Proliferation and Pollution Risks from Naval Nuclear Activities in Northwest-Russia

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August 12, 2000 Kursk, a state-of-the-art nuclear submarine, sank in the Barents Sea with the loss of all 118 crew-members. The accident was a dire reminder of the state of Russian naval nuclear affairs. The Northern Fleet is in heavy sea, with severe local pollution hazards and global proliferation risks in the wash of their nuclear prolusion activities.

The costal regions of the Northwest Russia, including the Kola Peninsula, have the greatest density of nuclear reactors on earth. Due to the extensive activities of the Russian Northern Fleet, almost one fifth of the world's reactors are located in this area. In addition to military submarine operations, several nuclear-powered naval surface vessels are in operation.

This article gives a snapshot of the proliferation and pollution potential associated with these naval reactor activities, including some background to and causes of today's problems. Russian nuclear policies and foreign nuclear safety and security assistance will be discussed. While important progress has been made, much of the foreign support came with some hard-learned experiences. All lessons learned, good and bad, should be used to improve new rounds of cooperative efforts to limit the persistent nuclear security and safety risks in the region.

History and future of the Northern Fleet

To catch up with the United States, the Soviet Union started building-up a modern fleet in Northwest-Russia at the end of the 1950s. Six new naval bases, some with nuclear submarine facilities, were built on the Kola Peninsula from Zapadnaya Litsa in the west to Gremikha in the east.[2] A number of smaller navy bases for other types of vessels were also established at the Pechenga Fjord in the west, Belomorsk to the east and Novaya Zemlya to the north. At the same time, five large naval yards were built on the Kola Peninsula and in Severodvinsk for the construction and maintenance of nuclear submarines.

Since 1958, the Soviet Union and Russia have constructed 249 nuclear-powered submarines, representing more than half of the submarines produced worldwide.[3] Two thirds of these vessels were delivered to the Northern Fleet, the rest were destined for the Pacific Fleet. In addition to the combat submarines, five research and development submarines and several full-size land-based submarine-training facilities have been produced.

Additionally, the eight ships in the Russian icebreaker fleet are nuclear propelled, each with one or two reactors, accompanied by four battle cruisers and a communication ship with twin reactors. Most Russian submarines are equipped with two reactors. The overall number of naval reactors produced by the Soviet Union/Russia is therefore at least 480.The vessels use fuel enriched from below 21% to 90%.[4] Of these, a total of 24 reactors are believed to have been designed to use uranium enriched to 90% U-235.[5]

Deployment reached a highpoint in 1989, when approximately 196 submarines were in service.[6] However, Russian submarines are now at an all-time low in terms of deployment and readiness. As of 2000, the Russia had 44 active submarines.[7] Russia's latest nuclear submarine, an Akula-class vessel, had its first test in November 2000. It was the first submarine to leave the Sevmash production facility in Severodvinsk in three years.[8]

The severe budget crunch has forced the Russian Navy to retire older submarines prematurely, and to concentrate its limited sources on maintaining only the most modern assets. Russia is likely to maintain a limited number of modern submarines (SSBNs) in the coming decade.[9] Consolidation of strategic operations to northern area could be likely if not enough new submarines are deployed.

The majority of the constructed submarines have now reached the end of their service lives and have been decommissioned. The vessels await dismantlement, a process with huge safety (pollution) and security (proliferation) challenges.[10]

Pollution risks

The use, maintenance and decommissioning of all nuclear reactors generate radioactive waste that must be processed, transported and stored. Existing storage capacities for spent fuel is stretched to the limits, with nuclear assets sometimes kept in the open.[11] The situation threatens accidents and leakages to the environment, with subsequent exposures to populations and contamination of the environment.

Almost all the radioactivity residues in the spent nuclear fuel. However, liquid radioactive waste is generated during refueling operations, and the reactor compartments, control rods and tailings from the reactor tank must be regarded as radioactive waste. Other potential sources of pollution include dumped radioactive (liquid and solid) material, naval nuclear accidents, and possible import of nuclear waste. An overview of radioactive waste, fuel and decommissioned submarines in Northwest-Russia is given in table 1.

Decommissioned submarines and spent naval fuel

By the end of 2000, 184 Russian nuclear submarines have been decommissioned. Of these vessels, 48 have been dismantled, 28 are in the process of being cut up, and 112 are still waiting the initiation of work at piers and quay structures. Most of the vessels still have loaded reactors.[12] At eight different locations, there are now inactive nuclear submarines stored and awaiting dismantling, or dismantling activities are under way.

33,600 assemblies are stored in land-based storage sites and in a variety of run-down service/storage vessels in the northern region.[13] An equivalent number is still nboard inactive submarines, and the total amount of the fuel assemblies will likely increase to as much as 100,000 over the next decade. [14] This will include spent fuel from submarines still in operation, submarines earmarked for retirement and the civilian nuclear powered icebreakers in Murmansk.

The Russian navy has clearly shown its inability to deal with the fuel backlog. Civilian ship is collecting spent fuel from naval a service vessel to help defueling a nuclear powered submarine.[15] In Soviet times, excess or spent nuclear fuel would have been transported by rail to the Mayak complex for reprocessing, but reprocessing activities are erratic. Even if an optimistic view is taken of the capacity of the Mayk plant to reprocess fuel, storages for more than 100,000 spent fuel assemblies are needed.[16] Moreover, transportation of the spent fuel is long and costly, and calls have thus been made for intermediate storage facilities in the northern region. [17]

Dumping of radioactive material

According to Russian sources, about one PBq[18] of liquid radioactive waste have been discharged by the Russian Navy directly into seawater within five allocated areas of the Barents Sea and in the Kara Sea.[19] 10 reactors without fuel and 6 reactors without fuel have been disposed at the east cost of the island Novaya Zemlya and in allocated areas in the open Kara Sea. In addition, 17 vessels with solid radioactive waste have been sunken, together with 6,508 containers with radioactive waste.[20]

Generally, no contribution from the dumped radioactive waste can be found in the waters, sediments and biota in the open sea dumping regions.[21] However, enhanced levels of artificially produced radionuclides in sediments collected in the very close vicinity of almost all localized dumped objects demonstrate that leakages occur. The dumped material represents long-term pollution hazards.

Accidents

As tragically evidenced by the Kursk, nuclear submarines are accident-prone. Most accidents have occurred while submarines have been on patrol, although some happened during refueling or repair operations (see below). Kursk is the fourth nuclear powered submarine from the Northern fleet to sink. All of the wrecked vessels had twin nuclear reactors, and two of them were carrying nuclear missiles. Long-term radioactive releases are likely. At the end of 2000, the Russians expressed interest in a joint Russian-Norwegian environmental impact assessment and surveillance programs to track radioactive releases from Kursk.[22] However, Russian officials recently claimed that the wreck will be hauled late summer 2001.[23]

The risk of criticality accidents during the handling of the highly enriched fuel may be pronounced. Some of the spent fuel is stored in uncontrolled geometry (e.g. at Andreeva Bay), and a moderator like water is provided accidentally.[24] Other possible causes of criticality accidents are collisions, fire or explosions. In 1985, during refueling a criticality accident occurred with a new core, contaminating the area surrounding a Pacific Soviet naval base in Chazhma Bay.[25] The releases are likely to primary to have local impact, but a similar criticality accident with a depleted core on the Kola shore could release quantities of radioactivity into the air and the Barents Sea, with effects on neighboring states.[26]

Imports of nuclear waste

Prospects of badly needed revenues have made Russia consider import of high-level radioactive waste. The powerful Ministry of Atomic Energy (Minatom) claims that the plan could reap $ 21 billion over the next decade, vault Russia into the global nuclear service-industry and to provide cash to clean up radioactive hot-spots.[27]

Others have raised concern that the import revenues will be used to boost the Minatom nuclear weapon complex, with the production of new and modernized warheads.[28] The import, likely to have a devastating effect on already critical and strained Russian storage capacities, awaits further considerations as the Russian Duma postponed voting on the nuclear fuel import bills March 22, 2001.[29]

Proliferation risks

Highly enriched uranium and plutonium are the essential ingredients of any nuclear device. Russia alone may hold as much as 80 to 85 metric tons of HEU for naval propulsion.[30] The radiation levels of the fresh fuel are low and the enrichment levels make it potentially attractive in nuclear weapons. Fresh fuel diversion and possible exports of naval HEU and reactor technologies thus both represent proliferation risks.

Naval technology exports are of concern as nuclear arms control treaties have very limited ability to control transfers fresh naval fuel.[31] Russian sales, civilian or military, can thus create new HEU-markets outside international control, and possibly a back-door to clandestine weapons-production.

Naval security upgrades

Russian naval fuel has been particularly exposed to the thefts in the past (see table 2), prompting the Northern Fleet to seek assistance to upgrade the security at its facilities. Now, the U.S. Material Protection, Control and Accounting (MPC&A) program for Russian naval fuel has made good progress in reducing the vulnerability of large amounts of HEU and nuclear weapons to theft or diversion.[32] Most of the Russian fresh naval fuel in the region is consolidated into a central facility.[33] In addition, the U.S. has assisted in developing physical protection upgrades for service ships involved in refueling operations.[34]

However, spent fuel, which may represent proliferation risks due to long cooling times and high levels of residual plutonium and HEU, is not covered by the upgrades.[35] Moreover, the U.S. has just stared assisting the Russians upgrading the 42 naval sites where nuclear weapons are stored. According to the U.S. Department of Energy, these sites contain 260 tons of nuclear material.[36]

Naval reactor technology exports

Existing infrastructure, technical expertise, and potential markets inside and outside Russia has lead to innovative suggestions for naval reactor technology use.[37] Floating nuclear power plants using naval reactors and HEU fuel has been a long-term goal. Minatom announced March 2001 that it will build a floating nuclear power plant in Severodvinsk.[38] Exports could give a badly needed boost to Russian nuclear industry.[39]

Military nuclear naval cooperation also takes place. In 1988, India leased a Russian Charlie-class nuclear submarine for three years. Late 2000, India again wanted a Russian SSN, and in March 2001, press reports indicate that Russia is ready to sell the Indian navy e.g. a Russian-built nuclear submarine.[40] Such sales, and future civilian exports inevitably will involve transfers of HEU. Russia has supplied fuel outside comprehensive safeguards in the past.[41]

Russian Naval Nuclear Policies and International Support

Russia has come a long way since the beginning of the 1990s. The country has adhered to the London Dumping Convention and abandoned its nuclear dumping,[42] and has open up for several bi- and multilateral nuclear safety and security initiatives. Domestically, the control over decommissioned submarines, spent fuel, and radioactive waste has been transferred from the navy to Minatom.[43]

Though not yet publicly available, Minatom has developed a conceptual plan for the management of radioactive wastes and spent fuel up to 2020.[44] The new policy involves interim storage of the spent fuel and is a significant, if temporary departure from a long-term closed cycle approach (reprocessing) to the management of spent fuel.[45]

Funds for submarine dismantlement now create “oases” of revenue within the Russian naval complex.[46] The U.S. aid focuses on strategic threat reduction with assistance for missile elimination, warhead security, strategic ballistic-missile submarine (SSBN) dismantlement, and the mentioned security upgrades at facilities with proliferation attractive fresh nuclear fuel and nuclear weapons.[47]

Neighboring countries, like Norway, give local assistance to stop contamination, and to spent fuel and radioactive waste management. In response to concerns over Russian radioactive waste contamination of Norwegian fisheries in the Barents and Kara Seas and general worries over nuclear safety on the Kola Peninsula, Norway initiated its Plan of Action for nuclear issues in 1994.[48] In addition, several European Union Countries are involved in joint security and safety projects under the Tasic-umbrella.[49]

However, while Russia, on one hand, is taking the problems seriously, and accepts international assistance where available, most of the problems persist. Mutual mistrust, cold war thinking and a relentless bureaucracy have hampered parts of this important cooperation. The most prominent cooperation deficiencies on both sides are summarized below.

Naval Nuclear Safety and Security Policy Deficiencies

While the project support has been fragmented, with a *lack of coordination* and an overall plan for the assistance on the donor side,[50] the receiver end has not been ready to meet the requirements and expectations following the international nuclear cooperation. To optimize resources allocated (avoid redundancy and duplication of efforts), assure that priority needs are made known to the international community, and to provide points of contact to facilitate cooperation, efforts of coordination on behalf of the donor countries need to be strengthened. An important development is the Contact Expert Group for International Radwaste Projects in the Russian Federation.

The current fragmented international "band-aid" approach is in part due to the *lack of prioritizing* of program areas Russia wants to emphasize, making concerted efforts harder. The overall Minatom-plan under development for waste management is definitively a step in the right direction, once it is made public. The cooperation has been characterized by *lack of facilitation* on the Russian side. This is evidenced by access denial, stringent Russian licensing and certification requirements, liability problems and taxation on the aid provided.

The lack of supervision is a serious problem. Limited access hinders assessments studies and progress reporting, and endangers future international funding. The current storage conditions violate both international and Russian nuclear regulations, but no navy facilities are subjected to independent domestic supervision. In July 1995, President Yeltsin signed an order depriving the Russian Federal Inspectorate for Nuclear and Radiation Safety, known in Russia by the acronym GAN, of control functions at defense ministry facilities. The summer of 2000, Minatom pushed through a government decree eliminating the rights of GAN to license and supervise any military-related facilities.[51]

After almost a decade of assistance the bulk part of the problems remains. Of the 184 decommissioned submarines, the U.S. has allocated funds for the dismantling of 36 SSBNs. However, there is a *lack of funds* for dismantling the remaining ones, including all general-purpose submarines, of which the majority still has fuel onboard.[52] Moreover, plans for building storage facilities for the naval fuel have stranded, without even intermediate solutions for the high level waste. Thus, again, there is a need for international donors to contribute and coordinate efforts.

Conclusion

Solving the problems associated with Russian naval activities is a sole Russian responsibility. However, the remediation of naval bases and the safe interim storages of spent fuel in Northwest-Russia is in the interest of the international community. The pollution is a cross-border problem and the possible proliferation of navel HEU fuel a global security risks.

With serious nuclear safety and security challenges remaining, the international interest in solving the problems stands at risk of declining due to the lack of progress and persistent cooperation difficulties. Thus, there is a definitive need for Russia to further open up, and to the widest extent possible, facilitate the assistance given. Increased access while respecting Russian security concerns can be accomplished, as evidenced by the unique progress made in the joint U.S.-Russian security upgrades on the sensitive naval fresh fuel.

To renew and expand the interest amongst a widest possible range of future sponsors, the need for a political "resell" of both challenges and opportunities for concerted nuclear safety and security efforts in Northwest-Russia should be anticipated.

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Table 1 Overview of radioactive contamination in Russia's Northern bases.[53]

Establishment	Role	Potentially dangerous assets
Zapadnaya Litsa/Andree	Naval base	26 operational nuclear submarines 2 inactive nuclear submarines, one with spent fuel 22,700 spent fuel assemblies 2,000 m^3 liquid radioactive waste 6,000 m^3 solid radioactive waste
Vidyayevo (Ura Bay ar Bay)	Naval bases	4 operational nuclear submarines 14 inactive nuclear submarines with spent fuel Small amounts of solid radioactive waste
Gadzhievo (Skalisiti) Saida Bay	Naval base Storage facility	Unknown number of nuclear submarines 200 m^3 liquid radioactive waste 2037 m^3 solid radioactive waste Occasional service ships with radioactive waste and/or fuel on board 12 submarine hulls with reactors
Severomorsk	Naval base	3 decommissioned nuclear powered battle cruisers
Gremikha	Naval base	17 inactive nuclear submarines 767 spent fuel assemblies, 6 liquid metal cooled reactor cores 300 m^3 solid radioactive waste 1960 m^3 liquid radioactive waste
Nerpa	Shipyard	1 submarine being decommissioned Periodic visit of service ships with spent fuel or liquid rad waste on board 300 m^3 solid radioactive waste 170 m^3 liquid radioactive waste
Shkval (Polyarny)	Shipyard	1 submarine in for maintenance 2 service ships with spent nuclear fuels or radioactive wast 7 inactive nuclear submarines with fuel Storage facility for solid radioactive waste 150 m^3 liquid radioactive waste
Sevmorput	Shipyard	2 inactive nuclear submarines Occasional service ships with liquid radioactive waste Storage for solid radioactive waste

Severodvinsk (Zvezdochka, Sevmash)	Shipyards	12,539 m^3 solid radioactive waste 3000 m^3 liquid radioactive waste 4 nuclear submarines for maintenance Dismantlement 12 inactive nuclear submarines 4 reactor compartments from submarines already decommis
Atomflot (Icebreaker flee	Harbor	8 nuclear powered icebreakers Fresh and spent fuel stored afloat Liquid and solid waste stored afloat and on-shore.
Russian Navy Nuclear W Sites	42 sites (in Northwest and the Far-East)	About 260 metric tons of nuclear material Number of nuclear warheads and locations are unknown
Kara and Barents Sea	Dumped nuclear waste	10 reactors with fuel 6 reactors with spent fuel 17 vessels with solid radioactive waste 6,508 containe radioactive waste

Table 2 Overview of registered thefts of highly enriched uranium from the Northwest-Russia.[54]

Location	Date	Theft	Enrichment	Perpetrators	Notes
Andrejeva Bay	July 1993	Two fuel ass (each element w 4.5 kg)	36 percent	Two sailors fr Navy's r protection depart	Two more officers c but the charge was wit on account of insu evidence.
Sevmorput installations, Mu	November 1993	Three fuel eleme 4.3 kg HEU	Approx. 20 perce	Three officers	The material was re and the perp sentenced.
The shipyard Se Severodvinsk	July 1994	Uranium dioxide	20-40 percent	Four businessm the area, in con with workers shipyard	On-going lawsuit
The shipyard Se Severodvinsk	October 1994	Fuel elements	Highly enriched	No information	Arrests in Arkhange prosecution.
The s Zvezdochka, Severodvinsk	July 1994	Fuel elements	No information	Employees hir contracts from Northern Fleet	The accused were before the uranium removed from the ship
The s Zvezdochka, Severodvinsk	January 1996	Fuel elements	No information	Employees hir contracts from Northern Fleet	Uranium removed fr shipyard. Arres Severodvinsk.

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[2] On the past production and the current problems of the Northern Fleet, see Thomas Nilsen, Igor Kudrik, and Alexandr Nikitin, "The Russian Northern Fleet", Bellona Report Volume 2:1996.

[3] 92 ballistic missile submarines (SSBNs), 67 cruise missile submarines (SSGNs), 90 attack submarines (SSNs).

[4] Oleg Bukharin and William Potter, "Potatoes were guarded better," *The Bulletin of the Atomic Scientists*, Vol. 51, No. 3, May/June (1995), p. 48.

[5] Oleg Bukharin, "Analysis of the Size and Qualities of Uranium Inventories in Russia". *Science and Global Security*, Vol. 6. (1996), p. 63.

[6] Oleg Bukharin and Joshua Handler, "Russian Nuclear-Powered Submarine Decommissioning", *Science & Global Security*, Vol. 5, No. 2 (1995), p. 246.

[7] 18 SSBNs, 8 SSGNs and 20 SSNs. Richard Sharpe,ed., Jane's Fighting Ships 2000-2001, 103rd edition (Surrey: Jane's Information Group Limited,2000), p. 552.

[8] Agence France Presse, "Russia to Test New Nuclear Submarine, November 15, 2000.

[9] William Arkin and Hans Kristensen, "Dangerous Directions" *The Bulletin of Atomic Scientists*, March/April (1998), p. 29.

[10] For descriptions of the challenges related to the decommissioning of the Russian submarine fleet, see e.g. Oleg Bukharin and Joshua Handler, "Russian Nuclear-Powered Submarine Decommissioning", James C. Moltz, and Tamara Robinson, "Dismantling Russia's Nuclear Subs: New Challenges to Non-proliferation", *Arms Control Today*, June (1999), and James C. Moltz, "Russian Nuclear Submarine Dismantlement and the Naval Fuel Cycle," *The Nonproliferation Review*, Spring (2000), pp. 76-86.

[11] One example is the 32 containers with a total of 200-220 spent fuel assemblies being stored at an open area at Andreeva Bay. Thomas Nilsen, Igor Kudrik, and Alexandr Nikitin, "The Russian Northern Fleet", Bellona Report Volume 2:1996, p. 102.

[12] Of the 110 nuclear powered submarines taken out of service by August 2000, 72 of them still had spent nuclear fuel onboard. Igor Kurik, "Russian Navy contracts civilians to manage spent fuel", August 31, 2000. www.bellona.no/imaker?id=17720&sub=1

[13] Contact Expert Group, "Working Material of the 11th Meeting", volume II, Cherbourg, France, 25-27 October 2000, p. 248.

[14] Thomas Nilsen, "Mayak spent fuel storage moves to Kola", March 20, 2000, www.bellona.no/imaker?id=15894&sub=1

[15] Igor Kudrik, "Russian Navy contracts civilians to manage spent fuel", August 31, 2000, www.bellona.no/imaker?id=17720&sub=1

[16] Contact Expert Group, "Working Material of the 11th Meeting", volume II, Cherbourg, France, 25-27 October 2000, p. 248.

[17] Bellona estimates the price for transportation, storage and reprocessing per trainload to be at least $500,000, and a have made several calls for an intermediate storage.

[18] 1 Ci = 3.7×10^{10} Bq (or 3.7×10^{10} transformations/s).

[19] From the White Book No.3, "Facts and Problems Related to Radioactive Disposals in Seas Adjacent to the Territory of the Russian Federation. Materials for a Report by the Government Commission on Matters Related to Radioactive Waste Disposals at Sea, Moscow, 1993.

[20] Al J. Venter, "Soviet nuclear legacy poses deadly threat", *Jane's Intelligence Review*, October (1999), p. 15.

[21] Per Strand, Alexander I. Nikitin, Bjorn Lind, Brit Salbu and Gordon C. Christensen, "Dumping of Radioactive Waste and Radioactive Contamination in the Kara Sea", Joint Norwegian-Russian expert Group for Investigation of Radioactive Contamination in the Northern Areas, 2nd edition, May, 1997, p. 49.

[22] The Norwegian Radiation Protection Authority, "Norwegian-Russian Monitoring of Kursk" (in Norwegian), December, 2000.

[23] NTB, "Everything ready for Kursk rescue" (in Norwegian), April 11, 2001.

[24] Contact Expert Group, "Working Material of the 11th Meeting", volume II, Cherbourg, France, 25-27 October 2000, p. 250.

[25] Ten workers were killed immediately. The total amount of material released has been estimated as 1.85×10^{17} Bq, not including 8.1×10^{16} Bq of noble gases. If these figures are correct, the radioactivity released was approximately one seventh of the total released in the Chernobyl accident. From http://ds.dial.pipex.com/cndscot/trisaf/ch4.htm

[26] Morten Bremer Maerli, Sigurd Boerresen, Knut Gussgard, Steinar Hoibraaten, and Matylda M. Sobieska, "Criticality Considerations on Russian Ship Reactors and Spent Nuclear Fuel", Norwegian Radiation Protection Authority, StrålevernRapport 1998:7 (1998).

[27] Fred Weir, "Russia as Nuclear Garbageman?", *The Christian Science Monitor*, February 21, 2001.

[28] Pavel Felgenhauer, "Why Russia Wants Waste", *The Moscow Times*, January 4, 2001,

[29] Vladislav Nikiforov, "Duma postpones fuel import bills reading", March 23, 2001, www.bellona.no/imaker?id=9995&sub=1

[30] Mark Hibbs, "Czech Find May Be Re-Enriched Repu to Naval Fuel or Research Reactors", *Nuclear Fuel*, Vol. 20, No.1, p. 12.

[31] Morten Bremer Maerli, "Deep Seas and Deep-Seated Secrets: Naval Nuclear Fuel Stockpiles and The Need for Transparency", Disarmament Diplomacy, Issue No 49 (2000) www.acronym.org.uk/49fuel.htm

[32] United States General Accounting Office, "Security of Russia's Nuclear Material Improving; Further Enhancements Needed", GAO-01-312, February 2001. See also Oleg Bukharinm Matthew Bunn, Kenneth N. Luongo, Renewing the Partnership: Recommendations for Accelerated Action To Secure Nuclear Material in the Former Soviet Union," Russian American Nuclear Security Advisory Council, August (2000), p. 60.

[33] For the Northern Fleet, the fuel is to be consolidated at Site 49 at Severomorsk. However, fresh fuel remains at at least two additional locations in the Northern region: At the civilian Icebreaker fleet and at the Sevmash submarine production facility in Severovinsk.

[34] Clay J. Moltz and Tamara C. Robinson, "Dismantling Russia's Nuclear Subs."

[35] Knut Gussgard and Ole Reistad, "Russian Spent Marine Fuel as a Global Security Risk", paper presented at the International Conference on Security of Material - Measures to Prevent, Intercept and

Respond to Illicit Uses of Nuclear Material and Radioactive Sources, Stockholm, Sweden, 7 - 11 May 2001.

[36] United States General Accounting Office, “Security of Russia’s Nuclear Material Improving; p. 32.

[37] Examples, still only on the drawing-board, include e.g. nuclear floating water desalination stations, the use of nuclear submarines for the shipment of commercial cargoes and underwater sea and gas production, and unattended self-regulative nuclear power sources for autonomous sea vehicles, all based on naval reactor technologies.

[38] Associated Press, “Russia Plans Floating Nuclear Power Plant”, March 14, 2001

[39] Possible exports, pollution and proliferation concerns are described in Kuznetsov, V.M. et al., ”Floating Nuclear Power Plants in Russia: A Threat to the Artic, World Ocean and Non-Proliferation Treaty,” Nuclear and Radiation Safety Program, Socio-Ecological Union, Greenpeace Russia, Center for Russian Environmental Policy

[40] IPR Strategic Business Information Database “Russia ready to sell India nuclear submarine”, March 13, 2001

[41] Reuters, “India Defends Importing Nuclear Fuel from Russia”, February 20, 2001, and Mark Hibbs, “China, Russia Challenge NPT Review over Full-Scope IAEA Safeguards,” *Nuclear Fuel*, Vol. 2, No. 8. April 17 (2000).

[42] The Convention on the Prevention of Marine Pollution By Dumping of Wastes and Other Materials, commonly known as the London Dumping Convention.

[43] Jurisdiction is transferred according to a May 28, 1998 governmental decree.

[44] Contact Expert Group, “Working Material of the 11th Meeting”, volume II, Cherbourg, France, 25-27 October 2000, p. 247.

[45] Ibid., p. 247.

[46] James C. Moltz, “Russian Nuclear Submarine Dismantlement and the Naval Fuel Cycle”, p.78.

[47] U.S. assistance is provided by the Cooperative Threat Reduction program and the U.S.-Russian cooperation on Nuclear Material Protection, Control and Accounting See Partnership For Nuclear Security - United States/Former Soviet Union Program of Cooperation on Nuclear Material Protection, Control and Accounting (September 1998). <www.nn.doe.gov/mpca/pubs/fr_inmm.htm>. The CTR-program has also approved funding for a small-scale reprocessing program to reduce the backlog material at various shipyards, due to its harmful impact on submarine dismantlement rates. James C. Moltz, “Russian Nuclear Submarine Dismantlement and the Naval Fuel Cycle”, p.78.

[48] Through this plan, funding for construction of a spent fuel transport vessel and spent fuel railcars, improvements in liquid radioactive waste storage at Severodvinsk, and construction of a mobile liquid radioactive waste processing facility for the Northern Fleet have been made available. James Clay Moltz and Tamara C. Robinson, “Dismantling Russia's Nuclear Subs”, p. 14.

[49] See http://europa.eu.int/comm/external_relations/ceeca/tacis/index.htm

[50] Interview with The Norwegian Deputy Secretary of State, Espen Barth Eide, Aftenposten, January, 24, 2001.

[51] Cristina Chuen and Elena Sokova, “Russia Risks Another Chernobyl”, International Herald Tribune, December 22, 2001.

[52] Cristina Chuen & Michael Jasinsk, “Russia’s Blue Water Blues,” *The Bulletin of the Atomic Scientists*, Vol. 57, No. 1, January/February (2001), p.69.

[53] Based on Al J. Venter, “Soviet nuclear legacy poses deadly threat”, *Jane’s Intelligence Review*, October 1999, p. 15, and updated and extended with more recent information.
[54] From R. Lee, ”Recent Trends in Nuclear Smuggling” in P. Williams, ed., in *Russian Organized Crime: The New Threat* ? (London: Frank Cass, 1996), p.118-119, with minor additions.