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Department of Defense
Research Related to Effect of Ocean Disposal of Munitions
in U.S. Coastal Waters
Report to Congress



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INTRODUCTION

This report responds to House Report (H.R.)114-102 accompanying H.R. 1735, the National Defense Authorization Act for Fiscal Year (FY) 2016, to report research activities conducted related to the inventory of ocean-disposal sites the Department of Defense (DoD) identified in the FY 2009 Defense Environmental Programs Annual Report to Congress. DoD refers to these as munitions sea-disposal sites. This report presents the status of the DoD's activities related to munitions sea-disposal sites in U.S. coastal waters¹. Specifically, the report discusses: (1) DoD's research to date regarding the effects of sea-disposed munitions on the ocean environment; (2) the feasibility of removing or otherwise remediating munitions sea-disposal sites; and (3) recommendations for additional research and remediation or cleanup of munitions sea-disposal sites.

DoD's research concludes that:

- sea-disposed munitions, which have become part of the ocean environment and also provide critical habitat to marine life, do not pose significant harm when left in place;
- removing or cleaning up munitions sea-disposal sites would have more serious effects on marine life and the ocean environment than would leaving them in place; and
- the potential health effects from sea-disposed munitions in U.S. coastal waters appear to be minimal.

At DoD's study sites, sea-disposed munitions did not appear to stress or have an adverse effect on marine life. Sea-disposed munitions were not destroying habitat or injuring mammals and other sea-life, instead they have provided habitat and become an integral part of the environment and ecosystem.

From an explosives safety perspective, DoD believes that it is best to leave sea-disposed munitions in place. DoD also found that the recovery of these munitions would likely result in a rapid release of munitions constituents that could cause more harm than would otherwise occur as the munitions continue to deteriorate over time.

For example, DoD found that a munition's deteriorated state and its encrustation by sea life make it virtually impossible to positively identify it as a munition or determine whether it is armed. Therefore, the uncertainty of this information would significantly increase the explosives safety risk posed to DoD personnel, the public, and the environment during recovery operations. As such, the risk to human health and the environment associated with the recovery of sea-disposed munitions is far greater than the risk of leaving the munitions in place and implementing an explosives safety education program, like DoD's 3Rs (Recognize, Retreat, Report) Explosives Safety Education Program.

DoD has programs in place to help ensure explosives safety and protect human health and the environment. DoD proactively uses the 3Rs Program to advise people of the actions to take

¹ DoD focused its research of munitions sea-disposal sites in U.S. coastal waters per Congressional direction in section 314 of the John Warner National Defense Authorization Act for FY 2007.

or avoid if they encounter or inadvertently recover a munition from the ocean. The 3Rs Program also includes explosives safety educational material targeted at the maritime industry and recreational ocean water users (e.g., divers, snorkelers) who may encounter munitions. DoD tailors its 3Rs Program to site-specific or location-specific conditions, targeted communities (e.g., maritime industry), or specific activities (e.g., recreational divers) to help ensure protectiveness. If a sea-disposed munition is determined to pose an unacceptable risk to the public or critical assets, DoD dispatches DoD explosives ordnance disposal personnel to prevent an accidental detonation.

DoD determined, based on its comprehensive research to date, that the potential health effects from sea-disposed munitions within U.S. coastal waters appear to be minimal. As such, DoD does not plan to clean up sea-disposal munitions sites in U.S. coastal waters. However, DoD will continue to support munitions and explosives emergencies that involve sea-disposed munitions that pose an unacceptable risk to the public or are inadvertently recovered during maritime activities.

DoD will continue targeted research to (1) determine the potential effects of different munitions constituents on marine life; and (2) assist in locating sea-disposed munitions in dynamic environments (e.g., surf zone) that can force munitions to the beach where they may pose an unacceptable risk to the public. Additionally, DoD intends to conduct follow-on monitoring at its study sites to determine whether a change in the munitions' condition has affected the ocean environment.

DoD believes its research and that of the international community provides sufficient information about the potential effects of sea-disposed munitions on the ocean environment. As such, DoD does not believe that research of additional munitions sea-disposal sites in U.S. coastal waters would provide significantly different findings.

I. STATUS OF DOD'S RESEARCH TO DATE

DoD researched the potential effects of sea-disposed munitions on the ocean environment and those that use it at two munitions sea-disposal sites in U.S. coastal waters in Hawaii. Both sites (Ordnance Reef and the Hawaii Undersea Military Munitions Assessment (HUMMA) Study Site) are off the Hawaiian Island of Oahu. The conditions at the two munitions sea-disposal sites where DoD conducted research, particularly the HUMMA Study Site, are similar to munitions sea-disposal sites in other U.S. coastal water bodies (e.g., Atlantic coast). Therefore, DoD is using this research to draw conclusions about other munitions sea-disposal sites in U.S. coastal waters. The findings from DoD's research at Ordnance Reef (see www.denix.osd.mil/orh/) and the HUMMA Study Site (see www.hummaproject.com) are widely published in peer-reviewed articles². (Many of these articles are available from the Marine Technology Society at <http://www.mtsociety.org/publications/>.)

² Examples of published DoD research on munitions sea-disposal sites:

Carton, Geoffrey, J. C. King, and R. Josh Bowers. "Munitions-related Technology Demonstrations at Ordnance Reef (HI-06), Hawaii." *Marine Technology Society Journal* 46.1 (2012): 63-82.

DoD's research is also well respected and used within the International Dialogue on Underwater Munitions community, a group of international policy, science, and technology experts who collaboratively discuss the risks, options, and procedures for addressing sea-disposed munitions. International consensus supports a preferred long-term approach to limit encounters by documenting munitions sea-disposal locations on nautical charts, restricting access and activities at these locations, and providing safety education to maritime and coastal communities. These actions have proven effective for reducing inadvertent encounters and for reducing the potential effects of such encounters.

Characteristics of Ordnance Reef and the HUMMA Study Site include:

- Ordnance Reef is located from the shoreline to approximately 1.5 nautical miles off Oahu's Waianae coast and contains conventional sea-disposed munitions at depths from 30 to over 300 feet. Because a number of sea-disposed munitions at Ordnance Reef are at depths less than 120 feet, this is considered a shallow-water site. The nearby shore property is used for residential and recreational purposes, with the waters used for maritime recreational activities and reportedly for subsistence fishing.
- HUMMA Study Site is located approximately five miles south of Pearl Harbor in waters in excess of 900 feet deep. Based on vague historical records, the Army believed this site potentially contained sea-disposed chemical warfare material (chemical munitions or bulk containers of chemical agent). As a result, the researchers designed their research effort to investigate both conventional and chemical munitions.

Appendix A summarizes the research studies and study conclusions for Ordnance Reef and the HUMMA Study Site. The table includes the web site link to the full report for further information.

Summary of the Effects of Sea-Disposed Munitions on the Ocean Environment

Ecological Effects

DoD takes a holistic approach when assessing the potential effects of munitions sea-disposal sites on the ocean environment and the people who use the ocean environment. These assessments look at how munitions, human activities, and natural phenomena impact marine life. For example, the waters off the Waianae coast where Ordnance Reef is located are subject to typical community activities (e.g., releases at the Waianae sewage outfall from sewage treatment, storms, runoff from highways) and natural activities (e.g., storms). These activities release contamination (e.g., lead, arsenic) to the ocean environment that may be the same as or similar to the release of munitions constituents from sea-disposed munitions. As such, when studying the

Silva, Jeff AK, and Taylor Chock. "Munitions Integrity and Corrosion Features Observed During the HUMMA Deep-Sea Munitions Disposal Site Investigations." *Deep Sea Research Part II: Topical Studies in Oceanography* (2015).

Edwards, Margo H., et al. "The Hawaii Undersea Military Munitions Assessment." *Deep Sea Research Part II: Topical Studies in Oceanography* 128 (2016): 4-13.

potential effects of sea-disposed munitions on human health and the ocean environment, the study team must identify and consider the cumulative effects of community, naturally-occurring, and munitions activities on the ocean environment.

At Ordnance Reef, researchers observed that area marine life is vibrant and concluded that there were no significant adverse effects from munitions on the reef community. Sea-disposed munitions have become habitat for marine life, with most of the munitions encrusted by corals. DoD's research has determined that these munitions, which have been present on the reef for over 60 years, do not pose a significant effect on human health or the environment. Based on its research, which included a demonstration of removal and disposal technologies, DoD believes action to recover sea-disposed munitions must be balanced against the potential harm to the reef community and increased explosives safety risk to workers and the surrounding communities. The researchers made similar observations at the HUMMA Study Site, which provide habitat for marine life at deeper depths.

Human Health Effects

A majority of munitions sea-disposal sites in U.S. coastal waters are in deep ocean water (e.g., depth over 900 feet), with munitions dispersed over a wide area. Key factors to determine whether munitions constituents pose a human health hazard are the quantity and dispersal of munitions within a munitions sea-disposal site, the depth of the disposal area, the effects of currents (e.g., direction, speed) and tidal flushing, and the quantity of munitions constituents released in a given period of time.

Based on laboratory and field research, DoD concluded that sea-disposed munitions in U.S. coastal waters pose no adverse effects on human health and the environment. Munitions constituents released to the marine environment: (1) may be released in such small quantities and not concentrated enough to be toxic; (2) degrade quickly; (3) do not bioaccumulate; and (4) do not appear to present a risk of exposure or toxicity to either human health or the environment. Moreover, sampling at both Ordnance Reef and the HUMMA Study Site did not detect munitions constituents in seawater and only detected low concentrations in the sediment. The detected concentrations rapidly decreased with increasing distance from the munitions.

For the HUMMA Study Site, where the depth of sea-disposed munitions range from 900 feet to over 1,800 feet, the maximum chemical agent (e.g., mustard) detection was in low parts per million. Chemical analysis revealed the detections were primarily limited to the vicinity of the munitions (e.g., within two meters). Analysis showed chemical agents and degradation products in sediments, but not biological samples. Analysis also showed explosives in biological samples (i.e., shrimp), but not sediments. Under current and potential future uses of the HUMMA Study Site, the health risks are within the U.S. Environmental Protection Agency (EPA) acceptable levels.

For Ordnance Reef, there is little evidence that munitions constituents from sea-disposed munitions pose a human health hazard to surrounding communities. Some communities reportedly use the area for subsistence. The Ordnance Reef Human Health Risk Assessment survey concluded that risks and hazards are acceptable if consumption is limited to quantities

consumed by an average resident. The conclusion from this risk assessment is consistent with the EPA and the U.S. Food and Drug Administration general consumption advisories for fish and shellfish.

II. FEASIBILITY OF REMOVAL OR REMEDIATION OF MUNITIONS AT SEA-DISPOSAL SITES

DoD has determined that known munitions sea-disposal sites in U.S. coastal waters do not pose an unacceptable risk to ecological, environmental, or human health or to maritime safety. DoD has not disposed of munitions in oceans since 1970.³ Removing or cleaning up these 45-year old munitions sites may pose several significant challenges.

Recovery of Sea-Disposed Munitions

Based on current research, the risk associated with recovering sea-disposed munitions appears to be far greater than the risk of leaving the munitions in place. Recovering sea-disposed munitions may cause them to either break apart and release their contents or detonate. Either scenario can have an adverse effect on human health and the environment.

An accidental detonation during recovery can destroy habitat, including protected or sensitive corals, injure mammals and other sea-life, or result in injury to workers or the public. Consistent with the DoD Explosives Safety Board's (DDESB's) recommendation, the Army implemented a comprehensive, targeted 3Rs explosives safety education program for the communities near Ordnance Reef. This program educated the public on munitions and, when followed, helps protect the local community from the explosives safety risks associated with the sea-disposed munitions present on the reef.

Destruction of Successfully Recovered Sea-Disposed Munitions

The demonstration of recovery technology concluded that once a sea-disposed munition is recovered from the ocean floor, its explosive risk increases until the munition is destroyed and the explosive or chemical agent hazard is removed. During the recovery process DoD must take actions to protect its workers, the public, recovery assets, and the environment in the event of an accidental detonation. For example, at the HUMMA Study Site, DoD found that recovery was directly affected by the type of sea-disposed munitions present (e.g., thick-skinned projectiles, thin-skinned bombs) and deteriorated state. The research showed that thinned-skinned chemical munitions are deteriorated to a point that recovery would likely result in a rapid release of more constituents than would slowly occur over time as the munitions continue to deteriorate. The rapid release could lead to greater concentrations of constituents and potential effects on human health and the environment. Many compounds (e.g., chemical agents) are degraded or continue to release at a slow rate. The low concentrations detected and the concentrations expected with the slow release over time do not have a significant effect on human health and the environment.

³ In 1969, the National Academy of Sciences released a report recommending that munitions be safety neutralized or destroyed as opposed to burying them intact on land or at sea. In 1972, Congress enacted the Ocean Dumping Act to prohibit the disposal of waste into the ocean waters of the United States, including prohibition of the offshore disposal of chemical warfare agents.

Upon recovery of a sea-disposed munition from the ocean floor, DoD must take some action to remove the explosive or chemical agent hazard. Due to the munitions deteriorated state, this increases the explosive risks to DoD personnel and the public until the munition can be transported to a location to be destroyed. Therefore, as indicated previously, safety considerations for DoD personnel and the public during recovery actions of sea-disposed munitions must be balanced against environmental effects.

Prior to its research at Ordnance Reef, several options were considered for addressing recovered sea-disposed munitions, including transporting recovered munitions to the beach or a safe location for destruction, floating munitions to a controlled area for destruction, or destroying recovered munitions at sea. Because of the greater explosive risk posed by these options, it was decided to destroy the munitions at sea and implement protective measures to reduce the explosives risk to DoD personnel and the public. Protective measures included:

- Establishing DDESB-approved explosives safety quantity distances from publicly accessible areas (e.g., beaches, residences, marinas);
- Establishing and enforcing exclusion zones for commercial vessels and recreational boats;
- Establishing a shielded control room on the barge to mount the energetics hazard destruction system;
- Imposing personnel restrictions during recovery and destruction operations at sea; and
- Using protective shielding within the energetics hazard destruction system, both for remote cutting operations and destruction of munitions.

At Ordnance Reef, the researchers learned that they could not easily recover sea-disposed munitions because the munitions had become cemented to the sea floor by coral encrustation.⁴

III. RECOMMENDATIONS FOR ADDITIONAL RESEARCH

DoD recognizes that each sea-disposal munitions site in U.S. coastal waters may differ slightly given currents, tides, and water column profile (i.e., temperature and salinity). However, based on our research, these variances would not provide significantly different findings. Sites located in stagnant waters, like the Baltic Sea where there is minimal water movement are likely to provide vastly different findings from those in U.S. coastal waters. It should be noted that none of the munitions sea-disposal sites in DoD's inventory are located in stagnant water. DoD can extrapolate information from the conclusions of its studies about the effects from the sea-disposed munitions in Hawaii and apply this information to munitions sea-disposal sites in other U.S. coastal waters. Additional research on munitions sea-disposal sites in other U.S. coastal waters are unlikely to provide different conclusions on how the coastal waters impact munitions than those drawn from existing research presented in this report.

⁴ The recoveries conducted or attempted during this demonstration resulted in minimal damage to coral and habitat that the sea-disposed munitions had created. However, it should be understood that the munitions the researchers selected for recovery were in areas surveyed by National Oceanic and Atmospheric Administration (NOAA) where NOAA had indicated damage would be minimized.

However, DoD believes that additional research, in targeted laboratories, is needed to determine the potential effects munitions constituents may have on marine life, including coral. Some additional research is needed to assist in locating sea-disposed munitions, particularly those in the surf zone or similar dynamic environments that can force munitions to the beach where they may pose an unacceptable risk to the public. Additionally, follow-on monitoring may be necessary at Ordnance Reef and HUMMA Study Site within the next 10-15 years given the types of munitions present and the potential effect on the coral reef. DoD intends, subject to the availability of funds, to demonstrate technology to remove the fill (e.g., explosives) from sea-disposed munitions in place without removing them from the water. Based on DoD's research to date and its current inventory, Table 1 presents a description and timelines, if known, for DoD's recommended future research initiatives.

Table 1: DoD Recommendations for Future Research Initiatives at Munitions Sea-Disposal Sites

Site / Timeframe	Description
Site: HUMMA Study Timeline: 2018 - 2020	Re-visit the HUMMA Study Site within the next 10-15 years to conduct another round of sampling near sea-disposed chemical munitions present at the site. Research to-date showed that the slightest disturbance (e.g., a touch during sampling) can cause sea-disposed chemical munitions, which are thinned skinned, to disintegrate. The Army believes additional sampling at the HUMMA Study Site would be beneficial to better understand the potential effect of chemical munitions on the ocean and the rate of deterioration.
Site: Ordnance Reef Timeline: 2020 - 2030	Monitoring the conventional munitions present at Ordnance Reef within the next 10-15 years to determine whether a change in the munitions' condition (e.g., deterioration) has affected the reef. DoD will consider the type of munitions present, the time span of the studies already complete, and the level of information known and data collected on the munitions to determine the scope of and necessity for monitoring.
Site: TBD Timeline: Upon availability of funding (approximately \$5M)	Prove that a technological approach to recover a munition's fill (e.g., explosive munitions constituents, chemical agent) without removing the munition from the ocean environment is feasible, and demonstrate the technology's ability to both render a munition safe by removing the fuze, recovering the fill and leaving the munitions body in place. The advantage of this approach include: <ul style="list-style-type: none"> ▪ Eliminating the risk to response workers and the public during recovery and avoiding potentially significant and costly environmental damage. ▪ Replacing current procedures that require munitions to be recovered and destroyed on the surface or destroyed in place by detonation. Both of which may destroy critical habitat and increase the risk to workers or the public. ▪ Leaving munitions casings, which provide habitat for marine life, in place unless such munitions are determined to pose an unacceptable risk to human safety.
Site: NA Timeline: 2013 - on-going	<ul style="list-style-type: none"> ▪ Study the uptake and toxicity of munitions constituents to aquatic organisms and publish these studies in peer-reviewed publications. These type studies are in controlled environments (i.e., aquariums in laboratories).

CONCLUSION

DoD's research at Ordnance Reef and the HUMMA Study Site show that sea-disposed munitions do not pose a significant threat to human health and the environment. Attempting to recover and remove these munitions from the water would have more serious consequences, such

as a rapid release of munitions constituents and harm to existing habitat and coral. DoD believes it is best to leave the sea-disposed munitions in place unless there is an explosives emergency or serious threat to human health or the environment. If an emergency situation arises, DoD has programs in place to address it. DoD will continue its research in support of sea-disposed munitions to ensure protection of human health and the environment.