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Detectability of the Underwater Nuclear Explosion Wigwam by radionuclide stations of today's IMS

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The Comprehensive Nuclear-Test-Ban Treaty (CTBT) bans all nuclear explosions, including those detonated underwater. To improve the understanding of the radionuclide signatures of such an event, and whether it would be detectable under the verification regime of the CTBT, the 1955 Wigwam underwater nuclear explosion has been modelled. Inventory calculations and atmospheric transport modelling have been performed to estimate the activity at the radionuclide stations of the International Monitoring System (IMS). This has utilized reported release values (0.92%) and meteorological data from the event. The research shows that there is a high probability that Wigwam would have been detectable at U.S. IMS stations at Wake Island (RN77) at 8.4 days, Guam (RN80) at 10.7 days and Sand Point, AK (RN71) at 13.7 days. At these locations, the majority of IMS relevant radionuclides were fission products, such that additional radionuclides from the seawater activation had largely decayed before reaching the stations.

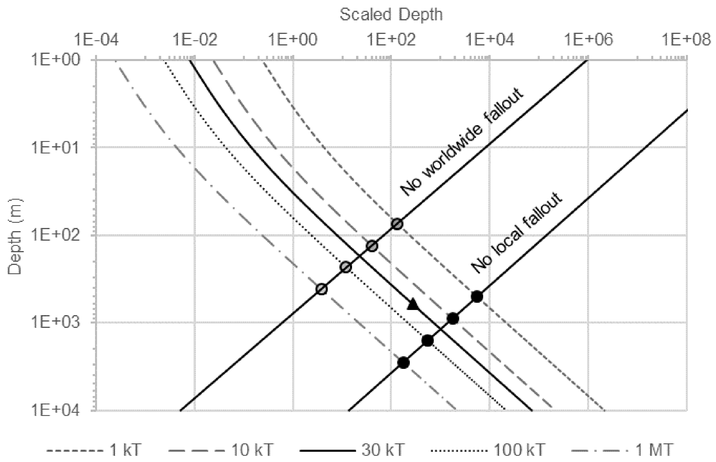
Wigwam Underwater Nuclear Explosion

- Deepest and most powerful underwater nuclear explosion (UNDEX)
- 14-05-1955 U.S. UNDEX 800 km from California
- Purpose was to study UNDEX effects on surface and submerged vessels
- 30 kT
- 610 m deep
- Sampling by air filters determined that 0.92% of radioactivity made it to the atmosphere.

What Happens in an Underwater Nuclear Explosion

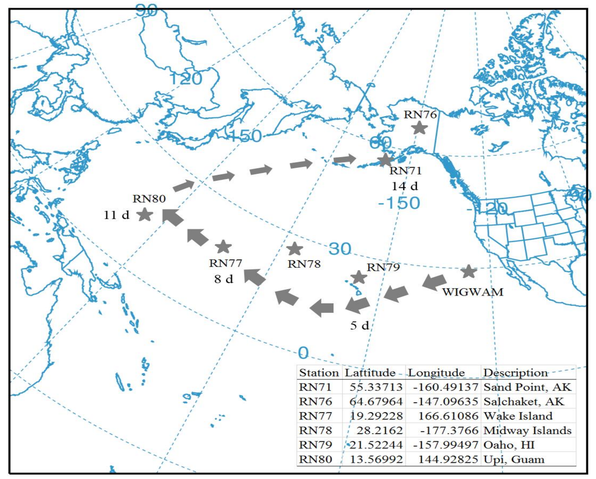
- Radiation superheats water causing the rapid expansion of a bubble and a shockwave
- Bubble rises, over-expanding and over-contracting as it tries to reach ambient pressure
- Bubble quickly reaches surface. (10-seconds for Wigwam, speed was over 320 km/hr at surface)
- At the surface, the bubble releases gaseous fission products and creates a large water plume
- Water falls back to the surface to create a base surge cloud
- Residual upwelling along explosion axis continues for some time

The extent to which radiation (and the bubble carrying it) reaches the atmosphere and surface depends on the depth and yield of the UNDEX. Based upon previous UNDEXes, the depth and yield combinations below which no worldwide or local fallout (pre-IMS categorizations) occurs are shown in the graph. Scaled Depth is Depth divided by the maximum first bubble radius, which is related to yield. The triangle in the graph represents Wigwam.



Detection of Wigwam (Had IMS Existed)

To assess to what degree the IMS would have detected Wigwam, we calculated an initial radionuclide inventory, applied the 0.92% release fraction (assuming no fractionation), and transported this plume via HYSPLIT using actual weather data from the event. The initial fission product plume was calculated at 10 seconds after the explosion, including in-growth from the independent fission yield. Activation products from seawater were also included in the plume. Subsequent plume activities were decay and in-growth corrected. Using MDC values calculated per IDC procedures and the dispersion factors from atmospheric transport to the station locations, we determined what radioisotopes would be detectable at the stations as well as the activity levels. The plume reached three of six U.S. station locations studied: RN77 at 8.4 days, RN80 at 10.7 days, and RN71 at 13.7 days.



	RN77	RN80	RN71
RXe isotopes detected	3	3	1
Max. activity	0.35 (^{133}Xe)	0.36 (^{133}Xe)	1.9 x 10^{-3} (^{133}Xe)
Fission particulates detected	33	33	19
Max. activity	0.21 (^{140}La)	0.27 (^{140}La)	1.8 x 10^{-3} (^{140}La)
Activation particulates detected	2	2	0
Max. activity	5.1 x 10^{-3} (^{24}Na)	5.7 x 10^{-4} (^{24}Na)	n/a

Activities shown are Bq/m^3. All isotopes listed are IMS relevant radionuclides. RN80 and RN71 are not currently RXe station locations.

References

F.A. French, "Fall-out and airborne activity in Operation Wigwam, with notes on surface effects", AD0617135, U.S. Naval Radiological Defense Laboratory (1955).

S. Glasstone and P.J. Dolan, *The Effects of Nuclear Weapons*, 3rd ed, U.S. Dept. of Defense and the Energy R&D Admin. ISBN: 978-1-60322-016-3 (1977).

H. Lee, "Scoping the impact of nuclear bursts at sea on the environment", DNA 4936F, U.S. Defense Nuclear Agency (1979).

R.R. Draxler and G.D. Rolph, HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory), http://ready.arl.noaa.gov/HYSPLIT.php.

J.L. Burnett and B.D. Milbrath, "Radionuclide observables of underwater nuclear explosive tests", J. Env. Rad. **153** p. 195 (2016).

The views expressed here do not necessarily reflect the opinion of the United States Government, the United States Department of Energy, the National Nuclear Security Administration, or the Pacific Northwest National Laboratory.

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