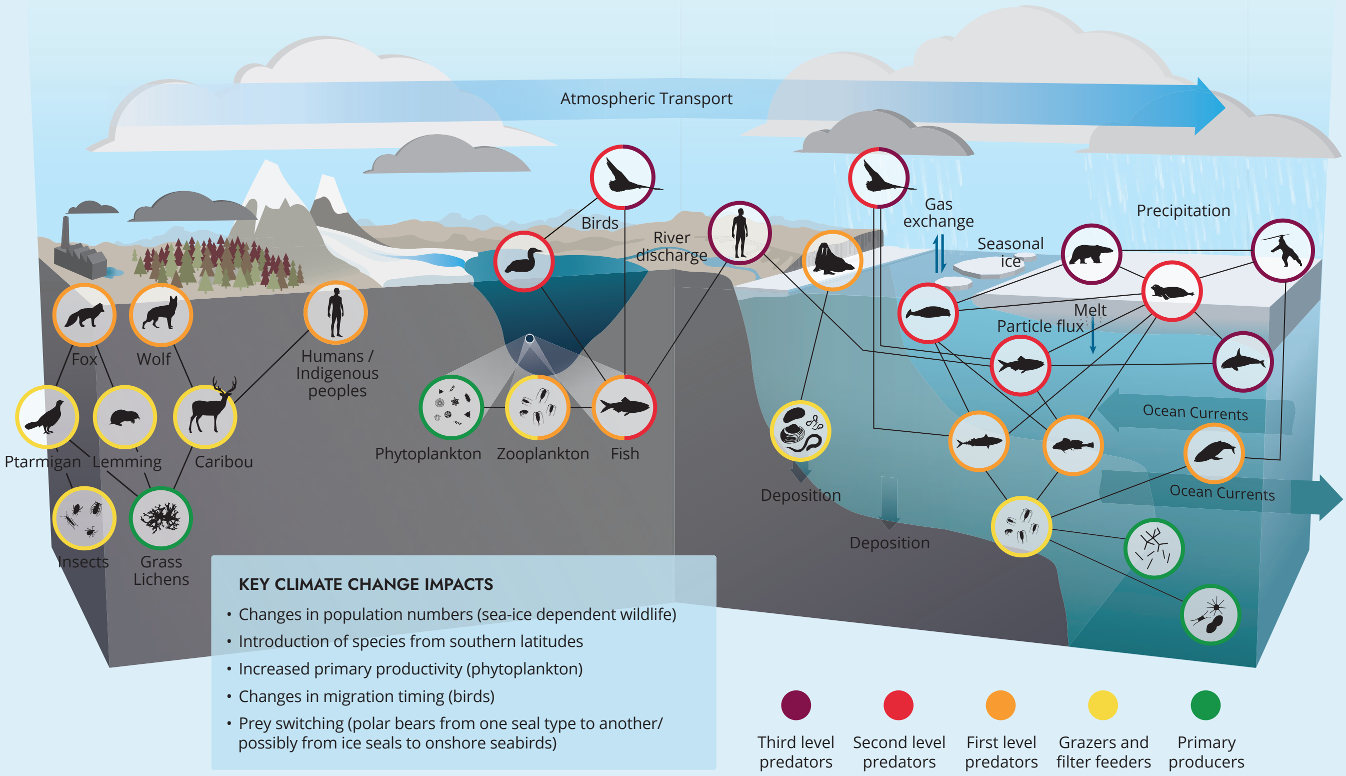
Higher inputs of POPs and CEACs to seawater, glacier-fed lakes and fjords have been associated with increased ice melting due to climate change. Contaminant levels in seals and polar bears have shown relationships with ice coverage and quality.

How are climate-related changes affecting contaminant accumulation and movement within the Arctic physical environment?

Observations indicate that climate change is clearly intensifying the mobility and transfer of POPs between physical environmental compartments of the Arctic; however, the overall net effect on levels in specific environmental compartments, such as air or seawater, is less clear. Climate change influences biogeochemical and contaminant pathways from multiple and sometimes opposing directions, making it difficult to estimate the combined impact of these changes. Moreover, many effects appear to be site- or region-specific, and, therefore, cannot be widely applied to all Arctic regions.

How will climate change influence the levels of POPs in Arctic biota and food webs?

Current findings indicate that climate change is affecting Arctic biota and food webs through numerous, overlapping mechanisms. As a result of these complex and interconnected environmental changes, the overall impacts on contaminant exposure in Arctic ecosystems are poorly understood. The direction and extent of changes in POP concentrations in biota are not consistent but depend on the species, ecosystem, and location and are not currently predictable; still, they are occurring. Climate-related impacts on a broad range of habitats, species, and processes are certain, which in turn are likely to disrupt the dynamics of POPs in Arctic food webs.



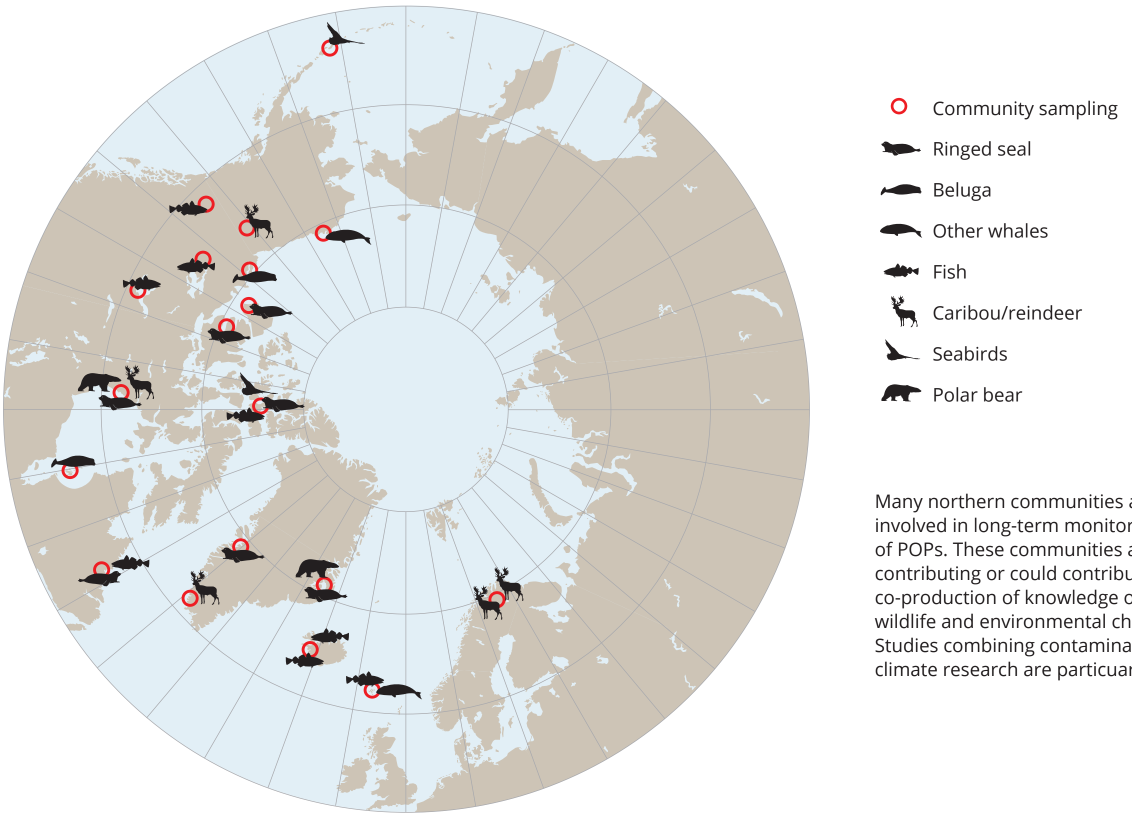
Climate-related changes in contaminant sources, pathways, and environmental fate are further acted upon by effects of abundance, habitat range, seasonality, prey accessibility, and physiology of individual wildlife species in Arctic ecological communities. The highly connected nature of Arctic food webs and various potential influences of climate change makes it difficult to estimate the overall impacts on contaminant exposure on Arctic species.

How can Indigenous Knowledge and Local Knowledge contribute to the discussion of climate-related effects on contaminant trends?

Northern Indigenous Peoples and Local Communities have been directly connected to Arctic ecosystems for centuries and have a rich repository of related knowledge. Indigenous Knowledge and local knowledge, combined with current observations of sea-ice conditions and ecological changes, could significantly enhance understanding of climate-related effects on contaminant trends in the Arctic.

The present AMAP assessment revealed the importance of long-term, site-specific monitoring efforts and the need for improved access to data on local and regional changes in climate-related conditions.

Northern communities are well-positioned to help address these needs. Some Indigenous communities already monitor sea-ice thickness, break-up dates, and other climate-related parameters. However, additional communities, especially those with a history of contaminant monitoring in the Arctic, could also lead or partner in the collection of climate-related information. Such community-led projects would help direct research based on needs of the community and sustain monitoring projects over the decadal time scales needed to identify climate influences on POPs trends.



Many northern communities are involved in long-term monitoring of POPs. These communities are contributing or could contribute to the co-production of knowledge on local wildlife and environmental changes. Studies combining contaminant and climate research are particuarly useful.

INFLUENCE OF CLIMATE CHANGE ON LONG-TERM TEMPORAL TRENDS OF CONTAMINANTS IN THE ARCTIC

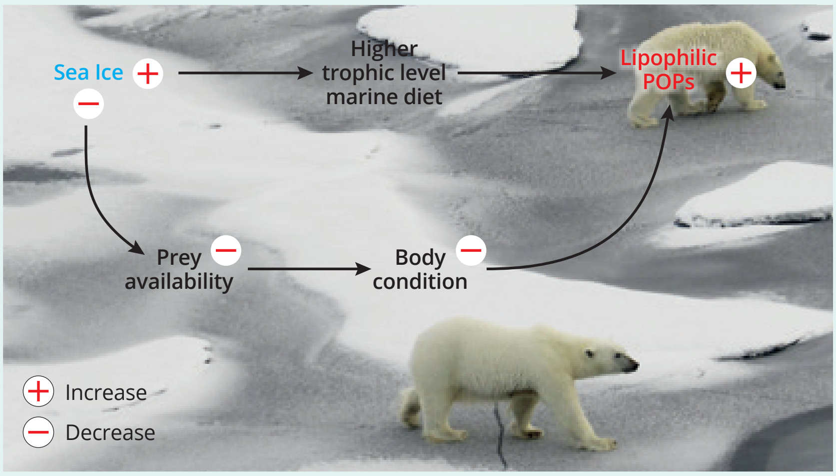
On-going environmental monitoring results in time series that further our understanding of contaminant trends in the Arctic. Temporal trends are critical for evaluating the effectiveness of global and regional POP regulations, supporting any new regulatory actions for CEACs, and protecting the food security and human health of Indigenous peoples who rely on traditional diets. Yet, the complex influences of climate change on contaminant sources, pathways, and fate in Arctic ecosystems can influence time trend data, thus impacting the interpretation of temporal trends used for decision-making.

Are temporal trends of POPs linked with climate parameters or food web changes?

Although many decadal time series for POPs now exist for Arctic air and biota, few have been explored for connections with climate parameters. Nonetheless, available findings indicate climate-related factors, including sea ice conditions and climate patterns reflected in oscillation indices, may influence the magnitude of contaminant trends in the Arctic physical environment and biota including fish, seabirds, seals, and polar bears. However, the relationship between climate and contaminant temporal trends are not uniform, and vary among locations, species, and compounds measured. Additionally, there may be a time lag between climate changes and effects on POP levels, thus, we may only be seeing the beginning of potentially larger climate influences on Arctic contaminant trends.

Do climate influences on contaminant temporal trends have implications for national and international regulations of chemicals?

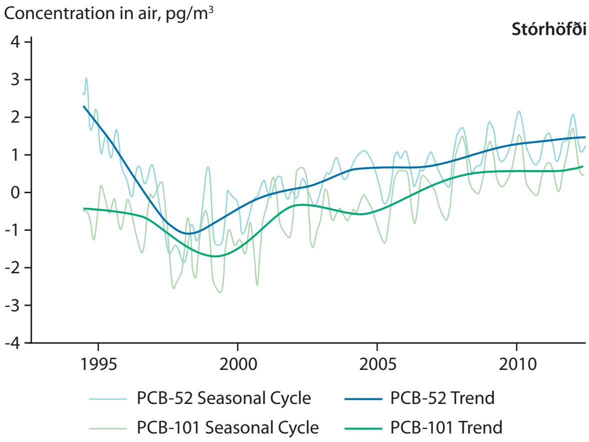
Modelled and measured results for some POPs included under the Stockholm Convention suggest that primary emissions are, and will continue to be, the main driver of Arctic contaminant trends. However, some time series show climate-related influences on trends that could affect the interpretation of contaminant time series used to evaluate the effectiveness of the Stockholm Convention and other POP regulations. Current findings suggest that climate impacts on contaminant trends cannot be generalized or applied widely across the Arctic, as the degree and direction of the climate influence can vary between pollutants, species, and locations. Location-specific factors may introduce a strong local or regional component into long-term POPs trends, thus, continued environmental monitoring for both contaminant and climate-related data will be essential for informing future regulatory actions.



Associations between climate indicators and contaminant trends in Arctic biota, including fish, seabirds, seals and polar bears have been observed, and in some cases, may be attributed to changes in prey species related to climate change.

Changes in sea ice extent alter prey availability and body condition in polar bears, with consequences for contaminant levels. Under conditions of reduced sea-ice extent, polar bears have reduced access to their preferred prey of seals, were thinner, and exhibited higher tissue concentrations of lipophilic POPs.

SLOWING OF POPs DOWNWARD TRENDS:
POTENTIAL INFLUENCES OF CLIMATE CHANGE



In some locations, the decline of certain POPs is slowing, and even reversing direction, potentially in association with climate-related changes. Levels of PCB-52 and PCB-101 in air are now increasing at the coastal site of Stórhöfði, Iceland in close proximity to retreating ice caps, after earlier decreases.

How well can we anticipate how contaminants will impact the Arctic under future climate change?

The present assessment has revealed a high complexity of overlapping direct and indirect effects of climate change on POPs in the Arctic. The overall impact of climate on contaminant levels and trends is dependent on numerous factors, including changes to contaminant sources, transport pathways, Arctic environments and ecological communities. Some of these changes will be apparent within weeks or months, while others will take years or decades to develop. Adding to this complexity, outcomes will depend on the chemical characteristics of individual pollutants and will vary by location and species. Underlying all of these variables is the inherent uncertainty associated with the progression of climate change globally.

Although there is now a growing amount of evidence indicating climate is influencing the contaminants within the Arctic, the complex factors controlling these changes are far from well understood, limiting the ability to predict future outcomes. However, at a large, regional scale, and over the longer term, current findings suggest that primary emissions continue to be the dominant factor controlling POPs exposure in the Arctic. Thus, global regulatory efforts are, and will be, essential in reducing future contaminant impacts to the region. At the same time, additional regional and national controls will be important for limiting the effects of currently unregulated CEACs.

To improve the ability to forecast climate influences on the Arctic, models that combine multiple environmental processes can be used, however, the accuracy of their projections are dependent on the understanding of ecosystem processes and interconnections, as well as the availability of data on emission estimates, physical-chemical properties, environmental levels, and trophic relationships between species. Thus, greater availability and access to environmental and ecological data will be key to improving future projections.

Knowledge gaps & needs for understanding climate influences on Arctic contaminants

While there are many uncertainties regarding the impacts of climate change in Arctic ecosystems, some knowledge gaps especially limit our understanding of contaminant fate under ongoing climate change and are thus recommended to be the focus of future research:

- Physical-chemical properties of contaminants, especially CEACs.
- Levels and sources of primary emissions of POPs and CEACs.
- Methods to distinguish between local, regional, and distant contaminant sources, including long-range transport.
- Climate-induced alterations in the Arctic physical environment.
- Changes in wildlife movements and structure of Arctic food webs.
- Mechanistic understanding of correlations between climate parameters and contaminant levels in the physical environment and biota.
- Data on contaminant and climate-related changes for terrestrial environments and low-trophic level biota.

RECOMMENDATIONS

Based on the findings of this AMAP assessment, the AMAP Working Group recommends the following steps:

1 INCORPORATING KNOWLEDGE OF CLIMATE CHANGE EFFECTS ON CONTAMINANTS INTO REGULATORY PROCESSES ADDRESSING POPs:

- **The groups responsible for effectiveness evaluation and risk assessment under the Stockholm Convention and UN ECE Air Convention (Convention on Long-Range Transboundary Air Pollution) implement procedures to account for the increasing influence of climate change on levels of POPs and some CEACs observed in the environment.**

2 REAFFIRMING CALLS FOR ACTION ON POPs AND CEACs:

- **Arctic Council Member States and Parties to the Stockholm Convention strengthen efforts to reduce primary emissions of POPs and continue to review CEACs for potential listing under the Stockholm Convention.** Based on climate and emissions modelling the expected effects of global regulatory efforts on reducing emissions will remain the primary factor determining levels of most POPs in the Arctic environment and Arctic biota in coming decades, and mask possible influences associated with climate change.
- **Arctic Council Member States and Observers support existing and consider new national, regional, and global initiatives for chemicals regulation and management of CEACs not covered by existing arrangements, and improve communication of associated risks to Arctic populations.** As the Arctic warms, increased human activity in the region will likely contribute to local releases of pollutants, including chemicals of emerging concern that fall outside the scope of the existing mechanisms for the regulation of long-range transported pollutants. Examples of existing legislation include the EU Chemical regulation (REACH) and the Canadian Environmental Protection Act (CEPA). Development and implementation of national legislation is a key element of the voluntary global framework for sound management of chemicals and waste currently under negotiation as a successor to the Strategic Approach to International Chemicals Management (SAICM).
- **Arctic States, consider independent actions to proactively control local contaminant sources,** including those associated with increased human activities, extreme weather events, and structural failure of local waste infrastructure as a consequence of permafrost thaw.

3 EXTENDING THE KNOWLEDGE BASE ON CLIMATE CHANGE EFFECTS ON CONTAMINANTS

Governments of Arctic States and observer countries, and international and national research funding agencies:

- **Expand studies considering the impact of climate change and related ecosystem changes on POPs and CEACs, including the role of extreme weather events on long-range transport and releases from secondary and local contaminant sources.** These studies should be expanded in both scope and geographical coverage, to improve the knowledge base and understanding of key processes.
- **Extend long-term contaminant monitoring programmes in geographic and analytical scope, including broadening analyses to include CEACs, and collection of ancillary biological, ecological, and climate/meteorological data.** The complex interactions between climate change and contaminants necessitate long-term and integrated environmental monitoring efforts that reflect the diversity of Arctic ecosystems and include ancillary data on climate parameters, environmental conditions, and wildlife populations which allow for meaningful interpretation of the contaminant findings.
- **Promote increased co-production of knowledge** by encouraging community-based studies and promoting capacity building in Arctic communities and scientific research programs. The use of Indigenous Knowledge and local knowledge for interpreting POPs trends and their links with climate change, would complement scientific studies and facilitate a better understanding of processes that affect POP and CEAC transport and fate under changing climate conditions and ecosystems.
- **Further develop temporal trend analytical methods and approaches to better incorporate and investigate relationships with climate-related parameters and apply these to retrospectively re-analyze trends in existing time-series,** thus building on the knowledge gained from the limited number of studies where such work has been done so far.
- **Encourage interdisciplinary research that reflects the complexity of physical, chemical and biological processes and the rapid developments both with regard to climate change and chemical contamination.** This integrative approach would benefit from collaboration among disciplines, government, universities, and Indigenous peoples and local communities.

ADDRESSING NEW FINDING

REINFORCING MESSAGE

ADDRESSING KNOWLEDGE GAPS

AMAP, established in 1991 under the eight-country Arctic Environmental Protection Strategy, monitors and assesses the status of the Arctic region with respect to pollution and climate change. AMAP produces science-based policy-relevant assessments and public outreach products to inform policy and decision-making processes. Since 1996, AMAP has served as one of the Arctic Council's six working groups.

The basis for this summary, the **AMAP Assessment 2020: POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change** report, is one of several reports and assessments published by AMAP in 2021. Readers are encouraged to review this, and the reports below, for more in-depth information on climate and pollution issues:

- *AMAP Assessment 2021: Mercury in the Arctic*
- *AMAP Assessment 2021: Impacts of Short-lived Climate Forcers on Arctic Climate, Air Quality, and Human Health*
- *AMAP Assessment 2021: Human Health in the Arctic*
- *AMAP Arctic Climate Change Update 2021: Key Trends and Impacts*

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Cover image: Kyra St Pierre *Thermokast slumps, Turnabout River (Qutinirpaaq National Park, Nunavut, Canada)*