Summary, Findings, and Policy Options 1

All major nuclear nations face nuclear waste problems. Many also share a common history of radioactive contamination incidents stemming from inadequate attention to environmental protection. The United States and Russia, in particular, have some similar nuclear waste management and contamination problems within their respective nuclear weapons complexes. Current work on these problems is enhanced by recently increased cooperation and improved public awareness of the benefits of environmental protection. However, radioactive contamination has endangered public health in some cases and still engenders serious public reaction worldwide for a number of reasons. Among these are the fear resulting from vivid portrayals of atomic bomb victims; concerns about chronic and long-term health impacts from radiation exposure; distrust of governments who kept most nuclear information secret for decades; and the presence of an environmental hazard that is difficult to detect and even more difficult for most people to understand. Any attempt to address solutions to environmental and human health threats from nuclear contamination must consider both the scientific and the social realities.

Protection of the environment and public health requires careful and responsible management and long-term control of nuclear waste. In recent years, as the Cold War and the nuclear arms race have abated, many nations, institutions, and individuals have become increasingly concerned about the environmental legacy of the nuclear age. Reports about nuclear waste dumping, radioactive discharges and accidents, and their potential human health effects have galvanized public attention and forced nations to seek solutions to these problems.

Nuclear waste in the Arctic is a subject that has been brought to the forefront by recent revelations about the dumping of Soviet submarine reactors and waste products in the sea over the past several decades when the region off the northwestern coast of Russia was a hub of nuclear fleet and nuclear testing activities. The Arctic elicits images of vast frozen expanses with little human habitation or industry and a relatively pristine environment. But these images are not always accurate, and contamination from both military and industrial activities has brought questions about its impact not only locally but in the wider Arctic region. Box 1-1 and figure 1-1 describe the geographic focus of this Office of Technology Assessment (OTA) study.

BOX 1-1: Geographic Focus of This Study

The Arctic region is frequently defined as all areas north of the Arctic circle (66.5°N latitude), which means it includes the Arctic Ocean, Greenland, and northern parts of the European, Asian, and North American continents. It has distinguishing characteristics in both political and ecological terms. There are eight Arctic circumpolar nations: the United States, Canada, Russia, Norway, Sweden, Iceland, Finland, and Denmark. All are signatories to the Declaration on Arctic Environmental Protection.

Alaska's northern coast borders the Arctic. Half of the Arctic coastline, however, lies within Russia. That country has historically used these waters as an important transportation route, linking its western and eastern northernmost regions, as well as providing access to the Atlantic and Pacific Oceans. The Arctic region is also home to two-thirds of Russia's fleet of nuclear submarines and icebreakers. To ensure access to harbors all year round, Russia maintains a nuclear-powered fleet of icebreakers, as well as a large number of radioisotope-powered lighthouses.

The central core of the Arctic region—its ocean—is "a sea bordered by prominent countries, all of which have concerns regarding security, resource exploitation, environmental protection, etc." (11). Covering about 390,000 square miles, the Arctic Ocean is the world's smallest. It is almost completely covered by six to 10 feet of ice in winter. In summer it becomes substantially open (ice free) only at its peripheries. There are two international outlets: the Bering Strait, which lies between Alaska and Russia, and the Fram Strait situated between Greenland and Norway's Spitsbergen Islands. These two straits are not only shipping lanes but also the principal routes for exchange of surface waters.

The Arctic Ocean is ringed by seas. Principal among them are the Beaufort (shared by Canada and Alaska); Chukchi (between Alaska and Russia); the East Siberian, Laptev, and Kara Seas of Russia; and the Barents, bordered by both Russia and Norway. The liquid and solid nuclear wastes dumped by the Soviet Navy are located in the Barents and Kara Seas, in the Pacific Ocean along the east coast of Kamchatka, and in the Sea of Japan. In addition, an island group called Novaya Zemlya which separates the Barents and Kara Seas was the site of most of the atmospheric and underground nuclear testing by the former Soviet Union.

Other than Canada's Mackenzie River, all the major rivers that flow into the Arctic's adjacent seas are Russian, and more than 40 percent of that flow is to the Kara Sea. Russia's Pechora, Ob, and Yenisey Rivers empty into the Kara Sea; its Kotuy and Lena Rivers, into the Laptev Sea; and the Indigirka and Kolyma, into the East Siberian Sea. The Pechora River, already severely polluted in some areas, has been under additional ecological threat from leaking oil pipelines, such as the Koma oil spill, which occurred early this year. Nuclear contamination created by facilities thousands of miles south in the Urals could possibly migrate to the Kara Sea and the mouths of the Ob and Yenisey Rivers.

The waters of the Arctic, its sea ice, and sediments are sinks for pollutants. The water, ice, and air currents serve as mechanisms for the transborder migration of pollutants (nuclear and otherwise) originating in all rim nations. Special characteristics of the Arctic region, such as low temperature, short and intensive growing seasons, a widely varying photocycle, permafrost, sea ice, and small number of species, make it very sensitive to environmental insult (6). Pollutants have long residence times, and because Arctic ecosystems are already under stress as a result of the harsh living conditions, they are highly sensitive. Food chains tend to be formed from very few species: therefore, they have large natural fluctuations and are more weakly balanced than those observed in temperate and tropical ecosystems (1).

This report examines the environmental and human health impacts from nuclear wastes dumped in the Arctic (and, to a lesser extent, the North Pacific), nuclear contaminants discharged into these marine environments, and radioactive releases from both past and future nuclear activities in these regions. Questions about the environmental and health impacts of these practices

cannot have clear and certain answers. Although some information about waste and contamination is available, it does not follow that we know how, when, or where they may affect people and their health. Because so many factors are involved and science cannot provide absolute answers to many questions, this study emphasizes the need for care, awareness, and prudence. It also stresses the need for a stable and enduring institutional framework for long-term observation or monitoring.

Arctic Nuclear Contamination

Despite popular perceptions of the Arctic as an unscathed area, it has become increasingly clear that this important ecosystem has not avoided the effects of industrialization and development. Evidence of contamination by persistent organic pollutants, heavy metals, and radioactivity has been gathered since the 1950s but did not attract much public interest. However, in the last three years a tremendous amount of attention has been directed to environmental contamination in the Arctic from Russian nuclear sources. Although the activities of several countries have released radionuclides into the Arctic environment for decades, the news of ocean dumping of submarine reactors and nuclear wastes by the former Soviet Union has generated particular interest and concern because it revealed previously secret activities and enhanced the long-standing public fear of radioactivity.

Past dumping of nuclear submarine reactors and fuel assemblies, as well as significant amounts of other radioactive wastes, into waters adjacent to the Arctic and North Pacific Oceans was disclosed in some detail by the Russian Federation in a 1993 white paper that is generally referred to as the "Yablokov report" (3). The ultimate fate and effects of this dumping are unknown, but possible impacts on regional environments and public health have brought concerns not only to Russia but to other countries in the Arctic and North Pacific regions. People in the United States—in particular, Alaska and the Pacific Northwest—want to know about this dumping and other discharges of radionuclides into the oceans. They also want to know about risks to these regions from other Russian nuclear activities, both past and future, and the potential threat to the environment and population beyond Russian borders.

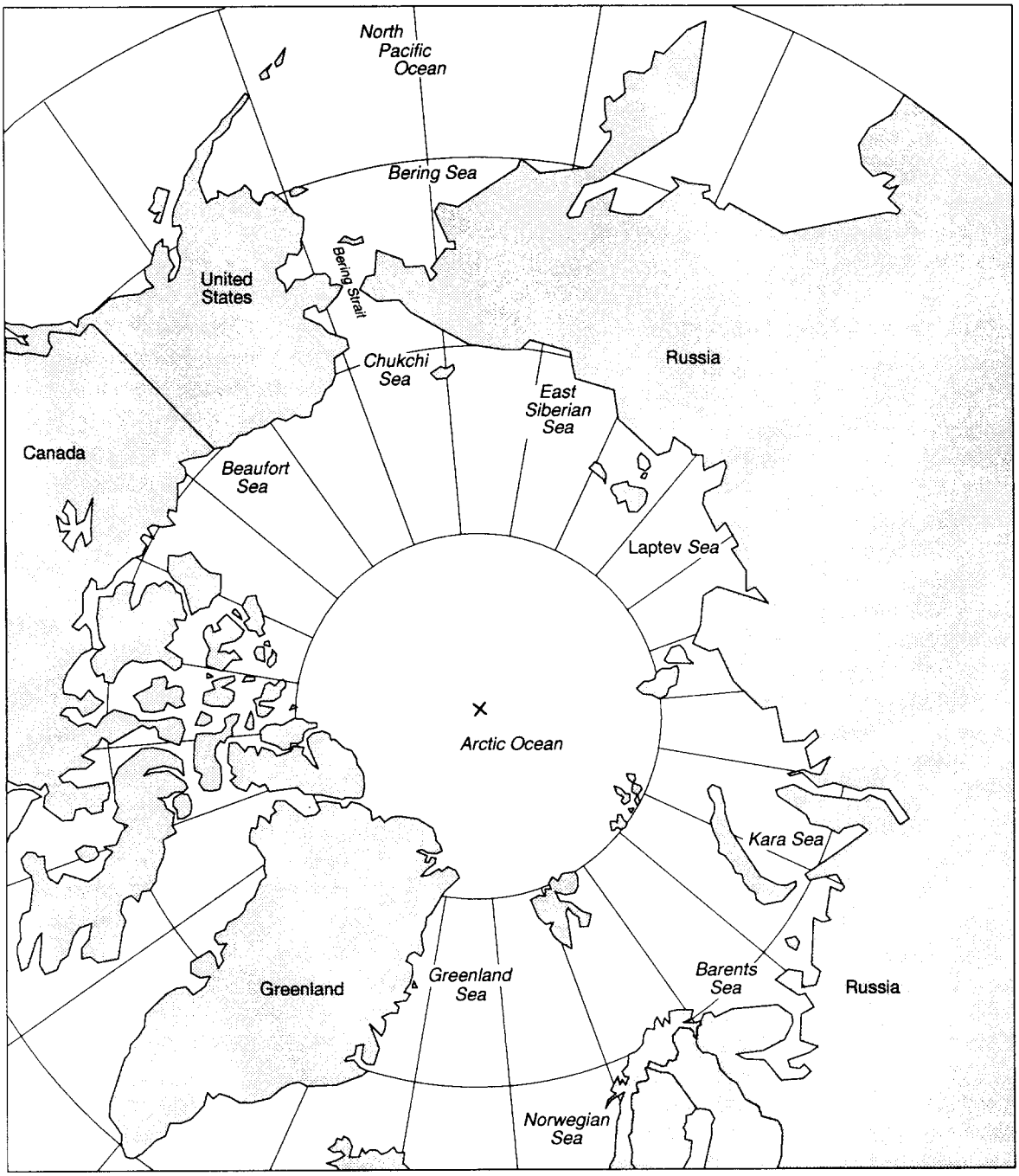
In the United States, a particular concern is the possible threat to Alaskan Native communities, their traditional food supplies, and other Alaskan fisheries resources. The impact of dumping radioactive wastes in Arctic waters is also a key concern of other nations, in particular Norway, which depends on a major fishery in the Barents Sea and is therefore very active in supporting research into such contamination in nearby waters.

Disclosures of Russian Nuclear Dumping

Rumors started to circulate in Russia in 1990 that dumping of nuclear waste had taken place in the Barents and Kara Seas. A conference organized by Greenpeace International in September 1991 brought international interest and concern. At the press conference, Andrei Zolotkov, a People's Deputy from Murmansk, presented a map showing purported dump sites used for radioactive wastes from 1964 to 1986 (13). Local papers published the maps with listings of the sites and numbers of dumped objects (2). When the Soviet Union made no official denial of these allegations at the subsequent 14th Consultative Meeting of the London Convention in November 1991, delegates demanded that it furnish information on past dumping (3).

Meanwhile, news of the Soviet dumping in the Arctic was causing some concern in the United States. In August 1992, Senator Murkowski chaired a hearing of the U.S. Senate Select Committee on Intelligence that focused attention on U.S. and Alaskan perspectives on the problem and the many questions remaining to be addressed. Government officials, scientists, and representatives of Native organizations stressed the need for more information and for cooperation with the Russian Federation to obtain it (9).

FIGURE 1-1: The Arctic Region



SOURCE: Office of Technology Assessment, 1995.

At the November 1992 meeting of the London Convention, the government of the new Russian Federation announced the formation (in October 1992) of a Presidential Commission under the direction of Alexei Yablokov, special environmental adviser to the president, to gather infor-

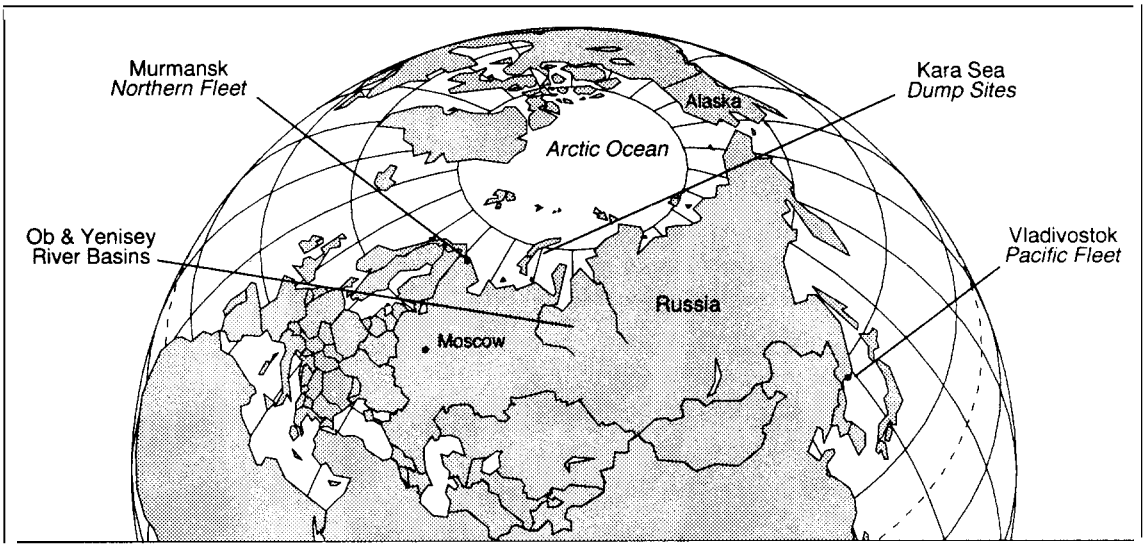
mation and "ensure Russia's compliance with obligations under international treaties which it signed as successor to the Soviet Union" (13).

The report of the commission (the Yablokov report), submitted to the president of the Russian Federation in early 1993, was a frank document presenting inventories of both liquid and solid radioactive waste dumping that occurred between 1959 and 1992. It was largely consistent with unofficial accounts (4) and detailed the dumping of damaged submarine reactors, spent fuel from the nuclear fleet, and other radioactive waste into the Kara Sea off the archipelago of Novaya Zemlya (as indicated in figure 1-2), into the Sea of Japan, and in other locations. Other than the estimated inventory of the activity of the items dumped, which has been refined since the release of the report by an expert group working with the International Atomic Energy Association (IAEA), and the precise locations of some of the dumped objects, most of the information presented in the Yablokov report remains a key source of data about the Russians' radioactive waste dumping in the Arctic.

The Yablokov report was a remarkable document to emerge from the new government of the Russian Federation. It represented the results of a tremendous effort to gather information, some of it decades old, from a multitude of Soviet ministries and agencies; to declassify that information; and to report it frankly to the international community and to the Russian people. It spelled out and acknowledged violations not only of international conventions such as the London Convention, but of normative documents that the former Soviet Union had approved, which required coordination with environmental bodies, as well as monitoring and supervision of nuclear safety in handling radioactive waste (3).

The report listed dumping that had taken place in the Arctic and North Pacific since 1959. Wastes listed as dumped in the Kara Sea and in fjords along the coast of Novaya Zemlya included containers, barges, ships, and submarines containing nuclear reactors both with and without spent reactor fuel. Figure 1-3 indicates

FIGURE 1-2: Arctic and North Pacific Fleet Headquarters and Kara Sea Dump Site



SOURCE: Office of Technology Assessment, 1995

TABLE 1-1: Objects Dumped by Northern Submarine and Icebreaker Fleets

Location	Objects	Depth (m)	Estimated activity in 1994 (kCi)
Ambrosimov Inlet	8 submarine reactors (3 with SNF)	20	37.9
Novaya Zemlya Depression	1 submarine reactor (1 with SNF)	300	7.8
Stepovoy Inlet	2 submarine reactors (2 with SNF)	50	22.7
Techeniye Inlet	2 submarine reactors	35-40	0.1
Tsivolka Inlet	3 reactors from icebreaker *Lenin* and shielding assembly from *Lenin* reactor assembly with SNF	50	59.4
Total	16 reactors (6 with SNF) 1 shielding assembly from icebreaker *Lenin* with SNF		127.9

KEY: kCi = kilocuries; SNF = spent nuclear fuel.

SOURCES: Government Commission on Matters Related to Radioactive Waste Disposal at Sea ("Yablokov Commission"), created by Decree No. 613 of the Russian Federation President, Oct. 24, 1992, *Facts and Problems Related to Radioactive Waste Disposal in Seas Adjacent to the Territory of the Russian Federation* (Moscow: 1993); translated by Paul Gallager and Elena Bloomstein (Albuquerque, NM: Small World Publishers, Inc., 1993); N. Lynn, et al., "Radionuclide Release from Submarine Reactors Dumped in the Kara Sea," presented at *Arctic Nuclear Waste Assessment Program Workshop*, Woods Hole Oceanographic Institution, Woods Hole, MA, May 1-4, 1995; Y. Sivintsev, "Study of Nuclide Composition and Characteristics of Fuel in Dumped Submarine Reactors and Atomic Icebreaker Lenin," Part I—Atomic Icebreaker (Moscow: Kurchatov Institute, December 1993); and M. Mount, Lawrence Livermore National Laboratory, personal communication, June 14, 1995.

the reported locations of the dumped wastes. A total of 16 reactors was dumped at five different sites. Six of the reactors and an additional container held spent reactor fuel. The total activity of these materials at the time of disposal was estimated in the Yablokov report to be more than 2 million curies.[1] U.S. and Russian scientists have concluded that, today, only about 5 percent of this activity[2] remains at these Kara Sea dump sites (see table 1-1).

In the Russian Far East, the Yablokov report listed similar dumping (but smaller quantities and lower levels of radioactivity) in the Sea of Japan and near the Kamchatka Peninsula (figure 1-4). It also described nuclear accidents; solid, low-level radioactive waste dumping; extensive low-level liquid waste discharges; the sinking of a nuclear submarine in the Norwegian Sea; and serious problems with the operation of current nuclear refueling vessels in both the Russian north and Far East.

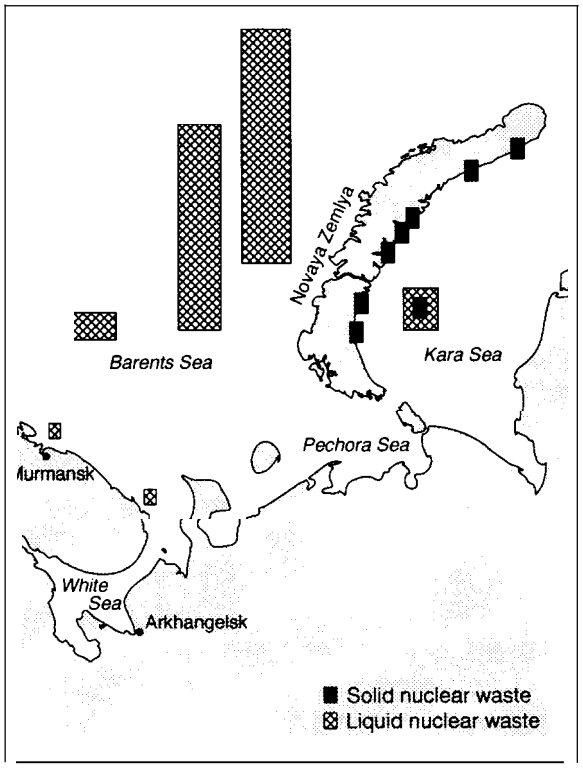
International Response to the Yablokov Report

The activities discussed in the Yablokov report generated tremendous international concern, both about the current status of the dumped waste and its contribution to radioactivity in the nearby Arctic Ocean and about the potential long-term effects of this waste. Since radionuclides can affect human health only if and when humans are exposed to them, the key question is whether and how they may migrate toward populations and other ecosystems (e.g., food supplies) in the future. Over the past two years since the Yablokov report, a number of data collection efforts and investigations to address this question have been undertaken by U.S. investigators, Norwegians, Russians, other nations close to the

[1] Radioactive decay rates ("activity") have two common units of measure, curies and becquerels, both named after scientists who were active late in the last century. The curie (Ci) represents the activity of 1 gram of radium, namely 3.7×10^{10} nuclear disintegrations per second. The becquerel (Bq) is a more modern unit and corresponds to 1 disintegration per second.

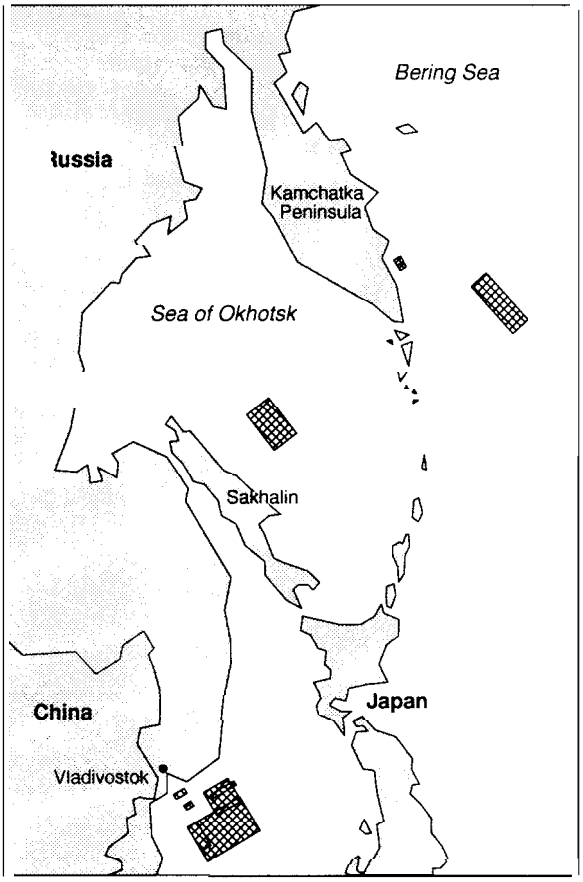
[2] This reduction in estimates is due both to corrections in original inventories and to radioactive decay over time.

FIGURE 1-3: Locations of Nuclear Waste Dumping in Russian Northern Seas



SOURCE: Office of Technology Assessment, compiled from data from Government Commission on Matters Related to Radioactive Waste Disposal at Sea ("Yablokov commission"), created by Decree No. 613 of the Russian Federation President, October 24, 1992, *Facts and Problems Related to Radioactive Waste Disposal in Seas Adjacent to the Territory of the Russian Federation (Moscow,* Russia: 1993).

FIGURE 1-4: Locations of Nuclear Waste Dumping in Russian Far Eastern Seas



SOURCE: Office of Technology Assessment. 1995, compiled from data from Government Commission on Matters Related to Radioactive Waste Disposal at Sea ("Yablokov commission"), created by Decree No. 613 of the Russian Federation President, October *24, 1992, Facts and Problems Related to Radioactive Waste Disposal in Seas Adjacent to the Territory of the Russian Federation (Moscow,* Russia: 1993).

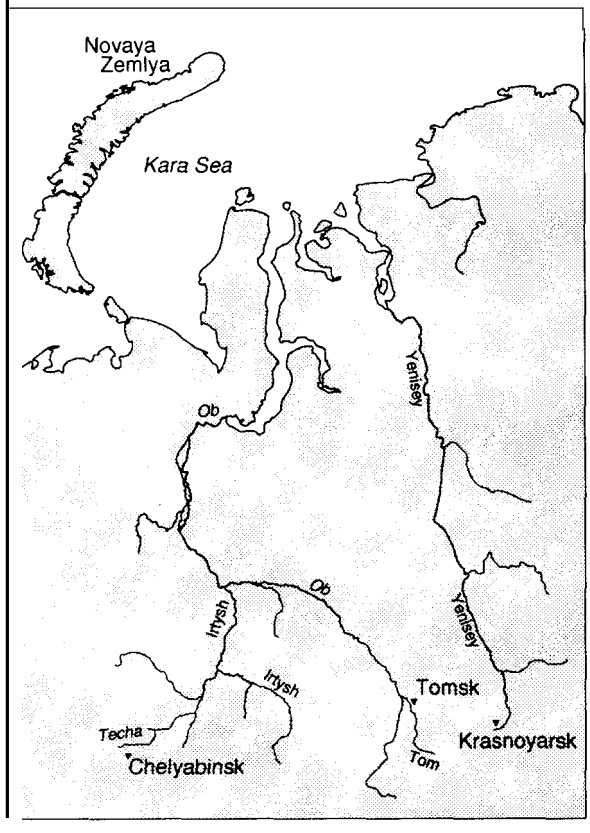
Russian sites, and international agencies such as the IAEA.

The United States has cooperated in a number of international efforts and has established some bilateral agreements with Russia (such as those concluded by the Gore-Chernomyrdin commission) relevant to nuclear dumping issues. The United States is also a party to the Declaration in Arctic Environmental Protection approved by the eight circumpolar nations[3] in June 1991. The Arctic Environmental Protection Strategy (AEPS), a part of the declaration, is a nonbinding statement of cooperation on the development and implementation of programs to protect the Arctic environment. Radioactivity is one of several pollutants identified under the strategy for priority action. The eight circumpolar nations are now planning to establish a new council that would provide the enforcement mechanism lacking in current multilateral agreements on protection of the Arctic.

The most significant U.S. efforts to investigate Arctic nuclear contamination have been the result of money set aside from "Nunn-Lugar"

[3]The United States, Canada, Norway, Russia, Finland, Iceland, Sweden, and Denmark.

FIGURE 1-5: The Ob and Yenisey Rivers



SOURCE Office of Technology Assessment, 1995.

funds appropriated by Congress for the Department of Defense (DOD) in FY 1993-95. During each of the past three years, $10 million has been assigned to DOD's Office of Naval Research (ONR) for the Arctic Nuclear Waste Assessment Program to address the nature and extent of nuclear contamination by the former Soviet Union in the Arctic region. With these finds, ONR has sponsored extensive research activities including nearly 70 different field, laboratory, modeling, and data analysis projects; three major workshops on nuclear contamination of the Arctic Ocean; and extensive collaboration with researchers from Russia, Norway, Germany, Canada, Japan, Korea, the International Atomic Energy Agency, and the Arctic Environmental Protection Strategy. The initial results from ONR's Arctic Nuclear Waste Assessment Program-in the view of many, a significant first step toward understanding the Arctic contamination problem—are expected to be published in scientific journals in 1997.

In the meantime, some tentative conclusions have been reached, but the data collected by these efforts are not yet sufficient to accurately predict the impacts of this dumping. Researchers have not found evidence of significant migration beyond the immediate vicinity of dumped radionuclides that might affect human health in the short run. However, some key unknowns have yet to be addressed, for example: 1) there has been no detailed inspection of many of the dump sites within the past two decades; 2) we have limited knowledge of the possible release rates and the long-term viability of materials used to encase the waste; and 3) some of the critical pathways by which radionuclides can affect humans, such as the biological food chain or transport on moving Arctic ice, are in the early stages of investigation. Several other possible "sources of contaminants that could affect the Arctic environment are also only beginning to be investigated.

In the Kara Sea region, for example, one potential source of contamination is from the large, northward-flowing Siberian rivers, at whose headwaters (more than 1,000 miles upstream) are located the major Russian nuclear weapons production facilities (see figure 1-5). At several of these sites, such as Chelyabinsk, Tomsk, and Krasnoyarsk, the largest releases of radioactive wastes in the world have been recorded over the last few decades. Wastes totaling more than 100 million curies were discharged into lakes and rivers at one site, and billions of curies have been injected directly underground. This contamination has clearly resulted in serious health problems among local populations and is now being studied. Research on whether the contamination may migrate down rivers such as the Ob or Yenisey into the Kara Sea and the Arctic Ocean in the future is now underway.

Overall State of the Environment in the Russian Federation

Although this OTA report focuses on nuclear contamination of the Arctic and North Pacific regions, this problem is part of severe and pervasive environmental degradation of all kinds throughout the former Soviet Union. Thus, while people in close proximity to past and continuing nuclear releases are at increased health risk from exposure to radionuclides, people all over the former Soviet Union are exposed to a host of other environmental contaminants. Extensive air and water contamination caused by nonnuclear industrial and other sources and wastes can also have health impacts. Therefore, the risks from radionuclide releases should be considered not in isolation, but in the context of the broader picture of environmental contamination that follows.

Annual environmental reports now published by Russia contain comprehensive data and information on other types of pollutant generation, releases, and impacts.[4] However, using these data to more fully understand environmental conditions in Russia is problematic. Of major concern are the accuracy and coverage of the data. A World Bank report says, for instance, that ". . .Bank missions have found that the [environmental] data provided was in considerable error (i.e., by factors of 2 to 5 times)" (12). International organizations providing assistance to Russia have recognized this deficiency and the problems it causes for analysis and policy decisionmaking. Both the World Bank, under its Russian Federation Environmental Management Project, and the European Environmental Action Programme for Central and Eastern Europe are helping to set up improved environmental information systems.

To some extent, however, data are not necessary to document the poor quality of environmental protection in Russia today. The problems resulting from chemical pollutants and waste are simply too visible. Descriptions abound of industrial cities with dark skies during the day, rivers that catch fire, and "dead" lakes. These images are reminiscent of conditions in heavily industrialized areas of the United States (and other Western countries) in the 1950s and 1960s, which sparked the enactment and implementation of environmental protection laws addressing air, water, and waste.

All sectors of the Russian economy are responsible for contributing to the country's state of the environment. In most cases, it is difficult to separate military and civilian sources, since under the Soviet system they were often one and the same. Today, massive industrial complexes, which may have been built primarily for military purposes, still emit a full range of air pollutants, release large quantities of untreated conventional and toxic pollutants into waterways, and dispose of hazardous wastes on land, generally in unlined lagoons and landfills (12). For instance, only 9 percent of the toxic waste generated by the ferrous and nonferrous metals industry in 1990 was reported recovered or safely disposed. Complexes built to produce nuclear weapons have released radioactive wastes directly into lakes and rivers and have injected them underground. Urban areas are faced with overcoming all major environmental problems. Situated as they often are amidst industrial zones, cities are subjected to the highest air pollution levels.

As a consequence of these policies and practices, the Russian Federation now faces major costs to clean up and prevent future degradation from all types of pollutants. Its 1992 State of the Environment report concluded that, consistent with economic decline, pollution emissions had decreased. However, the decrease was not as great as expected because enterprises cut back on expenditures for environmental protection. A year later, the State of the Environment report noted that "no appreciable changes" in these trends had occurred. In a recent speech, the Russian Minister for Environmental Protection stated that in 1994, a quarter of national enterprises had actually increased their discharges of harmful air emissions (7).

[4] These reports are called "Report on the State of the Environments of the Russian Federation."

So, while there may be some diminution of pollutant releases in the short-term, as Russia's market economy grows, future discharges into the environment will also grow. To prevent this, cleaner technologies must be incorporated into its industrial base, and proper environmental controls must be installed and maintained for residual wastes. These needed actions apply across the board to all pollution-generating sources, whether nuclear or not.

On the nuclear side, many waste generation and handling practices continue as before. Liquid wastes are still being discharged underground at weapons complex reprocessing facilities. And although the dumping of nuclear wastes into Arctic seas has been discontinued for now,[5] a growing volume of this waste is being generated due to the downsizing and dismantlement of the submarine fleets. Reprocessing of spent fuel from nuclear reactors continues—a practice that has been associated in Russia with increased waste and residue. Although efforts are underway to mitigate some of the contamination from nuclear reactor operations in the Urals, huge amounts of waste will remain uncontrolled in the environment for many decades, with the continuing risk of further migration.

Even as information about severe environmental contamination in the former Soviet Union has emerged from many sources, it is the nuclear contamination of the Arctic and North Pacific that has attracted most attention in the United States. The north coast of the State of Alaska sits adjacent to the Arctic Ocean. The Bering Strait, along Alaska's western coast, is a principal route for the exchange of surface waters between the Arctic and the North Pacific.

Potential Future Contamination

In addition to past radioactive contamination and releases in the Arctic, important questions remain about future releases, dumping, or accidents that could add significantly to the problem. Whereas past dumping has received considerable attention recently from scientists and analysts, the risk of future releases has not been subject to the same scrutiny or careful study. OTA has reviewed the nature and general magnitude of this future risk and the knowledge—or lack of it—about what actions have been, could be, or should be taken. Even though the potential for significant future releases may be difficult to assess from existing data, the proverbial ounce of prevention could well be worth pounds of cure.

Based on the limited information currently available, there are certain key areas that pose future contamination risks from Russian nuclear activities in the Arctic and the North Pacific regions. OTA has selected three of these areas for focus and analysis in this study because they appear to be most significant at this time: 1) the Russian Northern and Pacific nuclear fleets, and their vulnerabilities to accidents during the downsizing and dismantlement now under way; 2) the management of spent nuclear fuel and waste from these fleets, and concerns about effective containment, safety, security, and future releases; and 3) the possibility of accidents or releases from Russian civilian nuclear power plants, particularly those located in the Arctic.

It appears important to evaluate appropriate measures to prevent future releases, dumping, or accidents such as those that have occurred in the past. The management of spent fuel and other radioactive waste from the Russian nuclear fleet presents a special concern. Serious problems exist with the removal of spent nuclear fuel from submarine reactors; the storage of spent fuel aboard service ships that are used in submarine defueling; spent fuel handling and storage at naval bases in the Russian north and Far East;[6] the lack of capacity at land-based storage facilities; the management of damaged and nonstandard fuels for which no reprocessing system

[5] Russia is still not a signatory to the London Convention ban on dumping of all radioactive wastes but has announced informally its intention to refrain from dumping if possible.

[6] The northern naval bases are located mainly on the Kola Peninsula, near the Norwegian border and adjacent to the Barents Sea; the Far Eastern bases are generally near Vladivostok on the Sea of Japan and on the Kamchatka Peninsula.

exists; and the transportation and reprocessing of spent fuel at distant sites such as Mayak. Figure 1-2 shows the general location of the Russian Navy's Northern and Pacific Fleets.

During the past three decades, the Soviet Union built the largest fleet of nuclear submarines and the only fleet of nuclear-powered icebreakers in the world. The Russian Navy has been retiring and decommissioning older nuclear submarines at an increasing rate over the past several years. More than 120 Russian nuclear submarines have been taken out of service, and many are in various stages of dismantlement. Only about 40 of these have had their spent nuclear fuel removed. Some submarines have been out of service with nuclear fuel aboard for more than 15 years. The most serious factors contributing to this condition are the following: 1) Almost all spent fuel storage facilities at the nuclear fleet bases are full, and very little spent fuel is currently being transported to reprocessing sites to make room for fuel removed from nuclear submarines scheduled for decommissioning. 2) There is a lack of fuel reloading and storage equipment (including service ships, transfer bases, and land-based storage), and what does exist is poorly maintained. 3) There are shortages of safe transportation containers, limited facilities for loading and moving them, organizational problems at fuel transfer bases, and lack of upgrades of certain railways. The situation is deteriorating further, with many vessels and facilities lacking adequate maintenance, particularly at a time when the number of decommissioned submarines is expected to grow.[7]

Nonstandard and damaged fuel rods[8] from submarine and icebreaker reactors present another set of problems. Such fuel includes zirconium-uranium alloy fuel, fuel from liquid metal reactors, damaged and failed fuel assemblies, and fuel in damaged reactor cores. Removing this fuel from reactors for temporary storage and selecting or developing appropriate future treatment or storage technologies are challenging and costly and will require some technology not now available in Russia. This process is also moving at a very slow rate because of a lack of resources. Additional evaluation of specific situations and some focused research or development are probably needed to ensure safe management in the future. The question of risks from current or future operations to dismantle nuclear submarines and manage spent fuel has been addressed recently in several studies and is a priority concern.

Potential Health Effects from Nuclear Contamination

People are worried about how extensively the dumped wastes in the Arctic might contaminate the environment and whether they pose current or future hazards to human health or ecosystems. Understanding both current and future risks to human health requires information about the nature and amount of radionuclides released in the environment, and about their transport through the environment and through food chains to reach human beings. Understanding the risks to ecosystems requires additional information about the effects of radiation on the variety of organisms that make up the ecosystems.

Since the release of the Yablokov report describing dumping in the Arctic, more has been learned about some of the wastes, but their condition and likely radionuclide release rates remain largely unknown. Current levels of radionuclides in the seawater and sediment in Arctic marginal seas do not suggest that significant releases have already occurred. Even though current risks would not appear to be increased as a result of the dumping, future release rates and pathways to people remain to be evaluated. Investigations of these transport mechanisms are now under way.

[7] Although the rate of decommissioning will decline in the latter half of this decade, by that time there will be a large backlog of submarine reactor cores (300-350) with spent reactor fuel.

[8] Some reactor fuel is of unique design containing special materials that cannot be processed in current facilities. Other fuel has been damaged due to corrosion or handling and cannot be safely moved with existing equipment.

Scientists have developed models to approximate the behavior of pollutants such as radionuclides in the environment. These require a tremendous amount of site-specific information, much of which is not yet known either for the Arctic environment or for particular dump sites. Several efforts are now under way to model the transport of radionuclides dumped in the Arctic, as well as those released at sites within Russia along rivers that drain into the Arctic.

The most likely route of human exposure to radionuclides in the seas is through the food chain. Thus, in addition to information about radionuclide movement through the physical environment, specific data are needed for the Arctic about biological pathways to human beings. The marine food web is complex, and most available data were collected in temperate climates, rather than Arctic settings. Therefore, information about how radionuclides are transferred and sometimes concentrated through the food chain under special local and regional conditions is required.

People of the world are not equally at risk from radionuclides dumped in Arctic seas or in the Russian Far East. Current and future investigations need to focus on gathering relevant information about the dietary habits and other characteristics of the populations who are most likely to be exposed, such as Native northern populations and others who rely on Arctic marine resources. This information will be important for a thorough risk assessment to estimate the most likely effects on human health. Concerns about contaminants in food and the environment can lead to stress and a disruption of lifestyles that have a negative impact on peoples' lives. As data are gathered, it is critical that the public be involved in the process. Genuine efforts are necessary to ensure that the potentially affected communities participate in decisions, provide input, and have access to the information collected. Meaningful and understandable data are often unavailable to people affected by environmental contaminants; thus, their concerns go unanswered. Citizen participation in the decisionmaking process not only will help with data availability but will improve the credibility of the data and lead to more effective long-term solutions.

If the released radionuclides come in contact with people in amounts sufficient to cause health effects, these effects are most likely to be cancers. Radiation is a known cause of cancer and other health effects at high doses, but at the low doses that might occur from environmental contamination its effects are less certain. International and U.S. radiological agencies have developed radiation exposure limits for the protection of public health from nuclear-related practices. These can be used as reference points to calculate potential radiation exposures and the degree of hazard that radioactive discharges and dumped nuclear waste might pose. Research thus far shows that radionuclide concentrations measured in the Arctic Ocean near the United States are extremely low; thus, any existing exposures would be orders of magnitude below currently established limits.

However, certain contaminated sites within Russia contain very high levels of radionuclides that have exposed people to radiation doses exceeding those normally considered acceptable by the United States and international bodies. There is substantial evidence that radioactive wastes from certain Russian nuclear weapons plants and other facilities have had serious health impacts on local populations. Populations that have been exposed due to certain nuclear accidents are particularly at risk. Both Russian and U.S. experts are now collecting data from these experiences that will be valuable in future health effects studies.

Although Russian people have suffered health impacts from nearby radioactive releases, the situation is drastically different when large regions such as the Arctic are considered, given the uncertainties about very low-level exposures. There is not yet a clear answer to questions of what the future health impacts on the wider region may be from nuclear wastes dumped in the Arctic and North Pacific. Estimates and approximations of future impacts based on the information available do not suggest a noticeable

effect on human health or on plant and animal populations. However, many unknowns remain, from the status of the dumped wastes, to the likely movement of radionuclides through the environment, to the dietary intakes of those most likely to be exposed. Native populations in the Arctic depend on fish and marine mammals for a large portion of their diet; thus, special considerations are necessary when evaluating their potential for exposure to contaminants that may be present in the marine environment.

Institutional Framework and Policies

Many national and international institutions are involved in initiatives to address solutions to the problems of nuclear waste dumping and discharges into the sea. Some are addressing the threat of radioactive contamination to regional environments and human health. Others are working to ensure careful and safe future management of nuclear activities, materials, and wastes. An open question is whether these institutions are effective and whether their initiatives can bring about improvements. The improvements needed, and thus the goals of many programs, are not clearly defined and sometimes represent compromises among conflicting objectives. Because the problems are international, it is difficult to harmonize the policies and goals of each nation affected. In addition, many unilateral, bilateral, and multilateral organizations have developed over the years, each with missions that evolve and change to meet the challenges of the day and to reflect unique conflicts or cooperative moods of the time.

Against this complex backdrop, the United States and the international community are directing attention and resources to the problem of nuclear contamination in the Arctic and North Pacific Oceans. The current focus is principally on research and data collection. Although this focus can lead to better knowledge and understanding, it cannot provide all the answers to reasonable concerns about future impacts on human health and the environment any time soon. Therefore research initiatives should be supplemented to some degree by actions to monitor conditions; to provide early warnings should they be necessary; and to prevent future accidents or releases.

For decades, national security and strategic implications largely determined U.S. and international interest in the Arctic. After the dissolution of the former Soviet Union, and in response to various reports documenting that country's radioactive waste dumping practices, the United States and members of the international community began to support domestic and cooperative approaches to assess the potential impacts of these activities. The State of Alaska also plays an important role in these efforts.

The United States has focused most organized efforts on and made the greatest advances in its research initiatives. There are some gaps in the research program relating to regions covered (not much effort in the Far East and North Pacific, for example), pathways investigated (biological pathways), and other factors, but the program is evolving as a reasonably comprehensive investigation of key problems. Much work can still be performed by the United States, but more cooperation with Russia is needed, especially in the area of increased access to specific dump sites and dumped material.

The United States and other nations are now developing plans for possible future monitoring and warning initiatives. International cooperation in this area is imperative if an effective assessment and response program is to follow. International institutions may be the most appropriate organizations to carry out such initiatives. However, long-term consistent support and the adoption of rigorous scientific implementation programs must be ensured for these efforts to be effective.

Some attempts are under way to fund prevention initiatives, but because most of the key decisions must be made by Russia, it is difficult to engender support for long-term substantial assistance from the United States and other countries. OTA has identified some possible joint projects that could benefit both the United States and Russia and could be mutually supported. Other countries such as Norway are proposing support

for joint prevention projects. However, the United States Navy has not aggressively pursued cooperation with Russia in the prevention area because of its belief that the Russian military does not need U.S. assistance.

One of the more significant prevention programs relating to radioactive contamination, which has been in effect in Russia for the past several years, involves nuclear power plant safety. The United States and other countries have been funding programs to improve reactor safety in Russia as part of its overall efforts to prevent another Chernobyl. Improvements have been mainly in the areas of added auxiliary equipment, training, monitoring, and warning systems, and regulatory oversight for existing reactors. Efforts by the State of Alaska have also been successful in improving regional cooperation and information exchange. These efforts are particularly important at some sites in the far north where funding is limited and operations are of marginal quality. Here, again, more substantial improvements such as replacing old designs and equipment with safer systems require additional resources and major policy choices that Russia itself must make.

Crucial to U.S. and other international assistance efforts is the need for Russia to strengthen its institutional and legislative systems that are responsible for environmental protection and for the establishment of a nuclear safety culture. Prior to the dissolution of the Soviet Union, most government agencies and institutes responsible for managing nuclear materials operated behind a wall of secrecy with little or no external regulatory oversight. Today, Russia is only slowly beginning to develop the legal framework necessary to effectively enforce basic environmental protection laws, regulate the use of nuclear energy, and manage radioactive materials and wastes.

In sum, all three areas—research, monitoring, and prevention—are critical to protect human health and the environment from widespread and indiscriminate radioactive contamination in the Arctic and North Pacific. Poor waste management practices have alerted the international community. Kara Sea dumping activities by the former Soviet Union have yet to show a direct connection to human health impacts but have nonetheless raised concerns and questions that will require years to answer even partially. Long-term dedication and planning, as well as comprehensive programs within both U.S. and international institutions, will be necessary to adequately protect the Arctic environment and the health of Arctic populations in the future.

KEY FINDINGS OF STUDY

The following description of key findings from OTA's study is presented in summary form and reflects conclusions from our review of an enormous amount of work discussed and referenced in the other chapters of this report. It is also based on meetings, interviews, workshops, site visits, reviewer comments, and feedback from our Advisory Panel.

The first question that OTA addressed in this study was: What kinds of environmental and public health risks are posed by the Russian Arctic nuclear waste dumping disclosed in the Yablokov report, and how do they affect U.S. territory? This question must be answered with some caution. Research and data collection efforts regarding nuclear contamination in the Arctic marine environment are incomplete. Some major gaps exist in our understanding of Arctic systems and processes.

Even so, OTA's analyses suggest that adequate data have been assembled by expert scientists to reach conclusions about immediate risks. *In particular, the research and data collected to date indicate that no significant amounts of radioactive materials have migrated from the marine radioactive dumping in the Russian Arctic and Far East.* This dumping refers to the sites in the Kara Sea, the Barents Sea, and the Sea of Japan that were covered in the Yablokov report. Research to assess contamination from these sites was summarized most recently in May 1995 at a workshop of the principal investigators with the ONR Arctic Nuclear Waste Assessment Program, held in Woods Hole, Massachusetts, and

included other work sponsored by key international institutions.

Although only a few of the dump sites in the Kara Sea have been inspected recently by means of international survey cruises, and measurements were not exhaustive, no substantial leakage appears to have occurred, and only very local samples show elevated radionuclide levels. In similar measurements from U.S. and Russian expeditions near the mouths of Russian rivers, no large migration of radionuclides down the rivers has been detected.[9] It is well known that by far the largest amount of radioactivity released into the environment in Russia is found in regions around the major nuclear weapons plants located along the large Siberian rivers that flow into the Arctic. *Only minor releases and transport of these radionuclides into the Arctic Ocean have been suggested by recent research, but future migration and impacts beyond Russian borders constitute a plausible scenario and deserve investigation.*

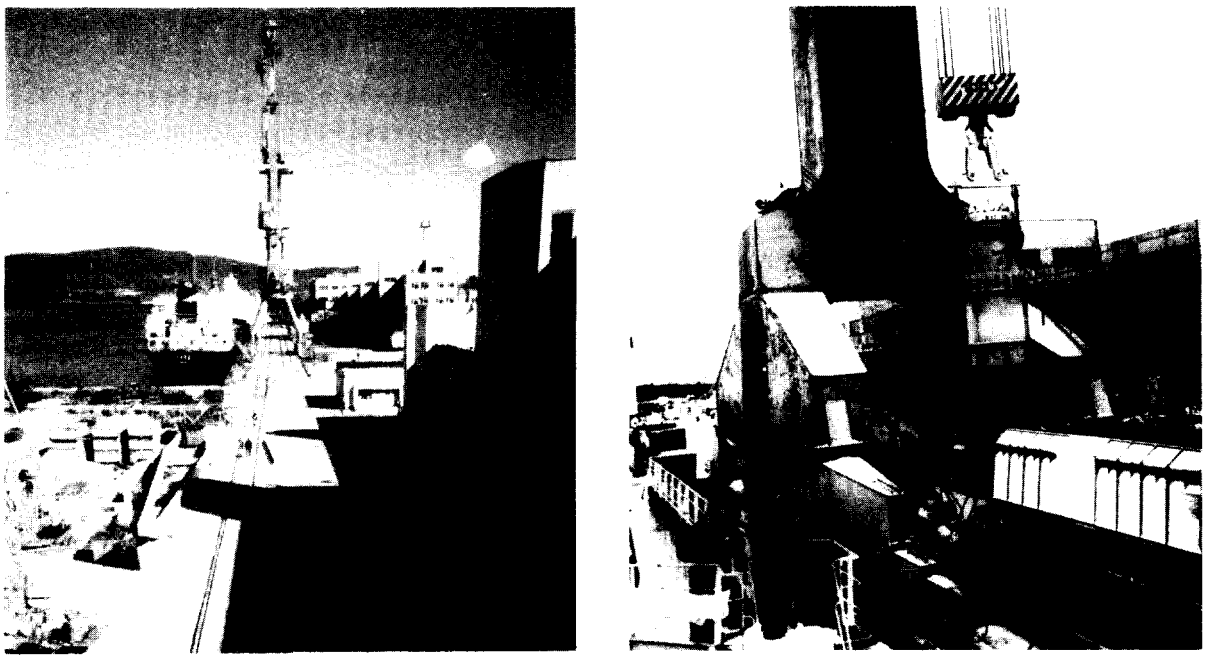
Research and data collection expeditions in the general Arctic Ocean region indicate that certain activities other than Russian Arctic dumping and river discharges are greater sources of the radionuclides measured to date. *Radioactive contamination from European reprocessing plants and atmospheric weapons testing in the 1960s is identified as contributing to current low-level Arctic contamination, whereas leakage from the nuclear dump sites in the Kara Sea or discharges from the Ob and Yenisey Rivers have not been confirmed in the wider Arctic basin.* European reprocessing sources have been studied and tracked for a long time and thus are well documented. Recent work on the European reprocessing discharge plume has provided good indications of how Arctic Ocean circulation has transported these radionuclides over long periods of time.

Many researchers are also concerned about Arctic contamination from nonnuclear hazardous materials. Although OTA has not investigated nonnuclear contamination, it is clear that industrial discharges and toxic wastes have entered the Arctic and could present problems. Thus, we have concluded that *contaminants other than radionuclides could have a significant impact on the Arctic environment. The relative magnitudes of risks from other sources such as heavy metals or persistent organics are currently unknown, but expanded risk assessments could help evaluate these factors*. While the ONR research program has been limited thus far to radioactive contamination, other contaminants could also be considered in the future.

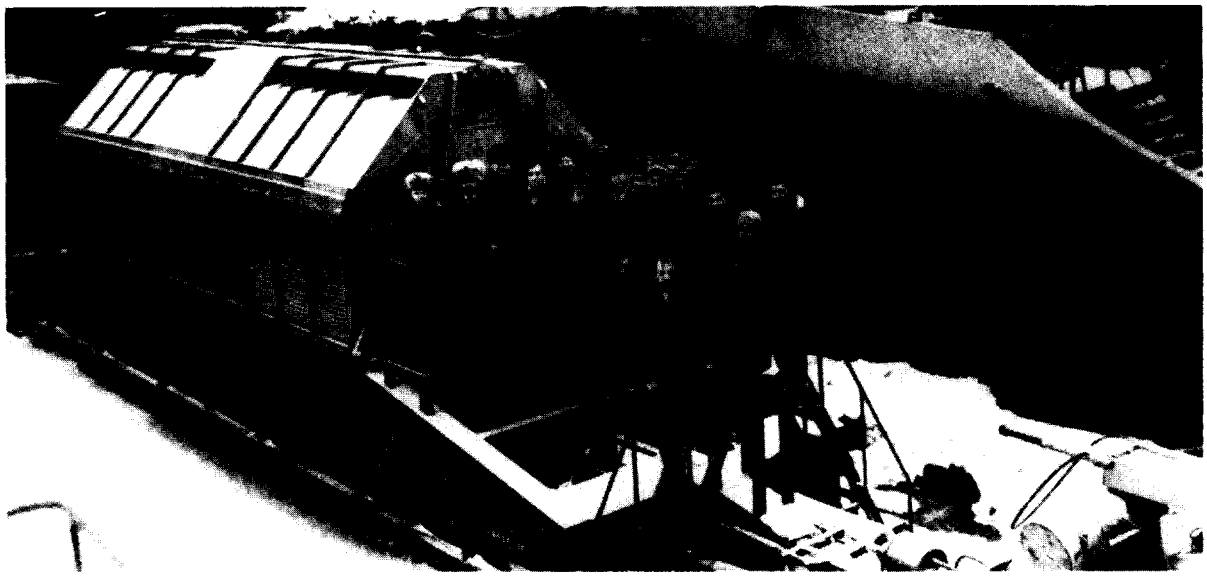
OTA has carefully investigated the programs within various federal agencies that have devoted attention to this nuclear contamination question and found no substantive long-term program with specific goals. We have concluded that *the Arctic Nuclear Waste Assessment Program administered by the Office of Naval Research is the only U.S. program specifically evaluating the Arctic radioactive contamination problem. It has accomplished significant data collection and evaluation work over the past three years. To fill some remaining data gaps, additional research is needed in areas such as ice transport, biological pathways, and human exposure assessments.* Many of the scientists engaged in the ONR program recognize the current data gaps and the need for continuing and augmenting the program to fill them. However, the ONR program is not a long-range effort with specific goals for the future.

[9] Sufficient data exist documenting the migration, at least at low levels, of radionuclides down the Yenisey River, probably originating from pass-through reactors and cooling waters. See Figure 1-5.

PETER JOHNSON



MURMANSK SHIPPING CO.



The Murmansk Shipping Company's Atomflot facility showing the dock and service ship Lotta *where spent nuclear fuel is stored (top left); a railroad car used for transporting spent nuclear fuel from Atomflot to the reprocessing plant at Mayak (top right); the dockside crane transferring a spent tie/ shipping cask from (he service ship* Lotta *to the railroad car (bottom).*

OTA's analysis suggests that now is the time to make long-range plans and to structure a more comprehensive program for the future. *Preliminary assessments do not suggest a major, long-term impact on human health for the broad Arctic region from radioactive dumping and discharges that have already occurred. However, identifying the potential for human exposure to radioactivity in the future will require some form of monitoring and a comprehensive, rigorous exposure assessment.* Planning for these has started, and it would be useful for policymakers to define the major goals and key questions so that the risk assessment can be useful and cost-effective.

Because the nuclear material dumped in the Arctic has not been adequately contained for long-term disposal, and because very little specific information exists about the condition of the dump sites, it has been suggested that some form of remediation be considered. Options for remediation range from encasement in place to removal and disposal at a different location. *Although remediation of past dumping is being investigated, it cannot be evaluated fully now because of the lack of data on waste sites and conditions. When such data are obtained, it would be productive to study remediation options further, estimate their risk reduction value and cost, and choose the optimum approaches.*

Most options for the remediation of nuclear wastes dumped into the environment are difficult and costly. *Because it is so difficult to take useful actions after radionuclides have been released into the environment, it is wise to consider prevention efforts now that could minimize future accidents, releases, or discharges. There are several opportunities to enhance safety and prevent future releases from Russian nuclear activities in the Arctic and Far East. Support for cooperative work in reactor safety, submarine dismantlement, spent fuel management, waste disposal, and other related matters deserves careful consideration.*

OTA's investigations of the situation at the local bases of the Russian nuclear fleet in the north and Far East show that severe problems exist in adequate management of nuclear wastes and spent fuel from submarine reactors. These problems include poorly maintained vessels and other equipment for handling spent fuel, overloaded storage and treatment facilities, and a substandard transportation infrastructure. These problems could lead to accidents or pressure to engage in more dumping in the future if they are not addressed soon.

There is, however, some evidence of progress toward improving spent fuel and nuclear waste management practices with regard to the Russian Northern Nuclear Fleet, with the help of international assistance and cooperative efforts. *With continuation and expansion of international efforts to address spent fuel problems in the Russian north (i.e., the Kola Peninsula, Murmansk), some significant improvements are possible in the prevention of future radioactive releases there. The situation in the Russian Far East is more problematic, however, with much less evidence of progress in international cooperation.*

The United States has recently been moving toward more cooperative work with Russia on Arctic nuclear waste issues. U.S.-Russian collaboration in research and reactor safety has grown, and many useful contacts have been made. OTA's analysis concludes that such efforts should continue and expand in the future. These contacts, in particular, could be used to foster and encourage more interaction in areas dealing with the environmental impacts of military activities. *Research on Arctic contamination is enhanced and more politically acceptable when it is conducted cooperatively with Russia and other countries. If monitoring and prevention projects are initiated, they will require further data from Russia and greater access to dump sites. Prevention initiatives will be difficult unless Russia takes the lead and assumes substantial responsibility.*

Even though Russia must be responsible for its own nuclear waste management, the interna-

tional community must also recognize that the country is limited in its current capabilities and resources. While the Russian government has taken initiatives to identify and describe past nuclear dumping activities, it has not been able to provide many resources for further research or other actions to address the problems. *Russian institutions for environmental protection and nuclear safety have yet to be effective in regulating the military or civilian nuclear complex, but they have been developing better capabilities that could be encouraged over the long term with outside assistance.*

POLICY ISSUES AND OPTIONS

OTA's analyses show that radioactive contamination in the Arctic and North Pacific regions is not an immediate crisis but a long-term, chronic problem requiring a certain level of comprehensive risk assessment, monitoring of conditions, and prevention of future releases. Such approaches would help ensure the greatest possible protection of human health and the environment. Current U.S. policies addressing these issues lack long-term goals or cohesiveness and are not likely to develop such goals without congressional direction and action.

Three possible policy areas that already have a considerable history and institutional framework could be considered by Congress in terms of the direction and support of federal programs to address Arctic nuclear contamination: 1) Arctic research policies; 2) international environmental protection policies; and 3) policies for assistance to or cooperative work with the former Soviet Union. In each case, some programs currently exist and have defined benefits and support. If Congress wished, it could strengthen these programs to help focus future attention and work on the nuclear contamination problem.

Arctic Research Policies

Current Policy Status

Efforts by the United States to assess the Arctic's radioactive contamination began only recently. Traditionally in Arctic research, the U.S. focus was on its strategic and national security importance. However, in 1993, as a response to reports documenting the Soviet Union's ocean waste dumping, the United States adopted the "Policy for the Arctic Region," emphasizing for the first time a commitment to the environmental protection of this important ecosystem and authorizing the State Department as the implementing agency.

Congressional support for research regarding Arctic radioactive contamination began with the passage of the Arctic Research Policy Act (ARPA) in 1984. Congress established the institutional infrastructure (i.e., the Arctic Research Commission and the Interagency Arctic Research Policy Committee, or IARPC) to develop and coordinate U.S. Arctic research programs. In 1992, radioactive contamination from Soviet activities was recognized as a potentially serious problem by ARPA. However, the statute does not provide any specific funds to support activities by the commission or by IARPC agencies[10] regarding research on radioactive contamination in the Arctic.

In 1994, IARPC proposed a $33-million increase in research funds to implement an Arctic Contamination Research and Assessment Program (ARCORA) which would begin in FY 1996. The requested funds, if provided, would support five essential research-related activities in the Arctic: 1) data and information management; 2) data retrieval and synthesis; 3) observation and monitoring; 4) development of models; and 5) analysis of risks. Work in these areas would allow participating U.S. agencies to assess the sources, transport, fate, and environmental

[10] The following federal agencies compose what is officially known as the Interagency Arctic Research Policy Committee (IARPC): Department of State; Defense Nuclear Agency; Naval Sea Systems Command; Central Intelligence Agency; U.S. Coast Guard; Department of Energy; Department of Interior; Environmental Protection Agency; U.S. Geological Survey; National Science Foundation; and National Oceanic and Atmospheric Administration.

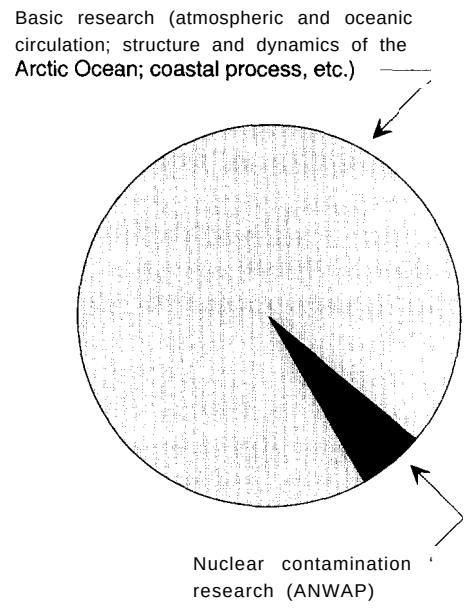
and health effects caused by pollutants discharged directly into the Arctic or accumulated from non-Arctic sources. The NOAA and the Department of Interiorly would be responsible for most of the work. The Environmental Protection Agency, Department of Energy (DOE), and National Science Foundation would also play active roles. Despite interest among proponents, this proposal to fund a federal Arctic contamination research program was not supported by the Administration.

Although the ARPA established the main institutional means for carrying out federal Arctic research, the only relevant program actually being implemented is the congressionally authorized Arctic Nuclear Waste Assessment Program (ANWAP) under the Office of Naval Research of the Department of Defense. For each of the past three years, Congress has mandated through DOD authorizations or Nunn-Lugar legislation that $10 million be allocated to ONR for Arctic research work. Figure 1-6 compares this ONR funding to overall expenditures for Arctic research for FY 1995.

The initial emphasis of the ONR program involved collecting and evaluating existing Arctic environmental data. Subsequent efforts have also included supporting numerous research projects; holding workshops; collaborating with various U.S. and international research organizations; and sponsoring scientific expeditions designed to gather data in the Arctic and evaluate potential transport pathways for radioactive waste. ONR is also expanding its scope of research to include the North Pacific and certain major Russian rivers discharging into the Arctic Ocean.

Support for U.S. research programs, other than ANWAP, depends on the priorities established by individual federal agencies that provide research funds. In the recent past, most federal agencies have not considered Arctic radioactive contamination a priority on their research agendas. At the June 6, 1995, OTA workshop on U.S.

FIGURE 1-6: Expenditures for Arctic Research and Radioactive Contamination Assessment, FY 1995



KEY: ANWAP = Arctic Nuclear Wastes Assessment Program.

SOURCE: C. Myers, National Science Foundation, personal communication, June 7, 1995; Office of Technology Assessment, 1995,

Arctic institutions, officials representing U.S. Arctic research programs stated that their agencies have not provided substantial support to carry out their national and international Arctic research work.

The State of Alaska has played a key role in encouraging cooperation in research with regional governments of the Russian Far East. This cooperation has proven successful in promoting information exchange on past contamination and possible preventive measures. Despite the progress made to date, long-term support for state research efforts remains limited.

During the next phase of its research program, ONR will make the information gathered available to the scientific community and to the populations most likely to be at risk from, or to have concerns about, Arctic contamination, The State of Alaska actively participates in several cooper-

[11] Namely, the U.S. Geological Survey, the U.S. Fish and Wildlife Service, and the National Biological Survey.

ative efforts to research and monitor Arctic contamination. Most efforts by the state emphasize the identification of existing and potential public health and safety hazards, particularly to its Native residents, and the sharing of environmental data among regional governments. Alaska has also been cooperating successfully with Russian regional governments in improving communications, nuclear safety, and emergency response with the involvement of Native communities.

Future Policy Initiatives

Despite the extensive institutional structure created to conduct research in the Arctic, the only U.S. program involved in research on radioactive contamination is ONR's Arctic Nuclear Waste Assessment Program. There is no current policy to continue this ONR work through the next logical phase or to use its results to plan for a transition to comprehensive risk assessments and monitoring.

Congress could continue its current level of financial support for ONR's Arctic Nuclear Waste Assessment Program through an initial risk assessment phase and until future monitoring or corrective measures are adequately identified. Funding of research efforts would most likely be short-term in nature since the main objective would be to collect the data required for future planning, for establishing monitoring programs, and for carrying out long-term risk assessments, if needed. When plans are completed, *Congress could direct ONR to conduct future monitoring and assessment activities as well.* However, the nature of these activities might require Congress to fund the ONR program on a multiyear basis to incorporate long-term planning.

Congress may, on the other hand, opt not to fund ONR's Arctic Nuclear Waste Assessment Program but instead request IARPC or any of the U.S. agencies with Arctic programs to adopt ONR's preliminary research findings and prepare the long-range plan needed to conduct risk assessments and monitoring. Congress might explicitly identify the level of funding for IARPC, or for the relevant federal agency or agencies. Some funds would be needed to adapt ANWAP results to other agencies' goals and to implement a long-range monitoring program. Any such program should delineate clearly the implementing roles of relevant federal agencies. Congress could also request an annual report covering the successes and failures associated with implementation of the plan.

The ONR program plan currently includes efforts to conduct preliminary risk assessment that would be accomplished with existing funding. If Congress does *not* fund the continuation of this research beyond FY 1995, this preliminary risk assessment as well as the publication of research results to date would probably be accomplished over the next one or two years, but no new work could be expected to fill data gaps, conduct monitoring, or investigate new areas. If Congress continues funding for ONR but not for other agencies, research on key unanswered questions could enhance a more rigorous risk assessment and reduce the uncertainties of environmental and health impacts. However, it would be difficult to establish useful long-term monitoring programs, to effectively engage the affected communities in risk assessments, or to address public health concerns without the more active participation and funding of other federal and state agencies on the IARPC.

International Environmental Protection Policies

Current Policy Status

U.S. support for international environmental protection and Arctic research has been effected mainly through bilateral cooperation agreements with Russia. Prior to the dissolution of the Soviet Union, most U.S. actions toward the former Soviet Union centered on mobilizing the economic and military resources needed to withstand any potential threat. Since the Soviet breakup, U.S. policy has become largely supportive of economic and political reform.

An extensive cooperative framework exists between the United States and Russia, but fund-

ing for work on Arctic radioactive contamination is limited. As part of their April 1993 Vancouver summit, the Presidents of Russia and the United States agreed, for the first time, to forge a new cooperative venture in many important economic and technical areas (e.g., energy, space, science, technology, environment). Despite its success in certain fields, progress by the Gore-Chernomyrdin commission—the implementing body for U.S.–Russian cooperation—regarding research monitoring of the Arctic's nuclear contamination problem is generally confined to developing institutional relationships, entering broadly defined agreements of cooperation, and in a few cases, studying the technical feasibility of possible environmental solutions.

Lack of funds and government leadership appears to have hindered progress by the Gore-Chernomyrdin commission in Arctic environmental work. At a January 1995 OTA workshop on Arctic institutions and programs, some experts emphasized that the commission lacks a funding mechanism or a specific budget item to support research on Arctic radioactive contamination. They also pointed to the obligation of federal agencies to conform to the Administration's policies and priorities. The limited resources provided under agreements preclude agencies from implementing fully the programs that the commission appears to support.

Considerable concern exists about the clearly inadequate information available on the extent of environmental contamination, particularly in the Russian Far East. The inadequacy of regional environmental data and of agency resources has also limited the ability to map the state of contamination in Russia. The fragmented nature of the institutional structure responsible for ensuring environmental protection in the Russian Arctic region is another matter of concern.

Several international efforts are under way to assess issues of Arctic contamination and to formulate future monitoring and preventive approaches. These will help provide information about contamination and serve as a vehicle for communication and cooperation in research and monitoring activities. The United States stands to benefit from active participation in these cooperative efforts. The United States has participated in several international initiatives, including the International Arctic Seas Assessment Program under the IAEA; the Arctic Environmental Protection Strategy established by the eight circumpolar nations; and other initiatives with Russia, Norway, and various European Nations. Many international environmental agreements and conventions have traditionally kept nuclear issues separate from those of other hazardous contaminants. This separation has made it difficult to formulate policy that would compare the needs and priorities of nuclear and nonnuclear environmental problems.

With regard to nuclear wastes, the United States has not provided an overall strategy for selecting and participating in the most appropriate international entities. Nor has it determined which federal agency would be responsible for developing relevant research strategies, for formulating and overseeing implementation strategies, and for providing the financial resources required in any joint efforts. Because so many institutions are involved in establishing international programs it would be much more efficient for the United States to concentrate on working with a few selected programs that could produce the most useful work and best advance U.S. policy goals.

Future Policy Initiatives

Congress could direct the Administration to prepare a coordinated plan for taking action on programs that result from international agreements. A coordinated plan should incorporate such multilateral efforts as the Arctic Environmental Protection Strategy, which includes the Arctic Monitoring and Assessment Program. It could incorporate the same level of U.S. leadership and commitment exercised through bilateral cooperative programs (i.e., the Gore-Chernomyrdin commission).

Similarly, *Congress could direct the Administration to maintain entities such as the Gore-Chernomyrdin commission and the State Department as instruments of U.S. cooperation and to*

give specific funding authority to certain federal agencies to implement any cooperative research and monitoring projects developed under a coordinated plan. One clear benefit of a coordinated international plan is that savings could be achieved if two or more nations have certain elements under their control such as access to sites, data, or key research work. Another benefit is avoidance of duplication and, thus, improved efficiency or cost-effectiveness.

Policies for Assistance to and Cooperation with the Former Soviet Union

Current Policy Status

Certain policies for cooperation with the former Soviet Union are designed as initiatives and programs to prevent future Arctic radioactive contamination. Included among the current initiatives are those designed to *improve radioactive waste management practices* and *upgrade Russia's older and most unsafe operating nuclear reactors*. Despite the differences in their nature and in the institutional framework involved, both types have proven useful in improving bilateral and multilateral cooperation with Russia.

One of the existing U.S.-supported initiatives to improve radioactive waste management in the Russian Arctic region is the Murmansk Initiative being implemented under the Gore-Chernomyrdin commission. This is a cooperative effort by Norway, the United States, and Russia to expand the liquid radioactive waste storage and processing capacity at the Murmansk Shipping Company, thereby halting the unsafe management and ocean dumping of these wastes. Currently, Russia continues to accumulate considerable amounts of liquid radioactive waste, particularly at sites where submarine and icebreaker reactors are repaired or refueled. Design work has been funded and construction funds have been identified for facility expansion, but the funding authority for implementing this initiative within the United States has often been unclear or imprecise.

The London Convention is a major international effort designed to prohibit dumping of radioactive waste in the world's oceans. Although its guidelines are voluntary in nature, Russia's failure to sign the convention's 1993 decision to ban ocean radioactive waste dumping is of great concern to many in the international community, particularly the circumpolar nations. One reason for concern is Russia's dumping of low-level liquid radioactive wastes in the Sea of Japan as recently as 1993. Although Russia has agreed to adhere to the principles of the London Convention prohibiting the disposal of all types of radioactive waste in the marine environment, it continues to be the only country that has failed to sign the ban formally. Therefore, the recent signing of the Murmansk Initiative within the framework of the 1994 U.S.-Russia Agreement on Pollution Prevention in the Arctic is significant because it will help Russia meet its commitment to abide by the principles of the London Convention. Russia's voluntary commitment to the convention, in combination with this cooperative agreement, is a good first step, but much more work is necessary to ensure long-term compliance.

In addition to the London Convention, the European Union, Japan, and Norway also support international cooperative initiatives designed to improve Russia's waste management and prevent radioactive contamination in the Arctic. The European Union, for example, is cooperating with Russia to identify and develop waste management technologies for application in the Kola Peninsula. The Government of Japan, on the other hand, is currently financing a project that would provide facilities for treatment of some of the liquid radioactive waste stored by the Russian Navy near the Sea of Japan.

Of the Arctic countries, Norway is the most active in searching for solutions to the Arctic radioactive contamination problem. Of primary concern to Norway are the operational safety of nuclear facilities and the management of nuclear materials and wastes at civilian and military nuclear sites operating near its borders. Recently, the Norwegian government created an interna-

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F/eating reactor compartments from decommissioned Russian submarines temporarily stored in Chazhma Bay near Vladivostok.

tional steering committee to cooperate technically and financially with Russia in the removal and cleanup of a Russian nuclear waste service ship in Murmansk (near the Norwegian border) containing damaged spent nuclear fuel from the naval and icebreaker fleets.

Another Norway-led initiative seeks cooperation among Norwegian, U. S., and Russian defense communities in the assessment of military sources of radioactive contamination in the Arctic region. On June 30, 1995, the U.S. Secretary of Defense and his Russian counterpart signed a Memorandum of Agreement to exchange information on the environment, particularly in the areas of environmental protection and cleanup, waste management, and disposal of weapons material. No specific timetable or plan of action was provided. Although this cooperative agreement is broad and lacks a clear plan of action, it constitutes a potentially useful attempt to address key problems relevant to future international Arctic protection efforts.

A second major type of preventive measure addresses commercial reactor safety. U.S. support for a nuclear safety initiative began immediately after the Chernobyl accident in April 1986. Initially, most cooperation consisted of information exchange by the Nuclear Regulatory Commission and the Department of Energy with their Russian counterparts. The commitment of the United States to cooperate with Russia in the field of nuclear reactor safety was expanded at the U.S.-Russian presidential summit in Vancouver, Canada, in 1993. The primary objectives of these initiatives were to help Russia to reduce the likelihood of future nuclear reactor accidents.

U.S. assistance to Russia on nuclear safety issues is multiagency in nature. The State Department and the Gore-Chernomyrdin commission are the principal coordinators; the U.S. Agency for International Development is the agency with overall management responsibilities; and the Department of Energy and Nuclear Regulatory Commission are the executors. Progress has been made under this initiative in the areas of technical training and the provision of some safety equipment.

The State of Alaska has played an important role in cooperating with Russia to achieve nuclear safety, particularly with the government of the region in which the Bilibino nuclear power plant—the nearest to Alaska—is located. Another Alaskan undertaking was the international radiological exercise held in June 1994 on emergency response procedures among Arctic nations. In general, these Alaskan initiatives have helped Arctic national and regional governments to strengthen communications and recognize the need for improved cooperation in the areas of nuclear safety and emergency response.

The United States also participates in the Nuclear Safety Account, a 1992 initiative that finances projects designed to improve the operational and technical safety of nuclear reactors in Russia and other states of the former Soviet Union. In addition to the United States, the European Union has also established a short-term nuclear safety improvement program at the Kola Peninsula Nuclear Power Plant near the Arctic.

OTA has found that a number of national and international programs are in place to improve Russia's nuclear waste management practices and prevent similar recurrence in the future. The varied nature and objectives of the national and international missions supporting these programs make it difficult to evaluate their effectiveness. No attempt has been made by the United States or the international community to evaluate the overall progress made by their cooperative nuclear safety initiatives in the Arctic and determine where improvement is needed.

Russia finds itself in the midst of a difficult transition related to nuclear safety and waste management. Thus far, the creation of new agencies and laws in Russia is just beginning to address the country's radioactive contamination problems and lack of a nuclear safety culture. It is crucial that Russia continue to strengthen these efforts. Equally important is the fact that the severe economic situation affecting this nation now requires creative and flexible approaches by the United States and other countries as a means to ensure long-term cooperation.

A number of U.S.-supported bilateral and multilateral initiatives are under way to collaborate with Russia in the prevention of future radioactive contamination in the Arctic. The major U.S. assistance program has focused on efforts to improve the operational safety of Russia's most dangerous nuclear reactors so as to prevent another Chernobyl-type accident. Continued attention to the goals and coordination of these efforts is needed.

However, the areas of improving spent fuel and nuclear waste management practices and enhancing submarine dismantlement to prevent future radioactive releases have only minimal U.S. support. International cooperative efforts in this area have been evolving, with Norway, the European Union, and Japan taking the lead. Although the United States may not be as threatened by future releases as other countries, it too could benefit from reduced contamination risks in the future, from additional progress in Russian submarine dismantlement, and from new business opportunities for U.S. firms.

Since the disintegration of the Soviet Union, the Russian government has made official its intent to improve environmental protection and nuclear safety. Although considerable progress has been made in the area of environmental regulations, more effective approaches are still needed. It is also crucial that Russia strengthen its agencies responsible for environmental protection and for establishing a nuclear safety culture.

Another benefit to the United States from cooperation with the former Soviet Union is continued, mutual demilitarization in the United States and Russia. The common public notion is that the Cold War is over. However, certain military institutions in both countries continue to distrust each other and are suspicious of the actions and motives of the other side. Existing and new international programs focusing on the environmental legacy of the Cold War could lead to a lowering of these post-Cold War tensions.

Future Policy Initiatives

Congress could continue current support for U.S. participation in bilateral and multilateral cooperative initiatives to improve radioactive waste management and nuclear safety of reactors in Russia. However, Congress could request that U.S. decisions at the bilateral level be coordinated with those involving multilateral approaches to avoid possible conflicts and unnecessary or costly duplication. Adopting a long-term approach is also helpful since establishing a government-supported regulatory and institutional framework and developing the safety culture needed to ensure that Russia's nuclear facilities are properly managed will take some time.

Existing cooperative initiatives, however, do not address issues of spent fuel and radioactive waste management related to Russian nuclear submarines and ships. To include this, *Congress could create a program within an appropriate agency such as DOD or DOE to provide bilateral or multilateral cooperative assistance for improving Russia's management of spent nuclear fuel*, particularly when such efforts would also be in the interest of the United States. To support this program, Congress could establish a new funding authority or make use of existing ones—for example, the Nunn-Lugar program if the initiative involves assistance in nuclear submarine dismantlement or the Nuclear Safety Initiative program if the purpose is mainly to prevent accidents and radioactive releases. Submarine dismantlement per se does not require advanced technology and is clearly within the capabilities of the shipyards that built Russia's submarine fleet. The challenging aspects of dismantlement, however, are the safe removal of spent nuclear fuel and the subsequent management of this and other nuclear wastes. The Russians have had problems in this area, some related to limited resources, and others to poor environmental protection practices; it is here that U.S. cooperation could lead to mutual benefit and advance U.S. interests. If Nunn-Lugar were the vehicle to provide assistance to Russia, it would have to be justified on the basis of an expanded sphere of coverage that, in the long run, could enhance demilitarization and encourage better transfer and safer storage of nuclear materials. Perhaps the greatest benefit to the United States would be a long-range improvement of the nuclear safety culture in Russia and a decrease in Cold War tensions.

REFERENCES

1. Aarkrog, A., Riso National Laboratory, Denmark, "Environmental Radioactivity in the Arctic," *Radioactive and Other Environmental Threats to the United States and the Arctic Resulting from Past Soviet Activities*, hearing before the Select Committee on Intelligence, United States Senate, Aug. 15, 1992, Senate Hearing, 102-1095 (Washington, DC: U.S. Government Printing Office, 1992).
2. "Crime Without Punishment," *Volna* [Wave], a sociopolitical newspaper of Arkhangelsk Oblast, Russia, No. 40, Oct. 3, 1991.
3. Government Commission on Matters Related to Radioactive Waste Disposal at Sea ("Yablokov Commission"), created by Decree No. 613 of the Russian Federation President, Oct. 24, 1992, *Facts and Problems Related to Radioactive Waste Disposal in Seas Adjacent to the Territory of the Russian Federation* (Moscow: 1993), translated by P. Gallager and E. Bloomstein (Albuquerque, NM: Small World Publishers, Inc., 1993).
4. Joint Russian-Norwegian Expert Group for Investigation of Radioactive Contamination in the Northern Seas, *A Survey of Artificial Radionuclides in the Kara Sea. Results from the Russian-Norwegian 1992 Expedition to the Barents and Kara Seas* (Osteras, Norway: Norwegian Radiation Protection Authority, 1993).
5. Lynn, N., et al., "Radionuclide Release from Submarine Reactors Dumped in the Kara Sea," presented at *Arctic Nuclear Waste Assessment Program Workshop* Woods Hole

Oceanographic Institution, Woods Hole, MA, May 1–4, 1995.

6. O'Dowd, D.D., "Characterization of the Arctic Environment: Introductory Comments," Proceedings of Workshop on Arctic Contamination, *Arctic Research of the United States*, 8:66–67, 1993.
7. Romanenkova, Veronika, "Minister Describes Pollution in Chechnya, Komi, Elsewhere," ITAR-TASS, in JPRS-TEN-95-003, Feb. 24, 1995, p. 45.
8. Sivintsev, Y., "Study of Nuclide Composition and Characteristics of Fuel in Dumped Submarine Reactors and Atomic Icebreaker *Lenin*," Part I-Atomic Icebreaker (Moscow: Kurchatov Institute, December 1993).
9. U.S. Congress, Senate Select Committee on Intelligence, *Radioactive and Other Environmental Threats to the United States and the Arctic Resulting from Past Soviet Activities*, Senate Hearing Aug. 15, 1992, 102-1095 (Washington, DC: U.S. Government).
10. U.S. National Aeronautics and Space Administration, Scientific and Technical Information Program, *Arctic and Antarctic Sea Ice, 1978–1987, Satellite Passive-Microwave Observations and Analysis*, NASA SP-511, (Washington, DC: NASA, 1992).
11. Westermeyer, W., and K. Shusterich, (eds.), *U.S. Arctic Interests: 1980s and 1990s* (New York: Springer-Verlag, 1994).
12. The World Bank, *Staff Appraisal Report, Russian Federation, Environmental Management Project*, Report No. 12838-RU (Washington, DC: The World Bank, Oct. 19, 1994).
13. Zolotkov, Andrei, People's Deputy (Supreme Soviet) for Murmansk region, translated presentation, "On the Dumping of Radioactive Waste at Sea Near Novaya Zemlya" at the Greenpeace Nuclear Free Seas Campaign, Russian Information Agency Seminar: *Violent Peace—Deadly Legacy*, Moscow, Sept. 23–24, 1991.