“NUCLEARISATION” status of the ARCTIC 2021

by

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Soviet Union/Russian Federation Nuclear Lighthouses: in the 1930s the Soviet Union began the construction of over 1,000 “nuclear lighthouses” along its Arctic coasts to assist navigation through the difficult waters of its arctic Northern Sea Route from Europe to the Pacific. These were powered by Radioisotope Thermo-electric Generators (RTGs) which utilised radioactive Strontium 90 as a heat source to power a thermo-electric battery which powered the lights.

Construction and maintenance of RTG powered lighthouses ceased with the collapse of the Soviet Union in the 1990s. It is reported that many of them had already fallen into major disrepair and that some have now been completely destroyed by weather and ice conditions, while other RTGs have been removed and broken for scrap materials by thieves. The number of “lost” RTGs is unknown.

More recently international teams have been permitted to attempt removal and decommissioning of aged RTGs and during their work have uncovered strong evidence that many of the RTGs had leaked radioactivity into the surrounding terrestrial and marine environments.

With the continuing development of the Norther Sea Route, the Russian Federation has recently announced that it is planning to install a new generation of RTGs at remote Arctic military and industrial sites. There are indications that some of these RTGs will be deployed on the Arctic sea-bed as well as at coastal terrestrial sites.

Nuclear Bomb testing:
Prior to the 1963 Test Ban Treaty (which prohibited all test detonations of nuclear weapons except for those conducted underground) Arctic indigenous communities had been in receipt of exposures of fallout radioactivity and were considered to be one of the most exposed populations to global fallout from the atmospheric testing of N. weapons from 1945 through to 1963.

The records show that the US carried out over a 1,000 such tests, many in the northern hemisphere, but none directly in the Arctic. However, from 1965 through to ’71 the US carried out a series of three tests at Amchitka, in the Aleutian Island Chain close to the Arctic Circle and situated between the Bering Sea to the north and east, and the Pacific Ocean to the south and west.

The final Amchitka (test named “Cannikin”) was a very large 5 megaton blast which created an earthquake of Richter Scale 7, with 15ft ground waves. It is reported that cliffs collapsed into the sea and that the sea boiled and thousands of sea birds, sea otters and other animals were killed. Amchitka is still the subject of regular radiological monitoring and the marine and terrestrial environments are still radioactive as a result of these three tests.

Soviet Union tests were performed between 1949 and 1990, during this period over 715 tests were carried out. Many of these tests took place at the Northern Test Site, on the Arctic island of Novaya Zemlya. Details of the Soviet tests are more obscure than the US data but it is likely that some, were of similar magnitude to the “Cannikin” test.

No matter where they were carried out, much of the airborne radioactivity from these northern hemisphere tests, even those several 1,000 kms distant from the Arctic was driven by wind and precipitation patterns to eventually fall out over the Arctic, contaminating land, water and the ground level atmosphere. Analysis of both sea ice and glacial and ice cap cores has proved the presence of a range of weapons test radionuclides including Cs 137, Sr 90, H3, and Pu.

There has been poor quantification of the amount of weapons test fallout that has been deposited on Arctic environments but academic research has shown that the diet and traditions of various indigenous groups mean that they have been, and still are, receiving verry significant contact, dietary and inhalation doses of weapons test nuclear fallout derived from hunted fish, sea mammals and terrestrial meat, gathered vegetable and other wild produce and inhalation of contaminated air and marine aerosols and sea sprays.

In the context of Climate Change, it is clear that the major ice loss melt trend currently effecting the Arctic is going to make a significant contribution to marine radioactivity concentrations as the reservoir of radioactive fallout locked in ice is released to the sea. I have found no evidence that this has (or can be) quantified.

Civilian nuclear power sites: Contemporary with the rising number of N weapons tests through the 50s and 60s was the massive increase in radioactivity discharges from the operation of the new breed of Civilian nuclear power stations and the reprocessor sites (including Sellafield and Cap de la Hague) built to extract weapons grade Plutonium from power station used irradiated fuel. These establishments discharged nuclear "waste" materials to both the atmosphere, in gaseous and particulate form through chimneys and stacks and to sea, in liquid and particulate form through sea discharge pipelines. As we have seen atmospheric fallout/washout onto the Arctic seems to be impossible to quantify.

Sadly, it seems to the case that the impact of distant marine discharges on the Arctic is similarly hard to accurately quantify. It was assumed by the nuclear industry that such materials would either dilute and disperse and hence all but vanish in the environment, or become "sequestered" in marine seabed sediments and thus locked away from contact with humans. However, some years after the first discharge to sea of radioactive effluent from Sellafield, it was blandly announced that the discharges had been experimental and that much useful information was being gathered. Amongst that information was the fact that much of the radioactivity discharged to sea did not dilute and disperse to nothing or become locked away forever in marine sediments.

Field research by both nuclear industry and independent academics has now proved that Sellafield sea-derived alpha emitting Plutonium, Caesium and other nuclides have penetrated the Arctic and contaminated the marine environment and foodwebs and delivered dietary doses of multiple nuclides to apex consumers including human populations. Sellafield discharges are easily identified because they have a specific "finger print" ratio of radionuclides. Other Atlantic and Pacific NPS discharges are less easily identified but must clearly follow the same distribution patterns of the reprocessor discharges. Research has now confirmed that Sellafield derived marine radioactivity has entered the Pacific via the Arctic northern sea routes.

Russia has embarked on a major exploitation of mineral reserves as the Arctic marine environment warms and the opportunities for safe and ice free maritime transport increase. A number of major industrial sites are under development along the Arctic coast of Russia, with new ports, industrial infrastructure and supporting urban areas under construction to exploit large reserves of metal ores (gold, nickel, copper etc), uranium, rare earths and oil and gas.

The use of nuclear energy to power these developments is rapidly becoming the preferred choice. Government policy appears to be strongly supportive of the use of a variety of smNr design types in the Arctic. There is a similarly flexible attitude to deployment methods with plans to deploy smNrs at offshore oil and gas rig complexes, either on the sea bed or as floating units, in addition to those moored at the coast.

A floating smNr power station is already in operation, having been constructed and fuelled in western Russia and then towed to Pevek on the coast of Chukotka in the east Siberian Sea, close to.US/Canada jurisdictions. Pevek is the site of newly opened copper and gold extraction and refining development, owned and manged by a group of “oligarchs” including Roman Abramovitch. Called “Alexander Lomonosov”, this un-propelled vessel carries two uranium fuelled nuclear reactors (developed from N.sub propulsion units). The reactors will require onsite refuelling every 3 years and a refit/overhaul every 12 years. The Lomonosov has been operating at Pevek since 2019. Four more such units are currently under construction, destined for similar resource extraction sites along the Siberian Arctic coast.

Clearly Russia’s current policy increases the risks of nuclear accidents in the Arctic. The obvious risks to the integrity of such units deployed in extreme Arctic conditions are exacerbated by the extreme distance from technical backup and expertise in the event of a nuclear “incident”. Additionally, the expectation that the reactors will be refuelled on site clearly indicates that Arctic Ocean maritime transports of both new fuel elements and used, irradiated nuclear fuels will increase exponentially as more of the planned smNrs come on stream.

Arctic nuclear civilian shipping: launched in 1988, the Soviet built nuclear powered freighter SEVMORPUT has been relatively inactive, largely due to the refusal of many Coastal States, and even Russian ports, to accept a visit from a nuclear powered vessel in the context of fears about reactor accidents and uncertain insurance regimes covering maritime nuclear reactors. In the late 1990s, SEVMORPUT was laid up in Murmansk due to delays in the refuelling of her reactor. The re-fuelling finally took place in 2001 and later the ship resumed low level service on the Arctic routes.

In August 2007, it was reported that SEVMORPUT would be converted into the world's first nuclear-powered drilling ship in the Arctic oil fields, due to lack of demand for cargo operators for lighters and the need of specialized drilling vessels in the Russian Arctic. However, that conversion never took place. In October 2009, the general director of Atomflot announced that SEVMORPUT could remain in service for 15 years. In late October 2012, it was reported that SEVMORPUT, which had been lying idle at the Atomflot base outside Murmansk since 2007, had been removed from the Russian Ship Register in July and would be sold for scrap.

However, in December 2013 it was reported that the decision to decommission the nuclear-powered ship had been cancelled and that the vessel would be brought back to service by February 2016. SEVMORPUT returned to service in 2016, and has been chartered mainly by the Russian MoD for transporting cargo related to the development of military infrastructure in the Arctic. In addition, she has occasionally transported supplies for oil and gas projects. The SEVMORPUT's new life has been punctuated by breakdowns and delayed operations, none of which have been attributed to reactor problems.

The re-deployment of the SEVMORPUT appears to be part of the ongoing "nuclearization" of Russia's Arctic shipping and follows recent statements that Russia is considering "alternative fuels" for its civilian polar fleets, having already built and operated 10 nuclear powered icebreakers (5 more in design and build stage) and 1 floating marine nuclear reactor power station (9 more in design or build stage) to power offshore Arctic Ocean oil drilling, mineral mining and the associated refining, manufacturing and urban/industrial activity.

China has also begun the construction of nuclear powered ice breakers with, certainly 1, possibly 2, such vessels powered by twin maritime PWRs under design and construction. The design/construction brief states that the vessels are intended to "open polar waterways", presumably intended to accompany future Chinese merchant vessels along the Arctic Northern Sea Route.

A series of nuclear accidents have made detectable impacts on the Arctics aquatic and terrestrial ecosystems. A number of research projects have concluded that Chernobyl accident radioactivity has entered the Arctic environment by way of multiple pathways including direct fallout/washout onto Arctic marine environments and inputs of radioactivity from the river systems of arctic and sub-arctic terrestrial environments contaminated by fallout and washout. As is the case with other input sources this has not been quantified either in terms of the quantity of radioactivity or the number of radio nuclides.

Research has recently reported that radioactivity released to sea during, and after, the Fukushima disaster has entered the Arctic Ocean and has been detected in both the Bering Sea on the Pacific outskirts of the Arctic Ocean and the Chukchi Sea which is a subdivision of the Arctic Ocean proper.

In the context of the fate and behaviour of weapons test fallout discussed above it seems inevitable that other northern hemisphere nuclear accidents, dating back to the 1957 UK Sellafield re-processor and the Soviet Union's Chelyabinsk/Mayak/Kyshtym re-processor accident also have made significant contributions to Arctic environmental radioactivity.

Sunk N.subs and sea dumped military nuclear wastes: despite the general secrecy around military nuclear activity there is a wide consensus that the Russian Arctic has been a military radioactive waste dump since the beginning of the cold war nuclear weapons race.

There is a wide consensus that the major issue is nuclear submarines. Reports from Russia confirm that the Soviet Union lost 5 N.subs, and subsequently the Russian Federation lost 2, in the Barents and Kara Seas at the European end of the Arctic Ocean. All but one of these sinkings occurred as a result of some form of onboard failure. One was deliberately scuttled following an onboard nuclear event which made the vessel too radioactive to be worked on. One was a diesel powered submarine carrying nuclear missiles. The others were nuclear powered, an uncertain number of which were carrying nuclear weapons. The sunken submarines were powered by twin nuclear reactors and each contained between 700 and 1000 kg of nuclear fuel (depending on vessel type).

Some observers have postulated that a significant leak (breach of containment) from any one of these vessels could raise radioactivity concentrations in the valuable Barents/Kara sea Cod, Capelin, Halibut and Crab stocks by 100 times in the years following any such leak.

Because of the risk of such environmental damage, Russia, with funding assistance from the EU, is planning to raise these sunken submarines and a suitable vessel has now entered the design stage and is planned for commissioning in 2026. Russian sources claim that all vessels will be removed from the marine environment by 2032 and taken land-side for decontamination and breaking.

Russian sources also confirm that, at one stage, there were over 100 disused nuclear submarines in wet dock storage complete with their reactors and that although most have now been decommissioned and scrapped some still remain. In addition, there is a growing fleet of retired nuclear powered ice-breakers complete with their reactors also moored around the Arctic coast and waiting decomm' and breaking.

All told it is reported that 17,000 containers of hazardous nuclear waste, 19 ex "nuclear support" vessels (tugs, barges, floating docks/pontoons and nuclear waste carriers), and 735 items of irradiated heavy machinery have also been sea-dumped into the Barents and Kara seas. While international nuclear expertise insists that nuclear waste should have been dumped into ocean deeps far offshore and at least 3km deep, some of the material discussed here has been dumped on seabed around 50 metres deep and clearly close to land.

Russia is not alone in its military radioactive pollution of the Arctic, because the US has also made its own notable contribution focussed on northern Greenland. In 1959 the US opened a proposed cold war nuclear missile site called Camp Century, buried beneath the ice cap in Northern Greenland, 150 miles from the US airbase at Thule. Three kms of tunnels were constructed beneath many feet of ice with accommodation for around 200 military personnel and the site was powered by a PM-2 portable, medium powered nuclear reactor. The project was abandoned in 1967 due to the instability of the covering ice and the reactor was dismantled and removed. However, in the expectation that Polar conditions would continue unabated and that the base would be snowed under and sealed, many tons of waste were abandoned on site including thousands of gallons of sewage, diesel fuel, PCBs and 47,000 gallons of liquid nuclear waste.

Given that the PM-2 was a water cooled, uranium 235 (enriched to 93%) fuelled reactor system it is inevitable that this liquid waste will contain alpha emitting Uranium and Plutonium nuclides, Tritium and a cocktail of other activation products. It is now widely agreed that, due to climate change driven ice melt, the site infrastructure is likely to be exposed by the end of this century. The potential radiological impact to run-off watercourses and the receiving environment of Greenland coastal waters is clearly a radiological threat awaiting the region. Regional marine food webs are un-likely to avoid bio-absorbtion and accumulation.

This issue was compounded when, in 1968 a US B22 bomber crashed and exploded on sea ice off the north Greenland coast. The explosion ruptured the “nuclear payload” consisting of four thermo-nuclear devices and scattered debris and nuclear material across a wide area of sea ice. Although Danish and US authorities undertook a clean-up and attempted to collect and remove the debris, it is clear that not all of the physical debris and contamination had been removed as the secondary stage of one bomb, containing U 238, Plutonium and Tritium, has never been recovered. On the basis of short-term research, it has been concluded by “the authorities” that most of the Plutonium (variously estimated to be between 7.5 and 24 kgs) is currently sequestered in sea bed sediments and not available to most biota or human populations. As is the case with the Camp Century pollution, in the context of climate change and the increasing severity of marine and meteorological conditions (increasing intensity of storminess, wave height and the possibility of major changes in regional marine residual currents) this sequestered isolation must not be expected to last.

Due to the relative isolation of the sites and the difficulties of working in Greenland's polar marine waters the radiological inventories of these events remain poorly quantified, as do the long term environmental, marine food web and human impacts.

Dose estimates: after the test Ban Treaty it was concluded that Arctic residents, whose diets comprise a large proportion of traditional hunted/ gathered foodstuffs, had received the highest radiation exposures to weapons test radionuclides in the Arctic. There is a consensus that these most exposed population groups in the Arctic can on average receive up to 50 times higher individual doses than members of the average population., whatever the source. Using arctic-specific information, the predicted collective population dose is five times higher than that estimated by UNSCEAR for more temperate areas.

Where the "source" of dose is reasonably well understood calculations have shown that significant doses can be delivered to Arctic populations. Individual annual doses to the most exposed residents of the Arctic from Chernobyl releases have been calculated at approximately 10 to 20 mSv/y in the most affected areas. By contrast, releases from the Sellafield fuel reprocessing plant provide a relatively small contribution to individual dose (i.e. in the range 0 to 0.05 mSv). It has been estimated that doses to humans from the reactors of sunken N.subs are currently very low indeed and this has been attributed to the fact that reactor shielding has not yet broken down. However, the Chernobyl related data quoted above gives powerful indication of the likely impact of in-Arctic reactor or nuclear warhead release.

Due to difficult working conditions and the remoteness of much of the Arctic … serious estimates of "aggregated" radioactivity locked in seabed and intertidal sediments, present in the Arctic water mass or in the remaining ice are non-existent. The few studies that have been undertaken have been widely spread across the sea area and present very variable outcomes. The majority of the research has focussed on the sunken Russian/Soviet N.subs in the Barents Sea and the Russian/Soviet nuclear test site at Novaya Zemlya in the Kara Sea, but elsewhere research has been very thinly spread and this militates against any comprehensive Arctic wide assessment.

For the same reasons, both individual and population dose estimates are similarly incomplete and incoherent, and are additionally inadequate because the prohibitive expense of analysing samples for ALL radionuclides likely to be present means that research tends to focus on a very limited number of radionuclides (sometimes only one) and thus returns thoroughly un-representative data. Dose estimates are also based on the out-dated assumption that marine radioactivity dose can only be acquired via a limited number of pathways (seafood consumption, skin contact with marine materials and accidental ingestion of marine materials … such as beach sand or sea water). Such assumptions have been clearly dis-proved by recent independent/ academic investigations which now recognise 9 such pathways of exposure to marine radioactivity.

Many potential sources of radiological threats: Russia has an ever growing fleet of nuclear subs…Arctic fleet has about 20, some capable of carrying 120 nuclear weapons missiles. **It is believed that as many as 1,000 nuclear warheads could be deployed in the Arctic by the Russian fleet.**

Russia has 10 nuclear powered, twin reactor Ice breakers (some decomm'ed) but more being built. The nuclear powered freighter Sevmorput has 2 reactors. The floating nuclear powered station (Akademik Lomonosov) also has two reactors (more floating NPS are in the build or design phase). **Currently at least 44 maritime reactors are deployed in the Arctic.**

In addition there are an unknown (but clearly growing) number of shipments of maritime civilian nuclear cargos: supply ships to floating reactors and military nuclear bases. unquantified but set to grow as other nuclear activity continues

+ Coastal terrestrial zone sources: military sites, test sites,

+ Historical/legacy, atmospheric (weapons test, Chernobyl, Fukushima et al), US inputs from Camp Century & lost bombs material, Russian marine dumps and "lost" n.subs

+ Ice/permafrost melt will release radioactive fallout/washout, increasing rainfall is likely to "flush" river systems and transport additional pollution from river basins to the ocean.

"distant" non-arctic marine sources: Sellafield, F'shima, fluvial inputs from Siberian river basins

It is important to remember that, as of yet there is no method for the radiological decontamination of environments, biota or humans and that "flushing" is the only process available. This can be achieved by applying copious amounts of water to the radioactively contaminated environment, as has been used at Fukushima and Chernobyl to dilute (not remove) the radioactivity.

Biota, including humans, can flush radioactivity be excreting it from the system, but since many radionuclides preferentially attach to bone, teeth, organs or blood, such processes will not remove ALL of the radioactivity and indeed provide the ideal scenario for long term internal exposure. Such excretory processes are of minimal benefit to those living a traditional life style and consuming a local diet gained from a long-term radiologically polluted environment.

Due to difficult working conditions and the remoteness of much of the Arctic, response to Arctic nuclear releases may be severely restricted due to ambient conditions of seasonality, meteorology, sea/ice state and time constraints imposed by distance.

It's my conclusion that significant nuclear accidents in the Arctic are inevitable, with accompanying major releases to atmosphere and aquatic environments of multiple radio-nuclides. In the context of the massive weaknesses and failures of response to Chernobyl, F'shima and other nuclear disasters situated close to relatively good communication and transport routes and a reservoir of technical expertise it seems that an Arctic Ocean nuclear disaster, occurring at enormous distances from such facilities, is likely to progress faster and further than Chernobyl or F'shima

The Arctic Ocean, with an area of about 6.1 million square miles, is the world's smallest Ocean. Yet has a long history of imported nuclear pollution and the in-ocean deployment of multiple uses of nuclear power. Under the current conditions it can without doubt be defined as the most nuclear

Ocean, with more marine nuclear activity, compressed into a smaller area than any other. All the signs are that the future can only see the process become more accelerated and the nuclearization and attendant radiological risk more intense.

In the context that the Arctic has numerous sources of its own man-made radiological inputs and that it is clearly also a conduit for the inter-ocean distribution of other northern hemisphere marine radioactivity (Atlantic to Arctic to Pacific) it is clear that Northern hemisphere coastal/maritime nations cannot escape the potential problems arising from the nuclearization of the Arctic.

It is imperative that Arctic, and other, Governments address this issue with alacrity and set in motion a series of international Arctic wide agreements to limit the nuclearisation process, set in place MOUs for the management and response to, and mitigation of any radiological incidents and consider the radiological implications for the Arctic marine environment and for both the traditional indigenous Arctic peoples and those many thousands of immigrants working and living in the new resource extraction industries and their associated urban developments.

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Tim Deere-Jones: (Marine Radioactivity Research & Consultancy) Dec: 2021