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# International Arctic Seas Assessment Project (IASAP)

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## INTRODUCTION

The purpose of this paper is to give an overall view of the International Arctic Seas Assessment Project (IASAP) and to describe progress in the working areas which are not covered by other presentations at this meeting.

The IASAP project was initiated in 1993 to address concerns about the possible health and environmental impacts of radioactive wastes dumped in the shallow waters of the Arctic seas by the former Soviet Union. The project is being executed as a part of the IAEA's responsibilities under the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention 1972). The results and conclusions of the project are expected to be reported to the London Convention in late 1996.

The objectives of the project are: (i) to assess the risks to human health and to the environment associated with the radioactive waste dumped in the Kara and Barents Seas; and (ii) to examine possible remedial actions related to the dumped wastes and to advise on whether they are necessary and justified. The project is organized in five working areas: source terms, existing environmental concentrations, transfer mechanisms and models, impact assessment and remedial measures. Progress made in all working areas of IASAP is reviewed each year by a group of senior scientists (IASAP Advisory Group Meeting).

## BACKGROUND ON THE DUMPED WASTES

In May 1993, the Russian Federation provided information to the IAEA about the high and low level radioactive waste dumped in the Arctic Seas and in the North-East Pacific during the years 1959-92 (Info May 21, 1993). According to this information the total amount of radioactivity dumped in the Arctic Seas was more than 90 PBq. From the viewpoint of potential hazards to health, the most important items dumped are the six nuclear submarine reactors containing fuel and a shielding assembly from an icebreaker reactor which also contains fuel. Together they comprise a total activity of 85 PBq. Ten other reactors without fuel together contain 3.7 PBq. The nuclear reactors were dumped in the shallow bays of Novaya Zemlya, where the depths of the dumping sites range from 20 to 50 m and in the trough of Novaya Zemlya, at a depth of 300 m (Fig. 1).

## EVALUATION OF THE CURRENT ENVIRONMENTAL SITUATION

The Joint Norwegian-Russian Expert Group arranged exploratory cruises to the dumping areas, with the participation of a scientist from IAEA-Marine Environment Laboratory (IAEA-MEL), in 1992, 1993 and 1994. All of the four sites where spent nuclear fuel was dumped have been visited by the cruises of the expert group, but only some of the reported dumped objects have yet been successfully localized. During the cruises, samples were taken, direct measurements were made and the objects were examined using side scanning sonar and video cameras. The results obtained during the cruises show that there is only low level localized contamination in the vicinity of the dumped wastes. At the present time, the wastes are not giving rise to significant radiological or environmental risks (Foyn and Nikitin, 1993; Foyn and Nikitin, 1994; N-R Expedition, 1993; Baxter, Hamilton, Harms, Osvath, Povinec and Scott, 1993). However, the gradual deterioration of the waste containments could lead to impacts in the future. Also, since the wastes are lying in shallow waters, the possibility of movement and transport of the waste packages by natural events (e.g. scour of sand by bottom currents), or human actions cannot be ruled out. The timescales for consideration are very long (up to tens of thousands of years) and the possible impact of climatic change has therefore also to be taken into account.

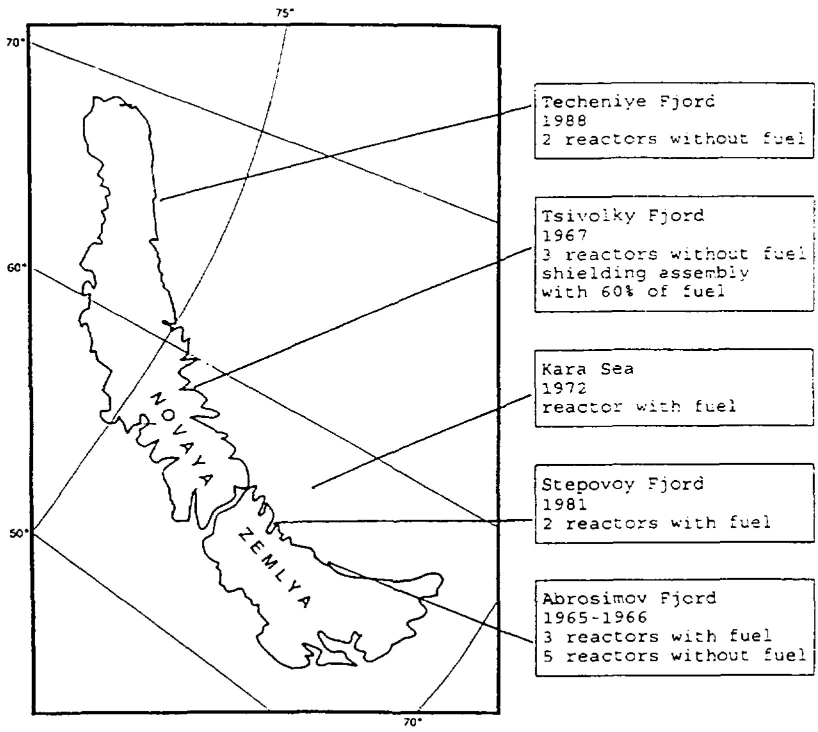


**Figure 1.** Dumping sites of the nuclear reactors.

## PROGRESS IN THE ASSESSMENT PROGRAMME

### Source terms

A Source Term Working Group was established to determine the information needed about the waste for use in impact assessment calculations. This involves obtaining detailed information on the radionuclide inventory and on the form of wastes and predicting the likely behaviour of the wastes as a function of time in the marine environment.

The information on the dumped waste provided by the Russian Federation in May 1993 did not include data on the radionuclide composition nor on the characteristics of the fuel in the different types of dumped reactors. For both impact assessment purposes and evaluation of the feasibility of possible remedial measures it is also necessary to have information on the protective barriers provided for the dumped reactors prior to dumping. In order to obtain all of this information it has been necessary to investigate the archives of the former Soviet Union.

As the first step, in January 1994, a nuclide by nuclide inventory of the commercial nuclear icebreaker "Lenin" was obtained (Sivintsev, 1994) (OK-150 in the Table), together with information on the structure of the dumped reactor containment. In July 1994, the Russian authorities declassified essential details of the structure, operational history and characteristics of the fuel of the dumped submarine reactors. This meant that the radionuclide inventories of the lead/bismuth-cooled submarine reactors (No. 601) (Yefimov, 1994) and the water-cooled submarine reactors (No's 254, 260, 285, 421, 538 and 901) (Sivintsev, 1994) could be made available to IASAP. The total activity of the dumped reactors at the time of dumping is now estimated to be 37 PBq; the first estimate provided in May 1993 by the Russian Federation was 89 PBq. Due to radioactive decay, the total activity of the dumped reactors at the present time is not more than 4.7 PBq (Table 1). Fig. 2 illustrates the development with time of the total amount of dumped radioactivity, taking into account radioactive decay. The maximum peak of radioactivity of the dumped material, 25 PBq, was reached in 1967, when the fuel assembly of one of the reactors of the icebreaker "Lenin", containing part of the spent fuel, was dumped.

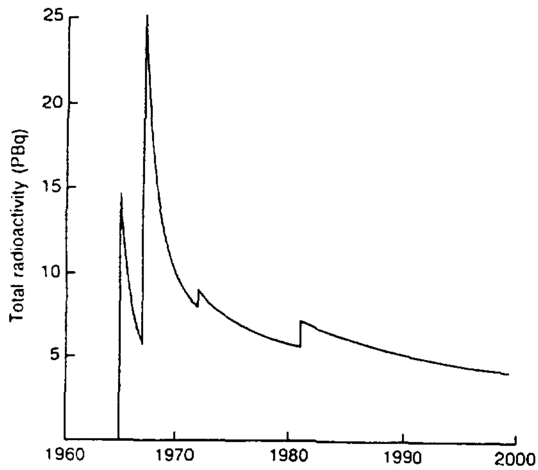


**Figure 2.** Development with time of the total amount of dumped radioactivity.

On the basis of an analysis of the weak points of the protective barriers provided for the reactors and the fuel assembly of the icebreaker "Lenin", the Source Term Working Group has prepared sets of possible time patterns for radionuclide release and release rates (J. Warden *et al.*, this conference).

**Table 1.** Data on the dumped nuclear reactors.

| Site | Year of dumping | Depth of dumping a | Factory number | Dumped unit | Number of reactors | | Total activity PBq | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Without spent nuclear fuel | Containing spent nuclear fuel | Initial Data (White Book) | Further Studies (IASAP) | |
| | | | | | | | At the time of dumping | At the time of dumping | 1993/94 |
| Abrosimov Fjord | 1965 | 20 (10-15) | (No. 285) | Reactor compartment | 1 | 1 | 29.6 | 11.6 | 0.655 |
| | | 20 (10-15) | (No. 901) | Reactor compartment | - | 2 | 14.8 | 2.95 | 0.727 |
| | | 20 | (No. 254) | Reactor compartment | 2 | - | b | 0.093 | 0.009 |
| | 1966 | 20 | (No. 260) | Reactor compartment | 2 | - | b | 0.044 | 0.005 |
| Tsivolka Fjord | 1967 | 50 | (OK-150) | Reactor compartment and a box containing fuel | 3 | 0.6 | b<br>3.7 | 19.5 | 2.2 |
| East Novaya Zemlya Trough | 1972 | 300 | (No. 421) | Reactor | - | 1 | 29.6 | 1.05 | 0.293 |
| Stepovoy Fjord | 1981 | 50 (30) | (No. 601) | Submarine | - | 2 | 7.4 | 1.72 | 0.838 |
| Techeniye Fjord | 1988 | 35-40 | (No. 538) | Reactors | 2 | - | b | 0.006 | 0.005 |
| **Total** | | | | | 10 | 6.6 | 89 | 37 | 4.7 |

a Depths from White Book, those in brackets from Norwegian-Russian Cruises.
b Reactors without spent fuel, not more than 3.7 PBq total.

**Existing environmental concentrations**
Information on the levels of radioactive contamination in the target area and other areas of the Arctic seas is being collected as input to the Global Marine Radioactivity Data Base (GLOMARD) organised by the IAEA-MEL (I. Osvath *et al.*, this conference).

**Transfer mechanisms and models**
A Co-ordinated Research Programme (CRP) entitled "Modelling of the radiological impact of waste dumping in the Arctic Seas" has been established with the objectives of developing realistic and reliable assessment models for the Arctic Sea areas and of coordinating the efforts of different laboratories in the field. Together nine laboratories including the IAEA-MEL are participating in the modelling programme (M. Scott *et al.*, this conference).

**Impact assessment**
Impact assessment calculations will be carried out on the basis of the concentration fields to be predicted by the modelling programme and using appropriate environmental transfer factors and demographic data. Predictions of future radiation doses, individual and collective, for local, regional and global populations will be calculated on the basis of 'best estimate' and 'worst case' release scenarios produced by the Source Term Working Group, taking into account both the average consumers and those individuals whose diet consists of considerable amounts of seafood. The assessments will also include estimates of radiation dose to local fauna such as marine mammals.

**Remedial measures**
The Contracting Parties to the London Convention requested the IAEA to examine possible remedial actions in relation to the dumped wastes and to consider their feasibility.

Within the limited timeframe of IASAP project it is not possible to undertake detailed evaluations of all possible remedial options and sources. Instead, a preliminary evaluation of the engineering feasibility and costs associated with five remedial options will be carried out for selected waste sources. The options are:

1. Injection of material into a dumped object to reduce corrosion and to provide additional barriers to radionuclide release;
2. Capping of an object *in situ* using concrete or other suitable material;
3. Recovery of an object to a land environment (i.e., delivery to a port or harbour on Novaya Zemlya) in a structurally sound and suitably preserved form for subsequent disposal in a deep land repository for high-level radioactive waste;
4. Creation of an underwater cavern for the isolation of dumped sources on the coast of Novaya Zemlya; and
5. Recovery and underwater shipment for relocation in a deep ocean site.

The feasibility of these various options is highly dependent on the structural integrity of the individual sources. Disturbing an object which has suffered sufficient external and internal corrosion to be in a very weak state of engineering integrity is likely to create the risk of a major structural failure and enhanced releases of radionuclides. On the other hand, an object that has maintained its structural integrity is amenable to a wide range of remedial options. Before an option is adopted it must be shown that it is likely to yield a net benefit in terms of the radiation doses averted when compared with the option of leaving the wastes as they are. It is, however, recognized that there are other, non-radiological factors, psychological, social and political, to be taken into account in making decisions on remediation.

The IASAP project can only address technical aspects such as the engineering feasibility and the radiological implications of different options; it can provide the technical basis for deciding whether particular remedial actions are appropriate or not, but the decision itself must be taken by relevant national authorities.

## PRODUCTS OF THE PROJECT

During the first two years of the IASAP project, a considerable amount of new information has been produced and published as IASAP working documents (Sivintsev, 1994; Yefimov, 1994; Sivintsev, 1994; Pavlov, 1994; Ivanov, 1994; Sazykina and Kryshev, 1994; IASAP Benchmark, 1994). Tens of experts from 15 countries and several international organizations are involved in the different Working Groups and Advisory Group Meetings of the project. It is planned that in addition to the report to the London Convention, which will be prepared by the Advisory Group, detailed technical reports covering the work of all areas of the IASAP will be produced.

## ACKNOWLEDGEMENT

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## REFERENCES

Info May 21, 1993. Official Information supplied to IAEA on 21 May 1993 by the Russian Federation in accordance with the request of the 15th Consultative Meeting of Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.

Foyn, L. , Nikitin, A., 1993. The joint Norwegian/Russian expedition to the dump sites for radioactive waste in the open Kara Sea, the Tsivolki Fjord and the Stepovogo Fjord, September-October 1993, Report from the expedition on board R/V Viktor Buinitsky with some preliminary results.

Foyn, L. , Nikitin, A., 1994. The joint Norwegian/Russian expedition to the dump sites for radioactive waste in the Abrosimov Fjord and the Stepovogo Fjord, August-September 1994, Report from the expedition on board R/V Viktor Buinitsky with some preliminary results.

Norwegian-Russian Expedition, 1994. Joint Norwegian-Russian Expert Group for Investigation of Radioactive Contamination in the Northern Areas, Radioactive Contamination at Dumping Sites for Nuclear Waste in the Kara Sea, Results from the Russian-Norwegian 1993 expedition to the Kara Sea.

Baxter, M.S., Hamilton, T.F., Harms, I., Osvath, I., Povinec, P.P. and Scott, E.M., 1993. IAEA Programmes Relevant to the Radioactive Waste Dumped in the Arctic Seas: Part 2: Projects at the IAEA Marine Environment Laboratory. In: P. Strand and E. Holm (Eds.): Environmental Radioactivity in the Arctic and Antarctic, Østerås, 1993.

Sivintsev, Y., 1994. Study of the Nuclides Composition and Characteristics of the Fuel in Dumped Submarine Reactors and Atomic Icebreaker "Lenin", Part 1 - Atomic Icebreaker, IAEA-IASAP-1, Working Document of the International Arctic Seas Assessment Project.

Yefimov, E., 1994. Radionuclides Composition, Characteristics of Shielding barriers and Analyses of Weak Points of the Dumped Reactors of Submarine N. 601, IAEA-IASAP-6, Working Document of the International Arctic Seas Assessment Project.

Sivintsev, Y., 1994. Study of Nuclides Composition and Characteristics of Fuel in Dumped Submarine Reactors and Atomic Icebreaker "Lenin", Part 2 - Nuclear Submarines, IAEA-IASAP-5, Working Document of the International Arctic Seas Assessment Project.

Pavlov, V.K., 1994. Oceanographical Description of the Kara and Barents Seas, IAEA-IASAP-2, Working Document of the International Arctic Seas Assessment Project.

Ivanov, V., 1994. Sedimentological Description of the Kara and Barents Seas, IAEA-IASAP-3, Working Document of the International Arctic Seas Assessment Project.

Sazykina, T.G. and Kryshev, I.I., 1994. Provision of site specific input data for and assessment of radiological impact of waste dumping into the Barents and Kara Seas, IAEA-IASAP-4, Working Document of the International Arctic Seas Assessment Project.

IASAP Benchmark, 1994. CRP on Modelling of the Radiological Impact of Radioactive Waste Dumping in the Arctic Seas, Benchmark Scenario, IAEA-IASAP-7, Working Document of the International Arctic Seas Assessment Project.