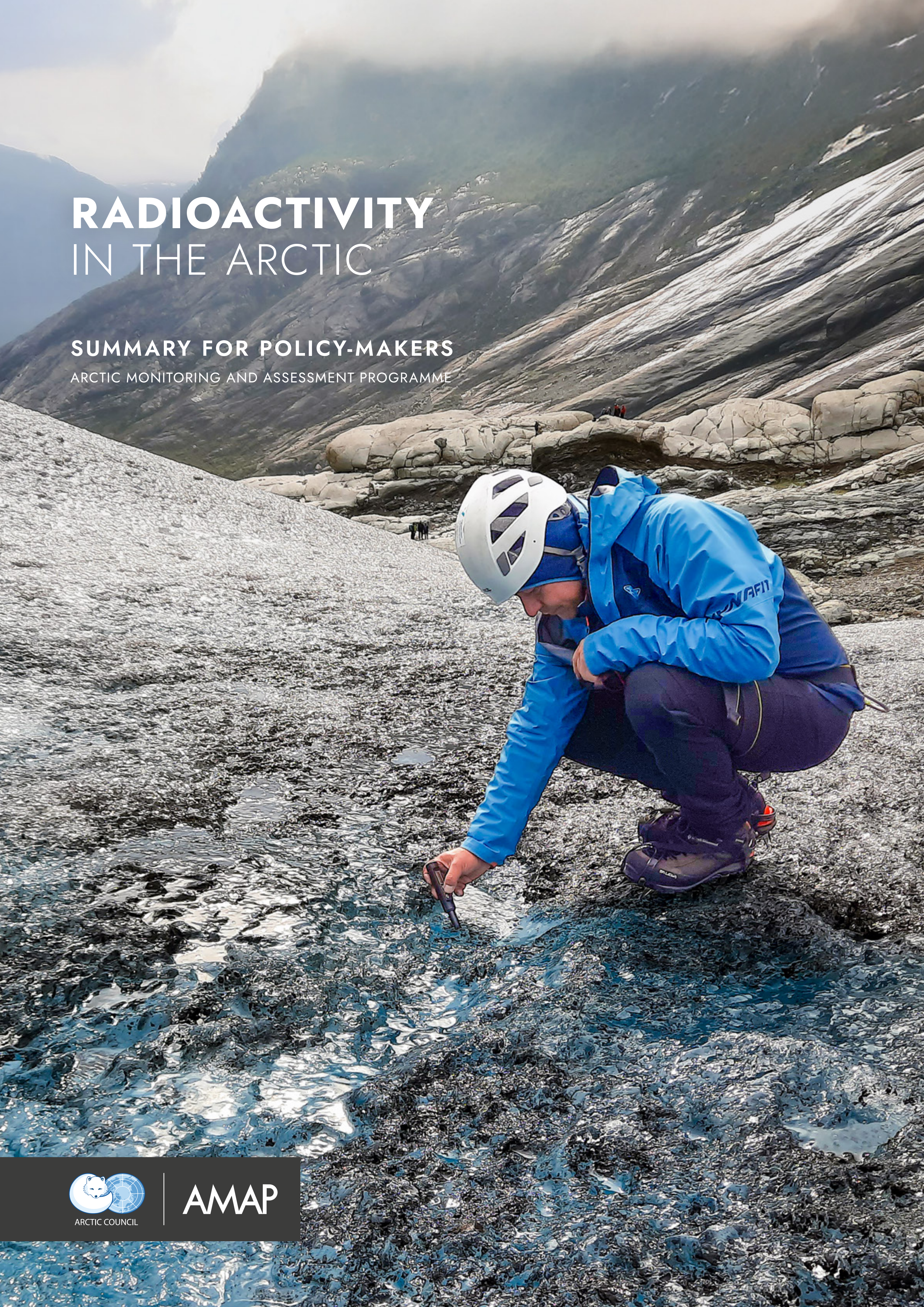
RADIOACTIVITY IN THE ARCTIC

SUMMARY FOR POLICY-MAKERS

ARCTIC MONITORING AND ASSESSMENT PROGRAMME



ARCTIC COUNCIL

AMAP

WHY RADIOACTIVITY IS A CONCERN IN THE ARCTIC

Radioactivity in the Arctic comes from man-made and naturally occurring radionuclides (NORs). A radionuclide is an unstable form of a chemical element that releases radioactivity as it breaks down and becomes more stable. Exposure to radioactivity can damage living tissues and organs. How radionuclides behave in the Arctic is changing, as a result of climate change, while potential new sources of radionuclides could threaten the region's vulnerable environment, the people who live there and their traditional livelihoods.

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The main sources of anthropogenic radioactivity in the Arctic remain fallout from atmospheric nuclear weapons testing worldwide in the 1950s and 1960s, and the long-range transport of radionuclides discharged by European nuclear fuel reprocessing facilities. Radionuclides from the Chernobyl disaster in 1986 contaminated the Arctic as, to a lesser degree, did those from the Fukushima accident in 2011.

There are other existing and potential sources of anthropogenic radioactivity within the Arctic, such as sunken nuclear power submarines and dumped radioactive waste. Accidents at nuclear facilities or involving the development and use of new nuclear technologies within the region could cause further contamination of the Arctic.

NORs occur naturally in the environment, but human activities both within and outside the Arctic – such as oil extraction, gas production and mining – can give rise to additional sources and levels of NORs.

AMAP has been assessing and reporting on radioactivity in the Arctic since the mid-1990s. Its previous work on the topic has been instrumental in drawing attention to the risks posed by radionuclides in the Arctic.

This publication summarizes the AMAP Assessment 2025: Radioactivity in the Arctic assessment, capturing data and information up to December 2021. This assessment builds on the 2015 AMAP report on the subject, with updated information on trends in radioactivity in the region, progress in management of radioactive waste and decommissioning, the impacts of climate change on radioactivity, considerations relating to future sources of radioactivity in the region, and public outreach.

KEY FINDINGS

Violeta Hansen

CURRENT LEVELS OF ANTHROPOGENIC RADIOACTIVITY WITHIN THE ARCTIC ARE LOW AND HAVE BEEN UNCHANGED OR DECLINING OVER RECENT DECADES.

Decreasing trends are due to, among other things, radioactive decay since atmospheric testing and nuclear accidents like Chernobyl, and reductions in discharges of radionuclides from nuclear fuel reprocessing facilities.

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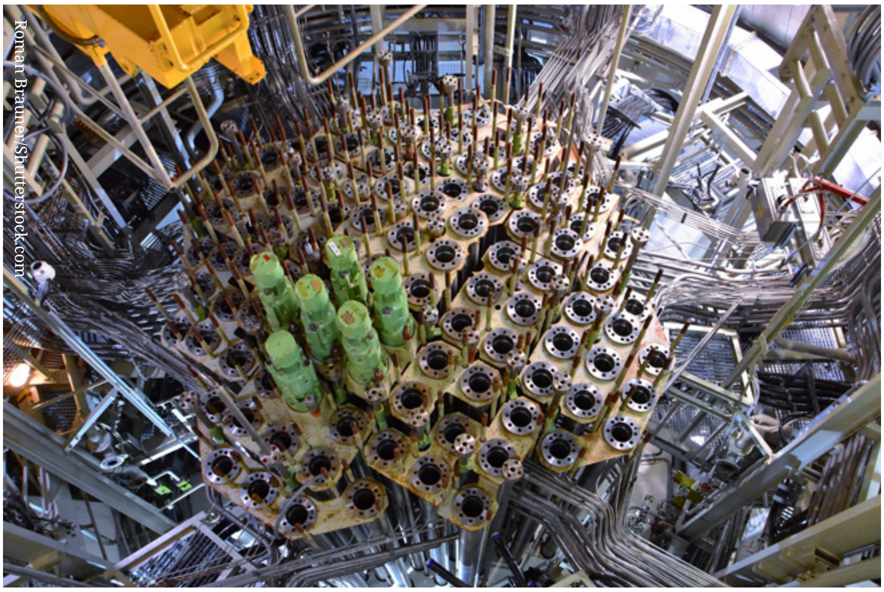
COMPARED WITH ANTHROPOGENIC RADIONUCLIDES, NATURALLY OCCURRING RADIONUCLIDES ARE THE MAIN CONTRIBUTORS TO THE ANNUAL EFFECTIVE DOSE OF RADIATION RECEIVED BY PEOPLE LIVING IN THE ARCTIC.

NORs occur naturally in the environment, but human activities both within and outside the Arctic – such as oil extraction, gas production and mining – can give rise to additional sources and levels of NORs.

Amanda Anderson

CONTINUING AND POTENTIAL RELEASES OF RADIONUCLIDES FROM VARIOUS ANTHROPOGENIC AND NATURAL SOURCES MAKE ONGOING MONITORING OF RADIOACTIVITY IN THE ARCTIC IMPORTANT FOR THE REGION.

It remains important to monitor levels in foodstuffs and the environment, to track baseline levels in the event of future nuclear accidents, and to understand how radionuclides behave in the context of climate change.



PROGRESS CONTINUES TO BE MADE IN ADDRESSING SPENT NUCLEAR FUEL AND RADIOACTIVE WASTE STORED IN THE ARCTIC.

Work has been completed in removing spent fuel from the Lepse and dismantling the vessel, decommissioning work continues at Andreeva Bay on schedule, while environmental and workforce monitoring continues of storage and transportation sites on the Barents Sea coast of the Kola Peninsula.

CLIMATE CHANGE IS AFFECTING HOW RADIONUCLIDES BEHAVE IN THE ARCTIC AND WILL LIKELY CONTINUE TO DO SO.

Permafrost thawing could lead to changes in indoor radon levels, while melting glaciers and ice sheets could become more significant secondary sources of radionuclides released in the atmosphere decades ago.

THE INCREASED PRESENCE OF NUCLEAR-POWERED OR -ARMED VESSELS AND THE POTENTIAL INSTALLATION OF SMALL NUCLEAR REACTORS IN THE ARCTIC WILL INCREASE THE NUMBER OF POTENTIAL SOURCES OF RADIOACTIVE CONTAMINATION AND MAY INCREASE THE RISK OF FUTURE ACCIDENTS AND RELEASES OF RADIOACTIVE CONTAMINATION.

Greater economic activity, such as oil and gas extraction and mining, may result in further sources of NORs.

Erlend Astad Lorentzen

TRENDS IN RADIOACTIVITY IN THE ARCTIC

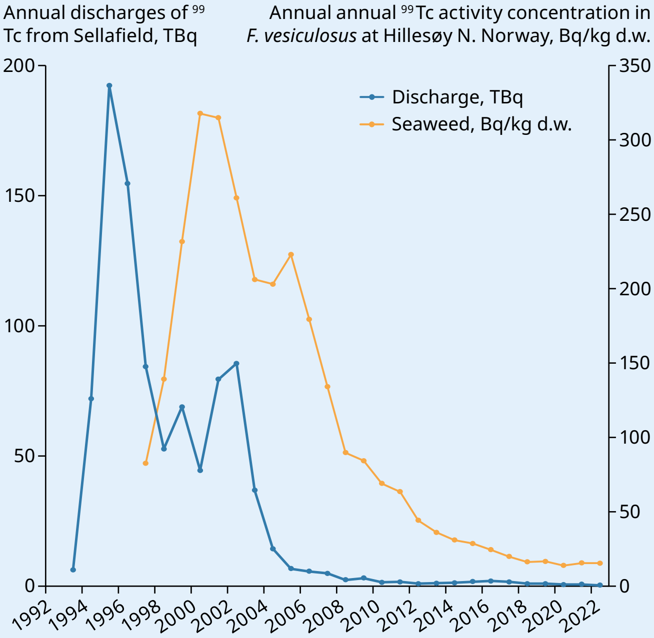
ANTHROPOGENIC RADIOACTIVITY

Anthropogenic radioactivity is released from, among other things, nuclear accidents, nuclear weapons tests and the reprocessing of spent nuclear fuel. Levels of anthropogenic radioactivity within the Arctic are low today and have been unchanged or declining over recent decades. Decreasing trends are due to, for example, radioactive decay over time, and continued reductions in discharges from the nuclear fuel reprocessing facilities at Sellafield, in the UK, and La Hague, in France.

Atmospheric monitoring shows that concentrations of tritium from nuclear weapons testing returned to natural background levels by the early 2000s.

Monitoring of the whole-body content of caesium-137 in reindeer herders from the Inari region in Finland has taken place regularly since the early 1960s. The results clearly show the impact of global fallout from nuclear weapon testing and the Chernobyl nuclear accident in 1986 but show a decreasing trend to the present.

However, the continued monitoring of radioactivity levels in the Arctic, including of foods, remains important, both to citizens and governments.



A comparison of annual technetium-99 discharges from Sellafield and annual average activity concentrations of technetium-99 in seaweed at Hillesøy, Northern Norway to illustrate the potential for long-range transport of radioactive contamination by ocean currents to the Arctic from sources further afield.

A potential nuclear accident inside or outside the Arctic may impact the Arctic, in which event information on baseline levels of radioactivity would be important. Further, monitoring data from the past decades gives us valuable insight into how radionuclides behave in Arctic ecosystems, which is very useful for anticipating the potential consequences of climate change.

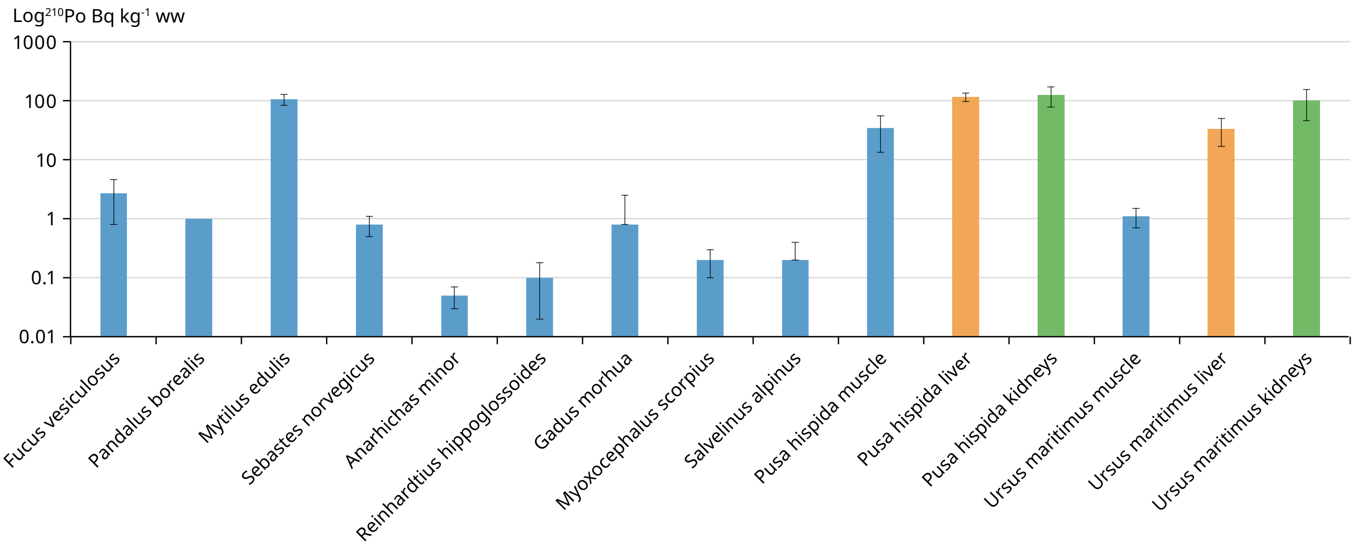
While levels of anthropogenic radioactivity are generally low in the Arctic, there continue to be risks of additional sources. The Ob and Yenisey Rivers are two important historic sources of anthropogenic radioactive contamination to the Kara Sea in the Arctic, due to the presence of nuclear sites within their catchments. In 2017 a large atmospheric release of ruthenium-106 was detected within the Arctic. This was likely to have been caused by a sizable and undeclared nuclear event from a facility outside the region. Like the Fukushima accident in Japan in 2011, which led to additional low levels of radionuclides reaching the Arctic, this demonstrates the potential for releases outside the Arctic to be transported to the region, whether through the atmosphere, by river or by sea.

NATURALLY OCCURRING RADIONUCLIDES

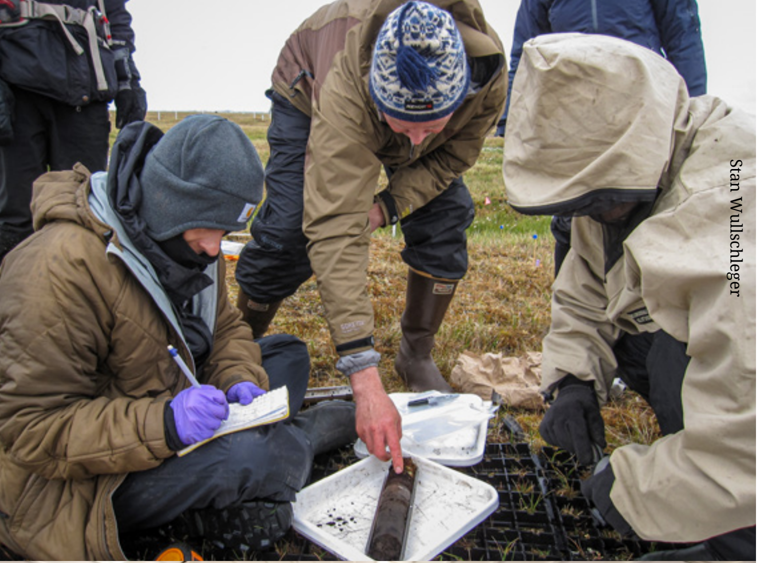
Indoor radon-222 is the second most significant cause of lung cancer, after tobacco, worldwide. Because of the length of Arctic winters, people tend to spend more time indoors than those in more temperate parts of the world, which may increase their exposure to radon. Recent studies found that adults in some areas of the Arctic receive a higher exposure to radiation from radon alone than the global average sum of all different exposure pathways. Prevention and mitigation actions can reduce levels of indoor radon in buildings.

Other NORs, such as polonium-210, lead-210, radium-226, and radium-228, also occur naturally in the environment and are redistributed within and transported to and from the Arctic through natural processes. Human activities both within and outside the Arctic – such as oil extraction, gas production and mining – can introduce additional sources and levels of NORs.

Despite the contribution made by NORs, a complete overview of levels of NORs across the AMAP areas in the marine, terrestrial, and atmospheric environments is lacking.



Polonium-210 activity concentrations (mean ± SD) in edible parts of seafood and marine mammals from Greenland.



Stan Wullschleger

Violeta Hansen

Hilde Elise Heldal

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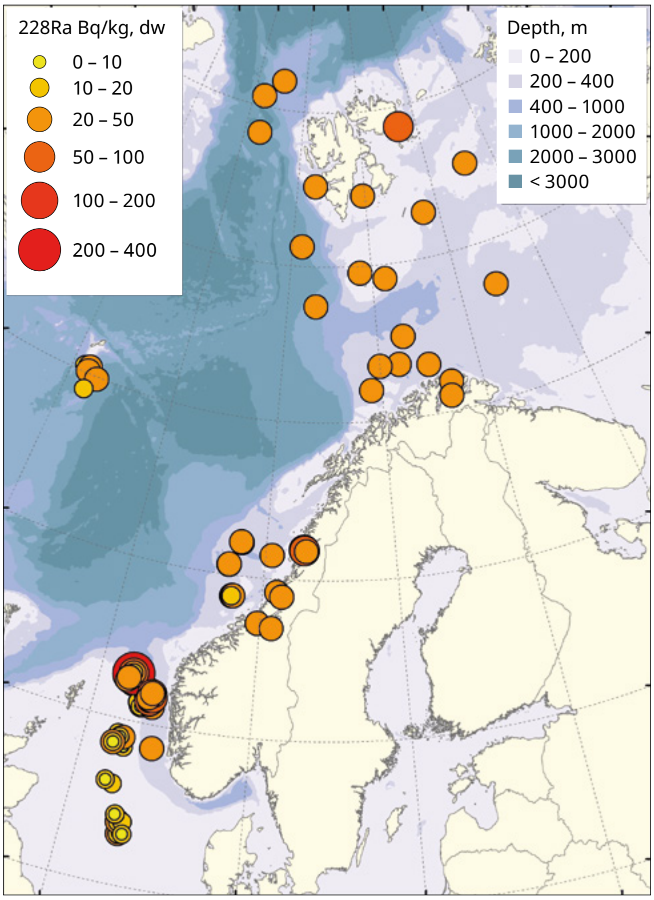

Concentrations of radium-228 in surface sediments (activity in bq/kg dry weight).

Understanding the sources and associated risks from NORs is necessary to support science-based decisionmaking in support of developing policy with the engagement of the public, including Indigenous peoples of the Arctic.

Polonium-210 is typically the main contributor to radiation exposure to humans through the diet, compared to all other naturally occurring and anthropogenic radionuclides. This naturally occurring radionuclide accumulates in many marine and terrestrial foods, which are important components of the traditional diets of many Arctic residents. Heavy consumers of such food items can have a higher background radiation exposure, although not to an extent that poses elevated risks to human health.

The monitoring of natural radionuclides can also provide useful insights into the long-range transport of air masses and other pollutants into the Arctic.

Human activities both within and outside the Arctic – such as oil and gas production and mining – can give rise to additional sources and levels of NORs.

The history of uranium mining and milling in northern Canada demonstrates the importance of continuous engagement with local stakeholders throughout the lifespan of these activities. Experience from Northern Saskatchewan also shows that Indigenous groups expect direct, independent engagement with both industry and regulators.


Stan Wullschleger

RADIOACTIVE WASTE AND DECOMMISSIONING

Spent nuclear fuel and radioactive waste stored in the Arctic represent potential sources of anthropogenic radionuclides. Addressing these sources has been a focus of international cooperation since the 1990s. This latest AMAP assessment provides updates on decommissioning work carried out in the Arctic since 2016. It describes surveys of storage facilities at the Andreeva Bay site on the Barents Sea coast of the Kola Peninsula, of nuclear fuel transportation routes in the area, and a project to remove spent nuclear fuel stored on the Lepse Floating Technical Base (FTB) outside the city of Murmansk, in Russia.


Thomas Nilsen

ANDREEVA BAY

Measurements taken within the Andreeva site boundary showed elevated levels of radioactivity, but these were similar or slightly lower than those reported in AMAP’s 2015 assessment. Measurements around the perimeter of the site, showed levels up to twice as high as background levels. Decommissioning work, including removal of spent fuel, proceeded on schedule over this period.

KOLA PENINSULA

The assessment also reviewed the radioecological state of the coast of the Kola Peninsula, including spent nuclear fuel storage sites, radioactive waste management facilities, and routes for transporting spent nuclear fuel. Fieldwork undertaken from 2017 to 2020 identified only low levels of radionuclides in the marine environment in Motovsky Bay and Kola Bay, as was the case in previous assessments. The fieldwork found no impacts of radiation on the ecology of the Murmansk foreshore, confirming assessments made in recent decades that it is safe from a radioecological point of view.

LEPSE UPDATE

The Lepse FTB was a timber vessel that was used to store spent nuclear fuel from the Russian nuclear fleet over several decades. A project, funded by the European Bank for Reconstruction and Development, to decommission and dismantle the Lepse and to safely remove and store this spent fuel and the vessel itself has been underway since 2008. The work was completed in 2023.

CLIMATE CHANGE AND RADIOACTIVITY

Conditions and processes within the Arctic, such as extreme cold, permafrost, sea ice and ice caps, influence the behavior and fate of radioactive contaminants. Climate change, which is accelerating faster than previously observed, as noted in recent IPCC and AMAP reports, is likely to have long-lasting impacts on Arctic ecosystems due to these and other changing dynamics.

A warming climate is thawing permafrost, leading to the release of both anthropogenic and naturally occurring radionuclides that were previously immobilized to Arctic environments. The thawing of permafrost may lead to changes in indoor and outdoor radon levels.

Glaciers act as sinks for atmospheric contaminants. As their melting accelerates due to global warming, they are becoming a more significant secondary source of contaminants originally released into the environment decades ago. Radionuclides are among the pollutants that accumulate in cryoconite material – a dark-colored mixture of mineral and organic material deposited on snow and ice – on the surface of glaciers and can be remobilized through ice melting. The levels of radioactivity found in cryoconite can be high, with activities among the highest reported for glacial terrestrial runoff environments in the Arctic, and are often orders of magnitude higher than in other terrestrial environments.

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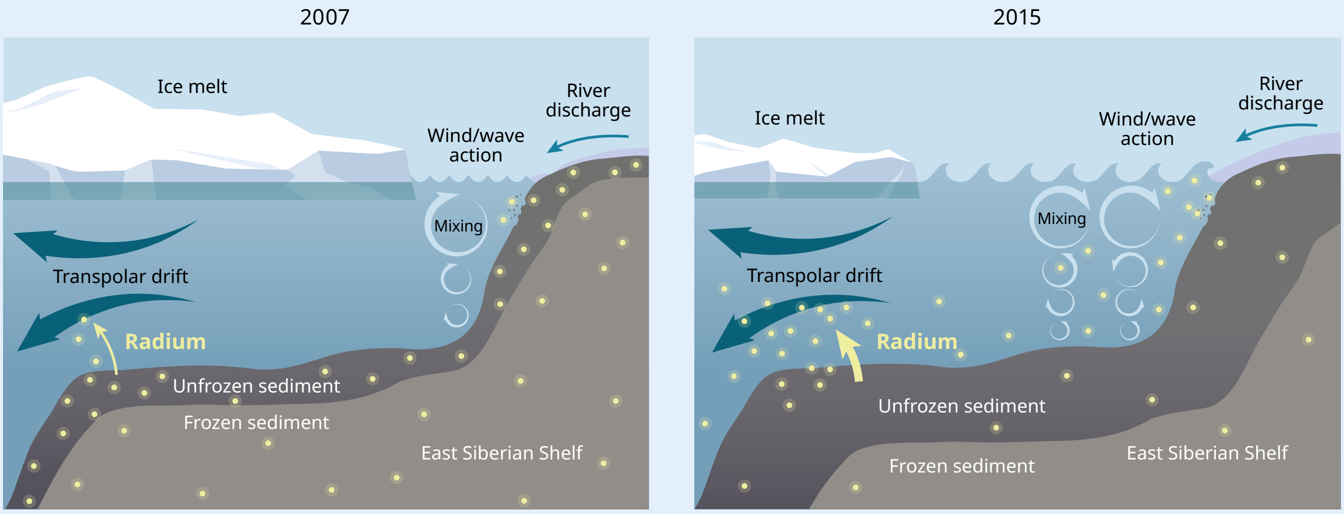

The loss of sea ice over Arctic shelves results in longer open water seasons and can increase wind- and wave- driven turbulence. This increased mixing can facilitate the release of radium and other shelf-derived materials into the overlying water column. Graphic by Natalie Renier, WHOI Creative Studio.

The pathways for the transfer of radionuclides between terrestrial and marine environments will be impacted by climate change. Key coastal areas, such as fjords, should be monitored. The Arctic marine environment is heavily influenced by inputs from continental shelves. Climate change is increasing this influence, through permafrost thaw, increased river discharge and reduced sea ice. Evidence for this has come from observed changes in the natural fluxes of NORs to the Arctic Ocean, which illustrates the potential for changes in the environmental fate of any radionuclide deposited in the Arctic.

Climate change is likely to affect human activity in the Arctic through changes in accessibility on land and at sea at high latitudes. Such changes may result in an increase in the number of actual and potential sources of radionuclides through economic development and increased military presence.


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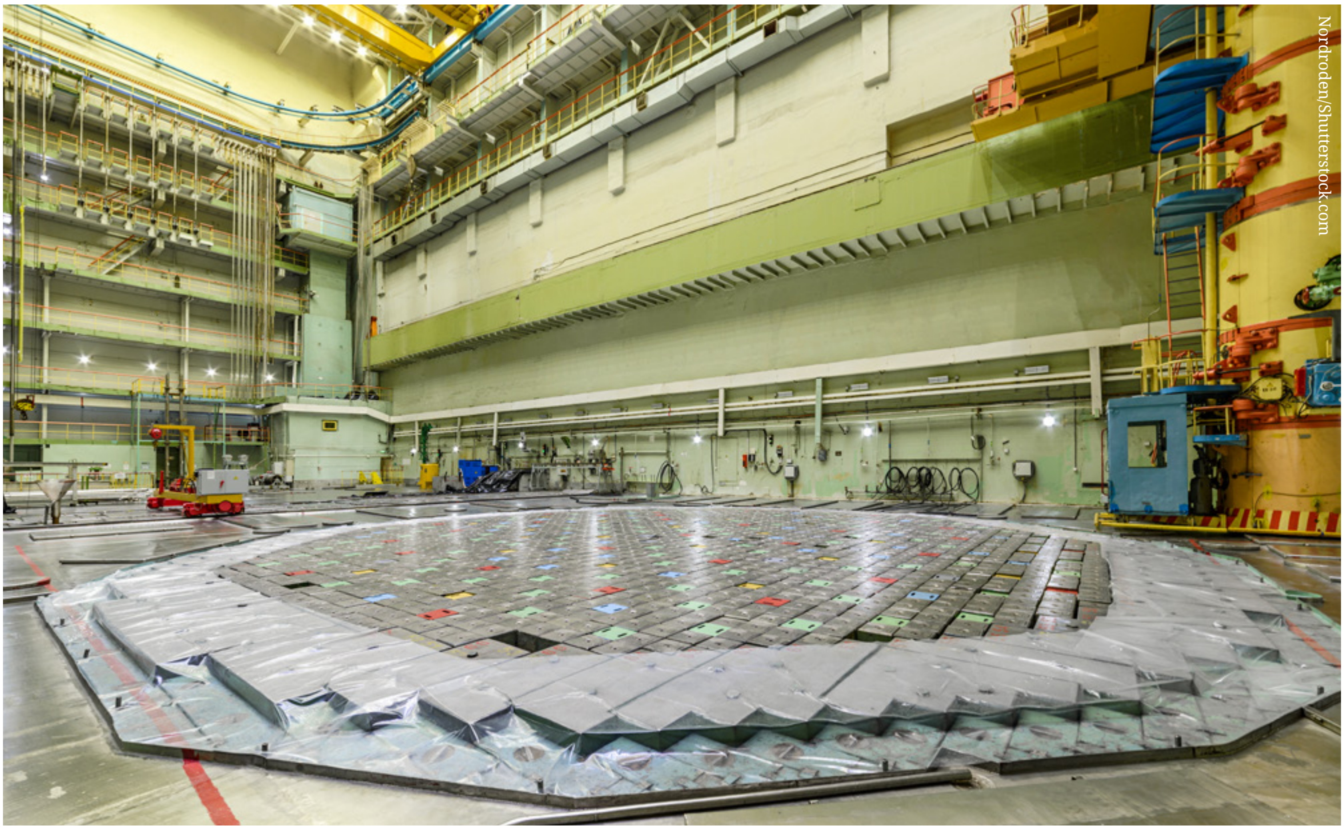
FUTURE CONCERNS

Currently, there are two civil nuclear power plants, and one floating nuclear plant, operating within the Arctic region, all in Russia. However, the use of new small modular reactors for the civil production of electricity, and which are designed to be pre-built in factories and transported to their desired location, has been discussed in a number of Arctic countries, with proposals to site these within or close to the Arctic. In addition, Russia has recently increased the size of its civilian fleet of nuclear-powered icebreakers from four to seven.

There has been an increased military presence in the Arctic in recent years, through the deployment of conventionally and nuclear-powered naval vessels which may carry nuclear weapons, strategic aircraft that also might carry nuclear arms and the development of new military nuclear technologies.

Any increase in the number of potential sources of radioactivity in the Arctic, and in particular with the development and use of new nuclear technologies, may increase the risk of future accidents and releases of radioactive contamination.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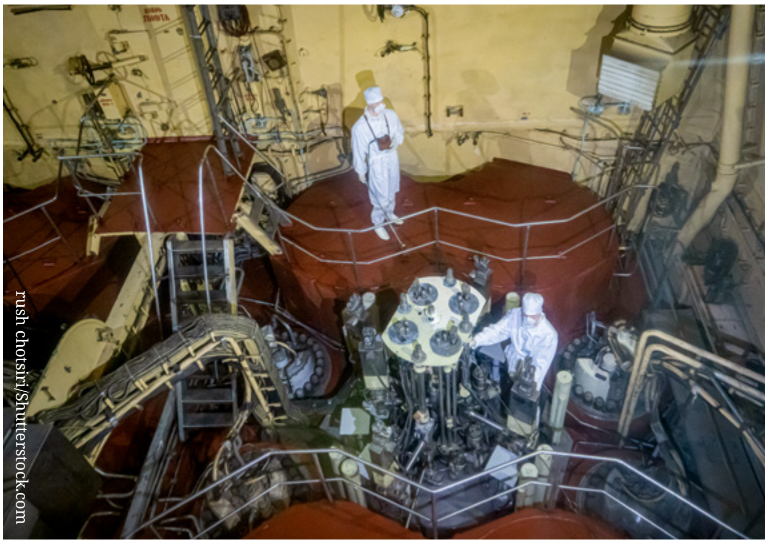
Violeta Hansen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RECOMMENDATIONS

Based on the Findings of the AMAP assessment, the AMAP Working Group recommends the following:

1

POLICY RECOMMENDATIONS:

Radon poses a risk to the health of Arctic residents. **Arctic Council Member States are encouraged to continue efforts to monitor for and protect Arctic residents from radon exposure.**

Stan Wullschleger

2

EXTENDING THE KNOWLEDGE BASE ON RADIOACTIVITY IN THE ARCTIC:

However, significant sources of radioactivity remain in the region, such as sunken nuclear powered submarines and dumped radioactive waste, posing potential economic, social and environmental threats. **Arctic Council Member State and Observer countries are encouraged to continue and to strengthen monitoring programs to improve our understanding of the impact of climate change on radionuclides in Arctic and any changes in impact from known and possible new sources.**

Atmospheric, terrestrial and marine monitoring of radionuclides in the Arctic has helped inform our understanding of the levels and sources of radionuclides within and to the region and provides reassurance to Arctic residents and important Arctic economic industries such as fishing. However, further work is still required to fully understand the behavior and fate of radionuclides in Arctic environments, particularly in the face a changing Arctic climate. **Arctic Council Member State and Observer governments are encouraged to expand ongoing coordination of atmospheric, terrestrial and marine monitoring within the Arctic, and related data harmonization and storage, to enable a better understanding of radionuclide levels, the behavior of other pollutants, and their associated risks.**

Arctic Council Member States are encouraged to consider initiating monitoring of levels of naturally occurring radionuclides in certain areas and evaluating dose and risk from exposure to these. Arctic Council Member States are also encouraged to consider the impacts of a changing Arctic climate for safety assessments related to potential sources, such as nuclear facilities, small modular reactors, and nuclear-powered vessels.

3

EXTENDING THE KNOWLEDGE BASE ON CLIMATE CHANGE EFFECTS ON RADIOACTIVITY IN THE ARCTIC:

Climate change is affecting the transport, behavior and fate of radionuclides in the Arctic and will likely continue to do so. **Arctic Council Member State and Observer countries are encouraged to continue and strengthen monitoring programs to improve our understanding of the impact of climate change on radionuclides in Arctic and any changes in impact from known and possible new sources.** Studies need to be carried out to better understand the impacts of permafrost thaw on indoor and outdoor exposure rates to radon.

Increased military presence, involving nuclear-powered or -armed vessels, and the development of new civil and military nuclear technologies increases the risk of accidents and releases of radioactive material. **Arctic Council Member State and Observer governments are encouraged to consider the consequences of a changing Arctic climate in relation to potential sources.**

4

ENGAGING WITH STAKEHOLDERS ON ISSUES AROUND RADIOACTIVITY:

Experience demonstrates the importance of long-term, continuous, and open engagement, transparency, educational outreach, and community-based monitoring programs. Ongoing community support for economic activities depends upon continued participation in and engagement with those activities, their associated environmental measures, and related decision-making. **Arctic Council Member States are encouraged to continue engaging with communities in planning, approving, developing, operating, and closing mining sites and other activities involving naturally occurring radionuclides, such as uranium mining and oil and gas extraction.**

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.

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