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Imagining Worst Case Scenarios: The legacy of nuclear weapons lost at sea.

What would you do if you found a nuclear weapon while preparing for, carrying out, or after conducting mining operations at sea? Would you recognize it as a nuclear weapon? Whom should one call? Who gets salvage rights?

Members of the deep-sea mining community no doubt already know the story of Project Azorian: **an effort to covertly recover a sunken Soviet ballistic missile submarine using the *Glomar Explorer* (https://nsarchive2.gwu.edu/nukevault/ebb305/index.htm)**. The cover story that

Howard Hughes was testing an experimental polymetallic nodule mining system provided early economic projections and kicked off a flurry of excitement around the possibility of mining the deep sea.

As an Anthropology PhD student at the University of New Mexico researching how humans create and circulate beliefs, values, and meanings about nuclear weapons, I am most familiar with the *Glomar Explorer* story as the event which provided a name to **the response (https://en.wikipedia.org/wiki/Glomar_response)** "we can neither confirm nor deny" that the United States Department of Energy (DOE) sends me for Freedom of Information Act requests that they regard as especially impertinent. In considering Project Azorian, we are reminded that deep-sea mining and exploration operations have been **confronting questions (https://www.csmonitor.com/layout/set/print/1985/0912/dtitan.html)** raised by encounters with **nuclear weapons, espionage, and geopolitics (https://www.businessinsider.com/cold-war-era-navy-mission-found-the-titanic-kept-it-secret-for-years-2018-8)** since the industry's inception. As deep-sea mining expands its operations on the largely unexplored seafloor, the chances of an encounter with remnants of a century of warfare and almost warfare, potentially including dozens of nuclear weapons and their components lost at sea, may increase.

Although unlikely, the possibility of encountering nuclear weapons—or nuclear materials more broadly—on the sea floor is not zero and will likely grow as a result of increased numbers of lost nuclear weapons and increases in sea mining activities. **Low probability events do happen (https://www.nytimes.com/2009/02/17/world/europe/17submarine.html)[1]**. In addition to the applicability of my basic advice—*stop! leave it alone! get an adult!*—for some other undersea hazards (such as dumped nuclear reactor cores, unlabeled chemical weapon caches, or ordnance from World War II) nuclear weapons and materials could pose unique risks to undersea exploration and mining operations.

Thinking through this possibility contributes an unusual and illuminating scenario to the development of risk analysis for deep-sea mining. I hope that this thought experiment can enable us to better chart our current and future behavior after considering the unfolding legacies of ocean dumping and the long-term consequences of even unfought wars.

Scope of Problem: What is a Nuclear Weapon Accident?

Believe it or not, the United States has been comparatively open about its history of nuclear weapons incidents and accidents. The US Department of Defense (DOD) has published a **collection of brief narrative summaries (https://unredacted.com/2013/10/09/document-friday-narrative-summaries-of-accidents-involving-nuclear-weapons/)** of the 32 nuclear weapon accidents that occurred from 1950 through 1980**[2]**. These thirty-two oopsies are fairly nasty and the

Department of Defense relegates less serious events—over 1,000 of them and including such butterfingers moments as dropping a nuclear weapon from the height of eight feet—to the category of "incidents" as opposed to accidents**(3)**. The Department of Defense in 1981, and generally still, defines an "accident involving nuclear weapons" (a.k.a., a Broken Arrow for most intents and purposes) as an "unexpected event involving nuclear weapons…or components"**(4)** that results in one or more of some very unpleasant outcomes including:

1. Accidental or unauthorized firing "of a nuclear capable system" by US or allied forces "which could create the risk of an outbreak of war."
2. "Nuclear detonation."
3. Burning of a nuclear weapon or burning or detonation of some or all of the conventional high explosives in a nuclear weapon.
4. "loss of a nuclear weapon or radioactive…component, including jettisoning."
5. "Radioactive contamination."
6. "Public hazard, actual or implied."**(5)**

Illustrative and Educational Nuclear Weapon Oopsie: Palomares, Spain 1966

The Palomares accident is particularly illustrative, since it includes what I believe to be the only claim for salvage remuneration made on a nuclear weapon lost at sea. In 1966, a B-52 bomber on airborne alert and a KC-135 fuel tanker collided over Spain, causing the B-52 to drop four Mk28 thermonuclear weapons of up to approximately 1.45 megatons in yield. Three of the weapons landed in and around the small village of Palomares—two of the weapons had their high explosives detonate scattering plutonium across the countryside—and one weapon went into the Mediterranean Sea. It took almost three months for the US to recover the lost hydrogen bomb and a fisherman, Francisco Simó Orts, provided important eyewitness information about where the bomb had fallen**(6)**.

The complexity of making salvage claims when nuclear weapons are involved is suggested by a wry sentence in the Defense Nuclear Agency summary report on the Palomares Broken Arrow: "[i]f the total volume of file space is an indication of the historical importance of a claim, that of Francisco Simo Orts certainly deserves to be included here."**(7)** In 1967 Orts submitted to the US-established Foreign Claims Commission a claim for five million dollars to compensate "'salvage service' to the U.S. Air Force."**(8)** In 1971 Orts was awarded a consent judgment of $10,000 in Admiralty Court in New York City.

Presumably, the legal complexities of salvage claims on nuclear weapons or materials would only be multiplied outside of territorial waters and absent the **relative national cooperation (https://nsarchive2.gwu.edu/nukevault/ebb475/docs/doc%207.pdf)** demonstrated by the United States and Spain in handling the Palomares Broken Arrow.

The United States does not have a perfect record of nuclear weapon recovery. In 1957 a B-47 bomber, after a collision with an F-86 during training, jettisoned a Mk15 thermonuclear weapon—minus its plutonium core but including uranium of unrevealed enrichment and quantity—somewhere around Tybee Island, Georgia**(9)**. In 1968 the nuclear submarine **USS Scorpion sank with two nuclear torpedoes (https://fas.org/sgp/othergov/doe/cg-hr-3/appb.pdf)** aboard and it appears that the US, at least for some period of time, monitored the site since "[i]t can be assumed with certainty that the integrity of the weapons was compromised due to sea pressure."**(10)** In 1957 two weapons of unidentified type were jettisoned by a C-124 off the Atlantic Coast of the United States and in 1965 an A-4 Skyhawk, including pilot and a Mk43 thermonuclear weapon, rolled off the elevator of the *USS Ticonderoga* "within 80 miles of the Japanse Ryuku islands and about 200 miles east of Okinawa."**(11)**

Only Neptune knows how many nuclear weapons and components have been involved or lost in accidents at sea. The rate of nuclear weapon accidents, including losses at sea, is not just a function of the number of weapons in a stockpile. The United States was especially enthusiastic about airborne alerts, airborne transport, and airborne training with nuclear weapons and this contributed to the number of accidents. My Russian colleagues report that the Soviet Union had many fewer nuclear weapon accidents because of their lower bomber and submarine force alert levels. This is plausible but impossible to verify without access to declassified Russian archives. As the *Glomar Explorer* incident demonstrates, the Soviets were not accident free and I find it difficult to believe the United Kingdom, France, and China have not also had their share of oopsies.

It is a safe bet that there will be more incidents at sea involving nuclear weapons if and when newer nuclear possessor states—such as China and India—begin regularly deploying nuclear-weapon-carrying ballistic missiles on submarines. India allegedly damaged their first nuclear powered ballistic missile submarine, the *INS Arihant*, by **improperly leaving a hatch open (https://nationalinterest.org/blog/buzz/india-did-major-damage-new-3-billion-submarine-leaving-hatch-open-52292)(12)**. Other possibilities include China tasking a redeveloped nuclear air force capability with anti-submarine or anti-ship warfare and Pakistan building nuclear depth charges for anti-submarine warfare against India (the US had at least five different types of nuclear depth charges depending on how you count). Meanwhile, North Korea has tested submarine–launched ballistic missiles.

General and Specific Risks from Nuclear Weapons in Deep-Sea Exploration and Mining

The specific risk contours of nuclear weapons and materials on the ocean floor will depend on the type of exploration or mining operations involved. Large scale and high power dredging of the sea floor, especially without a live monitored video feed, has some potential for bringing up surprises ranging from unexploded World War II ordnance to dumped chemical weapons. The major general hazard of nuclear weapons to deep-sea mining and exploration operations would be the partial or

complete detonation of the high explosives in the weapon. In addition, nuclear weapons contain toxic materials such as beryllium as well as explosive or dangerous components like solid rocket gas generators and high temperature thermal batteries.

The specific risks of nuclear weapons pertain mostly to their nuclear explosive and radiological characteristics. It is highly unlikely that a nuclear weapon encountered in marine mining (depending on your assumptions of whose it is and how long it has been there) would be capable of producing a nuclear detonation. However, **plutonium is notoriously difficult to clean up (https://apps.dtic.mil/dtic/tr/fulltext/u2/a283578.pdf)** and it would be expensive and vexing to accidentally mix—through mechanical, corrosive, or explosive dispersal—mined minerals with plutonium. Furthermore, **there is the possibility of shifting the geometry of the fissile material in the weapon (e.g., allowing water to flow into a corroded warhead bulkhead) and producing (https://www.newyorker.com/tech/annals-of-technology/demon-core-the-strange-death-of-louis-slotin)** a **prompt criticality event (https://www.newyorker.com/tech/annals-of-technology/demon-core-the-strange-death-of-louis-slotin)** with a burst of radiation lethal to people and electronics within some uncertain radius.

Concluding Thoughts: So What Happens if you Find a Nuclear Weapon in the Deep-Sea?

The issue of nuclear weapons—and other dangerous military materials—lost at sea strikes me as one that should be dealt with through treaties and agreements. Not having the United States as a ratified party to the United Nations Convention on the Law of the Sea makes it that much more difficult to deal with a low probability, potentially high consequence situation that is already rarely discussed.

Unfortunately, marine miners are unlikely to recognize a nuclear weapon encountered during mining. The United States, at as well as other nuclear powers, were not in the habit of obviously marking their nuclear weapons or releasing design schematics, and nuclear weapons vary significantly in shape and size. In addition, language differences and damage from mechanical, crush, or corrosive forces, will further hamper identification.

A slide from Sandia National Laboratory showing a nuclear weapon that toppled of a dolly.

In the meantime, I'd suggest that you not expect to become rich if you find a nuclear weapon on the sea floor and that you not disturb it gratuitously. I would suggest the same for any accidentally found chemical weapon dumps, unexploded World War II ordnance, and blasphemously eldritch shaped statues in sunken cities forgotten to humanity. The sea is deep and full of secrets.

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(1) It regularly blows my mind that the United Kingdom and France actually had a collision between their nuclear ballistic missile submarines. Burns, John F. 2009. "French and British Submarines Collide." *The New York Times*, February 16, 2009, Online edition. **https://www.nytimes.com/2009/02/17/world/europe/17submarine.html (https://www.nytimes.com/2009/02/17/world/europe/17submarine.html)**.

(2) Department of Defense. 1981. "Narrative Summaries of Accidents Involving U.S. Nuclear Weapons 1950-1980." *Department of Defense*: Washington DC.

(3) I have several Freedom of Information Act requests submitted for additional information on nuclear weapon accidents and incidents including since 1980 and including the declassified document referenced in the following citation: Hansen, Chuck. 1990. "Nuclear Weapons: 1,000 More Accidents Declassified." *Bulletin of the Atomic Scientists* 46 (5): 9, 41.

(4) DOD, 1981, "Narrative Summaries..."; For more recent discussion of accident categories see: Department of Defense. 1993. "Nuclear Accident and Incident Public Affairs Guidance." *Directive 5230.16*, December 20th.
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(5) DOD, 1981, "Narrative Summaries...," p.iii.

(6) The recovery of the fourth Palomares Mk28 is often explained as the result of a Bayesian search model. I, personally, feel the results of the formal aspects of the model (you can access the report on it **here (https://osf.io/az72g/)**), which includes the testimony of Orts, are overstated.

(7) Defense Nuclear Agency. 1985. "Palomares Summary Report." Department of Defense: Washington DC. **https://apps.dtic.mil/dtic/tr/fulltext/u2/a955702.pdf (https://apps.dtic.mil/dtic/tr/fulltext/u2/a955702.pdf)**. p. 176.

(8) *Ibid.*

(9) Maggelet, Michael C., and James C. Oskins. 2007. *Broken Arrow: The Declassified History of U.S. Nuclear Weapons Accidents*. Lulu.com (online self-publisher).

(10) Department of Energy. 2005. "Appendix B: Unrecovered Nuclear Weapons and Classified Components." Department of Energy: Washington DC. **https://fas.org/sgp/othergov/doe/cg-hr-3/appb.pdf (https://fas.org/sgp/othergov/doe/cg-hr-3/appb.pdf)**. p. B-8.

(11) Maggelet & Oskins, 2007, *Broken Arrow*, p.217.

(12) I find this account of the damage to the *INS Arihant* to be suspicious but my points are that accidents happen and that accidents will happen more often as more nuclear weapons return to sea after the massive decreases associated with the Presidential Nuclear Initiatives and post-Cold War reductions.

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