Scientia Canadensis
Canadian Journal of the History of Science, Technology and Medicine
Revue canadienne d'histoire des sciences, des techniques et de la médecine

Out with the Old: Munitions Disposal, Marine Environments, and the Canadian Military

Alex Souchen

Volume 45, numéro 1, 2023

Science and Technology in Military Contexts
Science et technologie en contexte militaire

URI : https://id.erudit.org/iderudit/1111979ar
DOI : https://doi.org/10.7202/1111979ar

Aller au sommaire du numéro

Éditeur(s)

CSTHA/AHSTC

ISSN

0829-2507 (imprimé)
1918-7750 (numérique)

Découvrir la revue

Citer cet article

Souchen, A. (2023). Out with the Old: Munitions Disposal, Marine Environments, and the Canadian Military. *Scientia Canadensis*, *45*(1), 68–90. https://doi.org/10.7202/1111979ar

Résumé de l'article

Cet article examine l'histoire des politiques et des pratiques de l'armée canadienne en matière d'élimination des munitions excédentaires et/ou obsolètes entre les années 1940 et 1960. Pendant cette période, l'armée a déversé en mer des munitions, des explosifs, des armes chimiques et d'autres munitions inutiles. Ces pratiques étaient courantes dans le monde entier et découlaient des immenses surplus d'armement après la fin de la Seconde Guerre mondiale. Cet article montre que des munitions ont été immergées sur les côtes de l'Atlantique et du Pacifique, dans les Grands Lacs, le fleuve Saint-Laurent et d'autres eaux intérieures. Il démontre également l'importance de placer les politiques et les opérations d'immersion canadiennes dans leur contexte historique, car des facteurs politiques, logistiques, scientifiques, environnementaux et militaires plus larges ont influencé la prise de décision et la mise en oeuvre. Pourtant, l'immersion n'a pas été sans conséquences graves pour les organismes marins, les environnements et les communautés qui dépendent de la mer pour leur subsistance. En adoptant une approche des technologies militaires centrée sur l'utilisation et en se concentrant sur les régimes d'élimination des munitions conventionnelles et chimiques, cet article documente les séquelles des technologies militaires et leur héritage environnemental.

Out with the Old: Munitions Disposal, Marine Environments, and the Canadian Military

Alex Souchen

Abstract: *This article examines the history of the Canadian military's disposal policies and practices for surplus and/or obsolete munitions from the 1940s to the 1960s. During that time, the military dumped ammunition, explosives, chemical weapons, and other unneeded ordnance at sea. Such practices were common worldwide and originated from the immense surpluses of weaponry leftover at the end of the Second World War. This article shows that munitions dumping took place on both the Atlantic and Pacific coasts, in the Great Lakes, the St. Lawrence River, and other inland waters. It further demonstrates the importance of placing Canadian dumping policies and operations within their historical context, as wider political, logistical, scientific, environmental, and military factors influenced decision-making and implementation. Yet dumping was not without serious consequences for marine organisms, environments, and the communities that depend on the sea for their livelihoods. By taking a use-centred approach to military technologies and focusing on the disposal regimes for conventional and chemical munitions, this article shows that the afterlives of military technologies can embody the environmental legacies of war.*

Résumé : *Cet article examine l'histoire des politiques et des pratiques de l'armée canadienne en matière d'élimination des munitions excédentaires et/ou obsolètes entre les années 1940 et 1960. Pendant cette période, l'armée a déversé en mer des munitions, des explosifs, des armes chimiques et d'autres munitions inutiles. Ces pratiques étaient courantes dans le monde entier et découlaient des immenses surplus d'armement après la fin de la Seconde Guerre mondiale. Cet article montre que des munitions ont été immergées sur les côtes de l'Atlantique et du Pacifique, dans les Grands Lacs, le fleuve Saint-Laurent et d'autres eaux intérieures. Il démontre également l'importance de placer les politiques et les opérations d'immersion canadiennes dans leur contexte historique, car des facteurs politiques, logistiques, scientifiques, environnementaux et militaires plus larges ont influencé la prise de décision et la mise en oeuvre. Pourtant, l'immersion n'a pas été sans conséquences graves pour les organismes marins, les environnements et les communautés qui dépendent de la mer pour leur subsistance. En adoptant une approche des technologies militaires centrée sur l'utilisation et en se concentrant sur les régimes d'élimination des munitions conventionnelles et chimiques, cet article documente les séquelles des technologies militaires et leur héritage environnemental.*

Keywords: Underwater Munitions; Canadian Military; Pollution; Military Technology; Environmental Policy

The history of science and technology is often cast as a history of innovation, acquisition, and modernity. New gadgets and great inventors soak up pages of text, as scholars explore the varied meanings of modernity, technology, and their wider impact on society and culture. The ambition for the "new" — whether as a talisman of status, knowledge, or technology — serves as a departure point for inquiries, allowing experts to locate their studies in a time and place, and evaluate the transformations, displacements, and adaptations caused by the new innovations. Sweeping narratives of progress result, often

 Alex Souchen, "Out with the Old: Munitions Disposal, Marine Environments, and the Canadian Military," *Scientia Canadensis* 45, no. 1 (2023): 68-90.

placing Western Europe and the United States at the epicentre of seismic shifts in global political and economic power, closely connected to scientific revolutions, engineering achievements, and military affairs.[1] Science and technology are therefore portrayed as inescapable forces of change for nature and society, thereby enabling new forms of control over natural environments and reshaping human experiences in line with the development of nation states, bureaucracies, industrialization, urbanization, resource exploitation, and power.[2]

To be sure, this innovation-based history and its focus on Western inventors and origins has not gone unchallenged. The emergence of postmodernism and postcolonial critiques in the late-twentieth and early twenty-first centuries questioned Eurocentric worldviews about European superiority, modernity, and the incumbent technological determinism at the heart of imperial conquests and colonization.[3] Other scholars have pointed out the short-comings of innovation-based history by highlighting the significance of technological failure, while still others have drawn attention to the persistence of traditional modes of production that have co-existed alongside the revolutionary moments central to innovation-based narratives.[4] Historians of technology have further investigated the diversity of responses to new technologies highlighting groups that resisted change and novelty, preferring instead to use "old" technologies whether because of apathy, neglect, stubbornness, cost, culture, or familiarity.[5]

As historian David Edgerton reminds us, in contrast to innovation-based paradigms, use-centred histories offer "a radically different picture of technology" — one that is more inclusive and representative. Use-centred histories are unbounded by the lineage of great men and great inventions, and instead animate an "invisible world of technologies" that occupy the hands of everyday people in different places and times across the world. Edgerton points to a history that looks beyond invention dates and towards an inquiry into the persistent survival of "old" technologies and their adaptation, integration, and disposal within specific social, political, economic, and environmental contexts — something Edgerton called "creole technology."[6] Historian David Arnold adds to Edgerton's thesis by exploring how everyday technologies can be diffused across different societies and cultures as dynamic amalgams of local applications and needs, non-Western technical imaginaries, and technological transfers within colonial systems.[7] Other historians, such as Giles Slade and Susan Strasser, have added their own critiques by exploring the afterlives of technologies (once they are no longer useful for most purposes) and the immense wastes derived from consumerism, mass production, and planned obsolescence.[8] Indeed, the decaying, obsolete, and discarded relics deserve more attention from historians of technology, as they maintain significance in varied ways, long after they broke down, were replaced, or became surplus.

This article seeks to bring a use-centred history of technology into conversation with Canadian military history, by exploring how the Canadian military managed the disposal of its unneeded weaponry after the Second World War and during the early Cold War period. Such an intervention is timely and necessary, given the prevalence of innovation-based discourse within the military community and wider historiography.[9] Quite often, when military technologies are discussed in public or academic forums commentators gravitate towards an innovation-based paradigm by cataloguing the

latest high-tech gadgets or describing how some new weapon system revolutionized tactical and operational doctrines to provide victorious advantages on the battlefield. It is also likely that these conversations zero-in on specific technological systems or debate the merits of investing in replacement weaponry developed by some private military contractors. In Canada, the long-standing and contentious process for replacing the Royal Canadian Air Force's mainstay jet fighter, the venerable CF-18 Hornet (in service since the 1980s) with the expensive F-35 Lightning, is just one example.[10]

Few military historians find the old technologies — the ones being replaced at the end of their lifecycles — as interesting as the future impact of new technologies. Nor are they drawn to the everyday items, like the ubiquitous, mundane, and low technologies that military units use constantly during training and combat operations. These types of technologies can include many different items — from rifles to radios and uniforms to utensils — but this article will focus on the broad category of military ordnance. Ammunition and explosives are items so prevalent in modern, industrial warfare that their omnipresence in arsenals is often taken for granted: the distant rumble of the guns on battlefields becomes a literary device for establishing the setting or relating a personal experience, while the withering barrages and bombardments offer writers a harrowing preamble to major battles or debates about combat effectiveness. Rarely are these objects studied on their own terms: as complex and sophisticated technological systems that are accompanied by immense logistical and bureaucratic processes supporting their production and disposal.

Munitions are precision technologies with many working parts that must be manufactured and calibrated perfectly or else they will fail to detonate on target. In addition to the technical specifications and skilled labour involved with manufacturing and distribution, procurement requires elaborate supply chains to direct all the chemicals, acids, explosive materials, metals, machinery, water, and other components into every stage of production. In Canada, these technological, industrial, and logistical networks were arguably only established in meaningful and permanent ways during the 1940s. Although Canada's munitions industry had performed well during the First World War, it was ravaged by closures and cutbacks during the Great Depression and interwar backlash against the so-called merchants of death — or those companies that had profited from the killing and destruction.[11] However, despite great deficiencies in technical expertise and production facilities at the outset, during the Second World War the Canadian government funded and operated an effective production program that eventually churned out billions of rounds of ammunition, artillery shells, and other explosives.

This article connects the production and usage of munitions during the Second World War to the immense disposal problem that plagued the postwar transition after victory in 1945. The disposal of surplus and obsolete ordnance — the "old" technologies — was a major headache for military and government officials, as limited storage capacities, uncertain postwar requirements, and technological advances in ordnance types caused serious logistical problems and necessitated destruction. From a range of imperfect methods, ocean dumping emerged as a favoured disposal method for Allied armies, particularly in the United States, United Kingdom, and Soviet Union, where

the disposal problem was greater in scope and scale by comparison to Canada. Thus, Canadian dumping policies and operations fit within this wider political and logistical context that was further supported by scientific experts who contended that dilution would lessen the environmental impact by comparison to land-based alternatives. Yet dumping was not without significant environmental consequences for marine organisms, environments, and the communities that depend on the sea for their livelihoods. By taking a use-centred approach to military technologies and focusing on the disposal regimes for conventional and chemical munitions at the end of their utility, this article shows that the afterlives of military technologies can embody the environmental legacies of war and carry forward important ramifications for political and military institutions.

The Disposal Problem

When Canada declared war on Nazi Germany on 10 September 1939, its armed forces were woefully unprepared. Less than 50,000 Canadians were serving in the army or part-time militia, and they trained with relic equipment leftover from 1918. The situation was no better in the Royal Canadian Navy and Royal Canadian Air Force, which lacked most modern weapon systems. Moreover, the Great Depression had devastated Canadian defence industries in the decade prior to the war, rendering the nation's potential for expansive munitions production dubious at best. In effect, the prospects of Canada making any major contributions to the Allied cause seemed remote, especially considering the early war policies of Prime Minister William Lyon Mackenzie King and his Liberal government. Haunted by the legacies of the conscription crisis during the First World War, the Liberals wanted to limit liabilities for overseas military deployments and avoid the mass casualties that would discourage voluntary enlistment. However, Britain's deteriorating strategic position (from the fall of France in June 1940 to the fall of Singapore in February 1942) forced the King government to mobilize for total war.[12]

And mobilize, they did. By 1945, Canada possessed one of the largest air forces and navies in the world, and an army of over five infantry and armoured divisions deployed overseas. Out of a total population of about 11.5 million, roughly 1.1 million served in uniform and over 1 million others had worked in a bustling wartime economy, brought back to life by the seemingly endless need for weaponry and equipment. At the heart of this transformation was the federal government's Department of Munitions and Supply (DMS), which was formed in April 1940 amidst the early Allied setbacks in western Europe. The DMS was a powerful, cabinet-level portfolio headed by the indefatigable C.D. Howe, a fifty-five-year-old American-born engineer and Liberal MP for Port Arthur, Ontario. Through various legal statutes, including the War Measures Act, it gained immense authority over Canada's natural resources and industries to expedite defence procurement, while steadily expanding its jurisdiction to mobilize, ration, allocate, or coordinate all production inputs, expertise, and machinery across practically every sector of the Canadian economy.[13] This unprecedented level of government intervention funnelled billions of dollars into the economy so Canadian factories could manufacture mountains of munitions and supplies. By VE-Day and VJ-Day, the war economy had produced some 800 naval and cargo vessels, 16,000 aircraft, 800,000

vehicles, 1.5 million firearms, and approximately 4.6 billion rounds of ammunition and artillery shells.[14]

However, this production surge was only temporary and would not continue long past the end of hostilities. In fact, once the war ended, such copious amounts of munitions and supplies caused major issues for the Canadian state, as victory triggered a massive disposal problem. Many assets and technologies accumulated for the fight were now suddenly unneeded, particularly after the King government made significant cuts to the defence budget following the war. Although civilian and military leaders debated the future size and cost of the armed forces well into the postwar period, in 1945 the military's three branches were on the precipice of a colossal demobilization. The downsizing was quick and dramatic: by 1947 fewer than 55,000 soldiers were on the army's payroll, down from a wartime peak of over 550,000.[15] Not only did these reductions release thousands of veterans into a fragile domestic economy weaned of defence dollars while transitioning to peacetime production, but they also generated large reserves of unneeded military kit and piles of other war junk with uncertain postwar value. Thus, strategizing disposal became an urgent priority that required careful consideration since the unfavourable optics of spending billions on suddenly worthless things would not sit well with taxpayers and future voters.

Fortunately, like other Allied governments, Canadian leaders foresaw the challenges destined to arise at the conclusion of hostilities. They benefited from prior experience and past mistakes following the end of the First World War, when few preparations were made for disposal and sales policies inadequately addressed the deflationary risks of liquidating large government-owned inventories at bargain prices.[16] Consequently, officials in all Allied countries got an early start on disposal during the Second World War and planned to address its many dynamic elements.[17] In November 1943, the Canadian government formed the Crown Assets Allocation Committee (CAAC) and War Assets Corporation (WAC) to plan and implement a disposal strategy. The two institutions worked cooperatively: the CAAC was an inter-departmental administrative hub that received surplus declarations from all federal departments and formulated general policies, while the WAC handled the physical aspects of disposal by appraising, storing, selling, or destroying surplus assets. In July 1944, Parliament passed the Surplus Crown Assets Act to establish a permanent framework for public property disposals, which still exists today.[18]

One of the greatest challenges was finding storage space for all the military's surplus assets prior to final disposal. During the war, the DMS and Department of National Defence (DND) accommodated the military's surging size by opening new bases and factories, constructing temporary buildings, or leasing property from civilian sources to meet expanding spatial needs. However, with looming budget cuts, the money was no longer available for rental payments, so the departments rapidly downsized during the 1945-46 and 1946-47 fiscal years. During that time the WAC was inundated by a tidal wave of government assets, and it had to move quickly to collect and relocate everything in order to preserve them for resale. At its peak, the WAC operated over 6 million square feet of indoor storage space at 51 warehouses across the country; and in conjunction with the armed forces, it also maintained several aircraft, vehicle, and ship

"boneyards" or places where larger weapon systems and technologies were stored until sold or scrapped.[19] These arrangements were central to efficient lifecycle management, particularly as technologies were liquidated for peacetime purposes — whether disassembled for spare parts and materials for new production or for upcycled purposes and business ventures.

However, ammunition, explosives, and chemical weapons posed special challenges that neither temporary structures nor rented facilities could accommodate. To safely store bombs and bullets, they must be placed in purpose-built magazines, such as those at the Bedford Ordnance Depot in Halifax Harbour, the largest facility in Canada. As a result, over the spring and summer of 1945, ordnance depots across the country became overcrowded with munitions. Although this situation was not unexpected, the amount of ordnance and the speed at which it piled up caught many off-guard. At Bedford, stowage bunkers were packed to the brim as personnel emptied the arsenals of 83 surplus warships between May and July. The overcrowding was so bad, personnel resorted to using floating magazines (anchored barges) for the contents of 23 ships and acquired tarpaulins to cover the remaining stocks piling up outdoors.[20] On the night of 18 July 1945, disaster struck when a fire broke out on the depot's south jetty which caused a chain reaction of explosions that destroyed large parts of the facility, killing one person and injuring dozens more. Although it was no where near as devastating as the 1917 explosion (that levelled large parts of Halifax and killed almost 2,000 people), this "other" Halifax explosion was a turning point in the history of munitions disposal in Canada.[21]

With so much ordnance littering the blast zone, and a large portion of Bedford's storage capacity out of commission, the navy was forced to adjust its retention and disposal policies. Ships and ordnance were redirected to the naval bases at Sydney and Shelburne, while bomb disposal teams in Halifax were instructed to consider all ordnance recovered from the blast zones defective or damaged. This approach eased the pressure on Halifax while expediting clearance operations with streamlined triage and destruction methods. However, sending ships elsewhere just relocated the storage problems and later made Sydney (and to a lesser extent, Shelburne) central hubs for dumping operations. Before the Bedford explosion, the base at Sydney had been de-storing ships (removing ammunition, supplies, and equipment from naval vessels) at a rate of 18 per week, but the work steadily increased after July.[22]

At the time, there was a limited range of disposal options: ordnance could be detonated in place, incinerated, scrapped, or dumped at sea. Around the world, the amount of leftover munitions and unexploded ordnance was so great that no method alone could handle the entire volume at a rate compatible with political and economic timetables for demobilization and reconstruction. Thus, Allied armies employed each method (or combination thereof) according to local circumstances, the type and volatility of the ordnance, and health and safety concerns for bomb disposal personnel. At Bedford, dumping was a preferred option, as defective ordnance could not be scrapped, and personnel detonated shells in situ only when it was unsafe to recover and dump them at sea. As the cleanup progressed during the fall of 1945, roughly 2,200 tons of munitions were dumped into the Emerald Basin, a 250-metre depression on the Scotian Shelf,

roughly forty nautical miles south of Halifax, that had been approved for dumping (in a five nautical mile radius of coordinates 44°12'N, 62°42'W) by the DND and other federal and provincial fisheries departments in June 1945.[23]

Dumping Policies

Pioneered by Allied governments a generation earlier after the First World War, munitions dumping emerged as a useful solution for postwar disposal problems in all belligerent countries. There were many reasons why this was the case. Dumping obviated the need for scrapping and offered a quick and cost-effective means for liquidating bulk stores without polluting or damaging more lands with burn pits, detonations, or wastewater. It also made use of available shipping surpluses and ensured that disposal took place from within existing supply channels. Therefore, dumping was an attractive option, and Allied officials came to rely on the ocean's seemingly infinite absorption capacity to disarm Germany and Japan, while also meeting their own disposal needs. In fact, as long as restrictions and guidelines were followed, it was hard for policymakers to argue against large-scale dumping operations when scientific and military advisors informed them that dilution might even lessen the environmental impact in comparison to land-based alternatives.[24]

Munitions dumping thus fits into humanity's long and complicated history of using waterways for waste disposal. For centuries prior to the world wars, societies dumped or discharged garbage, sewage, and industrial wastes directly into the closest body of water without much regard for the health and environmental consequences. In the nineteenth century, sanitary engineers and other scientific experts approved of the practice because they believed that dilution and fast-moving currents made water self-purifying, thereby reducing contamination to harmless concentrations that could not impact human health.[25] During the first half of the twentieth century, notions of "acceptable thresholds" and "assimilative capacities" continued to prevail amongst scientists studying marine pollution, which supported a permissive culture towards dumping for political, industrial, and military purposes.[26] However, within the field of oceanography there were also debates over the accuracy of dilution thresholds as well as the seafloor's physical composition and benthic zone, while dumping policies were formed long before the field's major discoveries in deep ocean circulation and breakthroughs in submersible technologies in the 1950s and 1960s.[27]

Newspapers reports transmitted these favourable expert opinions to wider audiences, shaping public opinion and downplaying the consequences to assuage anxiety about munitions dumping. In September 1945, for instance, the *Globe and Mail* reported (via *The New York Times*) that Britain was scuttling surplus cargo ships off the "West Coast" of Ireland filled with poison gas. The article explained that "the decision to dispose of the vast accumulations of poison gas in this way was taken after long conferences at the War Office…" and reassured its audience that "Scientists and experts in chemical warfare agreed that dumping in the sea was the safest and cheapest way of disposal. By the time sea water has corroded the containers the gas will be so diluted that it will be harmless."[28] This type of news coverage was typical in the 1940s, as authorities issued press releases that media outlets distributed with commentaries portraying dumping as

a logical and responsible course of action, given the situation and input from scientists. In fact, the voiceover in one newsreel clip from 1946 went as far as calling munitions dumping a "housecleaning job" — equating it to some form of common chore.[29]

Dumping was thus an unavoidable outcome and critical cog in the postwar transition. Across the world, the British, American, and Soviet militaries were beset by colossal disposal problems. From the jungles of southeast Asia and tiny islands stretched across the Pacific Ocean, to all the factories and bases at home and the occupation forces disarming Japan and Germany, stocks of leftover conventional and chemical munitions were enormous. As a result, all types of armaments and ordnance were destroyed by incineration in open-air pits or large and small controlled detonations, while many others were scrapped to salvage metals and technologies for peacetime applications.[30] Vast quantities were also dumped into practically every major body of water. In Europe, roughly 50,000 metric tons of chemical weapons were dumped at four sites in the Baltic Sea and an estimated 170,000 metric tons were scuttled inside dozens of cargo ships in the Skagerrak Strait from 1946 to 1948.[31]

Conventional munitions were dumped in far greater quantities, though officials were less scrupulous with documentation, so estimates can vary. Today, the Convention for the Protection of the Marine Environment of the North-East Atlantic (commonly known as the OSPAR Commission) identifies 148 dumpsites within its jurisdiction, including roughly 300,000 tons in the North Sea.[32] However, another report from Germany estimates that 1.8 million metric tons of munitions were dumped in German territorial waters alone, and after accounting for recovery and disposals over time, it speculates that about 1.3 million metric tons are still on the seafloor today.[33] British coastal waters are also littered with underwater munitions, with many concentrations found in the English Channel and North Sea, and along the Scottish and Irish coasts. By far the largest British dumpsite is Beaufort's Dyke in the Irish Sea, which received more than 200,000 metric tons by the end of 1946: today, officials estimate that it contains over 1 million tonnes.[34] Both coasts of the United States contain dumpsites as well. In 2001, the American Army reported that at least 32 dumping operations took place along American shores, with over 32,000 tons of chemical weapons and an unknown (but likely larger) tonnage of conventional munitions.[35] In Asia, during November and December 1945, American forces dumped an astounding 4,500 tons *per day* into the seas surrounding Japan and Okinawa.[36] Allied forces also made use of the South Pacific and Indian Oceans, as munitions were jettisoned near Australia, the Philippines, Vietnam, Singapore, Vanuatu, Marshall Islands, India, and countless other places.[37]

In Canada, dumping policies and operations followed these international precedents. Almost a year before the disaster at Bedford, the first policies about munitions dumping were approved by the King government on 4 August 1944. Order-in-council PC6099 authorized the destruction of surplus and unneeded ordnance "by the most suitable method of elimination, such as dumping into the sea or reducing to basic materials should such reduction be considered economical and the hazard involved therein be considered not excessive."[38] Moreover, earlier in May, the WAC had instructed the DND to destroy unneeded ammunition and explosives without declaring them surplus through regular channels. Such a policy allowed the WAC to avoid paying to operate a duplicate

network of ordnance depots while keeping the explosives safe under the watchful eyes of trained professionals. In effect, it made sense to give the military a wider prerogative in the disposal of its own stocks of old and unneeded munitions.

Yet the fact that these policies were on the books a year before the Bedford explosion casts an unfavourable light on the storage crisis leading up to the disaster. Instead of relieving the congestion inside depots by dumping ordnance prior to July 1945, naval authorities allowed it to pile up in contravention of their own safety regulations, while they negotiated in Ottawa against Mackenzie King's sweeping budget cuts. Therefore, unlike the 1917 explosion, when a chance collision between two ships in the harbour triggered the detonation, the disaster in 1945 was a direct by-product of political posturing. Until budgets were finalized, it made little sense for the navy to voluntarily relinquish any assets that might equip the larger fleet its leaders were advocating for and hoped to command.[39] Following the explosion, and once the first postwar defence budget was settled, large-scale dumping operations became unavoidable in Canadian waters.

Canadian Dumping Operations

Although Canadian occupational forces helped the British dump roughly 410,000 tons of munitions from the Emden-Wilhelmshaven area in Germany after the war, Canadian dumping operations were much smaller and more geographically localized by comparison to events elsewhere in the world.[40] According to an inventory submitted by the Naval-Officer-In-Charge at Sydney, Nova Scotia in September 1945, operations had commenced sometime in May or June. This inventory is a significant document since it is one of the only comprehensive lists available that provides an indication of the scale of dumping in 1945. It shows that 53 different types of ordnance were jettisoned by ships leaving Sydney from May to August, including over 250,000 cartridges of .303-inch ammunition, 20,000 cartridges of 2-pounder shells, and 2,300 depth charges.[41] Most, if not all, were dumped into the Sydney disposal site (in a five nautical mile radius of coordinates 46°18'N, 58°39'W) in the Laurentian Channel north of Cape Breton. In addition to the Sydney site and the Emerald Basin, authorities also approved dumpsites in the mouth of the St. Lawrence River (in a five nautical mile radius of coordinates 49°41'N, 66°31'W) and off the Gaspe peninsula (bordered in the north and west by the 100-fathom contour line along the North shore, in the south by latitude 49°30'N, and in the east by longitude 65°30'W). These sites were likely used to dump ordnance from bases in Quebec and by vessels destined for the scrapheap, as they sailed for Montreal and the WAC's ship graveyard in Sorel, Quebec.[42]

Weekly inventories remitted to Naval Headquarters in Ottawa during the fall of 1945 show that Canada's dumping program gained further momentum. These sources indicate that by October, at least nine warships were assigned dumping duties on an indefinite basis: HMCS *Inch Arran*, *Outremont*, *Jonquiere*, *St. Pierre*, *Victoriaville*, *Poundmaker*, *Buckingham*, *Middlesex*, and *Eastore*. Together, these ships averaged about 500 tons per week along the Atlantic coast. Depending on the weather, each ship managed to jettison about 35 tons per day.[43] *Middlesex*, in particular, was a workhorse. In the year following VE-Day it was dispatched up and down the Nova Scotian coast for numerous operations. In November 1945 and again in April and May 1946, it was sent to the

Figure 1. *Troops from the Royal Canadian Ordnance Corps dumping munitions item-by-item from the tugboat Northern in Dyer Bay, roughly 2 miles off the coast of the Bruce Peninsula in Georgian Bay. Credit: Library and Archives Canada/ Department of National Defence fonds/e011309315.*

Shelburne depot to dump unserviceable ammunition that had either accumulated from de-storing ships or arrived from the Renous depot further inland.[44] However, it was not the only vessel servicing Shelburne. In October 1945, *Jonquiere* made four trips out to sea to dump ammunition and at least 375 depth charges. In December, 385 Minol-filled depth charges were put aboard HMCS *Antigonish*, *Beacon Hill*, and *Levis* to use as ballast before being dumped at sea. HMCS *Arnprior* also carried out dumping operations from Shelburne in February 1946.[45]

The Canadian army undertook dumping programs in the 1940s as well. Although some ordnance was transferred to the navy for disposal, the army decided to use the Great Lakes to avoid moving stocks from central Canada to the coasts. In one notable case, the army dumped about 1,000 tons of obsolete munitions into Dyer Bay, roughly two miles from the Bruce Peninsula in Georgian Bay. To ease any apprehension and anxiety about the operations, the army sent a public relations team to photograph the events and facilitate interviews between military personnel and reporters. These efforts helped shape a positive and reassuring narrative for public consumption: *Globe and Mail* reporter James Vipond, for example, shared details about the site's selection and ordnance transportation, while also noting expert opinions about the

Figure 2. *The drums of mustard gas were stowed in the cargo hold of Landing Ship Tank (LST) 3521, stacked vertically with planks placed between each row. Of the 10,982 barrels, 763 were found leaking which caused 5 minor injuries that were promptly treated by medical staff. During the voyage and scuttling, several drums were dislodged and sunk by rifle fire from Middlesex. This photo was taken on 31 January 1946, almost three weeks before Operation Mustard commenced. Credit: J. W. Merrimen/Foundation Company of Canada (now AECON), via Sandy McClearn.*

practicality of using inland waterways.[46] Unfortunately, the dumping in Georgian Bay was not an isolated instance, as Canadian authorities periodically dumped surplus munitions in Lake Ontario and the US military dumped more than 2 million pounds of ammunition and other production wastes at several sites in Lake Superior.[47] Unexploded ordnance (UXO) from both Canadian and American military bases bordering the Great Lakes also remains a problem.

Dumping methods varied. As illustrated in Figure 1, munitions were frequently dumped by hand: troops would throw them overboard individually (either loose or crated) while the ship traversed the dumpsite. Ships were also retrofitted with platforms and rollers to speed disposal and ease the physical burden of heaving shells overboard. Despite the public-relations façade promoting the straightforward efficiency of dumping, it was far from perfect and replete with many challenges that newspapers hardly mentioned. Perhaps the greatest challenge was navigating ships to the correct coordinates: navigational technologies (such as the Decca and Loran systems) were imprecise by today's standards, and bad weather and rough seas could easily push vessels off course.[48] Moreover, it was not uncommon for crews to jettison ordnance before their

ships even reached authorized areas, a practice later termed "on-route" dumping.[49] An early start was preferred because dumping was a labour-intensive and time-consuming process, and ship captains were leery of navigating at night. As a result, cargos were often dumped in uneven concentrations at disposal sites, sometimes stretching beyond the approved five-kilometre radius, with debris trails from on-route dumping often going unrecorded, leaving a hazardous legacy in the ship's wake.

Chemical warfare agents (usually stored in 45- or 55-gallon steel drums, like those in Figure 2) were dumped by similar item-by-item methods. However, given their toxic nature, these weapons of mass destruction were often packed into surplus ships and scuttled at predesignated locations, such as in the Skagerrak in the North Sea or off the coasts of Ireland, California, New York State, and Florida.[50] Canada followed these practices to dispose of its stockpiles of mustard gas and other chemical weapons. In late 1945, Canadian authorities selected an unfinished vessel, Landing Ship Tank (LST) 3521, sitting idle at the Vickers shipyard in Montreal, and dispatched it to Halifax where roughly 2,000 tons of mustard gas and other chemical weapons were placed onboard in 10,982 barrels.[51] On 18 February 1946, a small convoy of ships, led by *Middlesex*, hauled LST 3521 out to sea, but a winter gale put them off course and forced the convoy's commanding officer to change plans and haphazardly sink the LST at the edge of the Scotian Shelf, far short of the designated site (Figure 3 and 4).[52]

The scuttling of LST 3521, however, did not eliminate all of Canada's surplus chemical weapons. A year later, as further stocks emerged, the Canadian army sent a train across Canada, bound for Esquimalt, British Columbia to collect surplus mustard gas, phosgene, smoke generators, and other conventional and chemical munitions from several bases, including Suffield, Petawawa, Trenton, and Toronto. Approximately 400 to 600 tons were collected and later dumped into the Pacific Ocean on 15, 18, and 22 September 1947 at a dumpsite located near coordinates 48°15'N, 127°00'W, about 125 km west of Vancouver Island and off the continental shelf. The site was authorized by federal and provincial fisheries departments, and selected for its significant depth (2,500m). To complete the three dumps, the tugboat HMCS *Heatherton* towed barges loaded with approximately 200 tons each out to sea and crews either jettisoned the cargo overboard item-by-item or used a hatch in the barge's hull.[53] These events garnered some media attention, but no where near as much as the earlier operations in Halifax, which had an accompanying vessel carrying reporters and a camera crew to document the sinking.[54]

Other types of dangerous materials were also dumped at sea. In August 1948, the WAC contacted DND about "drowning" 17,756 pounds of magnesium powder (a highly flammable substance used in incendiary bombs), stored in 79 drums at the Canadian Arsenals Ltd. factory in Valleyfield, Quebec.[55] However, naval officials informed the WAC that Canadian warships were prohibited from storing or transporting the powder because of its volatility in water, so the WAC arranged disposal with two private companies instead. Foundation Maritime provided the ship (M.V. *Traverse*) and employees from Quebec Salvage & Wrecking Company loaded the drums onboard its waist from Pier 9C in Halifax in March 1949. The plan was to set sail for the Emerald Basin and roll the drums overboard at "regulated" intervals to ensure everyone's safety.[56] The whole

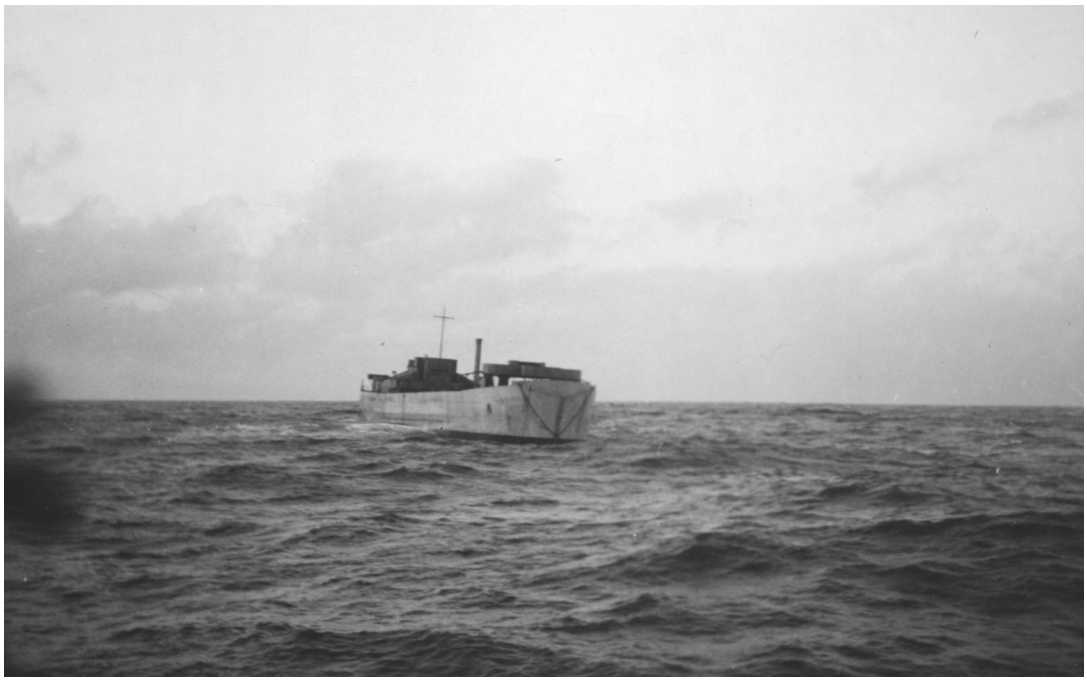

Figure 3. *LST 3521 was towed out to sea, but a storm put the convoy off course, and they had to scuttle the ship short of the designated site. This photo was taken on 18 February 1946, shortly after Foundation Maritime's tugboat Franklin slipped the tow. Credit: Foundation Company of Canada (now AECON), via Sandy McClearn.*

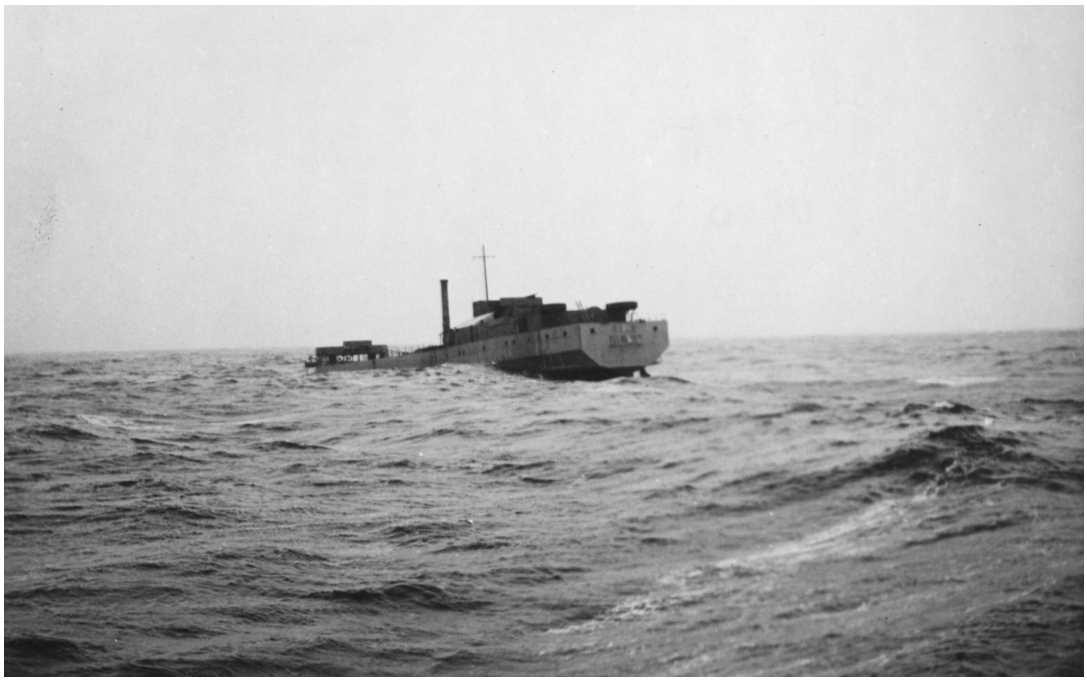

Figure 4. *The scuttling did not go as planned, as the private contractor failed to open the aft seacocks properly. By dawn on 19 February 1946, LST 3521 was only half submerged and Middlesex had to finish the job. When depth charges proved unsuccessful, the deck gun opened fire. After expending 400 rounds LST 3521 finally sunk. Credit: Foundation Company of Canada (now AECON), via Sandy McClearn.*

operation cost the WAC $2,800 and followed the precedents set by the Pacific "drownings" involving magnesium powder earlier in 1947.[57]

Given the dangerous nature of the cargo, the Dockyard Chemical Engineer in Halifax, R.P. Bailey, was assigned to the *Traverse* as technical advisor and he later submitted a first-hand account of the operation. According to Bailey, the drums were loaded onboard with only "slight leakage" from one on 25 March 1949. Shortly after the ship proceeded to the Emerald Basin, and about 35 miles offshore the crew began to jettison the cargo. Half the drums were rolled off the starboard side as the ship circled around at half-speed and the remainder were rolled over the port side as the ship completed its figure-eight course. About thirty minutes after the first drums entered the water, Bailey witnessed a momentous eruption as the hydrostatic pressure compromised the drums' integrity:

> … a large, solid circle of foam, about 100 yards in diameter, appeared a few hundred yards from the ship followed a few minutes later by two adjoining circles, each about 50 yards in diameter, on opposite sides; and a little later two or three more circular eruptions appeared within the area covered by the first three. However, no explosion or noise was heard and no shock was felt on the ship. For a foot or so over these "boiling" areas appeared a thin fog or vapour … About fifteen minutes after the first appearance of the foam circles … a yellow flame (about two or three feet wide and four or five feet in height) appeared at the surface level in the middle of the disturbed area, accompanied by a large cloud of white smoke, but without sound, and burned for several minutes. No other flame appeared and no further eruptions were observed, although the frothing still continued in the original five or six circles as the area passed out of sight astern.[58]

The magnesium powder boiled the sea water in a gigantic, underwater fire. The yellow flame, observed by Bailey, was only the tip of the iceberg. It rose nearly two metres out of the water, but it originated from drums that had been sinking to the seabed for nearly an hour.

Throughout the early Cold War, the armed forces continued dumping in Canadian waterways. In December 1959, the navy completed several operations that consigned about 850 tons of munitions into the Atlantic and another 163 tons into the Pacific.[59] In January 1960, the navy extended its "ammunition drowning programme" to dump surplus No. 24 Smoke Generators at a rate of 160 tons per week.[60] The navy also dumped radioactive materials. According to inventories submitted to naval headquarters, 24,930 pounds of "radioactive tubes" and over 45,000 pounds of ammunition and fuzes were dumped into the Pacific in 1960, while more than 130,000 pounds of ordnance and 15,512 pounds of "radioactive materials" were dumped into the Atlantic the following year. The navy's standard procedures for dumping radioactive wastes directed personnel to put the materials in old paint cans (likely lined with leftover lead-based paint) and encase them in concrete before dumping them into a minimum of 1,000 fathoms of water.[61]

Towards the end of the 1960s the practice of dumping munitions fell out of favour and was eventually banned by an international agreement signed in 1972: the Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matter (commonly known as the London Convention). As historian Jacob Hamblin has shown, the London Convention was an imperfect treaty and had its fair share of limitations and problems, but it did succeed at outlawing the dumping of wastes from ships at sea and was later

ratified by 15 nations, coming into force in 1975 (today there are over 80 signatory countries).[62] Yet the London Convention would never have occurred had it not been for the sustained political pressure exerted by the postwar environmental movement, which gained strength throughout the 1950s and 1960s, especially in the United States. Galvanized by the work of bestselling authors and ocean enthusiasts like Jacques Cousteau and Rachel Carson, environmentalists succeeded in pressuring American politicians to enact greater regulatory standards on chemicals and water pollution. By extension, these actions also "greened" international relations and turned President Richard Nixon's administration into something of an environmental champion.[63]

In Canada, as historian Ryan O'Connor has shown, environmentalists found their intellectual origins south of the border, but it was not until the CBC televised *The Air of Death* exposé in its primetime slot on 22 October 1967 that the movement really gained critical mass. The film was certainly not the first to profile the health hazards of heavy industry and air pollution, but its popularity fueled a growing movement for better air quality, while calls for stronger protections for drinking water and marine environments followed shortly thereafter. In 1969, for instance, environmentalists in Toronto organized a mock funeral for the heavily polluted Don River.[64] Such political pressure pushed the federal government to participate in the London Convention, eventually passing the Ocean Dumping Control Act in 1975 to bring Canada into the Convention's protocols and provisions.[65] However, the Ocean Dumping Control Act has its limitations. Although it prohibits indiscriminate dumping and has measures to protect marine environments by regulating the introduction of pollutants, it still allows munitions dumping to take place under exceptional circumstances. Nor did the act do anything to clean up the wastes that were already on the seabed when it came into force.

Indeed, our cultural fascination with the "new" is deeply embedded into our political and legal institutions: limiting future pollution took hold of the agenda, while procedures and investments for cleaning up the "old" materials already in the water were shelved in favour of consensus. Similar loopholes and oversights exist elsewhere, such as in the Chemical Weapons Convention (CWC). The CWC, which entered into force in 1997 and is administered by the Organization for the Prohibition of Chemical Weapons (OPCW), is the international arms control treaty banning the development, production, stockpiling, and use of chemical weapons. Under the terms of Article IV, the CWC does not apply to chemical weapons that were dumped prior to 1 January 1985. Yet, the vast bulk of chemical weapons were disposed of decades before the 1985 cutoff, meaning that the verification, monitoring, recovery, and disposal of about one million tonnes worldwide is not governed by international agreements. As long as they remain underwater, governments are free to ignore or address the issue as they see fit.[66]

Legacies for Today

Although this article has focused on dumping, the intentional disposal of munitions in waterways was not the only way that bombs ended up underwater, as unexploded ordnance (UXO) from training, combat operations, and shipwrecks add to the contamination. Indeed, UXO are particularly hazardous since these rounds were fuzed, armed, and discharged but failed to detonate on target because of some technical malfunction.

In some places, there have been fatal consequences. At Lac Saint-Pierre, Quebec, a freshwater lake located in the St. Lawrence River between Trois-Rivières and Sorel-Tracy, the Canadian Army established a gunnery school and experimental test centre in nearby Nicolet. For roughly fifty years, they used the lake for target practice to train artillery units and test new ordnance types. Consequently, UXO litter the area, with perhaps as many as 8,000 rounds failing to detonate. In 2005, the mayor of Nicolet called the lake, which was designated as a UNESCO biosphere reserve after the military closed the range in 2000, a "cemetery of shells."[67] Apart from signs and fencing, little was done to cleanup the hazards, and unfortunately, disaster struck in June 1982 when a group of young people were celebrating St. Jean Baptiste Day at a nearby beach. Someone threw what they thought was a piece of driftwood onto the bonfire — except it was a corroded artillery shell, with about two kilograms of high explosives inside. The resulting explosion killed one person and wounded nine others.[68]

Not all underwater munitions carry the same risks as UXO, as shells and ammunition slated for dumping were usually jettisoned separately from fuzes, and munitions from shipwrecks were stored in magazines with similar precautions. However, regardless of the circumstances, all underwater munitions carry forward some type of risk to public safety and the environment. As time goes on, corrosion erodes metal casings and can destabilize chemical compounds, making some types of explosives more sensitive to disturbances and liable to detonate spontaneously. In effect, water does not render these munitions inert, nor do they remain impervious to anthropogenic disturbances (from fishing, construction, or other offshore activities) and to the environmental effects of water currents, temperature, and salinity. No matter how they ended up underwater, all munitions contain dangerous and potent mixtures of toxic chemicals, heavy metals, explosive compounds, and other harmful substances. Today, these old munitions remain on the seafloor and lakebeds where they continue to corrode, leak, decay, or otherwise disperse their contents into the surrounding ecosystems.

Since the mid-1990s, European marine scientists have been closely studying the effects of underwater munitions in the Baltic and North Seas to better understand the risks and implications. What they have found is that some high explosives, chemical weapons, and their degradation products can be toxic, carcinogenic, and bioaccumulate in marine organisms, including seafood consumed by humans.[69] These risks are mitigated, however, by some environmental conditions that lessen the threat, such as the site's accessibility, dilution and dissolution rates, variable corrosion rates, and the small concentrations found in collected samples. According to one study, a person would need to eat 39g of mussels harvested continually from the immediate vicinity of exposed TNT everyday for 70 years to adversely affect their health. Given that such conditions are unlikely to be met, the study concluded that the consumption of mussels from the Baltic Sea is considered "safe from today's point of view."[70]

Yet, scientists cannot discount a future toxic problem emerging. Although most underwater munitions do not pose an acute toxicological risk, chronic exposure to dispersal plumes and small concentrations of munition compounds does lead to some bioaccumulation. This can cause sublethal effects on the health of mussels and fish (including tumours, hindered growth and reproduction, and damage to the nervous,

immune, and blood systems), which can affect the overall health and size of fish stocks. Moreover, there is a potential for this uptake to increase over time, as corrosion continues and releases more munition compounds into surrounding environments and food webs.[71] Additionally, climate change is expected to exacerbate the situation, as rising ocean temperatures will accelerate corrosion and the frequency of extreme weather events that may disturb dumpsites and shift ordnance.[72] As a result, most experts are in near unanimous agreement that continuous monitoring programs are needed to keep tabs on dumpsites and alert authorities to changing conditions, as scientists cannot preclude the fact that risks to human health and the environment might increase in the future.

Although consensus exists on the need for monitoring, not every scientist is convinced that the risks will increase over time. Jacek Bełdowski, a marine geochemist at the Polish Institute of Oceanology, and arguably the leading expert on Baltic Sea chemical munitions, frames the competing approaches as the "time bomb and catastrophe" versus the "unicorns and rainbows."[73] Those who fall into the latter camp, see underwater munitions as a site-specific concern and think that environmental factors will continue to limit the spread of contamination. They also place more importance on the isolation of underwater munitions since this decreases the likelihood of human interactions and sometimes marine life as well. As a result, they tend to argue against recovery and advocate instead for exclusion zones, greater public awareness, and the diversion of resources to risk mitigation in shallower waters and shoreline areas where human encounters are more likely.[74] Certainly, not everyone likes the idea of leaving the bombs where they are, but there is a valid justification for inaction: any intrusive investigations or attempts to remove the ordnance may inadvertently cause further deterioration and spread munition compounds over a wider area than if they were just left alone.

Those who favour the "time bomb and catastrophe" approach tend to want more action and remediation to stave off some future, corrosion-induced surge, but even they must concede that the range of possible solutions is limited. When mitigation is deemed necessary, the safety of explosive ordnance disposal (EOD) personnel and divers becomes paramount, so quite often removing the bombs from the water is not a viable option and they resort to in situ detonations. Blast-in-Place (BiP) methods are the most direct, cost-effective, and safest way of dealing with underwater munitions. However, recent biomonitoring studies in the Kolberger Heide region of the Baltic Sea have found that BiP might not be as effective as government and EOD organizations believe. Older, water-logged explosives do not readily decompose when detonated, meaning that the explosion does not convert all matter into energy, thereby dispersing explosive residues throughout the surrounding environment. The biomonitoring study used blue mussels to filter the water after nearby BiP operations and scientists found that concentrations of TNT increased inside the mussels.[75]

The Canadian government and military keep abreast of new international developments and protocols related to underwater munitions, but there is room for improvement. Starting in the early 2000s, the DND established the Legacy Sites Program to gather more information about UXO sites in Canada, so it can better manage the issues, locate problems, and cleanup the explosive remnants of past military activities. The top priority remains the energetic danger and limiting the potential for human encounters,

which leaves the underwater sites at a disadvantage for resources and attention given their relative isolation. Although encounters can take place along shorelines or in shallow waters, the DND's management priorities are primarily focused on land-based sites.[76] Of course, the DND and its EOD teams do not ignore underwater munitions: they respond whenever and wherever the need arises (and no matter the danger level), but there is a notable "hands-off" approach. For instance, during the most recent and well-publicized cleanup operation at Bell Island, Newfoundland in 2019 and 2021, 29 navy divers cleared about 130 projectiles from four Second World War shipwrecks to make the sites safer for recreational diving tours; but those diving tours had been in operation for over 20 years prior to the clearance operations.[77]

Given the new research findings about underwater munitions emerging from Europe, this "hands-off" approach may not be tenable moving forward. More proactive measures may be needed to better understand how Canadians are affected by underwater munitions, which means that on-going monitoring operations, updated risk assessments, and ecotoxicology studies are required for all dumpsites. Unfortunately, the DND does not currently perform or fund any of those tasks for any dumpsites under its jurisdiction. The only risk assessments available to the public (and released under the Access to Information Act) were completed in 2005 and 2008.[78] It is as if Canada's response to underwater munitions has been stuck in a policy vacuum ever since.

In sum, there is no magic solution for cleaning up the legacies of war and mitigating the environmental costs of disarmament. The final disposal of formerly disposed of munitions is a confounding issue and will remain so well into the future. After the Second World War, the Canadian military — like its allies around the world — managed the lifecycle of its assets and technologies, discarding the old and obsolete items according to contemporary political, scientific, and technological contexts. The programs and policies that emerged were far from perfect and replete with many challenges and considerations that deserve more attention. Therefore, exploring use-centred histories of technologies at the end of their operational lives opens new avenues for better understanding postwar demobilization and the military's significant environmental impact. The way in which the military handled munitions disposal after 1945 set a precedent that lasted into the 1960s and left behind a hazardous legacy that continues to impact the present day. Whether as an energetic danger to fishermen or as point-source emitters of contamination, the munitions produced to fight past wars remain capable of fulfilling their intended functions — even underwater. Hidden out of sight and mind, these old military technologies possess long and influential afterlives.

Alex Souchen is a tenure-track Assistant Professor at the University of Guelph, cross-appointed between the Department of History and Bachelor of Arts and Science Program. He is the author of War Junk: Munitions Disposal and Postwar Reconstruction in Canada (UBC Press, 2020), and co-editor of Silent Partners: The Origins and Influence of Canada's Military-Industrial Complex (UBC Press, 2023).

Endnotes

1 Edward Jones-Imhotep and Tina Adcock, "Introduction: Science, Technology, and the Modern in Canada," in *Made Modern: Science and Technology in Canadian History*, eds. Edward Jones-Imhotep and Tina Adcock (Vancouver: UBC Press, 2018), 3-7. For examples, see David S. Landes, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present* (Cambridge: Cambridge University Press, 1969); Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: Johns Hopkins University Press, 1983); David E. Nye, *American Technological Sublime* (Cambridge: The MIT Press, 1994).

2 For critical insights, see Stephen Bocking, *Nature's Experts: Science, Politics, and the Environment* (New Brunswick: Rutgers University Press, 2006); Edmund Russell, *War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring* (Cambridge: Cambridge University Press, 2001); James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1998).

3 For examples, see Michael Adas, *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance* (Ithaca: Cornell University Press, 1989); Dipesh Chakrabarty, *Provincializing Europe: Postcolonial Thought and Historical Difference* (Princeton: Princeton University Press, 2018).

4 Edward Jones-Imhotep, *The Unreliable Nation: Hostile Nature and Technological Failure in the Cold War* (Cambridge: The MIT Press, 2017); Royden Loewen, *Horse-And-Buggy Genius: Listening to Mennonites Contest the Modern World* (Winnipeg: University of Manitoba Press, 2016).

5 For example, David Edgerton, *The Shock of the Old: Technology and Global History Since 1900* (London: Profile Books, 2006).

6 Quotes from, Edgerton, *The Shock of the Old*, xi, 43-45.

7 David Arnold, *Everyday Technology: Machines and the Making of India's Modernity* (Chicago: University of Chicago Press, 2013).

8 Susan Strasser, *Waste and Want: A Social History of Trash* (New York: Henry Holt, 1999); Giles Slade, *Made to Break: Technology and Obsolescence in America* (Cambridge: Harvard University Press, 2006).

9 For example, see the books and trade magazines published by Janes Information Services in annual and weekly editions, such as *Janes Defence Weekly, Janes Fighting Ships,* or *Janes All the World's Aircraft*. For scholarly examples, see: Randall Wakelam, *Cold War Fighters: Canadian Aircraft Procurement, 1945-54* (Vancouver: UBC Press, 2011) or Frank Maas, *The Price of Alliance: The Politics and Procurement of Leopard Tanks for Canada's NATO Brigade* (Vancouver: UBC Press, 2017).

10 Murray Brewster, "Federal Government Inks Deal to Buy Fleet of F-35 Fighter Jets," *CBC News*, 9 January 2023, https://www.cbc.ca/news/politics/canada-f35-fighter-jet-deal-1.6707769.

11 Alex Souchen and Matthew S. Wiseman, "Introduction: A Canadian Military-Industrial Complex?" in *Silent Partners: The Origins and Influence of Canada's Military-Industrial Complex*, eds. Alex Souchen and Matthew S. Wiseman (Vancouver: UBC Press, 2023), 13-16.

12 For more, see C.P. Stacey, *Arms, Men, and Governments: The War Policies of Canada, 1939-1945* (Ottawa: HMSO, 1970); Graham Broad, *A Small Price to Pay: Consumer Culture on the Canadian Home Front, 1939-1945* (Vancouver: UBC Press, 2013); Jonathan Fennel, *Fighting the People's War: The British and Commonwealth Armies and the Second World War* (Cambridge: Cambridge University Press, 2019).

13 Robert Bothwell and William Kilbourn, *C.D. Howe: A Biography* (Toronto: McClelland and Stewart, 1979), 128-179.

14 Alex Souchen, *War Junk: Munitions Disposal and Postwar Reconstruction in Canada* (Vancouver: UBC Press, 2020): 5-7.

15 Andrew B. Godefroy, *In Peace Prepared: Innovation and Adaptation in Canada's Cold War Army* (Vancouver: UBC Press, 2014), 48-49; J.L. Granatstein, *Canada's Army: Waging War and Keeping the Peace* (Toronto: University of Toronto Press, 2002), 315-16.

16 A.D.H. Kaplan, *The Liquidation of War Production: Cancellation of War Contracts and Disposal of Government-Owned Plants and Surpluses* (New York: McGraw-Hill, 1944), 20-25; Souchen, *War Junk*, 62-68.

17 For examples see, Frank J. Dobney, "The Evolution of a Reconversion Policy: World War II and Surplus War Property Disposal," *Historian* 36 (1974): 498-519, https://www.jstor.org/stable/24443749; Sam Lebovic, "From War Junk to Educational Exchange: The World War II Origins of the Fulbright Program and the Foundations of American Cultural Globalism, 1945-1950," *Diplomatic History* 37, 2 (2013): 280-312. https://doi.org/10.1093/dh/dht002

18 Souchen, *War Junk*, 21-48.

19 Souchen, *War Junk*, 81-93.

20 Royal Canadian Navy, *Events Leading Up to the 1945 Explosion at RCN Magazines Bedford, N.S. and Clearance of Devastated Areas* (Director General of Naval Ordnance, 1952), 9.

21 For more, see John Griffith Armstrong, *The Halifax Explosion and the Royal Canadian Navy: Inquiry and Intrigue* (Vancouver: UBC Press, 2002) and H. Millard Wright, *The Other Halifax Explosion: Bedford Magazine July 18-20, 1945* (no publisher, no date).

22 Capt. J. McCulloch, "Memorandum: General Activities Sydney Sub Command," 6 July 1945, 1-2, file CSS-1-2-2, vol. 11686, RG24 Department of Defence fonds, Library and Archives Canada (LAC).

23 *Events Leading Up to the 1945 Explosion*, 24; Access to Information and Privacy (ATIP) Request A-2016-02453, Scott Conrod, Tom Windeyer, and Gary Willmore, "Final Report: The Identification of UXO Sites/Wrecks in the MARLANT Areas of Responsibility," Neill and Gunter (Nova Scotia) Limited (January 2005), 20 and historical document appendix (hereafter "Neill and Gunter Report").

24 Jamie Benidickson, *The Culture of Flushing: A Social and Legal History of Sewage* (Vancouver: UBC Press, 2007); Alex Souchen, "An Exceptional Mortality: Dumped Munitions, Inconclusive Science, and the Mass Death of Oysters in the Thames Estuary after the First World War," *Environmental History* 26, 4 (October 2021): 696-723. https://doi.org/10.1093/envhis/emab048

25 Benidickson, *The Culture of Flushing,* 213-266; Joel A. Tarr, *The Search for the Ultimate Sink: Urban Pollution in Historical Perspective* (Akron: The University of Akron Press, 1996), 159-178.

26 Tarr, *The Search for the Ultimate Sink*, 159-178; Jacob Darwin Hamblin, *Poison in the Well: Radioactive Waste in the Oceans at the Dawn of the Nuclear Age* (New Brunswick: Rutgers University Press, 2009), 10-38; Arn M. Keeling, "Charting Marine Pollution Science: Oceanography on Canada's Pacific Coast, 1938-1970," *Journal of Historical Geography* 33 (2007): 410, 415-16. https://doi.org/10.1016/j.jhg.2006.05.004

27 Naomi Oreskes, *Science on a Mission: How Military Funding Shaped What We Do and Don't Know about the Ocean* (Chicago: University of Chicago Press, 2021); Hamblin, *Poison in the Well*, 10-72.

28 "Britain Dumps Vast Stores of Poison Gas in Atlantic," *Globe and Mail*, 7 September 1945, 1; "British Sink Poison Gas in Sea West of Ireland," *New York Times*, 7 September 1945, 3.

29 "England Dumps Tons of WWII Ammunition into Ocean," *YouTube, Post by Buyout Footage Historic Film Archive*, 23 July 2014 [1946], https://www.youtube.com/watch?v=cSXtsqhRN5A.

30 For more see H. Lindsey Arison III, *European Disposal Operations: The Sea Disposal of Chemical Weapons* (Self-published, 2013), 128-149; Fredrik Laurin, "The Baltic and North Sea Dumping of Chemical Weapons: Still a Threat?" in *The Challenge of Old Chemical Munitions and Toxic Armament Wastes,* eds. Thomas Stock and Karlheinz Lohs (Oxford: Oxford University Press, 1997), 263.

31 Jacek Bełdowski, Terrence Long, and Martin Söderström, "Introduction," in *Towards the Monitoring of Dumped Munitions Threat (MODUM): A Study of Chemical Munitions Dumpsites in the Baltic Sea*, eds. Jacek Bełdowski, Robert Been, and Eyup Kuntay Turmus (Dordrecht: Springer, 2018), 2-3; Arison, *European Disposal Operations*, 128-149; Ron Chepesiuk, "A Sea of Trouble?" *Bulletin of Atomic Scientists* 55, 5 (1997): 42. https://doi.org/10.1080/00963402.1997.11456769 ; M.I. Greenberg, K.J. Sexton, and D. Vearrier, "Sea-Dumped Chemical Weapons: Environmental Risk, Occupational Hazard," *Clinical Toxicology* 56, 2 (2016): 79-91. https://doi.org/10.3109/15563650.2015.1121272; Ministry of Defence, *Report on the Sea Dumping of Chemical Weapons by the United Kingdom in the Skagerrak Waters Post World War Two* (London: Ministry of Defence, 1993), 1-16.

32 Convention for the Protection of the Marine Environment of the North-East Atlantic, *Assessment of the Impact of Dumped Conventional and Chemical Munitions* (London: OSPAR Commission, 2009), 3.

33 Claus Böttcher, et al., *Munitions in German Marine Waters – Stocktaking and Recommendations* (German Marine Monitoring Program, 2012), 4-5.

34 Ministry of Defence, *Beaufort's Dyke Dumping Ground* (London: Ministry of Defence, n.d.), 4-9; Rob Edwards, "The WW2 Bombs Dumped Off Western Scotland Washing Up On Beaches," *New Scientist*, 18 November 1995, updated 10 February 2020, https://www.newscientist.com/article/mg14820042-200-the-ww2-bombs-dumped-off-western-scotland-washing-up-on-beaches/.

35 Army Historical Research and Response Team, *Off-shore Disposal of Chemical Agents and Weapons Conducted by the United States* (Aberdeen: US Army Research, Development, and Engineering Command, 2001), 1-15; David M. Bearden, *U.S. Disposal of Chemical Weapons in the Ocean: Background and Issues for Congress* (Washington: Congressional Research Service, 2007), 1-22; Department of Defense, *Defense Environmental Programs Annual Report to Congress – Fiscal Year 2009* (Washington: Department of Defense, 2009), 85-120.

36 Supreme Allied Commander for the Pacific, *Reports of General MacArthur: MacArthur in Japan: The Occupation: Military Phase*, Vol. 1 (Washington: Center for Military History, 1994), 136.

37 For more on Pacific dumping see, Geoff Plunkett, *Chemical Warfare Agent Sea Dumping Off Australia* (Canberra: Department of Defence, 2003); Judith A. Bennett, *Natives and Exotics: World War II and Environment in the Southern Pacific* (Honolulu: University of Hawaii Press, 2009); Jon Mitchell, *Poisoning the Pacific: The US Military's Secret Dumping of Plutonium, Chemical Weapons, and Agent Orange* (London: Rowan & Littlefield, 2020).

38 Canada, Order-in-Council PC6099, 4 August 1944.

39 Souchen, *War Junk*, 85-86.

40 "Continental Movements & Shipping Committee, Minutes of 71st Meeting Held at Norfolk House on 27 June 45," 1, WO 107/233B, The National Archives (TNA). News reports exaggerated the total, as one report stated that 6 million tons were being dumped into the North Sea. Frank Swanson, "Dump into Sea Hun Ammunition," *Hamilton Spectator*, 21 July 1945, n.p.

41 "Explosive Stores Jettisoned," Capt. J. McCulloch to Commanding Officer Atlantic Coast, 19 September 1945, 1-3, file 70-2-6, vol. 11121, RG24, LAC.

42 Capt. R.W. Wood, "Confidential – Memorandum to Secretary – Naval Board," 14 September 1945, file 5130-1, vol. 34394, RG24, LAC; Neill and Gunter Report, 21, 24, and historical documents appendix.

43 Naval Message, n.d., file CSS-18-1-1, vol. 11684, RG24, LAC; Alex Souchen, "'Under Fathoms of Saltwater': Canada's Ammunition Dumping Program, 1944-1947," *Canadian Military History* 26, 2 (2017): 25-27. https://scholars.wlu.ca/cmh/vol26/iss2/3/

44 "Monthly Report of Proceedings R.C.N. Armament Depot, Shelburne, N.S." 3 June 1946, 1-2; "R.C.N. Armament Depot, Shelburne, N.S., Monthly Report for April 1946," 2 May 1946, 1-2; "Monthly Report of Proceedings R.C.N. Armament Depot, Shelburne, N.S.," 3 December 1945, 1-2, file S0-11-N, vol. 11501, RG24, LAC.

45 "Monthly Report of Proceedings R.C.N. Armament Depot, Shelburne, N.S.," 1 November 1945, 1-3; "R.C.N. Armament Depot, Shelburne, N.S., Monthly Report for February 1946," 4 March 1946, 1-2; "Monthly Report of Proceedings R.C.N. Armament Depot, Shelburne, N.S.," 31 December 1945, 1-2, file S0-11-N, vol. 11501, RG24, LAC.

46 James Vipond, "Dumped High Explosives in Georgian Bay: Ancient Ammo Racked In Old Davey's Locker," *Globe and Mail*, 21 November 1945, 15.

47 Elodie Charrière and Nancy Langston, "Dumping Military Waste into Lake Superior: The Historic Legacies of Secrecy, Censorship, and Uncertainty," *Water History* 15 (2023), 173-200. https://doi.org/10.1007/s12685-023-00329-y

48 Geoffrey Carton and Andrzej Jagusiewicz, "Historic Disposal of Munitions in U.S. and European Coastal Waters: How Historic Information Can be Used in Characterizing and Managing Risk," *Marine Technology Society Journal* 43, 4 (2009): 26. https://doi.org/10.4031/MTSJ.43.4.1

49 Helsinki Commission, *Chemical Munitions Dumped in the Baltic Sea* (Helsinki: Baltic Marine Environmental Protection Commission, 2013), 32-33.

50 *Off-shore Disposal of Chemical Agents and Weapons Conducted by the United States*, 1-15; Bearden, *U.S. Disposal of Chemical Weapons in the Ocean*, 1-22.

51 LST 3521 was the 209th ship built by Vickers in Montreal. An unfinished hulk, it must have been known colloquially as LST "209" around the yard, which explains why that moniker was mistakenly used in all official reports and communications, both at the time and today. LST 209 was the USS *Bamberg County*. For statistics on the number of barrels and chemical weapons, see ATIP Request A-2016-02453, Notra, Inc., "Risk Assessment of Canadian Deep Ocean Chemical Warfare Agent Disposal Sites," 31 March 2008, 10-1-2 (hereafter Notra Report).

52 Alex Souchen, "Chemical Weapons Disposal and the Scuttling of LST 3521 in 1946," *Canadian Naval Review* 16, 3 (2021): 14-19., https://www.navalreview.ca/past-issues-2020-to-2023/

53 ATIP Request, A-2016-02453, "Naval Staff Meeting, Minutes of 381st Meeting," 5 August 1947, 5-6; Notra Report, 12-1-3.

54 "Dump 600 Tons of Mustard Gas into Pacific Later This Month," *Globe and Mail*, 16 September 1947, 3.

55 R.H. Findlater to R.P. Bailey, "Re: Drowning of about 78 drums Magnesium Powder," 14 March 1949, 1-2, file 5030-3, vol. 1913, RG24, LAC.

56 H.R. Malley to J.F. Monroe, "Re: Drowning of Magnesium and Aluminum Powder off Halifax," 26 November 1948, 1-2; Quebec Salvage & Wrecking Company to War Assets Corporation, n.d., 1-2; and R.P. Bailey, "Disposal of Magnesium Powder," 31 March 1946, 1-2, file 5030-3, vol. 1913, RG24, LAC.

57 H.R. Malley to J.F. Monroe, "Re: Drowning of Magnesium and Aluminum Powder off Halifax," 26 November 1948, 1-2, file 5030-3, vol. 1913, RG24, LAC. It is unknown if the magnesium powder was dumped at the same time as the other chemical weapons in September 1947. Historical documentation about the West Coast dumpsites is limited and the relevant site profiles had information redacted from the ATIP release. ATIP Request, A-2016-02453, "Warfare Agent Disposal Project: Project Risk Management Plan" and the accompanying site profiles; Notra Report, 12-1-3.

58 Bailey, "Disposal of Magnesium Powder," 1, file 5030-3, vol. 1913, RG24, LAC.

59 "Ammunition Drowning Programme – 1959: East Coast," n.d., 1; "Ammunition Drowning Programme – 1959: West Coast," n.d., 1-3, file CSS 18-1-1, vol. 11684, RG24, LAC.

60 "Ammunition Drowning Programme," 23 November 1959, 1-2, file 5130-1 vol. 6, vol. 34395, RG24, LAC.

61 "Ammunition and Radio Active Materials, Disposal by Drowning," K.W. Walton to Chief of Naval Staff, 13 June 1961, 1-2, file 5130-1 vol. 7, vol. 34395, RG24, LAC.

62 Jacob Darwin Hamblin, "Gods and Devils in the Details: Marine Pollution, Radioactive Waste, and an Environmental Regime Circa 1972," *Diplomatic History* 32, 4 (2008): 539-560. https://doi.org/10.1111/j.1467-7709.2008.00712.x. See also International Maritime Organization, "Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter," https://www.imo.org/en/OurWork/Environment/Pages/London-Convention-Protocol.aspx

63 Rachel Carson, *The Sea Around Us* (New York: Oxford University Press, 1951); Jacques-Yves Cousteau and Frédéric Dumas, *The Silent World: A Story of Undersea Discovery and Adventure* (New York: Harper & Brothers, 1953); Rachel Carson, *Silent Spring* (Boston: Houghton Mifflin, 1962). See also: Adam Rome, "'Give Earth a Chance': The Environmental Movement and the Sixties," *Journal of American History* 90, 2 (2003): 525-554. https://doi.org/10.2307/3659443; Russell, *War and Nature*, 218-228; James Morton Turner and Andrew C. Isenberg, *The Republican Reversal: Conservatives and the Environment from Nixon to Trump* (Cambridge: Harvard University Press, 2018).

64 Ryan O'Connor, *The First Green Wave: Pollution Probe and the Origins of Environmental Activism in Ontario* (Vancouver: UBC Press, 2015), 1-38, 52-56.

65 The Dumping Control Act was folded into the Canadian Environmental Protection Act in the 1990s. In 2000 Canada joined the 1996 Protocol to the London Convention, which was an updated and more stringent agreement. Environment and Climate Change Canada, "Disposal at Sea: Program Information." https://www.canada.ca/en/environment-climate-change/services/disposal-at-sea/information.html.

66 Chemical Weapons Convention, *Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and on Their Destruction*, Article IV, Clause 17. https://www.opcw.org/chemical-weapons-convention/articles/article-iv-chemical-weapons.

67 Ingrid Peritz, "Bombs lie on bed of serene Quebec lake," *Globe and Mail*, 19 August 2005, 1,5.

68 Peritz, "Bombs lie on bed of serene Quebec lake," 1, 5.

69 Aaron J. Beck, et. al., "Explosives Compounds from Sea-Dumped Relic Munitions Accumulate in Marine Biota," *Science of the Total Environment* 806, 4 (2022): Article 151266. https://doi.org/10.1016/j.scitotenv.2021.151266.

70 Edmund Maser and Jennifer S. Strehse, "Can Seafood from Marine Sites of Dumped World War Relics Be Eaten?" *Archives of Toxicology* 95 (2021): 2259. https://doi.org/10.1007%2Fs00204-021-03045-9.

71 Maser and Strehse, "Can Seafood From Marine Sites of Dumped World War Relics Be Eaten?" 2257; Aaron J. Beck, et al. "Spread, Behavior, and Ecosystem Consequences of Conventional Munitions Compounds in Coastal Marine Waters," *Frontiers in Marine Science* 5 (2018): Article 141. https://doi.org/10.3389/fmars.2018.00141.

72 Jörn Peter Scharsack et al., "Effects of Climate Change on Marine Dumped Munitions and Possible Consequences for Inhabiting Biota," *Environmental Sciences Europe* 33 (2021): Article 102. https://doi.org/10.1186/s12302-021-00537-4.

73 Andrew Curry, "Chemical Weapons Dumped in the Ocean After World War II Could Threaten Waters Worldwide," *Smithsonian.com*, 11 November 2016, https://www.smithsonianmag.com/science-nature/decaying-weapons-world-war-II-threaten-waters-worldwide-180961046/.

74 For a summary of the positions, see J. Beddington and A.J. Kinloch, *Munitions Dumped at Sea: A Literature Review* (London: Imperial College Consultants, 2005), 47-59.

75 Edmund Maser and Jennifer S. Strehse, "'Don't Blast': Blast-in-Place (BiP) Operations of Dumped World War Munitions in the Oceans Significantly Increase Hazards to the Environment and the Human Seafood Consumer," *Archives of Toxicology* 94 (2020): 1941-1953. https://doi.org/10.1007/s00204-020-02743-0.

76 The DND's inventory lists over 800 legacy sites. Department of National Defence, "Unexploded Explosive Ordnance (UXO)." https://www.canada.ca/en/department-national-defence/services/uxo/unexploded-explosive-ordnance.html.

77 Ocean Quest, "Diving Trips," https://oceanquestadventures.com/diving-trips/; Rafsan Faruque Jugol, "Bell Island's got an explosive problem – and these military divers are back to defuse it," *CBC News*, 24 July 2021, https://www.cbc.ca/news/canada/newfoundland-labrador/bell-island-sunken-ordnance-1.6114953; Peter Cowan, "An explosive problem: How the navy cleans up WWII underwater leftovers," *CBC News*, 19 July 2019, https://www.cbc.ca/news/canada/newfoundland-labrador/bell-island-under-water-explosives-1.5217136.

78 ATIP Request A-2016-02453, Neill and Gunter Report; Notra Report.