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Nuclear Safety and Security in the Arctic: Crafting an Effective Regional Governance System

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Abstract
The Arctic is saturated with nuclear facilities bringing both benefits for regional economic and social development and risks of nuclear and radiological accidents and concerns about radioactive wastes. There is every reason to expect the Arctic will remain a nuclearized region during the foreseeable future. This makes it important to direct attention to issues of nuclear safety and security in the region. We identify several clusters of these issues in the Arctic, including the challenges of potential nuclear accidents, the handling of spent nuclear fuel and radioactive waste, the cleanup of radiological contaminants, and concerns about nuclear security. An analysis of international conventions and voluntary codes of conduct shows that they are applicable to Arctic nuclear safety and security, but only in general terms. This suggests a need for an Arctic-specific agreement on nuclear and radiological safety, emergency preparedness and response, and cleanup of radiological contaminants. The outbreak of military hostilities in Ukraine in February 2022 has disrupted normal procedures for addressing issues of common concern in the Arctic. But the need for cooperation regarding matters like nuclear safety and security will not go away. Assuming it is possible to devise "necessary modalities" for restarting the work of the Arctic Council following the acute phase of the Ukraine crisis, an Arctic-specific agreement on nuclear safety and security could be developed under the auspices of the Arctic Council, which already has taken an interest in nuclear safety through the activities of its Working Group on Emergency Prevention, Preparedness and Response. Once such an agreement is in place, it will become important to consider the infrastructure needed to ensure that its provisions are implemented effectively.

Keywords: *nuclear accidents, spent nuclear fuel, radioactive contaminants, nuclear security, governance*

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1 Introduction: A focus on nuclear safety and security in the Arctic

Whereas Antarctica remains largely denuclearized under the provisions of the 1959 Antarctic Treaty, the Arctic is a region in which nuclear power involving both military and civilian applications is a prominent feature of the political landscape. The Circumpolar North is a theater of operations for nuclear-powered submarines equipped with nuclear-tipped missiles as well as for manned bombers carrying nuclear weapons. Nuclear-powered icebreakers loom large in Russia's plans for the continued development of the Northern Sea Route as an important commercial artery. While experience with traditional high-energy nuclear power plants in the Far North is limited, recent developments involving small modular reactors have fueled growing interest in making use of nuclear power to meet the energy needs of remote communities in the Arctic otherwise dependent on diesel generators that are expensive to operate and produce pollutants including emissions of greenhouse gases.

For many years, international groups have campaigned to declare the Arctic a Nuclear-Weapon-Free Zone. But there is little prospect of success regarding such measures during the foreseeable future. The Arctic is an arena of geopolitical interest to the great powers, an area featuring large commercial enterprises, and a zone inhabited by sizable numbers of human residents whose well-being requires access to secure and affordable sources of energy.

Under the circumstances, there is every reason to expect that the Arctic will remain a nuclearized region during the foreseeable future. If anything, the role of nuclear energy in the Arctic is likely to rise rather than to decline. This makes it important to direct attention to issues of nuclear safety and security in the Arctic. How can we tackle issues of emergency prevention, preparedness and response with regard to various types of nuclear accidents? What are the options for dealing with the disposal or reprocessing of spent nuclear fuel? Is there more to be done in addressing issues of radiological safety and the treatment of nuclear debris in the Arctic resulting from past accidents or careless dumping practices? Can we foresee newly emerging issues of nuclear safety and security in the Arctic (e.g. dangers of nuclear terrorism)?

In this article, we deal with nuclear safety and security in the Arctic in several steps. The next section sets the stage; it compares the international regimes of Antarctica and the Arctic regarding nuclear activities and provides a brief account of military and civilian uses of nuclear power in the Arctic. Section 3 then identifies the principal issues of nuclear safety and security in the Arctic and characterizes them as actionable concerns for policymakers in both international and domestic settings. Section 4 turns to an assessment of international legal arrangements that are pertinent to addressing issues of nuclear safety and security in the Arctic. Here, we consider those global arrangements that are relevant to the Arctic. Section 5 then asks whether there are opportunities to take steps to enhance the applicability of global arrangements to the specific conditions arising in the Arctic. We analyze the case of nuclear safety and security in light of similar concerns relating to regional applications of arrangements pertaining to search and rescue and marine oil spills. Finally, in Section 6, we provide a preliminary account of issues relating to implementation. How can we move legal and political arrangements pertaining to nuclear safety and security from paper to practice in such a way as to maximize their effectiveness under conditions prevailing in the Arctic?

The onset of military hostilities in Ukraine in February 2022 has far-reaching implications for our analysis of options for addressing issues of nuclear safety and security in the Arctic. The crisis has led to the suspension of cooperative activities taking place within the framework of the Arctic Council.[1] More generally, the effect of the crisis has been to tighten the links between regional issues arising in the Arctic and the broader course of world affairs. Yet the crisis also highlights the importance of paying attention to issues of nuclear safety and security. The disruption of normal safeguards mandated by the International Atomic Energy Agency at Ukrainian nuclear power plants, for example, is cause for serious concern. This suggests that once the acute phase of the current crisis subsides, it will be important to renew our concern for issues of nuclear safety and security in the Arctic. It may be some time before the Arctic Council is able to resume work on specific issues, and the parties may wish to consider significant adjustments in the Council's structures and processes going forward. Under the circumstances, innovative thinking about effective procedures for addressing issues of governance relating to nuclear safety and security in the Arctic will be essential.

2 Polar Contrasts: Nuclear power in the antipodes

Issues of nuclear power in Antarctica are governed by the Antarctic Treaty, which was negotiated initially in 1959 by twelve countries, entered into force in 1961, and now has 54 parties.[2] The 1959 Treaty prohibits the use of Antarctica for any military purposes. According to Article I, "Antarctica shall be used for peaceful purposes only. There shall be prohibited, inter alia, any measures of a military nature, such as the establishment of military bases and fortifications, the carrying out of military maneuvers, as well as the testing of any type of weapons." In practice, the treaty made Antarctica the first Nuclear-Weapon-Free Zone in the world. As the United Nations Office for Disarmament Affairs puts it, the establishment of such zones constitutes "a regional approach to strengthen global nuclear non-proliferation and disarmament norms and consolidate international efforts towards peace and security."[3]

With regard to peaceful nuclear activities, the Antarctic Treaty imposes limits rather than total prohibitions. According to Article V, "any nuclear explosions in

Antarctica and the disposal there of radioactive waste material shall be prohibited." The prohibited "nuclear explosions" can be attributed to both military and civilian purposes. The Comprehensive Nuclear Test Ban Treaty (CTBT) signed in 1996 prohibits all types of "nuclear explosions." Despite the fact that the CTBT has not yet entered into force, no nuclear tests for peaceful purposes have been recorded since its signature.[4]

The ban in Article V of the 1959 Treaty on "radioactive waste disposal" also limits full-fledged nuclear activities in Antarctica since they require handling of nuclear waste. In practice, there are only a few known cases involving nuclear facilities in Antarctica. One well-documented case involved the deployment of a portable nuclear reactor at McMurdo Station, the largest US research base in Antarctica, from 1962 to 1972. During the 10 years of its operation, the McMurdo nuclear power plant produced electricity amounting to 1.8 MW as well as steam to operate a desalination plant for the production of freshwater in the amount of 14,000 gallons per day. To implement the Antarctic Treaty's provisions on radioactive waste, an extensive effort was undertaken to remove the reactor and tons of waste to the continental USA.[5]

Another case deals with radioisotope thermoelectric generators, which were used as power sources for automatic meteorological and geophysical stations installed by Soviet Antarctic Expeditions in the 1970–1980s. In 2015, due to ecological and security concerns, Russia (in cooperation with the United States) removed these generators as well as ionizing radiation sources from Antarctica.[6]

Since then, no nuclear activities have been recorded in Antarctica. Still, it would be legally acceptable to deploy nuclear-related technologies in the region, for medical purposes for example. Also, there is no legal prohibition on the use of nuclear-powered icebreakers in the harsh ice conditions around Antarctica, especially for emergency rescue operations or for the delivery of large cargoes. But taking into consideration the general anti-nuclear context of the 1959 Treaty, even such limited uses of nuclear-related technologies would require additional considerations and consultations among the Antarctic Treaty Participating States, which must exchange "information on nuclear equipment and techniques" under the terms of a decision adopted at the First Antarctic Treaty Consultative Meeting in 1961.[7]

The contrast between the two polar regions in these terms is striking. Despite the efforts of those advocating a nuclear-weapons-free-Arctic, the region remains a theater of operations for nuclear-powered ships and manned bombers equipped with nuclear weapons. Over time, several Russia-US Strategic Arms Reduction Treaties have restricted the numbers of nuclear weapons in their arsenals and limited their types. But they have not imposed geographical restrictions on the deployment of nuclear weapons, so there are no legal or political limits on the deployment of nuclear weapons and their carriers in the Arctic.

The Arctic also is saturated with civilian nuclear facilities, bringing benefits for regional economic and social development as well as risks of accidents and concerns for security.

Since 1954 when the world's first nuclear power plant came on stream in Obninsk, Russia,[8] new atomic energy technologies have been introduced, including Generation 3+ nuclear power plants, nuclear-powered icebreakers, floating nuclear power units, and small modular reactors. Governments of the Arctic states play a dual role as both *promoters* and *regulators* of the peaceful uses of "the atom tamed" (when large amounts of energy are produced by a chain reaction). Prominent accidents, such as the Three Mile Island nuclear disaster in the United States in 1979, the Chernobyl nuclear disaster in Ukraine in 1986, and the Fukushima disaster in Japan in 2011, have generated opposition to civilian uses of nuclear power. But they have not stopped the global pace of peaceful nuclear activities.

Today, the Arctic is home to dozens of nuclear reactors, nuclear storage facilities, nuclear waste depositories, nuclear research reactors, sea ports for handling nuclear materials, along with nuclear objects and materials dumped at sea in the past. Nuclear-powered icebreakers make use of Arctic waters.

As the largest Arctic country, with five million km^2 of the Arctic's landmass and over 40% of its human residents, Russia has the region's most extensive nuclear infrastructure. In the Russian Arctic, there are three operational nuclear power plants. In the Northwest European part of Russia, there are four nuclear power units in operation on the Kola Peninsula. They were upgraded to extend their operating lifespan to 2033–2034 for units 1 and 2, and 2041–2044 for units 3 and 4. In the eastern part of the Russian Arctic, three units of the Bilibino nuclear power plant are in service. They will be shut down, tentatively, in 2025. Their capacities are being replaced by the world's first floating nuclear power plant "Akademik Lomonosov," which was registered in 2020 in Pevek in Chukotka. There are plans to install another floating nuclear plant in Vilyuchinsk in Kamchatka. Projects are also under development for a transportable land-based small modular reactor at Ust-Kuyga in Yakutia.[9]

In addition, Russia is the only country that builds nuclear-powered icebreakers. These ships are indispensable for navigation in thick ice when conventional diesel icebreakers are ineffective. Advantages of nuclear-powered icebreakers are their capacity to break ice up to three meters thick, navigate without refueling for several months, and thus prolong navigation along the Northern Sea Route (NSR) for up to ten months of the year. In 2020, cargo traffic along the NSR reached 33 million tones. Today Russia employs three Arktika-class large nuclear-powered icebreakers: Yamal and 50 Years of Victory (50 MW each) and Arktika (60 MW). Two smaller nuclear-powered icebreakers – Taimyr and Vaygach (35 MW each) – are designed for shallow waters. Sevmorput (30 MW), a nuclear-powered container ship, is used for the delivery of heavy cargoes. The icebreakers' home-port is ice-free Murmansk. A new class of even stronger nuclear-powered icebreakers (Lider-class at 120MW) is coming on stream, tentatively in 2027.[10]

Novaya Zemlya, a Russian archipelago located between the Barents and the Kara Seas, was used during 1955–1990 as a test range for 135 nuclear weapons explosions. Two "peaceful" nuclear detonations were conducted in 1972 and 1984 in the mountains of the Kola Peninsula for the extraction of apatite ore.[11] In 1991 Russia declared a moratorium on all nuclear tests. Russia signed the Comprehensive Nuclear-Test-Ban Treaty in 1996 and ratified it in 2000.[12]

In the Arctic part of the United States, by contrast, there are no operating nuclear power plants. Alaska's first and so far only nuclear power facility was a medium-sized nuclear reactor used by the US Army at Fort Greely in Fairbanks. It was shut down in 1972 after ten years of operation. The reactor's uranium fuel and nuclear waste were shipped out of Alaska, but some radioactive waste and radioactive parts of the reactor were encased in concrete at the site. In 2021, the United States published plans to dismantle this facility entirely.[13] In 1958, the US Atomic Energy Commission initiated Project Chariot, a plan to construct an artificial harbor in Alaska by burying and detonating five nuclear devices. The project was cancelled after several years due to opposition from Indigenous and environmental groups.[14]

Camp Century, an American scientific as well as a military research base in Greenland, operated from 1959 until 1967 and was powered by a nuclear reactor. The reactor was removed, but hazardous waste left at the site remains an environmental concern because of the melting ice.[15]

None of the other Arctic states operates nuclear reactors in their Arctic zones, though several of them operate reactors or other nuclear facilities close to the Arctic. Finland has 4 nuclear reactors; two more are under construction.[16] Sweden has 6 nuclear power plants with 10 units; 6 reactors are undergoing decommissioning. Sweden also operates a Westinghouse fuel fabrication plant that produces about 400 tons of nuclear fuel per year.[17] Although about 15% of Canada's electricity comes from nuclear power, all reactors are located in southern (non-Arctic) parts of the country.[18] Norway had four nuclear research reactors. They are now shut down, but their decommissioning will take 20–25 years.[19]

Finland and Sweden use underground storage facilities for spent nuclear fuel and radioactive waste. Russia's strategy in this regard differs in some ways. Russia aims not to store spent fuel indefinitely, but to reprocess it. There is a key difference in this context between spent nuclear fuel and radioactive waste. Spent fuel can be reprocessed by extracting the unburnt uranium and its by-product plutonium and using them for the production of the fresh fuel. Radioactive waste, by contrast, is a useless and harmful substance. Russia is able to burn some radioactive waste using radiation-release-free technologies. Most other countries prefer to store both spent fuel and radioactive waste in depots.

The spent fuel from the Kola reactors is sent to the Mayak Chemical Combines in the Urals for reprocessing. Some amount of the enriched uranium extracted from the spent fuel yields fresh fuel for nuclear power plants. Some plutonium is blended in the MOX fuel to be "burned" in Russia's "fast-neutron/breeder reactors," which are presumed to be the world's next generation of advanced nuclear reactors. Enriched uranium and its by-product plutonium are potential nuclear-weapon proliferation risks. Reprocessing of spent fuel mitigates such risks.[20]

Several Arctic states are producers of uranium, including at sites in their northern territories. Controversies over uranium mining have become politically controversial in several cases. The Government of Nunavut in Canada endorsed uranium mining "for peaceful and environmentally responsible purposes" in 2012. In recent years, however, local authorities have debated a revision of this policy due to ecological concerns, among them the "impact of uranium mining on caribou."[21] In 2021, Greenland's parliament passed legislation that will ban uranium mining and terminate development of the Kuannersuit mine, one of the biggest rare earth deposits in the world.[22]

Due to concerns about safety, some countries have resolved to add a phase-out of nuclear power to their commitments to reduce and ultimately eliminate energy produced from the combustion of fossil fuels as a response to the threat of climate change. In the wake of the 2011 Fukushima disaster, for example, Japan remains reluctant to return to the use of nuclear power on a large scale. Germany has responded by adopting a policy calling for reliance on alternative energy sources. But there is no reason to conclude that efforts to address the problem of climate change will lead to a significant reduction in the production of nuclear energy overall. In fact, it is equally likely that the role of nuclear energy will increase as a source of power that is attractive precisely because it does not produce emissions of greenhouse gases. As a recent example, the European Union Executive Commission has issued a proposal to member states to include nuclear power and natural gas in its green "taxonomy" in designating sectors favorable to achieving carbon neutrality.[23] In the Arctic, developments relating to small modular reactors (SMRs) are making nuclear power particularly appealing. SMRs have the potential to replace diesel generators that are costly and significant sources of greenhouse gas emissions in remote Arctic communities.

3 The nuclear safety and security agenda

In thinking about nuclear safety and security in the Arctic, it is helpful to differentiate between several categories of issues that give rise to needs for governance and present opportunities for cooperation at different levels.

Nuclear and radiological accidents. No notable accidents at nuclear power plants or storage facilities have been recorded in or around the Arctic. However, some radioactive leaks from the nuclear icebreakers' reactors have resulted in their emergency dumping.[24] Several accidents involving military hardware have occurred. In 1968, an American B-52 bomber carrying four hydrogen bombs crashed near Thule Air Force Base in northern Greenland. Efforts to retrieve the bombs were not entirely successful, and concerns about radioactive contamination remain.[25] In 2000, the nuclear-powered Russian submarine K-141 (Kursk) sank in the Barents Sea as a result of an explosion in the torpedo compartment, with the loss of all its

118 sailors.[26] The submarine's nuclear reactors were not damaged and were later recovered. The Kursk did not carry nuclear weapons.

As a matter of governance, the issue of nuclear accidents raises issues of emergency prevention, preparedness, and response. While it is not possible to eliminate the possibility of nuclear accidents, it is relevant to consider imposing regional safety standards to minimize the potential of nuclear accidents. Beyond that, we can take steps in advance to enhance the promptness and effectiveness of response measures in the wake of a nuclear accident. What arrangements are needed both to ensure prompt notification of others who may be harmed by radioactive contamination generated by an accident and to minimize lasting harm to humans and the environment resulting from a nuclear or radiological accident?

Nuclear fuels and radioactive waste. Dealing with spent nuclear fuel is a major challenge with regard to both nuclear-powered ships and nuclear power plants. Basically, there are two options: reprocessing and waste disposal, taking into account that some nuclear waste will remain radioactive for centuries. The fact that there are no fully affordable methods for disposing of nuclear waste has long been a focus of opposition to increased reliance on nuclear energy. If anything, this problem is intensified in the Arctic where the environment is fragile and there are limited repositories for nuclear waste. Is it feasible to develop reprocessing facilities in the Arctic? Is it preferable to send nuclear waste to sites outside the Arctic for long-term storage?

Cleanup of radioactive sites. A third cluster of issues encompasses matters relating to cleaning up radioactive sites, especially those involving former Soviet military nuclear facilities. After the collapse of the Soviet Union, Russia dramatically reduced its military operations in the Arctic. As a result of the quick move from socialist to capitalist institutions during Yeltsin's presidency in the 1990s, Soviet nuclear infrastructure, including spent nuclear fuel, solid and liquid radioactive waste, and even nuclear submarines, was abandoned without proper precautions. To address this problem, a large Global Partnership (GP) Program of Western donors arose at the beginning of the 2000s to provide financial and technical assistance to the Russian Government to reduce its Soviet "nuclear legacy."[27] The GP helped Russia to dispose of all its 198 decommissioned nuclear submarines, handle safely spent nuclear fuel and radioactive waste, and clean up some of the relevant sites. Currently, international nuclear rehabilitation programs in the Arctic region of Russia are gradually coming to an end. By 2028, according to current plans, three more nuclear submarines, four nuclear icebreakers, and four support vessels will be dismantled. Tentatively, all work will be concluded by 2030–2032.[28] The GP and the European Union's Northern Dimension Environmental Partnership projects have successfully contributed to the improvement of environmental quality in the Arctic region and reduced the danger of radiological contamination in Arctic waters.[29]

Dumped radioactive contaminants. An even more acute problem is the fate of a large mass of dumped nuclear facilities and materials in the northwestern Russian Arctic. These include ~17,000 containers with solid radioactive waste, 16 nuclear reactors from submarines and icebreakers, and two dumped nuclear-powered submarines containing reactors (K-278 in 1989 in the Norwegian Sea and K-159 in 2003 in the Barents Sea). During 2020–2023, four Russia-Norway expeditions have been planned to analyze the seabed of the Russian Arctic to evaluate the most dangerous nuclear sites. The expeditions will determine next steps: either to lift some of these objects or, in the case of an ecological threat, to conserve them.[30]

In 2020, the President of the Russian Federation signed a Decree adopting a new Strategy for the Development of the Arctic. The Strategy anticipates "completion of the rehabilitation of areas of flooded and sunken facilities with spent nuclear fuel and radioactive waste."[31]

Nuclear security. In addition to these four major sets of concerns about nuclear safety, there are potential issues pertaining to nuclear security, including nuclear terrorism in the Arctic and unauthorized uses of various types of malware to compromise the security of both military and civilian systems involving nuclear energy. So far, no illegal activities in the Arctic regarding nuclear materials and facilities have been recorded. National authorities regularly conduct domestic or international exercises at nuclear power plants and other nuclear facilities to maintain their physical protection and counter-terrorism response procedures. The Russian Strategy for the Development of the Arctic provides for the "prevention of extremist and terrorist activities." Regional cooperation among the Arctic states on nuclear security, including cyber security of key nuclear infrastructure, should be a matter of common interest in the Arctic.

4 International law relevant to Arctic nuclear safety and security

All the Arctic states have domestic regimes in place dealing with matters of nuclear safety and security. So far, there have been no reports of serious accidents at civilian nuclear installations in the Arctic. But this does not eliminate the need for international agreements in this area. All the Arctic states are parties to the key international conventions that contribute to nuclear safety and security and to nuclear non-proliferation.

The universal environmental and maritime conventions provide an initial set of general principles and rules that are applicable to interstate relations and that are relevant to nuclear and radiological safety in the Arctic.

The 1958 *Convention on the High Seas* provides a general obligation on the part of the parties "to prevent pollution of the seas from the dumping of radioactive waste taking into account any standards and regulations which may be formulated by the competent international organizations" (Art. 25).[32] But it does not establish any specific governance mechanism.

Article 23 of the 1982 *UN Convention on the Law of the Sea* (UNCLOS) contains a brief reference to the transportation of nuclear substances and is relevant to innocent passage only: "Foreign nuclear-powered ships and ships carrying nuclear or other inherently dangerous or noxious substances shall, when exercising the right of innocent passage through the territorial sea, carry documents and observe special precautionary measures established for such ships by international agreements." The Convention further states that in the event of a "substantial discharge" in the Exclusive Economic Zone (EEZ) causing or threatening "significant pollution of the marine environment," the coastal state may undertake physical inspection of the vessel in the EEZ if the vessel has refused to provide the relevant information or has given manifestly incorrect information (Art. 220, para. 5). Needless to say, nuclear waste discharge or accidents with nuclear-powered ships might cause "significant pollution of the marine environment," especially in Arctic waters. Where a coastal state has prescribed national anti-pollution regulations for ice-covered areas in its EEZ authorized under the terms of Article 234 of UNCLOS, it may also enforce such regulations.[33] Unlike oil, "radioactive wastes are not biodegradable, nor is there any possibility of removing them from the sea once they have entered it. These substances … are absorbed by marine organisms, often becoming concentrated as they move up the food chain… In some cases, it is unsafe for humans to eat fish containing these substances."[34]

UNCLOS Part XII on "Protection and Preservation of the Marine Environment" provides for cooperation directly applicable to the Arctic in such aspects as "measures to prevent, reduce and control pollution of the marine environment" (Article 194). Although Part XII does not include specific rules to prevent nuclear or radioactive pollution, Article 194 para. 3 specifies that such measures "shall deal with all sources of pollution of the marine environment." In this regard, UNCLOS promotes cooperation "on a global basis and, as appropriate, on a regional basis, directly or through competent international organizations, in formulating and elaborating international rules, standards and recommended practices and procedures" (Article 197). UNCLOS lists preferable components of such cooperation including notification of imminent or actual damage (Article 198), contingency plans against pollution (Article 199), and monitoring and environmental assessment (Section 4).[35]

Under the *1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter* (the London Convention), Contracting Parties pledge to "take all practicable steps to prevent the pollution of the sea by the dumping of waste and other matter that is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea." Annex I of the Convention contains a list of substances the dumping of which is fully prohibited, including "radioactive wastes or other radioactive matter." In 1996, the parties adopted the "London Protocol" to modernize the Convention and, eventually, replace it. Under the Protocol, which entered into force in 2006, all dumping is prohibited, except (possibly) for acceptable wastes on the so-called "reverse list."[36]

The 1973 *International Convention for the Prevention of Pollution from Ships* (MARPOL Convention) provides rules to deal with pollution of the sea from ships, other than from dumping. Pollution standards are set in Annexes to MARPOL. Annex III on harmful substances carried by sea in packaged forms might be interpreted as applicable to nuclear waste carried by sea in containers.[37]

The 1974 *International Convention for the Safety of Life at Sea* (SOLAS) contains Chapter VIII on nuclear ships, which specifies basic requirements for nuclear-powered ships and is particularly concerned with radiation hazards.[38] It refers to the detailed and comprehensive voluntary Code of Safety for Nuclear Merchant Ships adopted in 1981.[39]

In 1993, the International Maritime Organization (IMO) introduced another voluntary *Code for the Safe Carriage of Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships* (INF Code), complementing the International Atomic Energy Agency's regulations. The Code contains recommendations for the design of ships transporting radioactive material and addresses such issues as stability after damage, fire protection, and structural resistance. In 2001, the INF Code was made mandatory and renamed the *International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Waste on Board Ships.*[40]

The Arctic States adhere to the IMO's *International Code for Ships Operating in Polar Waters* (Polar Code), which is mandatory under both SOLAS and MARPOL. The Polar Code entered into force in 2017, and covers the full range of design, construction, equipment, training, search and rescue, and environmental protection matters relevant to ships operating in the inhospitable waters surrounding the poles.[41]

The Arctic States also participate in a number of international agreements on civil liability for nuclear damage that ensure compensation for such damage, including transboundary damage, caused by a nuclear incident at a nuclear installation or in the process of transportation of nuclear material. The rules on nuclear liability are included in several different international conventions that share similar principles but establish different criteria regarding definitions, amounts and duration of liability. The 1960 *Paris Convention on Third Party Liability in the Field of Nuclear Energy* is open for OECD members only (among Arctic states, Denmark, Finland, Norway, and Sweden are Parties). The 1963 *Vienna Convention on Civil Liability for Nuclear Damage* (Russia is a Party) and the 1997 Protocol to amend it are open to all UN members. The 1997 *Convention on Supplementary Compensation for Nuclear Damage* unites, among others, the USA and Canada. This lack of integration among the liability instruments may cause certain inconsistencies in the practical implementation of rules of compensation for nuclear damage in the Arctic.[42]

As for specific legal norms and technical measures to ensure safe operation of nuclear facilities and handling of nuclear materials, the nuclear safety normative cluster is based on the following key international conventions.

The 1994 *Convention on Nuclear Safety* commits Contracting Parties that operate land-based civilian nuclear power plants to maintain a high level of safety by establishing fundamental safety principles. The Convention's focus is on the "legislative, regulatory and administrative measures and other steps" that should be taken at the national level to implement obligations under the Convention (Chapter 2, Article 4). The Convention does not specify corresponding options for international cooperation, except for review meetings of the contracting parties and submitting national reports on the implementation of their obligations for "peer review" at meetings at IAEA headquarters.[43]

The 1997 *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management* establishes fundamental safety rules, creating a "peer review" process similar to that established under the 1994 *Safety Convention*. But it does not specify other international cooperation procedures. The 1997 Convention provides for a regime covering spent fuel resulting from the operation of civilian (but not military) nuclear reactors.[44]

The 1986 *Convention on Early Notification of a Nuclear Accident* and its sister 1986 *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency* emerged as an international legal response to the Chernobyl nuclear plant accident. The *Early Notification Convention* establishes a notification system for nuclear accidents when a release of radioactive material occurs (or is likely to occur) and has resulted (or may result) in an international transboundary release affecting other states. It requires states to report an accident's time, location, nature, and other data essential to assess the situation. Notification must be made to affected states directly, or through the IAEA, and to IAEA itself.[45]

The 1986 *Assistance Convention* sets out an international framework for cooperation to facilitate prompt support in the event of a nuclear accident or radiological emergency. It requires states to notify the IAEA of their available experts, equipment, and materials for providing assistance.[46]

What seems important for our purposes is that both 1986 Conventions encourage creating other bilateral or multilateral arrangements addressing nuclear accidents. Both Conventions provide that States Parties may consider the conclusion of bilateral or multilateral arrangements. This means that the Arctic States may find it appropriate to develop a regional arrangement on preventing nuclear accidents in the Arctic and minimizing the consequences of such accidents. Such a regional arrangement would be *lex specialis* in relation to the 1986 Conventions.

In fact, some Arctic States have gone even further in terms of nuclear and radiological safety cooperation in the Arctic. For example, as a follow-up to the 1986 Convention on Early Notification of a Nuclear Accident, Russia has signed relevant bilateral agreements with the Scandinavian countries on early notification of a nuclear accident and the exchange of information on nuclear installations: with Sweden in 1988, updated 2919; with Norway in 1992, updated in 2020; with Finland in 1995, updated in 2016. These agreements cover existing nuclear power plants and those under construction; nuclear reactors in ships; fresh and spent nuclear fuel storage facilities; research reactors, and other nuclear installations located throughout the territories of Sweden, Norway and Finland, respectively. On the Russian side, the Agreement covers nuclear facilities on the territory of the Kaliningrad Region as well as those situated at a distance of up to 300 kilometers from the western border of the Russian Federation in the Northwest, including nuclear power plants in the Kola and Leningrad regions.[47]

The nuclear security cluster includes legal norms and technical measures to prevent, detect and respond to criminal, terrorist and other unlawful acts involving nuclear or radioactive material and facilities. Such legal norms are provided, first and foremost, in the *Convention on the Physical Protection of Nuclear Material and Nuclear Facilities* as amended in 2005. The early version of the Convention, which entered into force in 1987, established physical protection measures to be applied to nuclear material in international transit as well as counter-measures against criminal offenses related to nuclear material. A 2005 amendment to the Convention, which entered into force in 2016, broadened the scope of the Convention by including the protection of domestic nuclear facilities and their material. It also anticipates expanded nuclear security cooperation regarding rapid actions to locate and recover stolen or smuggled nuclear material, mitigate radiological consequences of sabotage, and prevent and counter related offenses. Taking into account increases in shipping in the Arctic, the practical significance of this legal agreement is growing. While the Convention does not provide for an international mechanism, its focus on nuclear security measures makes it relevant to the Arctic.[48]

All the Arctic States are parties to the 2005 *International Convention for the Suppression of Acts of Nuclear Terrorism.* This convention covers, *inter alia*, offenses relating to the unlawful and intentional possession and use of radioactive material or radioactive devices and the unlawful use of or damage to nuclear facilities. The 2005 Convention promotes cooperation through information sharing and assistance for investigations and extraditions, which may well be relevant to the Arctic.[49]

All Arctic states cooperate closely with the International Atomic Energy Agency and are parties to the 1968 *Nuclear Non-Proliferation Treaty*.[50]

5 Adapting international law to the Arctic setting

This broad array of multilateral conventions coupled with bilateral legal instruments may seem to meet general expectations of the Arctic states regarding nuclear safety and security. But considering that nuclear activities in the Arctic are likely to increase and that environmental concerns associated with the consequences of melting ice and thawing permafrost are rising, further improvements of the legal basis of governance of nuclear activities at the regional level may be appropriate. The prospect that radioactive contaminants from external sources may penetrate the Arctic reinforces this observation. For example, radioactive cesium-134 was found in waters north of Alaska in 2020, having migrated apparently from the damaged Fukushima-1 nuclear power plant.[51]

Nuclear safety and security issues are already on the agendas of some Arctic regional intergovernmental bodies. For example, the Barents Euro-Arctic Council (BEAC), an intergovernmental forum of Denmark, Finland, Iceland, Norway, Russia, Sweden, and the European Union concentrates on sustainable development issues of that particular region.[52] The Northern Dimension, a policy framework for cooperation among the European Union, its Member States, and northern partner countries including Iceland, Norway and Russia, aims to address risks associated with the Soviet-era nuclear legacy in Northwest Russia.[53]

That said, the Arctic Council is undoubtedly the primary forum for enhanced cooperation on nuclear safety and security in the Arctic. The Council is the leading regional intergovernmental forum in the Arctic, including the eight Arctic States as members together with Indigenous peoples organizations as Permanent Participants, and non-Arctic actors as Observers. The Council promotes cooperation, coordination and interaction across the Arctic regarding issues of sustainable development and environmental protection through the activities of six Working Groups.[54] Its Working Group on Emergency Prevention, Preparedness and Response (EPPR) deals with environmental emergencies including radiological and nuclear incidents in the Arctic. EPPR maintains a "cross countries" cooperation network to improve emergency prevention, response, and the safety of rescue workers in the case of a maritime accident involving any potential release of radioactive substances in the Arctic. The network conducts regular meetings and undertakes specific activities, such as technical workshops, joint exercises and inter-sessional work. Several exercises have already been conducted on search and rescue operations in radiological hazardous environments at sea and on radiological emergency scenarios in the Arctic.[55]

In January 2021, EPPR issued two reports on nuclear issues. The *EPPR Consensus Report: The Radiological/Nuclear Risk Assessment in the Arctic* identifies radiological/nuclear materials and activities that may impact the Arctic within the next ten years, and uses scenarios to assess the risks associated with potential emergencies.[56] The *RADSAR Report: Sharing of Competence within Search and Rescue in a Maritime Radiological/Nuclear Scenario* aims to identify possible challenges and ways to improve national and international emergency preparedness and response related to search and rescue operations in a radiological hazardous environment in the Arctic. This effort focuses on international cooperation including notification, information exchange and situational awareness, resource needs and utilization, international assistance, protective measures, and possible harmonization of decisions.[57]

It is not surprising, then, that the 2021 Reykjavik Declaration on the Occasion of the 12th Ministerial Meeting of the Arctic Council "noted with satisfaction the cooperation to share knowledge and experience of preparedness and response to accidents and threats from the release of radionuclides, [and] welcomed the establishment of an expert group on radiation… to examine related risks, including with regard to nuclear waste, and mitigation measures."[58] The Arctic Council Strategic Plan 2021–2030 also adopted at the 2021 ministerial meeting "encourage[s] actions at all levels to address pollutants and hazardous and radioactive substances, that affect human health and the environment in the Arctic and raise Arctic inhabitants' awareness of these issues as appropriate."[59]

Depending on the trajectory and pace of developments relating to nuclear activities in the Arctic in the coming years, this account suggests that it may make sense to consider crafting a regional agreement on Arctic nuclear safety and security. The rationale for such an arrangement would parallel the experience with the 2011 *Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic*,[60] which features a regional application of the general provisions set forth in the 1979 *International Convention on Search and Rescue*,[61] and the 2013 *Agreement on Cooperation on Marine Oil Pollution, Preparedness, and Response in the Arctic*,[62] which adapts the broader provisions of the 1990 *International Convention on Oil Spill Preparedness, Response, and Cooperation*.[63] These are legally-binding agreements whose provisions were developed through the efforts of Arctic Council Task Forces co-led by Russia and the United States.

If the case for an Arctic nuclear safety and security agreement becomes convincing, a logical step would be to create a Council task force to consider what should go into such an agreement. At this writing, the EPPR Radiation Expert Group (EPPR RAD EG) is working to articulate the case for such an agreement.[64]

The focus of this agreement would be a regional governance mechanism on Arctic safety and security. The agreement could identify competent national authorities in the Arctic states responsible for monitoring and regional information sharing in the event of a nuclear/radiological emergency. The agreement could also provide protocols for joint emergency actions in the event of a nuclear or radiological accident. A joint reserve of equipment, radiation detectors, medical supplies and other required materiel for rescue assistance in the severe Arctic conditions would be appropriate. Each Party would take responsibility for maintaining its contribution to this reserve, which should be stand-by ready for a joint emergency response. Regular joint exercises based on scenarios regarding matters of nuclear security would be appropriate. In addition, the agreement could provide for the exchange of experienced specialists and relevant technologies and know-how as well as addressing financial and logistical matters.

A regional agreement could charge the Arctic Council's EPPR Working Group with assessing previous experience relevant to this effort and preparing a road map for implementing the terms of the agreement. The road map should identify (a) options for constant emergency monitoring, (b) procedures for information sharing, (c) the elements of a joint pool of emergency assistance facilities, (d) national material contributions to be provided to the pool, and (e) protocols for command and control in emergency assistance operations.

As we observed in the Introduction, however, the feasibility of moving forward with any effort along these lines will be subject to the prospects for resuming the work of the Arctic Council in the aftermath of the Ukraine crisis. The crisis does not alter the logic of the argument we have developed in this section. If anything, events in Ukraine have reinforced the concern about issues of nuclear safety and security in the Arctic. At the same time, it is apparent that the crisis will disrupt efforts to address specific issues through the activities of the Council for some time to come and may well lead to significant changes in the practices of the Council as the Parties endeavor to devise "necessary modalities" governing the work of this body in the future. Under the circumstances, a wait-and-see perspective on any specific prospects for addressing issues of nuclear safety and security in the Arctic is in order for the near future.

6 Implementation: Moving from paper to practice

International agreements are seldom self-executing. Arrangements pertaining to nuclear safety and security in the Arctic are no exception. Particular organizations and infrastructure needed to implement agreements effectively will vary depending on the exact nature of the arrangements in question. Here, we initiate a consideration of this topic by identifying some of the major issues likely to arise in this context.

With regard to the problem of nuclear accidents at sea, it would make sense to consider applications of requirements under the Polar Code and the Code of Safety for Nuclear Merchant Ships. Such requirements would include the development of certification procedures and compliance mechanisms in a manner similar to the implementation of the safety provisions of the Polar Code applicable to commercial vessels operating in Arctic waters.

If and when accidents do occur, issues of search and rescue and prompt notification come into focus. A relevant question concerns the extent to which the Arctic Coast Guard Forum, created pursuant to the 2011 Search and Rescue Agreement, could play a constructive role in this context. The critical issue with regard to notification centers on monitoring the dispersal of radioactive fallout associated with nuclear accidents. Although some existing facilities (e.g. those located at Ny Ålesund on Svalbard) may be useful in this connection, it seems likely that tracking the dispersal of radioactive fallout in the Arctic would require the development of new facilities.

In the case of issues relating to nuclear and radiological safety, an important question is the fate of radioactive waste and spent nuclear fuel. Much of the opposition to nuclear power centers on controversies relating to options for the disposal of radioactive waste. There is little prospect that these controversies will be resolved in a generally satisfactory manner during the foreseeable future. As a result, the critical concern in this realm focuses on the prospects for safe handling of radioactive waste and reprocessing of spent nuclear fuel. What sorts of facilities would be needed to reprocess spent nuclear fuel used in the Arctic? Where might such facilities be located? Can they be operated efficiently?

Beyond this lies the issue of cooperative arrangements needed to clean up existing radioactive contaminants. The principal focus of attention to date has been on two major concerns in the Russian Arctic.

The first involves the rehabilitation of radioactive hazards resulting from Soviet military activities. Several international efforts have dealt with this challenge. The *Arctic Military Environmental Cooperation Program* (AMEC), launched in 1995 as a joint effort on the part of Russia, Norway, and the United States, developed into a mechanism to fund Russian efforts to deal with spent nuclear fuel and radioactive waste associated with the activities of the Northern Fleet.[65] "AMEC's goal was not only to mitigate the impact of radioactive waste on the fragile Arctic environment, but also to foster interaction and confidence between the militaries of the AMEC member states."[66] A more specific objective was to enhance and improve technical means for measuring and controlling radiation exposure of personnel, local populations, and sites of decommissioning and dismantlement of Soviet nuclear submarines, and for handling and disposition of spent nuclear fuel and liquid radioactive waste. This has involved the development, demonstration and installation of an automated centralized radiological monitoring system at the Russian service base for the fleet of nuclear-powered icebreakers. The system consists of fifteen monitoring points including detectors for gamma emissions, and radioactive particles present in the air and in water.[67]

In addition, a Working Group of the Arctic Council, the *Arctic Contaminants Action Programme* (ACAP) established in 2006, endeavors to prevent pollution of the Arctic environment and to reduce environmental, human health, and socio-economic risks, including those arising from radioactive contaminants.[68] Because ACAP lacks funding of its own, implementation of ACAP initiatives requires separate financial infrastructure.

A second even more pressing concern focuses on ways to retrieve or conserve dumped nuclear debris, including solid waste containers, reactors, and two submarines containing reactors located on the seafloor in the Barents and Kara Seas. The Arctic Council's EPPR could initiate a joint study on the assessment of methods and infrastructure needed to deal with dumped hazardous radioactive objects in Arctic waters.

If key elements of the Arctic nuclear safety and security regime prove effective, the problem of dealing with radioactive contaminants should decline over time. That is, once the legacy of the past is dealt with, new challenges may become less severe. Nevertheless, it is important to recognize that cleaning up radioactive contaminants in the Arctic is a challenging and costly proposition. The case for encouraging international cooperation to deal with this issue is compelling.

7 Conclusion

There is no denying the disruptive impact of the 2022 Ukraine crisis on all efforts to address Arctic issues, including nuclear safety and security, requiring international collaboration and preferably explicit cooperation. At this writing, it is impossible to anticipate either the timing or the nature of next steps in this realm. It is likely that it will be some time before the Arctic Council is able to resume anything approaching normal operations, and the Parties may decide to make significant adjustments in Council processes when it does become feasible politically to resume operations.

Nevertheless, it seems clear that the issue of Arctic nuclear safety and security will remain important during the foreseeable future. If anything, the intrusion of great-power politics into the Arctic is likely to intensify concern about this matter. Nuclear-powered ships, including military vessels and civilian icebreakers will continue to operate in the Arctic. There is a good chance that small modular reactors, including floating models, will be deployed in a number of Arctic communities. This means that there will be an ongoing need to address potential issues of nuclear accidents, spent nuclear fuel and waste, and radioactive contaminants, and to pay attention to the development of the organizational capacity and infrastructure to meet this need.

The general international agreements pertaining to nuclear safety apply to the Arctic as well as to other parts of the world. As in the cases of search and rescue and marine oil spills, however, there are good reasons to consider developing a region-specific arrangement to bring these agreements to bear on conditions prevailing in the Arctic and to supplement them to address Arctic-specific issues. Once the Arctic Council is able to resume operations, it may be able to play a constructive role in this regard, providing a venue in which those concerned with Arctic nuclear safety and security can negotiate specific elements that may go into a region-specific governance system.

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Conflict of interest

The authors declare no conflict of interest.

NOTES

1. Statement. 2022. "Arctic Council suspends operation over Ukraine situation – statement of 3 March 2022," https://en/interfax.news/general/806479.html (accessed 3 April 2022).
2. Antarctic Treaty. 1959. *Antarctic Treaty.* https://www.ats.aq/e/antarctictreaty.html (accessed 31 January 2022).

3. UN Office for Disarmament Affairs. "Nuclear-Weapon-Free Zones," https://www.un.org/disarmament/wmd/nuclear/nwfz/ (accessed 31 January 2022).
4. CTBT. 1996. *Comprehensive Nuclear-Test-Ban Treaty.* https://www.ctbto.org/fileadmin/content/treaty/treaty_text.pdf (accessed 31 January 2022).
5. Tyler, R. 2014. *Nuclear Power at McMurdo Station, Antarctica.* Stanford University, http://large.stanford.edu/courses/2014/ph241/reid2/ (accessed 31 January 2022).
6. Russia-U.S. 2015. "Removal of Radioisotope Thermoelectric Generators from the Antarctic," https://view.officeapps.live.com/op/view/aspx?src=https%3A%F%2documents.at.aq%2FATCM38%2Fip%FATCM38_ip068_e.doc&wdOrigin=BROWSELIN (accessed 31 January 2022).
7. ATCM. 1961. "First Antarctic Treaty Consultative Meeting," https://www.ats.aq/devAS/Meetings/Past/lang=e (accessed 31 January 2022.
8. Smith, S. 2017. *Obninsk Nuclear Power Plant.* Stanford University, http://large.stanford.edu/courses/2017/ph241/smith-sl/ (accessed 31 January 2022).
9. WNO. 2021b. *Nuclear Power in Russia.* World Nuclear Association. https://www.world.nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx (accessed 31 January 2022).
10. *Ibid.;* Rosatom 2020. *Annual Public Report.* https://report.rosatom.ru/655 (accessed 31 January 2022).
11. "Soviet/Russian Nuclear Weapons Program." 23 Dec. 2021. http://www.atomicforum.org/russia/russia.html; Kola Ecological Center. March 30, 2019. https://kec.org.ru/organisation/histrory/ (accessed 31 January 2022).
12. UN Office for Disarmament Affairs. Comprehensive Nuclear-Test-Ban Treaty. https://treaties.unoda.org/t/ctbt (accessed 31 January 2022).
13. Ellis, T. 2021. *Army releases plan to get rid of Alaska's first and only nuclear power plant.* https://www.ktoo.org/2021/03/05/nearly-50-years-after-it-was-shut-down-army-releases-planto-get-rid-of-alaskas-first-and-only-nuclear-power-plant/ (accessed 31 January 2022).
14. Hacket, J. 2015. *Actual 1950s Proposal: Nuke Alaska.* Atlas Obscura. https://www.atlasobscura.com/articles/actual-1950s-proposal-nuke-alaska (accessed 31 January 2022).
15. Colgan, J. And W. Colgan. 2016. "Melting Ice Threatens to Expose Former U.S. Nuclear Base in Greenland," Wilson Center, New Security Beat https://www.newsecuritybeat.org/2016/10/melting-ice-threatens-expose-u-s-nuclear-base-greenland/ (accessed 31 January 2022).
16. WNO. 2021a. *Nuclear Power in Finland.* World Nuclear Association. https://www.world-nuclear.org/information-library/country-profiles/cpuntries-a-f/finland.aspx (accessed 31 January 2022).
17. WNO. 2021c. *Nuclear Power in Sweden.* World Nuclear Association. https://www.world-nuclear-org/information-library/country-profiles/countries-o-s/sweden.aspx (accessed 31 January 2022).
18. WNO. 2021. *Nuclear Power in Canada.* World Nuclear Association. https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/canada-uranium.aspx (accessed 31 January 2022).
19. World Nuclear News. Norway considers future of Halden research reactor. 30 April 2018. https://www.world-nuclear-news.org/Articles/Norway-considers-future-of-Halden-research-reactor (accessed 31 January 2022).
20. WNO. 2021b. *Nuclear Power in Russia.* World Nuclear Association. https://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power-aspx (accessed 31 January 2022); Rosatom. 2021. *Annual Public Report.* https://report.rosatom.ru/655 (accessed 31 January 2022).

21. Government of Nunavut Uranium Policy Statement. 2012. http://www.uranium.gov.nu.ca/; Nunavut should revisit uranium policy, says legislator. November 6, 2020. https://www.arctictoday.com/nunavut-should-revisit-uranium-policy-says-legislator/?msclkid=1b4cddcfb1bd11ec8e950b7b5345e204 (accessed 31 January 2022).
22. Reuters. 2021. "Greenland bans uranium mining" https://www.reuters.com/world/americas/greenland-bans-uranium-mining-halting-rare-earths-project-2011-11-10/ (accessed 31 January 2022).
23. EU Commission. 2021. «EU Commission proposes including gas, nuclear as clean energy sources» https://ec.europa.eu/commission/presscorner/detail/en/ip_22_2 (accessed 31 January 2022).
24. Atomic Energy. 2020. "Russia prepares to eliminate the Soviet atomic legacy." https://www.atomic-energy.ru/SMI/2020/08/10/106166 (accessed 31 January 2022).
25. Greenwald. J. (2021). "1968 Thule Air Base B-52 Crash with 4 Hydrogen Bombs on Board," https://www.theblackvault.com/documentarchive/1968-thule-air-base-b-52-crash-with-4-hydrogen-bombs-on-board/ (accessed 31 January 2022).
26. Burleson, C. 2002. *Kursk Down*. Warner Books.
27. Kobyakov, D. And V. Orlov. 2005. "The G8 Global Partnership on Weapons of Mass Destruction: What Next?" GCSP Occasional Paper Series, No. 47, https://mail.pircenter.org/media/content/files/11/13649723990.pdf (accessed 31 January 2022).
28. Rosatom. 2020a. "Rosatom discussed the issue of handling objects dumped in the Arctic seas," https://www.atomic-energy.ru/news/2020/01/30/101036 (accessed 31 January 2022).
29. EU Commission. 2021a. "Joint Communication to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of Regions. A Stronger EU engagement for a peaceful, sustainable and prosperous Arctic," https://eeas.europa.eu/sites/default/files2_en_actpart1_v7.pdf (accessed 31 January 2022).
30. Atomic Energy. 2021. "Norway and Russia are pleased with their cooperation on nuclear and radiation safety," https://www.atomic.energy.ru/news/2021/06/18/114878 (accessed 31 January 2022).
31. President of Russia. 2020. *Strategy for the development of the Arctic zone of the Russian Federation and ensuring national security for the period up to 2035.* http:/en.kremlin.ru/acts/news/64274 (accessed 1 June 2021).
32. Convention on the High Seas. 1958. *United Nations Convention on the High Seas.* https://legal-tools.org/doc/7b4abc-1/pdf/ (accessed 7 April 2022).
33. UNCLOS. 1982. *United Nations Convention on the Law of the Sea.* https://www.un.org/depts/los/convention_agreements/texts/unclos/closindx.htm (accessed 31 January 2022).
34. Churchill, R.R. and A.V. Lowe. 1999. *The Law of the Sea.* 3rd. ed. Manchester University Press: Manchester, UK., 331.
35. UNCLOS. 1982. *United Nations Convention on the Law of the Sea.* https://www.un.org/depts/los/convention_agreements/texts/unclos/closindx.htm (accessed 31 January 2022).
36. London Convention. 1972. *Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.* https://imo.org/en/OurWork/Environment/Pages/London-Convention-Protocol.aspx (accessed 31 January 2022).
37. MARPOL. 1973. *International Convention for the Prevention of Pollution from Ships.* https://imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx (accessed 31 January 2022).
38. SOLAS. 1974. *International Convention for the Safety of Life at Sea.* https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Safety-of-:ife-at-Sea-(SOLAS)-1974.aspx (accessed 31 January 2022).
39. Code for Merchant Ships. 1981. *Code of Safety for Nuclear Merchant Ships,* International Maritime Organization, A.491(XII), 19 November 1981. https://wwwcdn.imo.org/

localresources/en/KnowledgeCentre/IndexfIMOResolutions/AseeblyDocuments/A491(12).pdf (accessed 31 January 2022).

40. Code for Safe Carriage. 2001. *International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Waste on Board Ships.* https://www.imo.org/en/OurWork/Safety/Pages/INF-Code.aspx (accessed 31 January 2022).
41. Polar Code. 2017. *International Code for Ships Operating in Polar Waters.* https://www.imo.org/ed/MediaCentre/HotTopics/Pages/polar-default.aspx (accessed 31 January 2022).
42. The IAEA. Nuclear liability conventions. https://www.iaea.org/topics/nuclear-liabiliy-conventions (accessed 31 January 2022).
43. Safety Convention. 1994. *Convention on Nuclear Safety.* https://www.iaea.org/topics/nuclear-safety-conventions/convention-early-notification-nuclear-accident (accessed 31 January 2022).
44. Joint Convention. 1997. *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.* https://www.iaes.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste (accessed 31 January 2022).
45. Early Notification Convention. 1986. *Convention on Early Notification of a Nuclear Accident.* https://iaea.org/publications/documents/infcircs/convention-early-notification-nuclear-accident (accessed 8 February 2022).
46. Assistance Convention. 1986. *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.* https://iaea.org/topics/nuclear-safety-conventions/convention-assistance-case-nuclear-accident-or-radiological-emergency (accessed 31 January 2022).
47. Early Notification Agreements. 2021. *Agreement Between the Government of the Russian Federation and the Government f the Kingdom of Sweden Amending the Agreement Between the Government of the Union of Soviet Socialist Republics and the Government of Sweden About the Early Notification of a Nuclear Accident and Exchange of Information on Nuclear Facilities of 13 January 1988.* https://www.mid.ru/ru/foreign_policy/international_contracts/international_contracts/2_contract/59228. For the parallel agreements with Norway see https://ria.ru/20150915/1253097011.html and Finland see http://atominfo.ru/newsso/v08.htm (accessed 31 January 2022).
48. Physical Protection Convention. 2005. *Convention on the Physical Protection of Nuclear Material and Nuclear Facilities as amended in 2005.* https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1275_web.pdf (accessed 31 January 2022).
49. Suppression of Nuclear Terrorism Convention. 2005. *International Convention for the Suppression of Acts of Nuclear Terrorism.* https://www-ns.iaea.org/downloads/conventions-codes-resolutions/suppression-of-terrorism-convention.pdf (accessed 31 January 2022).
50. Nuclear Non-proliferation Treaty. 1968. *Treaty on the Non-Proliferation of Nuclear Weapons (NPT)*. https://un.org/disarmament/wmd/nuclear/npt/text (accessed 8 February 2022).
51. Gura, E. 2020. "Radioactive cesium from Fukushima was found in the Arctic Ocean," https://news.mail.ru/society/49234420/?utm_partner_id=901 (accessed 31 January 2022).
52. BEAC. 2021. *The Barents Euro-Arctic Council.* https://www.barents-council.org/ (accessed 31 January 2022).
53. EU Commission. 2021a. "Joint Communication to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions. A Stronger EU Engagement for a peaceful, sustainable and prosperous Arctic" https://eeas.europa.eu/sites/default/files2_en_act_part1_v7.pdf accessed 31 January 2022.
54. Arctic Council. 2021. *Official Website of the Arctic Council* https://arctic-council.org/ (accessed 31 January 2022).

55. EPPR. 2021. *Official Website of the Arctic Council Emergency Prevention, Preparedness and Response Working Group.* https://oaarchive.arctic-council.org/handle/11374/3 (accessed 31 January 2022).
56. EPPR. 2021a. *EPPR Consensus Report. Radiological/Nuclear Risk Assessment in the Arctic.* https://oaarchive.arctic-council.org/bitstream/handle/11374/2619/MMIS12_2021_REYKJAVIK_EPPR_Radiological-Nuclear-Risk-in-the-Arctic.pdf?sequence=1&isAllowed=y (accessed 31 January 2022).
57. EPPR. 2021b. *RADSAR Report: Sharing the Competence Within Search and Rescue in a Maritime Radiological/Nuclear Scenario.* https://oaarchive.arctic-council.org/handle/11374/3 (accessed 31 January 2022).
58. Arctic Council. 2021a. *Reykjavik Declaration 2021 On the Occasion of the 12th Ministerial Meeting of the Arctic Council.* https://oaarchive.arctic-council.org/bitstream/handle/11374/2600/declaration%202021%20web%20EN.pdf?sequence=9&isAllowed=y (accessed 31 January 2022).
59. Arctic Council. 2021b. *Arctic Council Strategic Plan 2021 to 2030.* https://oaarchive.arctic-council.org/bitstream/handle/11374/2601/MMIS12_2021_REYKJAVIK_Strategic-Plan_2021_2030.pdf?sequence=1&isAllowed=y (accessed 31 January 2022).
60. Arctic Search and Rescue. 2011. *Agreement on Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic.* https://oaarchive.arctic-council.org/handle/11374/531 (accessed 31 January 2022).
61. SAR. 1979. *International Convention on Maritime Search and Rescue.* https://imo.org.en/About/Conventions/Pages/International-Convention-on-Maritime-Search-and-Rescue-(SAR)-aspx (accessed 31 January 2022).
62. Arctic Oil Pollution Response. 2013. *Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic.* https://oaarchive.arctic-council.org/handle/11374/529 (accessed 31 January 2022).
63. OPRC. 1990. *International Convention on Oil Pollution Preparedness, Response and Co-operation.* https://www.imo.org/en/About/Conventions/Pages/International-Convention-on-Oil-Pollution-Preparedness-Response-and-Co-operation-(OPRC).aspx (accessed 31 January 2022).
64. Personal communication from Øyvind Aas-Hansen, EPPR RAD EG Chair, 15 February 2022.
65. Sawhill, S.G. 2000. "Cleaning-up the Arctic's Cold War Legacy: Nuclear Waste and Arctic Military Environmental Cooperation," *Cooperation and Conflict*, 35(1): 5–36.
66. Ortman, Cate. 2009. *Radioactive Waste Impacts Mitigated by the Arctic Military Environmental Cooperation Program: Lessons in International Cooperation.* Dissertation. Churchill College, University of Cambridge. https://www.spri.cam.ac.uk/people/ortman/mphil.pdf (accessed 31 January 2022).
67. AMEC 2005. *FFI-rapport 2005/03619 AMEC Project 1.5-1 Radiation Control at Facilities: Application of the PICASSO System – Installation at FSUE Atomflot.*
68. ACAP. 2021. *Arctic Contaminants Action Programme.* https://arctic-council.org/about/working-groups/acap/home/ (accessed 31 January 2022).