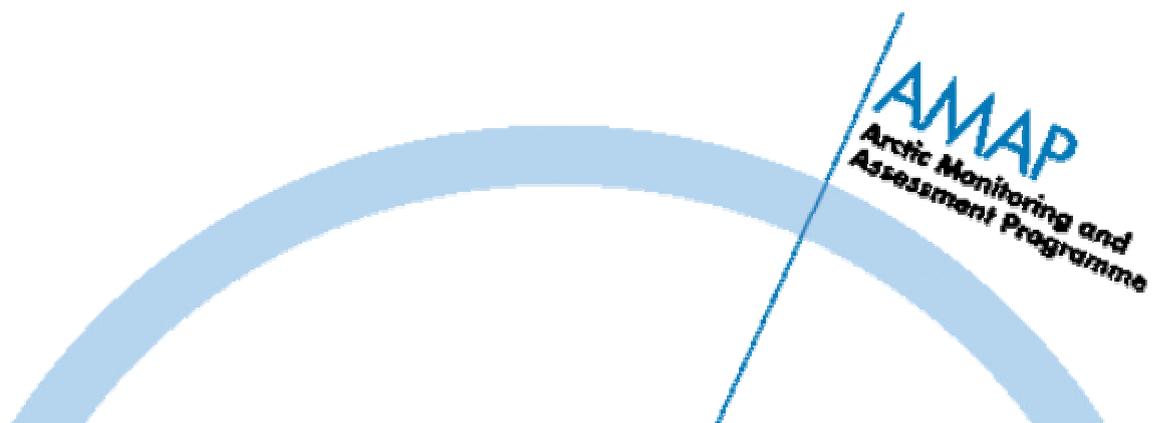


*Brief Synopsis of the State of the Arctic Marine
Environment in the Context of the Development of a
Regional Plan of Action to Protect the Marine
Environment from Land-Based Activities (RPA)*

June, 1998



BRIEF SYNOPSIS OF THE STATE OF THE ARCTIC MARINE ENVIRONMENT IN THE CONTEXT OF THE DEVELOPMENT OF A REGIONAL PLAN OF ACTION TO PROTECT THE MARINE ENVIRONMENT FROM LAND-BASED ACTIVITIES (RPA).

Prepared by representatives of AMAP to assist PAME (Reykjavik, June 2, 1998).

CONTEXT:

The following synopsis is based primarily upon the AMAP report «Arctic Pollution Issues - A State of the Arctic Environment Report» (SOAER), which was accepted by ministers at Alta, in June 1997. Occasionally, details have been included from the more detailed «AMAP Assessment Report - Arctic Pollution Issues» (AAR), which provided the scientific foundation to the SOAER. The AAR utilized only data which had passed a quality assurance regime, or information which had been published in an international peer reviewed journal.

GENERAL CONSIDERATIONS:

The Arctic Ocean and its biota are generally very clean in relation to other oceans and marginal seas.

- 1) Most biological production in the Arctic ocean takes place in the upper 200m of the water column. This layer is dominated by the influence of inflows from the Atlantic and the Pacific. They account for 98% of the water entering the Arctic Ocean and the contribution from the Atlantic is the most significant. The remainder is derived from rivers.*
- 2) Marine animals occupying a similar ecological niche at the top of the food chain (such as small toothed whales or seals) in the North Atlantic and North Pacific carry burdens of some biomagnifying pollutants such as PCBs, DDT, and Chlordane, that are many times higher than in their Arctic relatives.*
- 3) The burden being accumulated by Atlantic organisms must be ultimately derived from land-based sources. Since the Atlantic water plays such a significant role in determining the characteristics of the biologically active layer of the eastern and central Arctic, a significant aspect for the RPA for the Arctic could be to scrutinize the «downstream pollution history» of this inflow, just as the RPA looks at potential pollution sources within an Arctic riverine watershed.*

There are 2 important categories of exception to the statement that the Arctic Ocean is very clean.

Category 1) Combinations of physical and biological mechanisms have the potential to focus particular contaminants in certain geographical locations and /or species.

- (a) Examples of levels attributable to geographic focusing due to atmospheric trajectories, oceanographic and ice transport, and of biomagnification are given in the POPs section below. The result of the latter may even be the elevation of levels from close to background in seawater to levels in upper food chain biota which approach recognized levels of concern.
- (b) Substances which under certain circumstances are elevated from low levels in seawater to high levels in top marine predators are generally those which are derived from far distant sources in the northern hemisphere and the world, which are rapidly transported and dispersed by atmospheric transport, subsequently deposited in the ocean or into watersheds, and which are then subject to biomagnification. These are primarily POPs and different species of mercury. Ministers have recognized since 1993 that multi-national action on a northern hemispheric and a global scale is necessary to address this category and in their Alta Declaration put their strong support behind the relevant international instruments and negotiations.

Category 2) Pollution sources within the Arctic and / or located in the coastal zone can be attributed to geographically localized elevations in levels in the marine or estuarine environment. In some cases, the levels attained may approach or exceed recognized levels of concern. It will be noted that examples relating to this category given in the pollutant family sections below are dominated by observations from the Russian Arctic.

Since the actions to address the long-range category of pollutants are in progress in appropriate multilateral fora, the most effective arena for emphasis in the RPA may be to address the «within Arctic and /or local sources category» (Category 2). If particular attention is paid to assisting Russia to address problems in this category, care is advised to ensure coordination with programmes of assistance already underway through such organizations as NEFCO, the Barents Council, and the European Union.

In some areas discrete signals in the marine environment can be detected as, e.g., elevated concentrations of contaminants in the lower reaches of the Ob, but have not been positively linked to any given source(s). Identification of the relevant source(s) will be the initial work item in any future actions addressing such areas of concern.

As our coverage of monitoring data improves, further geographical areas of concern may be identified.

The scope and depth of the AMAP assessment was limited by the availability of quality assured data. In the absence of data, some assumptions can be made on the likely behaviour of various contaminants once released to the environment (as a result of a land-based activity), and the subsequent probability of levels being attained in the marine environment which may justify intervention. This depends largely on the geo-chemical partitioning characteristics of the substance concerned.

1) Some pollutants are:

Very particle active, are rapidly bound to sediment, and therefore do not travel far from source (for example, Lead and Plutonium).

Others undergo physical and/or biological degradation (e.g. oil).

Others are soluble (e.g. Caesium 137 and Cadmium) or volatile or semi-volatile (e.g. Caesium 137 and most POPs) and therefore travel far from source.

Others biomagnify (e.g. Organic Mercury and most POPs).

Some appear to be naturally elevated in many regions of the Arctic (e.g. Cadmium, Mercury and some hydrocarbons and PAHs)

Some possess a combination of the partitioning properties outlined above (e.g. many POPs).

Some have a negligible impact on the marine environment, regardless of their rate of delivery (e.g. sulphate acidifying substances).

2) Knowledge of the above characteristics assists in addressing paragraph 22 of the GPA methodology in those cases where little or no data is available to assess the likely spatial scale of impact in the marine environment attributable to an identified land-based source.

SPECIFIC CONSIDERATION OF CONTAMINANT GROUPS

POPS:

Current and past use of POPs in mid-latitudes of the northern hemisphere are the major source of POPs in the Arctic marine environment. The initial transport mechanism from source is usually via the atmosphere either directly to the sea or through deposition into watersheds. Some sources are located within the Arctic and these will include production of dioxins, furans and HCB at municipal incineration sites, direct discharge of dioxins and furans from certain pulp and paper facilities to fresh and marine water bodies, loss of PCBs from electrical installations and other past uses.

The highest concentrations of alpha-HCH in the world's oceans are found in the Canadian Arctic Archipelago, but this reflects the fact that old Arctic water isolated from atmospheric exchange is exiting the Arctic by this route rather than indicating current sources. Some elevated levels of POPs are seen around Svalbard, East Greenland and the Barents Sea, which is believed to reflect a focusing of atmospheric deposition, due to winter weather patterns; the meeting of warm Atlantic water with cold Arctic water at the polar front; and, possibly, the seasonal melting of sea ice in this area, thus releasing a winter's accumulation of atmospheric deposition to the ice. Some of this ice may have originated from Russian shelves and contain incorporated sediment from those areas.

Levels of POPs in Arctic marine species are generally lower than in comparable species in temperate areas. For example, for PCBs in top marine predators, burdens observed in beluga whale are one-tenth to one-hundredth of those found in N. Atlantic bottle nosed dolphin; various

seal species exhibit 20-fold lower concentrations in Arctic waters N. of Norway compared to seals in the Baltic or North Seas. Nevertheless, current concentrations of chemically related PCBs and dioxins/furans in several Arctic marine species (ringed seal, beluga, certain seabirds, harbour porpoise, walrus, polar bear, Arctic fox) are at or above known threshold effects associated with reproductive, immunosuppressive and neuro-behavioural effects in related species. Populations of northern peoples harvesting and consuming the lipid rich tissues of these species have the potential for exceeding dietary intake levels set by health authorities.

The lack of substantial spatial patterns in concentrations in the marine environment is indicative of the overriding significance of northern hemispheric scale transportation and dispersal processes from distant sources. However, signals indicating local sources can be detected. For example:

- High PCBs and sum-DDTs on suspended solids in the Ob and Yenisey rivers and of HCH in water of the Ob and lakes of the Taimyr Peninsula are substantially higher than found in river water of industrialised areas of Europe and N. America. The signature of the DDT data indicates recent use. Although both of these observations need further verification, the PCB, DDT and HCH information suggests sources in the water- and air-sheds of these rivers. This general trend is also evident in snow, seawater, coastal sediments, fish and the few data collected for fish, reindeer, lemming, seabirds, seal and beluga;
- Elevated PCB levels in nearshore areas have been detected close to abandoned or existing military installations, e.g. Cambridge Bay, NWT, Canada; Thule, Greenland and around naval bases along the Norwegian coast; information was not available to assess the situation elsewhere;
- Elevated PCB levels have also been detected in marine sediments close to landfills on Svalbard; and local dioxin/furan contamination has been detected close to a smelter in Kirkenes;
- Studies in the Archangelsk area show local contamination with dioxins and furans from pulp mills on the N. Dvina and tributaries which may extend to the White Sea, however, they are not believed to be major sources to the offshore Arctic Ocean.

Conclusion on POPs for the RPA:

(A) Because most POPs rapidly and widely disperse from distant sources and efficiently biomagnify in freshwater and marine foodwebs, Arctic Ministers should be encouraged to continue to assign the priority they accorded at Alta and to address these substances through the hemispheric actions now agreed upon under the LRTAP Convention and about to be initiated in a global context under UNEP.

(B) Where local sources have been identified (see below), and these may significantly contribute to levels in the marine environment where health or ecosystem effects may arise, specific actions could be initiated under the RPA. This should recognize the fact that the identified sources do not constitute a comprehensive list of all such sources, and

thus there is a need for further work to locate other comparable local sources of POPs, especially associated with, e.g. decommissioned military and radar installations.

Signals indicating local sources are as follows:

- *High PCBs and sum-DDTs on suspended solids in the Ob and Yenisey rivers and of HCH in water of the Ob and lakes of the Taimyr Peninsula are substantially higher than found in river water of industrialised areas of Europe and N. America. The signature of the DDT data indicates recent use. Although both of these observations need further verification, the PCB, DDT and HCH information suggests sources in the water- and air-sheds of these rivers. This general trend is also evident in snow, seawater, coastal sediments, fish and the few data collected for fish, reindeer, lemming, seabirds, seal and beluga;*
- *Elevated PCB levels in nearshore areas have been detected close to abandoned or existing military installations, e.g. Cambridge Bay, NWT, Canada; Thule, Greenland; and around naval bases along the Norwegian coast. Similar situations may be expected to occur in other Arctic countries;*
- *In addition to handling PCB at military sites, there are industrial complexes using PCB, e.g. the large power plants in Murmansk, Archangels and Severodvinsk, but also at the heavy industry and mining activities on Kola Peninsula. A phasing-out of PCB with alternatives and handling of the waste PCB and contaminated equipment are again practical initiatives which could be included in an RPA and would be consistent with LRTAP Protocol obligations;*
- *Elevated PCB levels have been detected in marine sediments close to landfills on Svalbard;*
- *Local dioxin/furan contamination has been detected close to a smelter in Kirkenes;*
- *Actions should be taken both to clean up contaminated sites, and to establish safe routines for handling of PCB oil, contaminated equipment, and to introduce use of alternative fluids. Although this applies to all Arctic countries, it is clear that Russia will be in a special situation due to the economic situation. Bi-lateral and joint projects should be initiated and supported by the Eight Arctic countries.*
- *Some of the biggest pulp and paper mills in Europe are situated along the Northern Dvina that empties into the White Sea. Little treatment exists on the discharges to air and water which include quantities of chlorine and mercury. Some of the Pulp and Paper mills are close to the N. Dvina river mouth and are contaminating the river delta and the White Sea (Archangels pulp and paper mill in Novodvinsk and Solombola in Archangels city), while others are further upstream (Kotlas) and are mainly affecting the river. The contamination can clearly be seen in the river sediments and the White Sea.*

- *Studies in the Archangelsk area show local contamination with dioxins and furans from pulp mills on the N. Dvina and tributaries which extend to the White Sea. However, they are not believed to be major sources to the offshore Arctic Ocean. Drinking water to Archangels city is taken 1 km downstream of the outlet from Archangels pulp and paper mill*

METALS:

Heavy metals occur naturally in all ecosystems, but with large concentration variations. They are also released to the environment by many different anthropogenic activities. The metals of concern in the Arctic context are Hg, Cd and Pb, but in the marine environment Pb is normally only of significance around local sources.

The fate and biological availability of these metals in the Arctic marine environment is highly dependent upon the geochemical partitioning characteristics outlined in the general considerations section above.

The Arctic marine environment receives heavy metals from atmospheric deposition, influx of waters from more southerly oceans, riverine runoff and local pollution. The relative importance of these sources differs between regions and between metals.

During winter about two-thirds of the heavy metals in the air in the High Arctic are transported from regions with industrial activities on the Kola Peninsula, the Norilsk smelter complex, the Urals and the Pechora Basin. Five to ten percent of these emissions are deposited in the High Arctic. The remaining one third of the heavy metals in the High Arctic air in winter is transported from industrial regions in Europe and North America. In summer local sources dominate in contamination of the High Arctic. The highest concentrations of atmospheric heavy metals in the Arctic air occur in the vicinity of smelter complexes on the Kola Peninsula and the Norilsk and result from emissions from these smelters.

In the Arctic, mining and metallurgical industries on the Kola Peninsula and in the Norilsk region are major contributors of metals to the aquatic environment. Local contamination around mines, such as Black Angel mine in Greenland and Strathcona Sound in northern Baffin Bay, is also a recognized problem. However, at point sources such as mine sites and some Russian estuaries background levels are only generally exceeded within distances of up to 30 km from the source.

Riverine transport of heavy metals towards the Arctic Basin is approximately half the atmospheric contribution for metals like Cd and Pb, while for others such as Zn the rivers are most important being a factor 5 higher than the atmospheric emission. Mass balance calculations of loadings change considerably with the distance from the sources, and according to geochemical partitioning characteristics. In addition, the source contributions are strongly seasonal.

The concentration of trace elements in marine sediments is dependent on local geology, particle size, the amount of organic matter and anthropogenic influence. The background geographical distribution of Pb, Cd, Hg and Cu in marine sediments is related to the geological provinces within the Arctic.

Metal levels in Arctic Ocean water away from local sources are generally similar to global background levels. An overall assessment is that lead levels in the Arctic marine environment are low, and there is no indication that they increase at higher trophic levels. The only instances where effects on biota resulting from anthropogenic lead contamination are likely to occur are hot spots such as mining areas and possibly in some Russian estuaries.

Large scale regional geographical differences in metal concentrations of benthic flora and fauna as well as in fish are not very apparent. Regional differences in metal burdens in marine mammals for Pb, Cd and Hg strongly imply that tissue concentrations depend to some degree on regional geology and bio-geochemistry. For Cd and Pb, there is no clear evidence of compromise of Arctic marine biological resources due to anthropogenic introductions.

The concentration of heavy metals measured in sub-Arctic air has decreased during the last two decades. All the heavy metals show strong seasonal variation in the high Arctic. Hg in Arctic sediments and some evidence in marine mammals shows increasing temporal trends indicating a widespread regional process.

The most important metals in the arctic biosphere are Cd and Hg because they tend to accumulate in the food chain to concentrations that might have health implications for individual animals or the human consumers. Cd levels in marine organisms from large parts of the Arctic exceed global background. Hg and Se levels in marine mammals are high, but not exceeding the highest global levels. Pb levels in large parts of the Arctic are at the lower end of global background.

Health effects have so far not been investigated in Arctic biota. However, the Cd levels in seabirds and marine mammals from Northwest Greenland may be high enough to cause kidney damage. It is likewise uncertain whether Hg poses a health problem to the highest exposed groups of marine mammals in the western Canadian Arctic and pilot whales from the Faroe Islands. However, there are indications that Se is present in concentrations that can protect against Hg poisoning.

Relative to the concentration limits proposed by the Nordic Council of Ministers for Cd in kidney, liver and muscle tissue all caribou in Canada, most game birds and marine mammals across the Arctic would also exceed these limits. In almost all cases, Pb levels in marine organisms from the Arctic are well below food standard limits; however, this is not the case for hot spot areas such as mining areas and some Russian estuaries. No food standard limits are given for Se in food, but in some cases, human intake of Se is estimated to be high.

Conclusion on metals for the RPA:

- (A) The metals of concern in the Arctic context are Hg, Cd and Pb but in the marine environment Pb is normally only of significance around local sources.***
- (B) These metals occur in all Arctic marine ecosystems as a result of natural sources and take part in natural geochemical cycling processes. Metal levels in Arctic Ocean water away from local sources are generally similar to background levels. Regional differences in metal burdens in marine mammals for Pb, Cd and Hg strongly imply that tissue concentrations depend largely on regional geology and bio-geochemistry.***
- (C) Widespread contamination of the Arctic marine environment also occurs as a result of anthropogenic activities, in particular from sources in the industrialised regions of Europe, Asia and North America. Emissions from these areas are subject to long-range transport by the atmosphere or ocean currents. This is especially so in the case of Hg which exhibits characteristics similar to those of POPs. Arctic Ministers should be encouraged to continue to assign the priority they accorded at Alta and to address these substances through the hemispheric actions now agreed upon under the LRTAP Convention.***
- (D) A major source of mercury to the Arctic marine environment will be atmospheric emissions from coal burning power stations. This source is likely to increase in importance in the future as global energy demand increases. International agreement through, for example, the LRTAP Convention heavy metals protocol to reduce these emissions should be a priority.***
- (E) Mining and metallurgical industries on the Kola Peninsula and in the Norilsk region are major contributors of metals to the local aquatic environment, and to elevated metal concentrations in air in these regions. The atmospheric emissions from these sources within the Arctic supplement the atmospheric loadings from Eurasian sources further south. Downstream of Norilsk, the lower reaches of the Yenisey river is at global background levels for heavy metals, indicating that Norilsk may not be making a significant contribution to the pollution of the adjacent marine environment.***
- (F) River systems can be significant in transporting metals, in particular for Zn and to a lesser extent, Cd and Pb, to the marine environment. However, levels away from local sources are generally similar to background levels. The flux of metals to the marine environment depends on season, the characteristics of the river system, and distance from the source. Metal-laden sediments transported to the coast by rivers are generally deposited on the shelf seas and only a minor proportion reach the open ocean. Natural sources of metals are important and in many cases are found to be the main source to the marine environment.***

- (G) Local sources which may impact directly on the marine environment include mines and industrial activities located on or close to the coast. These may have significant local impacts at distances generally within 30 km of the source.***
- (H) Local sources with impacts restricted largely to a local scale also include untreated sewage sludge which is contaminating the Kola fjord and part of the White Sea from discharges in Murmansk and Archangelsk, respectively. Other potential sites for remedial and preventative action from municipal and industrial waste disposal are Svermorsk City, the region between Archangelsk and Severodvinsk on the White Sea, and facilities on the delta of the N. Dvina.***
- (I) Incineration plants such as those at Murmansk emit heavy metals (Pb, Zn, Hg, Cd) and other pollutants, largely in particulate form, leading to deposition in the nearby coastal environment. Installation of appropriate technologies would be a potential project for remedial action for consideration under the RPA.***

ACIDIFYING SUBSTANCES:

The Arctic region is widely contaminated by low levels of acidifying substances, primarily as a result of atmospheric transport of emissions from industrialised areas of Europe, Asia and North America. Significant sources within the Arctic include the metal smelters on the Kola Peninsula and at Norilsk, and these give rise to high levels of local deposition at distances of up to a few hundred kilometers from the source.

Although the deposition of acidifying substances gives rise to significant impacts in certain terrestrial and freshwater environments, there is no evidence of any direct effects on the marine environment due to its large buffering capacity.

International collaboration on a N. Hemispheric scale has been in existence for many years under the auspices of the LRTAP Convention.

Conclusion on acidifying substances for the RPA:

- (A) The lack of any documented impacts of acidifying substances on the marine, freshwater, and brackish water environments implies a lack of priority for this issue within the RPA.***
- (B) It is conceivable that denudation of vegetation in coastal zones and in wetlands as a result of acid depositions could effect nearshore and estuarine species and habitat, but this has not been examined by AMAP. From a precautionary approach, Arctic Ministers should therefore be encouraged to continue to assign the priority they accorded at Alta and to address these substances through the hemispheric actions now agreed upon under the LRTAP Convention, by encouraging ratification of existing protocols and expeditious completion of the second NO_x protocol.***

RADIOACTIVITY:

Radionuclide activity concentrations in marine biota have consistently been low in the Arctic compared to levels found in terrestrial biota. Even during the heaviest fallout periods in the mid 1960s, average ^{137}Cs activity concentrations in marine fish and marine mammals in N. European Seas did not exceed 10 Bq/kg.

A major direct input of radionuclides into the marine environment has been from European nuclear reprocessing plants, particularly Sellafield on the shore of the Irish Sea. Currents transport the material along the Norwegian coast and into the Arctic Ocean. After 6 to 8 years, some of the contamination leaves the Arctic by way of the East Greenland Current, but the remainder resides in the Arctic Basin for a longer period. The levels observed in the Arctic are well below intervention levels.

During the late 1960s, ^{90}Sr activity concentrations in seawater were about 20-30 Bq/m³. No measurements for ^{137}Cs in seawater from that period are available but by applying the established ratio between ^{137}Cs and ^{90}Sr in nuclear weapons fallout, ^{137}Cs activity concentrations in seawater can be estimated to have been up to 50 Bq/m³. Equivalent and higher values were also found in the Barents Sea in the early 1980s due to Sellafield releases.

Smaller scale releases from accidents in military operations, such as those in northern Russia, the plutonium spill at Thule in Greenland, or the loss of the *Komsomolets* submarine in the Norwegian Sea, have resulted in no significant radiation exposures within Arctic human populations. The estimated increase in ^{137}Cs in Arctic waters due to the *Komsomolets* accident was about 0.02 Bq/m³ in 1991, 0.01 Bq/m³ in 1995 and will decrease to about 0.001 Bq/m³ in 2089. However, a limited number of military personnel have been exposed to significant doses in connection with accidents on nuclear vessels. It has been estimated that the collective doses to personnel operating Russian nuclear vessels was in the range 17-74 manSv with the highest individual doses in the range 0.2-0.6 Sv.

During 1961 – 1991 the Russian military and the Murmansk Shipping Company dumped radioactive waste and nuclear reactors at sea. Six submarine reactors containing spent fuel, some spent fuel from the Icebreaker »Lenin» and eleven reactors without fuel have been disposed in three bays at the East coast of Novaya Zemlya and in a dedicated area of the Open Kara Sea within the Novaya Zemlya Trough.

Russia has three fuel reprocessing plants, at Mayak, Krasnoyarsk and Tomsk, which are all situated south of the Arctic. Radioactive releases from the Mayak and Tomsk installations enter the drainage area of the Ob River and those from Krasnoyarsk go directly into the Yenisey river. Both these rivers outflow to the Kara Sea.

The Chernobyl accident added caesium to the Arctic Ocean and continues to do so via outflow from the Baltic Sea.

The AMAP study shows that people eating marine products only, for instance fish and marine mammals, receive doses from anthropogenic radionuclides that are at least an order of magnitude lower than those of people consuming terrestrial products such as caribou/reindeer, freshwater fish and mushrooms. For this reason, individuals predominantly consuming seafood have lower dose rates and lifetime doses than average members of both the Arctic and northern hemisphere populations.

Radioactivity issues of relevance to the Arctic marine environment are currently of a potential nature rather than representing health and environmental concerns due to current levels. Two groups of future environmental contamination and threat from radioactive sources may be identified: (a) Accidental releases and (b) Future leakages of contaminated radioactive materials and run-off of deposited radioactive materials.

Accidental releases are mainly connected to operation of reactors (civilian and military, naval and installation on land) or storage of spent nuclear fuel. Accident scenarios involving nuclear weapons also constitute a possible concern.

Leakage from radioactive sources is connected with storage of spent nuclear fuel, either on board non-operative submarines or in intermediate storage. High level waste can also be in open storage sites in the environment. Although these may be contained at present, they may still represent a potential for future releases (e.g. Mayak).

Consequences from group a) probably have the potential for the most serious and far-reaching accidents. However, different scenarios within group b) may seem at present to have a considerably larger probability of occurring, and may give very serious effects locally and may possibly contaminate a large area, with associated serious economic consequences.

Conclusion on radioactivity for the RPA:

(A) The Arctic marine environment has been historically contaminated by fallout from nuclear weapons testing and by releases from European reprocessing plants. The associated levels of contamination peaked in earlier decades and current levels of contamination of the Arctic marine environment are low.

(B) Recent releases of Technetium-99 from Sellafield indicate significant increases, and recent observations in Norwegian coastal areas indicate that this maybe a concern for the Euro-Arctic marine region in the future.

(C) All other releases associated with, for example, waste management practises and military accidents, although often detectable in the Arctic marine environment, are minor in comparison with nuclear testing fallout and European reprocessing plant releases.

(D) Radioactivity issues of relevance to the Arctic marine environment are currently of a potential nature rather than representing health and environmental concerns due to current levels. Most of the information relevant to such potential threats was provided by Russia. In this context, two groups of future environmental contamination and threat from radioactive sources may be identified:

- **Accidental releases:**

Potential large scale releases associated with accidents at existing nuclear sites in the Arctic, as well as accidental releases in connection with handling of the nuclear waste produced during normal operation of a nuclear reactor, and handling of spent nuclear fuel from nuclear reactors, constitutes particular topics of concern.

- *In the Kola region there is one nuclear power plant and many nuclear-powered vessels. Due to the presence of the Russian Northern Fleet, North West Russia contains the highest concentration of nuclear powered vessels and nuclear reactors in the world.*
- *190 military naval reactors, 13 civilian naval reactors and 4 reactors in Nuclear power plants are in operation in North West Russia. Spent Nuclear Fuel (SNF) is produced during operation of the reactors, and consists of activation products and contaminated tools. SNF is highly active and needs special treatment, and is often stored temporarily close to the reactors, to allow the decay of short-lived fission products.*
- *Considerable numbers of nuclear weapons are stored at military sites in northern Russia and on-board naval ships and aircraft.*

Under the RPA, Ministers may be encouraged to continue their Alta Declaration statements concerning the safe operation of nuclear power facilities.

- **Future leakages of contaminated radioactive materials and run-off of deposited radioactive materials:**

At the military bases in Russia, about 250 reactor cores are temporarily stored. This includes approximately 150 reactors containing nuclear fuel and decommissioned 76 submarines. Among the on land stored reactor cores about 80% are stored at the naval base in Andreyeva fjord, 15% are at the Gremnika base and at the Murmansk Shipping Company (including the «Lepse»), and 5% at other locations including the Severodvinsk shipyard.

Leakage from the dumped reactors and waste constitute potential sources of future radioactive contamination of the Arctic Oceans, especially the Kara Sea.

At the reprocessing plant in Mayak, (next to the Tetcha river, a tributary river to the Ob river that empties to the Kara Sea), there are considerable amounts of stored radioactive material contained in lakes, reservoirs and river beds, especially close to the MAYA reprocessing plant. It has been assessed that transport of radioactive material by rivers to Arctic Seas from the plants at Tomsk and Krasnoyarsk is unlikely. The assessment also concluded that the contribution of Mayak to the radioactive contamination of the Kara Sea has been significantly less than from other sources (e.g. fall-out from atmospheric testing of nuclear bombs and from Sellafield). However, there remains a potential for further transport of radioactive material from Mayak through the river systems to the Arctic seas should there be a failure in containment facilities. Therefore actions to assist the restoration and clean-up of contaminated lakes, reservoirs and riverbeds close to Mayak reprocessing plant may be warranted under the RPA.

Other potential projects to address the above issues under the RPA include addressing handling and transport of radioactive waste and spent nuclear fuel along the coast of Murmansk and Archangels Oblast; improving regional storage for radioactive waste and spent nuclear fuel in Murmansk and Archangels Oblast, and development of alternative techniques for decommissioning of nuclear submarines.

- **Petroleum Hydrocarbons and PAHs**

Hydrocarbons can be detected in seawater throughout the Arctic. Except for local pollution in, e.g., harbours, the highest levels occur just off river mouths. Concentrations in the marine waters of the Russian Arctic are generally much higher than those found in North American waters. One explanation might be differences in analytical technique, but oil pollution carried by the large Russian rivers probably contributes. Except for areas affected by local chronic sources and spills, anthropogenic input to the Arctic marine environment to date is relatively low and does not have any ecological significance.

In addition to contamination from sources within the Arctic, petroleum hydrocarbons are transported from heavily industrialized areas by air currents, ocean currents, and rivers. The main pathway is probably via the atmosphere. Based on models, it has been estimated that atmospheric transport annually adds about 40 000 tonnes of hydrocarbons to the Arctic marine environment.

Natural oil seeps from the Mackenzie River contribute the largest quantities of hydrocarbons to the Beaufort Sea region. Oil seeps have also been detected in eight areas of the United States Arctic, several of which are located along the Beaufort Sea coast.

Long-term monitoring of petroleum hydrocarbons in Russian river water indicates high pollution levels in the areas of oil and gas exploration and production. This is especially true in the lower part of the Ob River. However, even where local freshwater or terrestrial contamination is severe, riverine and other physical and biological processes tend to limit the contribution reaching the salt water environment. For example, during the Komi oil spill, only a minor portion of the spilled oil reached the mouth of the Pechora River.

Several areas of the Arctic have elevated levels of PAHs in seawater and marine sediments relative to global background concentrations. The Beaufort Sea is an area with particularly high levels. These are believed to be related to natural sources including atmospheric deposits from forest fires, and the Mackenzie River, which flows through regions with known fossil fuel deposits, natural hydrocarbon seepage.

The relationship between different PAH compounds can be used to identify their main sources. Alaskan marine sediments point to petroleum hydrocarbons, while PAHs in the Barents Sea show a greater contribution from combustion sources. The Canadian Beaufort Sea has a mixture of the two sources, which is also the case for Russia's marine environment. Sediments near Spitsbergen are enriched in PAHs compared with the Russian sediments, which probably reflects contamination from coal particles and petroleum products.

There are a number of legal instruments to prevent oil pollution of marine waters. Some are aimed at shipping while others specifically address oil and gas exploitation.

Conclusion on petroleum hydrocarbons and PAHs for the RPA:

- (A) Petroleum hydrocarbon contamination in the circumpolar Arctic marine environment is always expected to be subregional or local in extent.***
- (B) In relation to subregional petroleum hydrocarbon contamination of the Arctic marine environment resulting from land-based activities, the threats are essentially potential in nature and related to possible unintentional releases from existing facilities and future development of oil and gas resources (including related oil transportation infrastructure) in the coastal zone or watersheds of north flowing rivers. A key feature in evaluating potential threats will be the distance from the marine environment and the characteristics of the relevant riverine environment. As such, they can best be addressed by proactive measures aimed at ensuring that future development of oil and gas resources in or close to the Arctic marine environment takes due account of appropriate environmental protection measures (EIA, BAT, BEP, etc.) and targeted remedial and preventative measures at sites with existing problems. Environmental observations in the lower part of the Ob River and in the Pechora suggest that initial attention could be directed towards facilities located within these watersheds.***
- (C) Since the harbour of Murmansk has no facilities for receiving and treating liquid or solid waste from ships, this and the general lack of wastewater treatment facilities may represent a substantial multi-pollutant local source including petroleum hydrocarbons. Similar situations may exist in other Russian Arctic ports and major coastal cities and these may be potential items for inclusion in an RPA.***
- (D) Incineration plants such as those at Murmansk emit PAHs (including benzo(a) pyrene) and other pollutants, often associated with particles, leading to deposition in the nearby coastal environment. Installation of appropriate technologies would be a potential project for remedial action for consideration under the RPA.***