Special Report

Russian Nuclear Submarine Dismantlement and the Naval Fuel Cycle

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In December 1998, seven months after the Russian Ministry of Atomic Energy (Minatom) had assumed supervisory control over nuclear submarine dismantlement and spent fuel issues, Deputy Minister Nikolai Yegorov described conditions in the Russian naval fuel cycle as an "accident-prone situation,"[2] given the extensive stockpiles of fresh and spent fuel spread across naval yards in the Far North and Far East. Russian sources estimate, for example, that some 60 to 70 tons of highly enriched uranium (HEU) naval fuel (with enrichment levels of over 20 percent) currently reside in active-duty Russian nuclear submarines, icebreakers, and cruisers, and in the large number of decommissioned submarines that still contain operating reactors.[3] Consolidating fresh naval fuel, ensuring adequate physical protection, dismantling nuclear submarines (especially those with long-range, sea-launched ballistic missiles [SLBMs]), and dealing with spent fuel from their reactors all remain critical tasks for nonproliferation policy.

The possible theft, diversion, or sale of fissile material (including both fresh and spent naval fuel) is the greatest proliferation and security risk arising from current conditions in the Russian naval nuclear fuel cycle. In 1993, for example, two diversions of fresh naval fuel occurred in the Northern Fleet: the theft of 1.8 kilograms of HEU naval fuel from a storage site at the Zapadnaya Litsa naval base and the seizure of 4.5 kilograms of HEU fuel from the Sevmorput shipyard in Murmansk.[4] Another threat is possible terrorism involving active-duty submarines or decommissioned submarines that have not been defueled. One such act occurred at the Gadzhiyevo base in September 1998, when a sailor frustrated by deteriorating conditions killed eight other servicemen before barricading himself in the torpedo room of his *Akula*-class attack submarine (SSN). He held the vessel hostage for 24 hours, threatening to blow it up with its weapons and two nuclear reactors, before dying in an explosion he apparently set.[5] Still other concerns include the possible theft of a poorly guarded decommissioned nuclear submarine by a rogue state, the possible sale of decommissioned nuclear submarines to third countries, and the possible Russian recommissioning of decommissioned nuclear submarines whose reactors are still fueled.[6] In the Pacific Fleet, Russian officials caught two North Korean agents in 1994 in a scheme involving the attempted purchase of cruising patterns for active duty nuclear sub-

marines as well as dismantlement schedules for decommissioned vessels.[7] The bulk of the Russian Far East's naval fuel cycle and dismantlement facilities are located less than 100 miles from the North Korean border. Notably, a US court convicted a former Chinese national in 1999 for exporting highly advanced speedboats (reportedly capable of speeds up to 160 miles per hour) to North Korea.[8]

The following assessment of US assistance programs in the naval fuel and submarine dismantlement sectors—including work to date at approximately a half dozen sites in the Northern Fleet (primarily near Murmansk and Severodvinsk) and a smaller number in the Pacific Fleet (primarily near Vladivostok)—uses as its primary measure their effectiveness as nonproliferation tools. To those people in the Departments of Defense (DOD) and Energy (DOE) who have worked very hard on particular programs with narrower official mandates, such as the dismantlement of specific classes of submarines or safeguarding of particular types of fuel, this may seem like an unfair measure. Notably, the analysis presented here shows that these mandates have been pursued with exceptional dedication by DOD and DOE personnel. However, it is important that the next Congress, the next administration, and the American public consider the full range of possible proliferation threats in the Russian naval sector as the United States considers the future of its assistance programs.

BACKGROUND TO AND CAUSES OF TODAY'S PROBLEMS

From the early 1960s to the early 1990s, the Soviet Union constructed the world's largest fleet of nuclear-powered vessels: a total of 257, compared to 199 constructed by the United States.[9] Of the Soviet total, 244 consisted of various types of nuclear submarines (ballistic missile, attack, and cruise missile boats); the rest included nuclear cruisers, space-tracking vessels, and civilian icebreakers. In most cases, Soviet nuclear submarines carried two nuclear reactors apiece, each powered by HEU fuel. During the Soviet period, very few of these vessels had to be decommissioned. Those few with reactor problems were often disposed of by scuttling them at sea, usually with their reactors fully loaded. In three cases, nuclear submarines with both reactors and nuclear weapons aboard went to the bottom in uncontrolled accidents, in two cases killing most of their crews.

In the area of fissile material storage, fresh HEU fuel was protected during the Soviet period by a multiple-layered system of physical protection that banned access by any foreigners to most cities and kept even Soviet citizens from a large number of closed military areas. There were no known cases of diversion, and it would have been extremely difficult for persons to have sold this material due to close KGB surveillance of contacts between Soviet citizens and any foreigners. Spent fuel (which contains significant quantities of HEU, as well as plutonium) was taken by rail to the Mayak facility for reprocessing into reactor fuel. Problems with the storage of these materials in cooling ponds at naval facilities had already become an environmental problem during the late Soviet period, due to shoddy construction and inadequate storage capacity.[10] Physical protection of spent fuel, moreover, remained a secondary priority.

Similar to the practices of other countries before the London Dumping Convention established stricter rules, common Soviet-era policies included the dumping of low-level liquid radioactive wastes (LRW) at sea, thus obviating the need for LRW storage or filtration. During the late Soviet period, it had already become clear that dismantlement would become a major new activity, but the Soviet government failed to plan for the backlog of decommissioned nuclear vessels that had already begun to appear at various facilities.[11] One former Soviet admiral explains that even in the late 1980s "top-ranking state officials…didn't fully realize that [the] piling up of obsolete nuclear-powered submarines constitute[d] a danger incomparable to that of other armaments which were to be written off."[12] To the very end, the focus of the Soviet military system was on production and operations, not on long-term proliferation or environmental problems. As a result, these issues were largely ignored.[13]

By 1991, it was too late to avoid the consequences of this neglect. The Russian Federation's lack of financial resources and the Soviet government's almost complete failure to plan ahead for the time-consuming process of nuclear submarine dismantlement led to a series of dangerous problems: a backlog in dismantlement work, inadequate liquid-waste storage, lack of transport capacity for spent fuel, and lack of storage capacity for spent fuel. Decommissioned submarines, spent fuel, and radioactive waste began to pile up. Moreover, Russia's continuing economic decline led to serious gaps in security at a number of facilities, most importantly at sites with

stockpiles of proliferation-sensitive HEU submarine and icebreaker fuel. Civilian staff failed to receive salaries and military units suffered from low wages, poor morale, and understaffing.[14] A related problem was the accelerated rate of nuclear submarine decommissioning that took place in the early to mid-1990s, due to a lack of financial resources within the Russian Navy to keep a large number of submarines operational. Many of these vessels had not reached the end of their service lives. But additional submarines and material kept coming offline, while the dismantlement rate remained between three and six submarines per year nationwide. A huge backlog accumulated so that by the end of 1999, the Russian Federation had decommissioned nearly 180 nuclear submarines, yet had defueled less than one third and had fully dismantled only a handful. Russia still has not implemented a "cradle-to-grave" system for full submarine recycling, dismantlement, fuel disposition, and long-term reactor compartment storage.

US ASSISTANCE PROGRAMS AND ACCOMPLISHMENTS

Cooperative Threat Reduction (CTR) Activities

At the outset, it is important to note that the original congressional mandate for the DOD's CTR program focused on the narrow area of SLBM (launcher) elimination. This mandate, and the necessity of maintaining congressional support, limited how much the program in its early years could contribute to the achievement of broader nonproliferation aims. However, changes in the program have facilitated greater effectiveness over time in achieving wider nonproliferation goals.

Early US programs offered assistance for missile elimination and warhead security and provided technology to three shipyards to assist in strategic ballistic-missile submarine (SSBN) dismantlement. It must be kept in mind that Russian shipyards had not previously engaged in submarine dismantlement and were therefore learning from scratch from US technical personnel, some of whom themselves had limited experience in nuclear submarine dismantlement work. The US Navy provided only tacit support for the program, although later the US Navy Sea Systems Command did allow (albeit reluctantly) Russian Ministry of Defense, Navy, and shipyard representatives to visit the main US submarine dismantlement facility, the Puget Sound Naval Shipyard in Bremerton, Washington.[15]

Initial US CTR activities in the submarine field during the mid-1990s focused on the provision of launcher elimination and dismantlement technology to three START I-designated shipyards where Russia declared it would be dismantling its SSBNs: Nerpa (Murmansk), Zvezdochka (Severodvinsk), and Zvezda (Bolshoy Kamen). This equipment included baler shears, oxyacetylene torches, cranes, protective equipment, and other technology deemed to be useful in cutting out launcher tubes and in dismantling nuclear submarines. This assistance aided in the destruction of five SSBNs,[16] a much smaller number than US officials had hoped for. By 1997, indeed, it was becoming clear that the CTR program was suffering from some serious problems. As Russian Duma Deputy Alexei Arbatov noted ironically regarding the perspective of impoverished shipyard workers toward existing assistance, "…the beautiful US equipment did not bring them any happiness."[17] More troubling from the US perspective, dismantlement rates remained low due to problems endemic to the Russian shipyards: up to eight months in wage arrears, and shortages of other inputs necessary for operation and maintenance of the US equipment at anywhere near an optimal rate. Workers' strikes plagued a number of facilities during this period. Key infrastructure (heat, electricity, and even water) was not being maintained at facilities, and shortfalls made regular work impossible. Many skilled workers left the shipyards due to an inability to support themselves or their families.[18]

As a result, CTR officials undertook a major program review in 1996 and recognized that the United States could not complete its goals in the submarine field without significant changes. Russians complained that the program had provided US technology (to the benefit of US companies) but little else of direct benefit to the Russian shipyards that had to pay to operate this equipment in conditions where they received no funds from Moscow. The Russian side was unable to pay workers to dismantle submarines, yet congressional mandates prevented CTR from paying salaries at these sites. Congress also strongly favored US vendors in the provision of equipment, even when factors related to installation, operation, and maintenance ("sustainability") suggested the logic of buying from Russian providers.

Various proposals were discussed, including the possibility of hiring a single US contractor for submarine work. However, DOD officials selected a more direct route that recognized the inherent difficulty of trying to task a

US entity with sensitive work inside Russian facilities to which it would have limited access. Beginning in 1997, the United States initiated a pilot program to provide direct contracts to shipyards for dismantlement work on a "deliverables" basis: that is, CTR would provide funds for work to be verified on completion, as it does with US contractors. In addition, procurement rules shifted from the previously exclusive "buy American" dictate to allowing a "buy the best and the cheapest" guideline, thus leveling the playing field for new Russian companies.[19]

CTR officials signed the first direct contract with the Zvezdochka facility in Severodvinsk on March 10, 1997, to dismantle an already defueled submarine in dry dock for $4.25 million.[20] The test proved successful and additional contracts have followed with the other three main shipyards, bringing the total of submarines under contract to 17. Eventually, at total of 31 SSBNs will be dismantled on this basis: 17 from the Northern Fleet and 14 from the Pacific Fleet.

These significant changes in the program had immediate positive results. The Zvezda shipyard, for example, used the funds from its contracts to bring its workers' salaries up to date and, after years of layoffs and decline, actually began to hire new workers.[21] After suffering debilitating strikes as late as May 1998 by workers complaining about wage arrears, officials from Northern Fleet shipyards now express great satisfaction with the CTR program; they even lobbied officials in Moscow to approve the extension of the CTR protocol with the United States in the summer of 1999.[22] CTR funds are now creating "oases" of success within the Russian naval complex, as the US DOD is the only entity that provides reliable funding to many of these shipyards. Those facilities outside the program, however, are continuing to suffer from conditions of severe decline. While this is a natural process as Russia moves to lower levels of submarines and a consolidation of material, there are a few facilities where desperate conditions and the presence of sensitive materials warrant further US attention (as noted below).

The official "CTR Scorecard" for work in dismantling SSBNs through 1999 lists as "completed" five SSBNs dismantled in 1995-98 using CTR-provided equipment plus seven with their launcher tubes removed (and under contract for full dismantlement) at four shipyards (Nerpa, Zvezdochka, Zvezda, and Sevmash), with an overall goal of 36 vessels slated for dismantlement by 2003.[23] When combined with expenses for upgrading defueling facilities and eliminating SLBM launchers, the total CTR budget for this work is $455 million through 2002.[24] At $14.7 million per SSBN, this is still much cheaper than the approximately $27 million per submarine cost in the United States. The completion of the dismantlement assistance program will leave Russia with a still significant but more manageable force of nine SSBNs, unless additional vessels enter into service. Given current progress, the odds are good that current CTR goals will be achieved on or nearly on schedule, depending on whether dock space is available to increase current dismantlement rates. The fact that the DOD has been able to work within a difficult set of US regulations and amid extensive Russian suspicion to facilitate a cooperative program to dismantle up to 36 Russian SSBNs is a significant accomplishment, attributable to the tremendous dedication and resourcefulness of CTR officials. But the current US mandate will still leave untouched nearly 140 SSNs (80 in the Northern Fleet and 60 in the Pacific Fleet) in various stages of decommissioning and dismantlement, most of them still with operating nuclear reactors.

The CTR program has also approved funding for a small-scale reprocessing program to reduce the backlog of material at various shipyards. This will involve paying the Mayak facility to reprocess spent naval fuel from six (and possibly up to 15) SSBNs at the RT-1 facility, for use in civilian reactors. Plutonium generated from the process will be stored under the existing DOE Material Protection, Control, and Accounting (MPC&A) assistance program at the facility. The CTR program has been eager to reduce the spent fuel backlog at shipyards because of its harmful impact on submarine dismantlement rates. As one CTR official describes it, spent fuel is now the main "nemesis" of the US program.[25]

Another assistance project involving US participation is the Arctic Military Environmental Cooperation (AMEC) program.[26] This work began in 1993 under the CTR umbrella to reduce the environmental impact of military activities in the Far North, particularly those associated with nuclear submarines. The Russian and Norwegian Ministries of Defense are partners in the AMEC program. Today, the activities under this project include a pilot program to build storage casks for spent fuel located at a number of facilities. A new, semi-private organization under Minatom, Nucleid, is doing this work in St. Petersburg and plans to install these casks at civilian shipyards in both the Northern and Pacific Fleets to facilitate defueling of submarines at civilian-controlled

facilities. The related program activities slated for the Zvezda shipyard in the Far East have been dubbed the Pacific Military Environmental Cooperation (PMEC) program and will involve a different set of countries.[27]

DOE MPC&A Activities

DOE programs in the naval sector began in 1996. To date, the DOE naval fuel program has pursued two complementary aims: (1) the consolidation of fissile material, especially fresh naval fuel; and (2) physical protection at consolidated sites. In 1996-98, the program focused its efforts at sites in the Northern Fleet. This work included provision of physical protection upgrades for a storage ship (*Imandra*) that is owned by the Murmansk Shipping Company (Atomflot) and houses fresh icebreaker fuel. These activities fall under the jurisdiction of the Russian Ministry of Transportation.[28] Simultaneously, DOE initiated a project for fresh fuel storage at the Severomorsk naval facility near Murmansk (Site 49, in Russian references) and later for enhancing protection on floating refueling and storage facilities at the Sevmash shipyard in Severodvisk (ship PM-63) and at Nerpa (ship PM-12). Civilian shipyards working on nuclear submarines fall under the jurisdiction of the Ministry of Economy.[29]

In line with priorities set by the Russian Navy, which deemed threats in the Northern Fleet to be more severe, it was two years after the start of programs in the North before DOE established a similar, but more limited, set of projects for the Pacific Fleet. The first such activity began in 1998 with a site visit to Chazhma Bay (Site 34), where the Pacific Fleet stores fresh fuel. In 1999, a second visit initiated work on spent fuel at nearby Cape Sysoeva (Site 32), while a third project aimed at providing physical protection upgrades for a floating facility handling fresh and spent fuel (ship PM-74).[30]

The DOE teams have succeeded in establishing a positive working relationship with the Russian side, in part because of the facilitator role played by the Kurchatov Institute, following an initial agreement signed in July 1996.[31] Thus, US laboratory scientists and weapons specialists have been able to deal with their technical counterparts at Kurchatov, who in turn handle direct negotiations and access questions with the Russian Navy, the Ministry of Economy, and the Ministry of Transportation. Various sources report that the relationships forged over time and the continuity of the DOE team members have been key factors in the success of the various projects undertaken thus far.[32] There have been comparatively few problems of access for DOE team members and a generally de-politicized work environment where personnel can focus on the tasks at hand. It is also worth noting that DOE has spent approximately 80 percent of its funds in Russia,[33] thus providing work for Russian contractors in support of US sustainability aims. Other efforts have been made to provide training for naval MPC&A workers at a special facility in Obninsk, which uses the same technologies provided by US programs at naval sites.

DOE's mission has recently expanded to include consideration of future SSN dismantlement. In this regard, the Russian Navy and the Kurchatov Institute raised a proposal with DOE officials in early 1999 to conduct a pilot SSN-dismantlement program at the Gornyak facility (Shipyard 49-K) in Vilyuchinsk near the Rybachiy naval base (located south of Petropavlovsk on the Kamchatka Peninsula). The proposal suggested possible US funding to refit the shipyard to allow for Russian dismantlement of 22 SSNs and one SSBN. To date, the Russian Navy has defueled a number of decommissioned submarines at Rybachiy, but has not been able to undertake dismantlement work due to a lack of equipment at the nearby shipyard and the absence of funding. The Russian side also argues that there could be safety problems in trying to move the boats to existing dismantlement facilities in the south. This would be the first US assistance program oriented to the large number of decommissioned nuclear submarines located on Kamchatka. The US side has now commissioned a feasibility study from the Kurchatov Institute and also launched a joint DOE/DOD study aimed at examining the total scope of possible SSN work in Russia in order to determine whether such an expansion of US activities would serve core US security interests.

To date, SSN dismantlement has been treated as largely an "environmental" issue, not one of strategic concern, due to the absence of strategic missiles on these vessels. However, SSNs can be fitted with nuclear-tipped cruise missiles and torpedoes. Attack submarines also house two nuclear reactors with HEU fuel, which in older, decommissioned submarines has lost much of its "self-protecting" radioactivity due to the normal process of decay. This makes SSN fuel a proliferation threat as well as an object of possible terrorist interest.

ASSESSMENT OF PROBLEMS AND POLICY RECOMMENDATIONS

Cooperative Threat Reduction Program

While CTR activities in the submarine dismantlement field have overcome early obstacles and are achieving considerable effectiveness in their main objective (removing missile launchers and delivery vehicles), areas outside of this narrow mandate provide some grounds for concern. The CTR program has not yet enunciated a viable "end game" strategy for its work, although current timelines indicate that DOD's current activities will be completed by 2003, or shortly thereafter.[34] However, US interests may be served by the continuation of some contact with the shipyards and the maintenance of dismantlement equipment after that date. Moreover, giving certain issues, such as nuclear attack submarine dismantlement, greater attention before 2003 may also be advisable.

Facilitate SSN Dismantlement

It is unlikely that Russia will be required to dismantle additional SSBNs beyond the 36 already on US CTR lists even with a future START III agreement. However, large-scale SSN dismantlement is unavoidable and could make good use of the dismantlement technology already in place at the four SSBN shipyards after 2003, if provisions were made for conducting this work. Given the large backlog of SSNs (nearly 140 vessels, of which some 110 still have operational reactors), the ability of the shipyards to make use of this equipment could be a great benefit, assuming adequate maintenance and funding could be provided by either the Russian or US sides. Unfortunately, there has been little public discussion of CTR intentions in this regard, despite the current joint DOE/DOD study of possible Russian SSN dismantlement. Even if the Gornyak project is adopted by DOE, however, this project will make only a small dent in the backlog of SSNs waiting, often in hazardous conditions, to be dismantled at various naval bases around the country. Despite possibilities at some locations, there has been little effort to consolidate these decommissioned submarines in order to facilitate dismantlement work using existing lines. Once the vessels are decommissioned and lose their full crews, it is more difficult to bring them to consolidated sites since they have to be towed.

- **Recommendation:** The United States and its allies need to recognize that SSN dismantlement is a proliferation threat and not just an environmental problem. This is due both to the high HEU content in spent fuel, which could be reprocessed for use in weapons, and the fact that submarines decommissioned before the end of their service lives have low-irradiated fuel, making such fuel less dangerous to steal or divert. There is also the threat that SSNs could be recommissioned and reloaded with tactical nuclear weapons or, alternatively, sold abroad. For these reasons, a concerted effort to address the SSN problem is needed. More attention needs to be paid to how SSN dismantlement programs can be started in the two respective fleets and how they might deal with the backlog already in the system. The Chazhma Bay facility in Primorskiy Kray, for example, could be utilized to conduct SSN dismantlement. There is also dry dock space at the Vostok shipyard in Bolshoy Kamen that could be leased if the Zvezda factory decides to undertake this work, perhaps with Japanese funding. Similar options may exist at other underutilized shipyards in the Northern Fleet. Alternatively, the United States could decide to wait until 2003 and then try to work out an arrangement with the existing four shipyards to conduct SSN work. Waiting, however, entails significant proliferation risks as well as the possibility that US-Russian relations may deteriorate to an extent that Russia would no longer cooperate in this effort. This is why near-term action to begin SSN dismantlement is highly desirable.

Increase Information-Sharing and Use of Regional Experts

The joint consideration of SSN work is helping to bridge what has been a considerable communication gap in the past between DOD and DOE regarding Russian submarine activities. Until 1999, teams from the two departments visiting the same facilities often did not know of the other team's visits and were not even acquainted with the individuals involved.[35] The first trip to Petropavlovsk in spring 1999, however, involved representatives from both the CTR and DOE teams, providing one of the first opportunities for the two sides to benefit from each other's experience. Similarly, to date, there has been little effort by either of the two teams (but particularly by DOD) to draw upon the expertise available in the US and Russian non-governmental communities related to regional political and economic factors that might affect future submarine projects. Such information would be relatively easy and inexpensive to tap into,

yet would provide considerable benefits in terms of trouble-shooting possible future problems.

• **Recommendation:** While the DOE naval MPC&A team has made some steps to solicit advice and feedback from relevant outsiders, more such work is needed in order to avoid possible pitfalls in areas where regional economic and political factors could limit program activities, such as on Kamchatka and in Primorskiy Kray. Problems with the local population at Bolshoy Kamen, for example, have plagued Japan's attempts to implement its assistance program for liquid radioactive waste filtration. Greater use of specialists on regional economics regarding labor issues and material supply questions could be especially valuable in evaluating the chances for success with the dismantlement program on Kamchatka, particularly while the project is still in its planning stages. This will require greater openness about future plans, but would be rewarded by a wealth of useful information that will benefit future programs.

Halt US Support for Russian Reprocessing

CTR officials have pursued their mission with a single-mindedness that has kept them from "mission creep." In many respects, this focus on getting on with the business of dismantling submarines to the exclusion of other concerns has led to positive results. However, DOD's decision to pursue reprocessing of submarine fuel sets a poor example for broader US nonproliferation policies. While this decision may free up additional vessels for dismantlement, it also facilitates Russian plutonium separation and the creation of new nuclear fuel, setting a dubious precedent. Instead, additional efforts to provide for safer storage at naval facilities and to encourage a long-term solution to the spent fuel problem in Russia need to be made.

• **Recommendation:** The United States should avoid falling into the trap of funding Russian naval fuel reprocessing. Instead, more effort needs to be made to improve cask storage at facilities, to investigate other interim storage options in the Far North and Far East, and to facilitate improvements in rail transport and additional storage options at Mayak.

Solicit Financial Support from Allied Countries

Finally, there has been a tendency within the CTR program to want to "go it alone" in its pursuit of cooperation with Russia in submarine dismantlement. Such a strategy may have been the right one early on when these programs were being established, but a failure to bring in more allied country support may be exposed as a future problem, particularly if the United States moves into SSN dismantlement. Due to the greater volume of work called for, the scale of funding will be much greater.

• **Recommendation:** Although CTR (and/or DOE) may be granted some additional funding for this follow-on work, DOD and the administration need to work more vigorously with US allies who are affected by the submarine threat and have the funds and technology to assist in their dismantlement (Norway, France, Germany, Japan, Australia, New Zealand, and South Korea). Such efforts will help insulate the programs against likely future problems in the US Congress in the wake of expected difficulties with Russia over Chechnya and missile defenses.

DOE/Naval MPC&A Program

Extend Fresh Fuel Consolidation and Protection

To date, DOE programs have made considerable progress in the physical protection of fresh naval fuel and in its consolidation. However, even in this area, one needs to supplement DOE statements that fresh naval fuel has been consolidated from "20 sites to two"[36] with some important caveats. Besides the Atomflot facility for fresh icebreaker fuel, there is fresh naval fuel at a facility in Nizhniy Novgorod, where material intended for submarine construction has been withdrawn from a Ministry of Economy shipyard to a nearby Russian Navy facility.[37] In addition, there is fresh fuel at the Leninskiy Komsomol (Amurskiy Zavod) shipyard in Komsomolsk-na-Amure in a partially constructed nuclear submarine.[38] This is one of two submarines that have been under construction since before Boris Yeltsin's 1992 order ending nuclear submarine construction at the facility. Instead, work has plodded along with partial funding to a point where the fueled vessel (still in dry dock) is 80 percent completed and the other is 60 percent completed, nearing the stage when fresh fuel would normally be provided to its two reactors. Other Ministry of Defense storage locations and a few sites with experimental submarine reactors may have additional fresh fuel stocks not appearing on DOE lists.

• **Recommendation:** DOE needs to renew its efforts to determine the possible presence of additional stocks of fresh naval fuel at non-declared locations. In the

cases of the two known facilities noted above, DOE should discuss with the Russian Navy possible means of consolidating the fresh fuel at Nizhniy Novgorod to a central facility and dismantling the two vessels at the Leninskiy Komsomol shipyard in Komsomolsk-na-Amure and removing the fresh fuel. At both sites, the US goal should be to continue progress towards material consolidation while removing possible incentives to re-open the nuclear submarine production lines there. In the Far East, the United States (possibly in conjunction with Japan or other regional allies) could provide financial incentives to this beleaguered shipyard in the form of a modest submarine dismantlement program (about $5 million), as well as offering to pay for the defueling of the one loaded reactor and the transport of the fresh fuel to the Pacific Fleet storage site at Chazhma Bay. Further positive incentives for conversion work at the shipyards might also be offered through other US programs to encourage movement away from military production and promote implementation of the Yeltsin government's 1992 order to conduct all future nuclear submarine construction only at the Sevmash facility in Severodvinsk. (Also see recommendations on shipyard conversion below).

Improve Spent Fuel Storage Options

Another aspect of the DOE program in the naval sector that merits further attention, related to the issues of spent fuel storage mentioned above, is the need to improve physical protection at spent fuel storage sites. While current DOE programs have made significant progress at the largest and most sensitive fresh fuel sites, protection of spent fuel remains extremely weak. Access to these facilities is not well monitored or controlled, due to gaps in the protection of large naval facilities caused by budget cuts and the downsizing of forces. The problems in this area relate to the unplanned presence and increasingly large volume of old submarine fuel at these locations. Fuel that has only recently been removed from submarines is highly radioactive and is therefore relatively resistant to theft, except perhaps by terrorists who are prepared to die for their cause. However, older fuel loses these characteristics and is therefore a much greater proliferation risk, particularly for insiders who know where it is located. With over 28,000 spent fuel rods at locations in the Far North and over 10,000 in the Far East,[39] conditions are ripe for possible future thefts by terrorists, rogue states, or other groups interested in obtaining HEU and plutonium for reprocessing into weapons-grade material.

• **Recommendation:** Given the likelihood that large quantities of spent fuel will remain at shipyards and naval bases for some time to come, DOE should work with the Russian Navy to develop improved physical protection measures, including reconstruction of fences, installation of motion detectors, and, where necessary, reconstruction of buildings and doors. This simple, low-cost work is extremely important to reduce the threat that sensitive (and highly vulnerable) materials may be diverted. The facility most at risk today is the large submarine base at Andreyeva Guba, which houses the bulk of spent fuel for the Northern Fleet in an extremely dilapidated set of buildings and, in some cases, open air locations.[40] Similar to its approach in the fresh fuel area, DOE should work from the greatest threat to the least. One saving grace of these programs is that the work and technologies involved are relatively simple and inexpensive. But the payoff would be significant. An additional benefit of these programs is that they could be used to encourage Russia to bring its MPC&A practices up to international standards, as this is an area where its current procedures lag far behind.

Enhance Naval Fuel Training Efforts

A final area worth further DOE attention arises from the planned turnover of many responsibilities related to the custodianship over decommissioned nuclear submarines to Minatom's Nucleid organization. This may be a positive development, as many analysts have raised questions about whether naval conscripts have the necessary incentives and training for this sensitive work. However, this plan will succeed only if Nucleid workers are better trained and better motivated. Nucleid personnel motivated only by financial aims may also prove no better than naval personnel (and possibly worse) if they do not understand and embrace the nonproliferation mission behind their work. Moreover, at least one Russian scientist who has worked at these facilities has questioned whether civilian Nucleid technicians will be able to provide adequate physical protection of decommissioned submarines, when compared to armed naval personnel.[41]

• **Recommendation:** DOE should encourage the inclusion of Nucleid staff in future naval MPC&A training programs at Obninsk and expand other planned training efforts in order to raise morale, improve safety, and assist in sustainability. DOE should also

encourage Minatom to exercise greater openness about the Nucleid organization and its personnel practices in order to promote better understanding of its role. Finally, physical protection of sites operated by Nucleid, as well as the possible hiring of guard forces, needs to be examined in cooperation with outside observers, such as the Kurchatov Institute, in order to ensure that standards are in fact raised, not lowered. If needed, supplemental training should be provided by appropriate programs (possibly with US support).

Problems on the Russian Side

Any balanced assessment of the difficulties in the Russian submarine dismantlement and naval fuel cycle areas also needs to consider problems on the Russian side. Clearly, US programs are limited in what they can do, and Russia itself must ultimately take responsibility for the vessels it has built and the fuel cycle it has created and allowed to reach such a dangerous state.

Establish a Full-Cycle Process

The overriding problem in the submarine field is that Russia still lacks a full dismantlement cycle. The main issue here is the lack of adequate storage facilities for spent fuel. A second problem, less well recognized, is that Russia has no current plan for long-term storage of separated reactor compartments in either fleet. Both of these obstacles must be solved if Russia is going to be able to free up space at shipyards for the dismantlement of additional vessels. Unfortunately, this process is not going to be simple.

• **Recommendation:** Minatom and the Russian Navy need to work out a complete "cradle-to-grave" submarine dismantlement cycle for the Northern and Pacific Fleets, as well as for icebreakers and other nuclear-powered vessels. Even if the Mayak storage facility is opened soon and were to decide to accept naval fuel, it is likely that spent fuel and reactor compartment storage facilities will be needed in each of the two fleets, given the amount of material, Russia's size, and the difficulties of transport. Assistance from the United States could be particularly helpful in developing plans for reactor compartment storage, as one of Russia's primary problems relates to transport of separated reactor compartments, an area where the United States has extensive experience from its own dismantlement program. Another approach might be to provide a special grant within the context of the International Science and Technology Center in Moscow for a Russian institute or enterprise to conduct a study of this problem as well. Funds might then be provided through the Initiatives for Proliferation Prevention program[42] to expand joint US-Russian activities for submarine dismantlement.

Increase Defense Conversion Efforts

Another serious problem is the continued lack of defense conversion at Russian shipyards. Despite government plans to phase out several submarine shipyards, no effort has been made to shut down the dangerously crippled line at the Leninskiy Komsomol shipyard in the Far East or to assist workers there in moving to new careers. While this work is outside the current mandate of the CTR and DOE programs, conversion is a necessary pre-condition for the long-term reduction of problems caused by Russia's inability to control its naval fuel cycle. To date, the Russian government has failed to enunciate any serious strategy to facilitate conversion by boosting civilian orders, retraining workers, or, when such options are unfeasible, shutting facilities and providing funds for the relocation of workers.

• **Recommendation:** The United States and its allies should undertake a joint program (outside of existing DOD and DOE programs) to encourage defense conversion at Russian shipyards by providing incentives for Western firms operating in Russia to contract with these enterprises for civilian projects. These incentives could take the form of tax benefits both in Russia and in Western countries for foreign firms placing such orders, as this work will serve the national interests of all countries concerned. Even a small number of orders for transport vessels, tug boats, or oil rigs could mean the difference between an enterprise laying off desperate workers (who might resort to theft or terrorism involving fissile material) and one that can survive these difficult times and build a base for future civilian operations to assist in the economic development of Russia's Far North and Far East. The United States should also develop new commercially oriented re-training programs (perhaps through the Department of Commerce or the US Agency for International Development) focused specifically on shipyard workers to assist them in moving from military to civilian occupations.

Facilitate Access and Transparency

While US programs have played a crucial role in much of the progress seen to date, they cannot meet their objectives without Russian support. The success of future assistance programs continues to depend on US access to facilities. Unfortunately, increasing political tensions between the United States and Russia have caused the Russian side to tighten access to facilities by DOD and DOE assistance teams. If continued, these political constraints could injure future assistance programs. This issue is of particular concern as the United States considers assistance to military shipyards, such as the Gornyak facility, where Russian security officials may raise future concerns about US experts entering the closed military zone where the enterprise is located. In addition, Russian facilities have been very reluctant to open their finances to any Western scrutiny, even simply to verify that funds provided for CTR work are getting to workers for salaries. This kind of secrecy hinders cooperation and imperils future funding streams.

- **Recommendation:** Russia needs to ensure continued US access to facilities, while also working to increase the transparency of finances at its shipyards. Such moves are needed in order to help assure the US Congress and other outside donors that the specified work is being done and that funds are not being diverted to other uses, such as the personal accounts of factory directors. Providing evidence of improvement of conditions for workers and infrastructure maintenance would be two useful measures of progress.

Increase Commitment to Sustainability

Sustainability is another area where there has been little progress on the Russian side outside the limited reach of selective US programs. Indeed, there are few signs that Russia will undertake nuclear submarine dismantlement on its own (despite the dangerous proliferation and environmental consequences) without continued US assistance. Minatom seems to be taking its new responsibilities in this area seriously, which may provide some grounds for hope. But it is too soon to know whether this will be an on-going and serious approach or is merely the optimism of a newcomer to this difficult work. The Russian Navy has recently treated the problems of dismantlement and fuel disposition very seriously. What is less clear is that there is a firm commitment on the part of the Russian Duma and the presidential administration that safe submarine recycling and naval fuel cycle activities constitute high priorities for Russia.

- **Recommendation:** A new commitment needs to endorsed by all parts of the Russian government to act responsibly in this area and to begin to treat safe management of the naval fuel cycle as a national (not US) responsibility. More work needs to be done by Minatom with new Duma members and with the Russian presidential administration, with which Minatom appears to hold considerable influence, to ensure that these needs are included in future budgets and that future political issues do not jeopardize this funding.

Refuse to Export Nuclear Submarines

Finally, a problem related to the lack of conversion at shipyards is the growing threat that enterprises in the nuclear submarine field may seek sales in foreign markets as a means of survival, given the current absence of Russian state orders. Unfortunately, such a development is extremely dangerous from a proliferation perspective and also threatens support for assistance programs, in some cases, to these very same shipyards. Russia needs to recognize that its future deployments and especially possible foreign sales of nuclear submarines will influence the future of foreign assistance. If Russian shipyards move aggressively into potential markets in India, China, and elsewhere, the support for US assistance programs in the US Congress will likely collapse.[43]

- **Recommendation:** The United States and its allies must signal clearly to the Russian government and to its naval shipyards that any sales of nuclear submarines or related materials and technologies to foreign countries could mean the end of assistance programs in the nuclear field. Russia enterprises should understand that by accepting nonproliferation assistance funding they are undertaking an obligation not to engage in activities that would promote proliferation in third countries.

CONCLUSION

There has been considerable progress to date in the general processes of nuclear submarine dismantlement in Russia. A large portion of the Soviet Union's SSBN force will be laid safely to rest by 2003, if current work under the CTR program is adequately funded and US-Russian cooperation continues. Fresh fuel storage is also in considerably better shape than it was in 1991, with

material consolidation and safety upgrades having made significant steps forward in both the Northern and Pacific Fleets. However, numerous problems remain due to the large amount of fissile material within the naval fuel cycle, the failure of existing programs to reach all fresh fuel sites, and widespread problems in the protection of spent fuel. The United States and other countries need to help manage the gradual reduction of the Russian naval fuel cycle until the amount of fissile material in the system reaches a level that is sustainable at a reasonable level of safety by the Russians themselves. The future completion of the SSBN dismantlement mission and the continuation of programs in the areas of fresh fuel and spent fuel therefore remain crucial to the goal of preventing proliferation threats. Existing cooperative programs have accomplished a great deal through the hard work of both the US and Russian sides. Keeping these efforts going and protecting them from political interference should be a priority in future bilateral relations.

[1] The author thanks Matthew Bunn, David Caskey, Sarah J. Diehl, Thomas Kuenning, Michael O'Brien, Tamara C. Robinson, Garry Tittemore, and Nikolai Yurasov for their many useful comments. Information for this study was drawn from dozens of interviews conducted during 1998 and 1999 by the author in Washington, Moscow, Vladivostok, and other locations with Russian and US participants in the various naval assistance programs.

[2] Remarks by Minatom Deputy Minister Nikolai Yegorov at the workshop on "International Cooperation in the Dismantlement of Russian Nuclear Submarines," Moscow, December 11, 1998. Many in the nonproliferation field were impressed with Mr. Yegorov's knowledge of the submarine field and deeply saddened by his death in the fall of 1999 after a long illness.

[3] Figure provided in presentation by Dr. Nikolai Ponomarev-Stepnoj of the Kurchatov Institute at the American Nuclear Society's "Global 99" meeting, Jackson Hole, Wyoming, August 29-September 3, 1999.

[4] For more on these cases, see Oleg Bukharin and William Potter, "'Potatoes were guarded better'," *Bulletin of the Atomic Scientists* 51 (May/June 1995).

[5] Russian commandoes finally stormed the torpedo compartment and found the sailor dead from head wounds, apparently caused by an explosion. Reports conflict on the explosion's cause. Russian officials denied that a fire or detonation of weapons could have caused the reactor to explode, yet they quietly moved all other vessels from the harbor during the incident.

[6] For more on these threats, see James Clay Moltz and Tamara C. Robinson, "Dismantling Russia's Nuclear Subs: New Challenges to Non-Proliferation," *Arms Control Today* 29 (June 1999).

[7] *Segodnya* (Moscow), October 21, 1994, cited by Alexander Zhebin, "A Political History of Soviet-North Korean Nuclear Cooperation," in James Clay Moltz and Alexandre Y. Mansourov, eds., *The North Korean Nuclear Program: Security, Strategy, and New Perspectives from Russia* (New York: Routledge, 2000), p. 36.

[8] "American Sentenced for Exporting Speedboats to NK," *Joongang Ilbo* (Seoul), November 2, 1999, reported on the Northeast Asian Peace and Security Network, November 3, 1999, Nautilus Institute, Berkeley, California, <http://nautilus.org/napsnet>.

[9] Povl L. Olgaard, "Worldwide Decommissioning of Nuclear Submarines: Plans and Problems," in Elizabeth J. Kirk, ed., *Decommissioned Submarines in the Russian Northwest: Assessing and Eliminating Risks* (Dordrecht, Netherlands: Kluwer Academic Publishers, 1997), p. 14.

[10] See, for example, Thomas Nilsen, Igor Kudrik, and Alexandr Nikitin, "The Russian Northern Fleet: Radioactive waste at the naval bases" (dated August 19, 1996), Bellona Foundation website, <http://www.bellona.no/e/index.htm>.

[11] See Georgi Kostev, *Nuclear Safety Challenges in the Operation and Dismantlement of Russian Nuclear Submarines* (Moscow: Committee for Critical Technologies and Non-Proliferation, 1997).

[12] Ibid., p. 7.

[13] A draft study was apparently completed by the Kurchatov Institute in Moscow, but it never reached the attention of higher officials or was given funding for implementation. Staff member of the Kurchatov Institute, author's interview, Monterey, California, December 11, 1999.

[14] Information contained in the rest of this paragraph is drawn from the author's interviews with various Russian officials (1998-99), statements by Russian experts at a conference on "International Cooperation in the Dismantlement of Russian Nuclear Submarines" in Moscow (December 11, 1998), statements by Russian officials at a joint Monterey Institute/Carnegie Endowment seminar held in Washington (June 7, 1999), and material contained in Kostev, *Nuclear Safety Challenges*.

[15] Head of the Puget Sound Naval Shipyard, interview with author at the Bangor Naval Base, Washington, November 21, 1997.

[16] CTR official at the Defense Threat Reduction Agency, Dulles, Virginia, phone interview with author, November 30, 1999.

[17] Remarks by Duma member Alexei Arbatov at the conference on "International Cooperation in the Dismantlement of Russian Nuclear Submarines," Moscow, December 11, 1998.

[18] Senior scientist in the Russian Academy of Sciences who works with the Pacific Fleet, interview with author in Vladivostok, Russia, October 18, 1999.

[19] Major Ron Alberto, the chief implementing officer for CTR's submarine dismantlement contracts in Russia, interview with author at the Defense Threat Reduction Agency, Dulles, Virginia, January 14, 1999.

[20] Ibid.

[21] Senior scientist in the Russian Academy of Sciences who works with the Pacific Fleet, interview with author in Vladivostok, Russia, October 18, 1999.

[22] Paper for CNS's CTR assessment project by Russian journalist Dmitri Litovkin, based on interviews with shipyard officials in Severodvinsk.

[23] Presentation by Gen. (ret.) Thomas Kuenning, director of the Cooperative Threat Reduction Program, at the annual meeting of the American Association for the Advancement of Slavic Studies, St. Louis, November 18-21, 1999.

[24] Figures provided by Major Ron Alberto, the chief implementing officer for CTR's submarine dismantlement contracts in Russia, e-mail message, January 7, 2000.

[25] Major Ron Alberto, interview with author at the Defense Threat Reduction Agency, Dulles, Virginia, January 14, 1999.

[26] Information regarding the AMEC program is drawn mainly from press releases and reports appearing on the US Environmental Protection Agency's Office of International Activities website, <http://ww.eap.gov/oiamount.htm>.

[27] US Consul General Lysbeth Rickerman, interview with author in Vladivostok, Russia, October 18, 1999.

[28] DOE Nuclear Materials Task Force staff member, interview by Tamara Robinson, Washington, DC, May 29, 1999.

[29] However, a reform announced in May 1999 will reportedly bring shipyards dealing with submarine work under a new Governmental Agency for Shipbuilding, which itself will be taken out from under the Ministry of Economy and report directly to a reformed State Commission on Defense Industry under the Russian Security Council. (See *Segodnya*, May 27, 1999, p. 1.)

[30] DOE team members, various interviews conducted by author, 1999.

[31] Presentation by Dr. Nikolai Ponomarev-Stepnoj of the Kurchatov Institute at the American Nuclear Society's "Global 99" meeting, Jackson Hole, Wyoming, August 29-September 3, 1999.

[32] Author's interviews with dozens of US and Russian participants and analysts from 1998-99.
[33] Comments by the head of DOE's naval MPC&A program Garry Tittemore at the conference on "Assessing US Dismantlement and Nonproliferation Assistance Programs in the Newly Independent States," organized by the Center for Nonproliferation Studies, Monterey, California, December 11-13, 1999.
[34] Presentation by Gen. (ret.) Thomas Kuenning, director of the Cooperative Threat Reduction Program, at the annual meeting of the American Association for the Advancement of Slavic Studies, St. Louis, November 18-21, 1999.
[35] During the research that led up to this study, the author frequently asked respective DOD and DOE team members about their counterparts (whom he had interviewed). Before 1999, they invariably did not know the other parties or anything beyond the most basic knowledge regarding the other team's activities.
[36] Presentation by The Honorable Rose Gottemoeller at the American Nuclear Society's "Global 99" meeting, Jackson Hole, Wyoming, August 29-September 3, 1999.
[37] Senior Russian scientist with experience in naval fuel issues, interview with author, Monterey, California, December 11, 1999.
[38] Khabarovsk economist Evgeniya Gudkova (who visited the facility in 1998 and interviewed the shipyard's director), interview with author in Khabarovsk, Russia, October 21, 1999. The director also complained about the shipyard's lack of funding and stated that so many specialists had left the factory that, even with the provision of new funding by Moscow, the shipyard lacked the technical expertise to complete the two submarines, putting the vessels (and their fuel) in a very precarious situation.
[39] Aggregate figures calculated from facility-based charts appearing in Tamara C. Robinson, "Submarine Dismantlement and Material Storage: Challenges for Russian Nuclear Propulsion," paper presented at the Naval Postgraduate School's conference on "The Future of Russia as a Maritime Power," Monterey, California, March 16-17, 1999.
[40] For more information on Andreyeva Guba, see the Bellona Foundation website, <http://www.bellona.no/e/index.htm>.
[41] Senior scientist in the Russian Academy of Sciences who works with the Pacific Fleet, interview with author in Vladivostok, Russia, October 18, 1999.
[42] On the IPP program, see Scott Parrish and Tamara Robinson, "Efforts to Strengthen Export Controls and Combat Illicit Trafficking and Brain Drain," *The Nonproliferation Review* 7 (Spring 2000).
[43] For more on this problem, see James Clay Moltz, "Closing the NPT Loophole on Exports of Naval Propulsion Reactors," *The Nonproliferation Review* 6 (Fall 1998).