StrålevernInfo 5·00

NRPA Bulletin

Statens strålevern

Loss of the Russian nuclear submarine Kursk in the Barents Sea – possible consequences of radioactive pollution

On August 12th 2000, a Russian submarine sunk outside Rybatschi Peninsula in the Barents Sea. This vessel is the 7th in a list of American and Russian submarines abandoned on the sea floor because of accidents. In addition, Russia has dumped larger amounts of radioactive waste, including several reactors, in the Kara Sea. Investigations in connection with earlier accidents and dumping of radioactive waste show elevated concentrations of radioactive substances in close proximity to the wrecks and dumping sites. However, the hazard posed to health and environment is generally minor.

On the morning of August 12th 2000, a Russian submarine sunk in international waters east of Rybatschi Peninsula in the Barents Sea. The submarine, a Russian Oscar class II attack submarine, sunk to 108 meters depth about 250 km from Norway. Kursk is 154 meters long and weighs 14 000 tons. The submarine was commissioned in 1995, and is powered by two pressurised water reactors. This is the most common reactor type. Each reactor has a thermal effect of 190 megawatt, or less than 10 % of a typical nuclear power plant (Russian sources and Jane's Fighting Ships). The reactors are according to official Russian information shut down. Shortly after the accident, information that the submarine was not carrying nuclear weapons, was distributed by the Russians.

In collaboration with the Headquarters of Defence Command in Norway, the Norwegian Radiation Protection Authority (NRPA) carried out measurements on sea water samples taken near the site of the accident. The choice of sampling location is dependent on the sea currents and wind direction and is decided after consultation with the Norwegian Institute of Marine Research, the Norwegian Meteorological Institute and the Norwegian Polar Institute. The NRPA also has very sensitive stations for monitoring radioactivity in air at Viksjøfjell and Svanvik in eastern Finnmark. Further, NRPA has access to monitoring networks in Russia, Finland, Sweden and Norway, which will register increases in radioactivity levels. An overview of the monitoring stations is given in Figure 1.

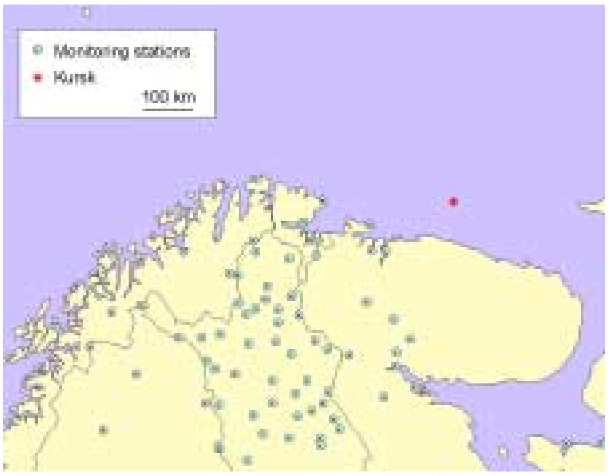

Figure 1: Network for monitoring radioactivity in the Northern areas.

As a consequence of earlier accidents, a total of six (seven counting Kursk) Russian and American submarines are abandoned on the sea floor. Moreover, Russia has dumped several submarines and reactors in the Kara Sea.

The Russian submarine Komsomolets sunk in the Norwegian Sea in 1989. Norwegian authorities have been involved in investigations connected to possible environmental effects as a consequence of the loss. Assessments connected to the Komsomolets loss are also relevant in relation to the Kursk accident.

K-278 – Komsomolets (Mike class)
Lost: April 7th, 1989
Position: Norwegian Sea, south of Bear Island
Depth: 1 685 meters
The sunken submarine contains one nuclear reactor with an inventory of long-lived radioactive

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ISSN 0806-895X
August 20, 2000

substances: $2.8 \cdot 10^{15}$ becquerels of strontium-90 and $3.1 \cdot 10^{15}$ becquerels of cesium-137. Two nuclear torpedoes with mixed uranium/plutonium warheads, situated in the forepart of the hull contain about $1.6 \cdot 10^{13}$ becquerels of weapons-grade plutonium. In 1999, minor releases of radioactive substances from the reactor compartment had been detected in the close vicinity of the submarine wreck. Surveys indicated releases of radioactive substances through a reactor ventilation tube. However, the likelihood of large-scale releases of radioactive substances from the *Komsomolets* submarine in the near future is small. As the containment barriers in the submarine are breached by corrosion, further gradual releases may occur and these will be increasingly comprised of long-lived fission products from the reactor and uranium and plutonium from the nuclear-tipped weapons. While uranium is relatively soluble and will be mobilised as the structural integrity of the torpedo and warhead casings is breached, the environmental contribution will be essentially insignificant in the context of the natural uranium content of the surrounding environment. Plutonium has limited solubility and a high affinity for particles. Accordingly, most of the plutonium released from the warheads is likely to be retained in sediments within the immediate vicinity of the wreck (AMAP, 1999).

There have been two major assessments of the radiological threat posed by the Komsomolets. The first of these was carried out by Norwegian experts under the auspices of the NATO Sub-Committee on Challenges to Modern Society, (CCMS/CDSM/NATO, 1995) and the second by experts from the Russian Navy (Lisovsky *et al*., 1996). In addition, a study of the release and transport of radioactive substances from the wreck has been carried out (Blindheim, 1994). The hull and several barriers inside the reactor are expected to prevent corrosion of the reactor fuel for about two thousand years. By that time, only plutonium and americium isotopes will be present in the reactor in significant amounts. In the intervening period, the main pathway for release of radioactive substances from the reactor will be through the reactor compartment ventilation tube.

The warheads are not protected from sea water to the same degree, and are expected to be open to corrosion much earlier than the reactor fuel. Plutonium released is likely to be retained in marine sediments close to the point of release.

The NRPA participated in the expeditions to the Komsomolets in 1993 and 1994, led by the Norwegian Institute of Marine Research. The conclusion after analysing bottom water, surface water and sediments was that Komsomolets at the moment poses no threat to the environment (NRPA-report 1995:7).

Other submarine losses
Russian
K-129 (Golf class)
Lost: April 11th 1968
Position: Northwest of Oahu, Hawaii, the Pacific
Depth: 5 000 meters

K-8 (November class)
Lost: April 8th, 1970
Position: The Bay of Biscay
Depth: 4 680 meters

K-219 (Yankee class)
Lost: October 6th, 1986
Position: Atlantic Ocean, north of the Bermuda Islands
Depth: 5 000 meters

American
USS Thresher
Lost: April 10th, 1963
Position: 160 km south of Cape Cod
Depth: 2 600 meters
Studies show low levels of radioactivity in the sediments (12 becquerels per kg of cobolt-60) (Ølgard, 1993).

USS Scorpion
Lost: May 22nd, 1968
Position: 650 km southwest of the Azores
Depth: 3 600 meter
Measurements in the area show very low levels of radioactivity in the sediments.

Dumping in the Kara Sea
Reactors and reactor chambers both with and without reactor fuel are dumped in the Kara Sea. Six nuclear submarines and one shielding unit from a nuclear icebreaker are dumped in the Arctic Ocean ($85 \cdot 10^{15}$ becquerels). Additionally, 10 reactors without fuel are dumped ($3.7 \cdot 10^{15}$ becquerels). The reactors are dumped at depths varying between 12 and 300 meters near Novaya Semlya.
A Joint Norwegian-Russian Expert Group was established in 1992 to investigate radioactive

contamination in the Northern areas, associated with dumped nuclear waste in the Barents and Kara Seas. During exploratory cruises to the dumping areas in 1992, 1993 and 1994, samples of sediment, sea water and biota near the dumped objects were taken (JNREG, 1996). In the Abrosimov Fjord, where three reactors with spent fuel and three without spent fuel in addition to other radioactive material are dumped, sediments with elevated levels of several radioactive compounds. Levels of radioactivity in the water did not differ from the levels in the open Kara Sea.

Measurements have also been conducted on sea water and sediments in the other fjords at Novaya Semlya where radioactive material has been dumped. Elevated levels of radioactive substances were found not only in the sediments, but also in the bottom water in the Stepovogo Fjord. Details from a dumped submarine in the Stepovogo Fjord can be seen in Figure 2. In the Tsivolki Fjord, the levels of radioactive substances in water and sediments were low. One reactor with fuel is dumped in the Novaya Semlya Trough. The levels of radioactive substances are low, even here (JNREG, 1996).

Figure 2: Details from a dumped submarine in Stepovogo Fjord.

While it appears that no significant global or regional effects have yet resulted from the dumping of radioactive waste in the Arctic, there is concern about the gradual deterioration of the waste containments that could lead to releases of radioactivity in the future. These could result in contamination of the marine food chain. Because the wastes are lying in shallow waters, the possibility of radiation exposure by other routes, such as direct exposures following movement by natural events or human actions cannot be totally ruled out. Studies conducted by the IASAP (The International Arctic Seas Assessment Project) conclude that the radiological risks posed to human health and the environment are minor.

Protection of the Arctic environment – Arctic Monitoring and Assessment Programme (AMAP)

The arctic ecosystems are vulnerable to radioactive contamination. The largest threat to the environment and the population in the Arctic today is connected to potential accidents in nuclear power plants, during handling and storage of nuclear weapons, decommissioning and refuelling of nuclear powered vessels and during storage of radioactive waste. Arctic Monitoring and Assessment Programme (AMAP) was established in 1991, when environmental ministers from the 8 Arctic countries requested an investigation of the levels of man-made contaminants and an assessment of the effects in different parts of the Arctic environment. The first phase of AMAP was finalised in 1998, and the second phase of the project is initialised. Norway and the NRPA are together with Russia leading the radioactive contamination work.

The marine surveillance programme

In 1993 the NRPA, financed by the Norwegian Ministry of Fisheries, initialised a systematic monitoring of Norwegian fish, as a response to available information regarding radioactive sources and potential pollution of the Northern Seas. This monitoring was extended to a marine surveillance programme in 1999, financed by the Norwegian Ministry of Environment. The purpose of the programme is to monitor trends in radioactive pollution of water, sediments, fish and other important marine species. Results from the surveillance programme are published in several NRPA reports, and show that the main sources to today's radioactive pollution are fallout from nuclear weapons tests conducted in the 50ties and 60ties, discharges from Sellafield in UK, and fallout from the Chernobyl accident.

The Norwegian-Russian expert group

On January 15th 1988, the Norwegian and Russian prime ministers signed an agreement on environmental co-operation. A central issue in the first period of co-operation was the investigation of pollutant effects and the preparation of measures to reduce pollution, particularly in the border areas between Russia and Norway. The political development in Russia called for a re-negotiation of the environmental agreement in 1992.

In the Storting report No. 58 (1996-97) "Environmental Policy for a Sustainable Development", the Norwegian Government put long-term goals for the Norwegian-Russian co-operation to paper. Where as early efforts were directed towards solving individual environmental problems in the border areas, the current efforts are aimed at the entire Barents region.

In April 1992, the Norwegian-Russian expert group for examination of radioactive contamination in northern areas was established. Information stating that the Russians had dumped radioactive material in the Barents and Kara Sea, triggered the extensive work under the expert group. The first research expeditions to the Kara Sea were conducted the same year.

Today the co-operation is coordinated with the Norwegian governments nuclear action plan. As a follow-up to the Storting report No. 34, a plan of action was presented in 1995 regarding nuclear safety including the following principle areas:

- Safety at nuclear installations
- Treatment, storage and disposal of radioactive waste and spent nuclear fuel
- Radioactive contamination of northern areas
- Weapon-related environmental hazards including control and physical securing of fissile material

The existing Norwegian-Russian environmental co-operation is very suitable for a close co-operation also in the long term following up of the Kursk accident.

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