

Introduction

Beginning during World War II and continuing through the twentieth century, Vieques Island served as the Navy’s premier training range for ensuring combat readiness of U.S. forces and NATO allies. Over that time, more than 300,000 munitions were fired onto the land and surrounding waters during military training operations. Military training activities ceased in 2001, and between then and 2003 the former installation was transferred to federal and local agencies, mostly for conservation as part of the Vieques National Wildlife Refuge.



Figure 1. The former Vieques Naval Installation is 23,000 acres, with another 12,000 acres of surrounding waters.

In response to the Commonwealth of Puerto Rico identifying Vieques as its highest priority for cleanup, the 23,000-acre former training facility and another 12,000 acres offshore were placed on the National Priorities List (NPL) in 2005 for cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Since that time, nearly 120,000 potentially explosive munitions have been eliminated, over 8 million munitions and munitions-related material have been removed from the former training ranges, and over 17 million pounds of this material has been recycled. The environmental restoration of Vieques remains the highest priority and the costliest project in the Navy's Munitions Response Program.



Figure 2. Due to unique regulatory, environmental, and natural and cultural resource conditions associated with Vieques, NAVFAC Atlantic teams with over a dozen Federal and Commonwealth agencies throughout the East Coast and Puerto Rico. To promote effective communications, the Vieques Environmental Restoration Program Team meets frequently among themselves and with the many other stakeholders, including the local community, academia, and scientific organizations.

The refuge and surrounding waters host a variety of natural resources, including sensitive habitats such as mangroves, subtropical dry forests, lagoons, and coral reefs, and endangered species such as sea turtles, manatees, and brown pelicans. As the cleanup progresses, areas are opened to the general public for recreation and for access to culturally significant sites.

Background

The environmental restoration of Vieques faces the challenges of unexploded ordnance (UXO) and associated contaminants across more than 25,000 acres of land and seafloor, abundant ecologically and culturally sensitive resources, and the often-disparate objectives of numerous stakeholders, including the local community, educational and scientific organizations, and various advocacy groups. To meet these challenges, the Vieques Environmental Restoration Program Team comprises representatives from Naval Facilities Engineering Systems Command (NAVFAC) Atlantic, the Environmental Protection Agency (EPA), Puerto Rico Department of Natural and Environmental Resources (PRDNER), National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Department of Interior (DOI), and United States Fish and Wildlife Service (USFWS).

Team Purpose and Goals

The 2007 Federal Facilities Agreement (FFA) establishes the framework under CERCLA for the stakeholder agencies on the Vieques team to collaboratively implement the Environmental Restoration Program to achieve the following objectives:

- Develop safe, innovative, and cost-effective techniques to reduce risk
- Engage the local community to promote safety and public involvement in the cleanup process
- Apply sustainable approaches to preserve sensitive habitat and endangered species
- Partner with federal, commonwealth, and local authorities to return land to beneficial reuse as quickly as possible
- Support the DoD research community in developing and transferring new approaches to others

Summary of Accomplishments

Accelerated Environmental Cleanup and Green Remediation

Site Prioritization and Sustainable Remediation Accelerates Beneficial Reuse of over 5,000 Acres – In a collaborative effort among the Navy, USFWS, and regulatory stakeholder agencies, a large portion of the former Eastern Maneuver Area (EMA) was prioritized for accelerated cleanup. This 5,300-acre area represents over 35 percent of the former Vieques Naval Training Range (VNTR), and it contains miles of trails planned for public hiking, biking, horseback riding, and nature observation. In addition, the EMA



Figure 3. Nineteenth-century Spanish lighthouse, one of the many cultural, natural, and recreational destinations the Navy and other stakeholder agencies are making available to the public via site cleanup prioritization.

contains large areas designated for permitted activities that will support the local economy, such as hunting and land crab hunting. The EMA also contains significant cultural resources including a 19th century lighthouse and a freshwater spring known in local legend as the “fountain of youth.” Typically, a munitions cleanup would involve vegetation clearance and surface removal across 100 percent of a site; however, to foster accelerated public access to areas of the EMA, the stakeholder agencies worked together for many months to develop a “green” cleanup strategy that limits munitions removal to areas of planned public use and deters access to other areas, thereby protecting public safety and preserving the dense vegetative cover and valuable habitat across 99 percent of the site’s 5,300 acres. This green, accelerated approach was formalized in a Record of Decision (ROD) for the majority of the EMA signed by the agencies in January 2021. In addition to preserving a vast area of natural habitat, reducing the carbon footprint of the remedy by 99 percent, and accelerating both cleanup and beneficial reuse by over 10 years, the remedial actions at the EMA are estimated to save the Navy over \$100M compared to a conventional approach.

Reducing Risk to Human Health and the Environment

Offshore Public Safety and Ecology

Preservation – During past military training at Vieques, short falls, overshoots, explosive arcs, and offshore targets have resulted in a significant amount of underwater munitions in the offshore environment. There are more than 30 miles of coastline surrounding the former VNTR, including a number of beaches and nearshore waters that are highly sought out by boaters and beachgoers, who trespass in these areas despite the presence of underwater munitions. In response, the Navy has implemented a three-pronged approach to protect the public from underwater explosive hazards. First, the already robust community outreach program has been expanded to include educational flyers, warning signs, and buoys that increase public awareness of underwater munitions. Second, the Navy collaborated closely with the U.S. Coast Guard to implement and provide for enforcement of offshore “Safety Zones” intended to deter boater access to restricted areas. The Safety Zones and associated enforcement mechanisms were formally established in the Code of Federal Regulations on April 1, 2021.

Third, the Navy initiated expedited removal of underwater munitions lying just offshore of six of the most frequented beaches along the former VNTR. While removing underwater munitions and enhancing public safety were primary goals, a significant component of the munitions removal action was the



Figure 4. A 1,000-lb bomb resting on the ocean floor is among the 320 underwater munitions the Navy has removed to prioritize public safety at popular beaches.

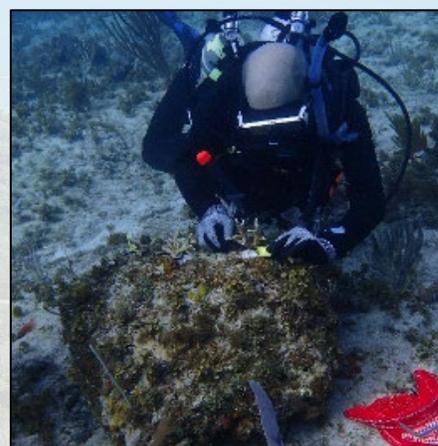


Figure 5. Scientific diver transplanting and tagging endangered staghorn coral detached from a munition prior to its removal from the seafloor. The coral relocation process was jointly developed by the Navy and National Marine Fisheries Service to protect marine ecology during underwater munitions cleanup.

protection of marine ecology. The protective measures were jointly developed by the Navy and National Marine Fisheries Service (NMFS) via a programmatic underwater Biological Assessment and associated Biological Opinion. To achieve both the safety and ecological protection objectives, the Navy assembled an integrated team of munitions divers to safely remove munitions from the seafloor, and scientific divers to ensure the protection of threatened and endangered coral species, critical fish habitat, and other marine life. In some cases, there were corals growing directly on or immediately adjacent to a munition planned for removal. In these circumstances, the scientific divers specially trained in relocation techniques transferred these corals to another location to protect them from damage or destruction during removal of the munition. Between October 2019 and August 2021, this collaborative effort resulted in the removal of 320 munitions from the nearshore environment, protection of the marine ecology, and the transplantation of dozens of coral specimens.

Underwater Munitions Remedial Action to Support Recreational Use while Conserving Ecological Resources – On the west end of Vieques, there is a 200-acre offshore site where underwater munitions may be present as a result of historical open burn/open detonation (OB/OD) operations at the adjacent terrestrial site. The underwater site is desired by the public for recreational uses such as wading, swimming, snorkeling, and fishing. Additionally, the site supports a broad, vibrant coral reef community. In recognition of these co-located features, the Navy and regulatory agencies jointly developed a unique remedial approach that focuses on the likely ways in which recreational users may contact the seafloor where munitions could be present. During this process, the Navy presented evidence that the offshore recreational users would not come in contact with buried munitions. As a result, the regulatory agencies agreed to confine the remedial action to surface clearance of the seafloor in a relatively narrow near-shore area where the potential for bottom contact by all user types is highest, thereby minimizing both the potential explosive hazards and potential deleterious effects on the marine ecological resources across the site. Compared to a munitions clearance involving surface and sub-seafloor removal across 100 percent of the site, the upcoming remedy will save over \$15,000,000 and accelerate beneficial use by several years.

Groundbreaking Technologies and Innovative Strategies

Using Advanced Geophysics to Make Public Beaches Safe – Ongoing beach investigations recently raised concern about the potential presence of munitions at two Vieques beaches historically open to the public. Based on this, the Navy and regulatory agencies moved quickly to ensure the beaches remained safe for public use by implementing an Advanced Geophysical Classification (AGC)-based Time-Critical Removal Action (TCRA) in early 2021. While over 2,500 subsurface geophysical anomalies were identified



Figure 6. Use of Advanced Geophysical Classification at public beaches reduced the time and cost of a Time-Critical Removal Action (TCRA) by 70% and verified the beaches remained safe for public use.

between both beaches, AGC determined that over 70 percent of the anomalies were not munitions, resulting in over 70-percent reduction in subsurface digging and removal, and over \$500,000 in cost savings. This successful TCRA approach allowed the beaches to be reopened immediately following the TCRA implementation.

Innovative Use of Water Jet Cutting for Disposition of Munitions

– Many of the munitions recovered on Vieques have been documented as safe, but they must be cut into pieces that no longer resemble munitions items prior to sending them to a recycling facility. For large munitions such as 16-inch projectiles and 500- to 2,000-lb bombs, the process is complicated by their large size and weight. Because of this, the Navy sought out an innovative, cost-effective approach to overcome these hurdles. In 2021, the Navy procured a water jet cutting system that uses remotely operated, high-pressure water jet system containing an abrasive material to cut the inert munitions into manageable pieces, thereby enabling the pieces to be shipped offsite for recycling and beneficial reuse.



Figure 7. Inert munitions, including bombs up to 2,000 pounds, awaiting dismantling by the water jet, a system of high-pressure water and abrasive material that can cut munitions into manageable pieces for recycling and beneficial reuse.

Novel Munitions Characterization Approach for Near-shore Waters Adjacent to Public Beaches

– There are 29 beaches within the former VNTR that are currently open to the public or are intended for future public use. In order to accelerate public use of these beaches, the Navy collaborated with the regulatory agencies to identify a 600-acre nearshore area that must be cleared in order to support public use of the adjacent beaches. While characterizing munitions sites on land has unique challenges, doing so in a marine environment significantly elevates the logistical complexity, and the design of CERCLA underwater Remedial Investigations (RIs) is in its infancy. The Navy developed an innovative and efficient investigation approach based on an in-depth analysis of exposure categories, including wading, swimming, snorkeling, scuba diving, spear fishing, and boat anchoring. Using this exposure analysis, the nearshore area was divided into two portions based on the expected potential for contact with munitions. After 2 years of negotiations with the regulatory agencies, the investigation approach has been approved and documented within the RI Quality Assurance Project Plan (QAPP). It will involve divers performing instrument-aided surveys along transects within each area and limited intrusive investigation to determine nature and extent of the underwater munitions. This exposure-based approach addresses real life risk and provides for a rapid and cost-effective characterization across large underwater areas. Through their technical support role on the Navy Munitions Response Workgroup, the Vieques team is sharing this approach with other managers who are beginning to plan underwater investigations throughout the Navy Environmental Restoration Program.

Partnerships with Government, Academic, and Community Stakeholders to Enhance Safety, Protect the Environment, and Reduce Costs

Innovative Approach to Address Munitions Surf-zone Munitions – Within coastal areas, the nearshore represents one of the most complex and logistically challenging environments for munitions remediation but is also where interest in recreational use is highest. Breaking waves, turbulence, and poor underwater visibility combine with the explosive hazard to make the removal of munitions in this area inherently difficult, labor-intensive, dangerous, and costly. In response to an Environmental Security Technology Certification Program (ESTCP) Munitions Response in Underwater Environments solicitation, a proposal was approved to demonstrate a breakthrough in the long-standing problem of addressing surf-zone explosive hazards. The research project, which is currently being planned for 2022 implementation, will utilize temporary, inflatable cofferdams to perform nearshore dewatering adjacent to beaches in Vieques that represent a variety of conditions such as beach size, water depths, and wave frequency, magnitude, and direction. The dewatering will allow munitions removal to be performed faster, safer, and more economically with conventional land-based methods.

Mobile, Buoyant Artificial Reef Offers Innovative Coral Mitigation Opportunities – Along with addressing the underwater munitions associated with past military training in Vieques and around the world, protecting the marine ecology is an integral component of the Navy’s cleanup mission. In fact, where coral reefs and threatened and endangered coral species may be impacted by Navy cleanup activities, mitigation measures may be legally required. To help meet this challenge, the Navy is partnering with researchers from the Naval Information Warfare Center Pacific (NIWC Pacific), Harvard, and San Diego State University to demonstrate the use of coral reef “arks” for the restoration and conservation of coral reef resources. The “ark” is an 8-foot-diameter geodesic sphere comprising triangular sub-elements to which platforms containing transplanted and naturally recruited corals and other biota are attached to form the buoyant “reef.” As part of this demonstration project, conducted under ESTCP, the Vieques team has provided a location to do the work, logistical support, and an integrated team of engineering divers and scientific divers to help deploy two ark structures.

In the coming years, the Navy will continue to support NIWC and academic researchers during periodic monitoring to evaluate the reef development and the degree to which coral arks can support reef mitigation measures.



Figure 8. The first-of-its-kind mobile, buoyant artificial reef, nicknamed “ark” being prepared for deployment offshore of Vieques to evaluate its potential use for marine ecology mitigation in underwater areas impacted by Navy cleanup.

Groundbreaking Autonomous Technology Significantly Enhances Data Collection Capabilities at Underwater Munitions Sites

– It is estimated that tens of thousands of munitions lie on or beneath the seafloor just offshore of the former VNTR. Characterizing these areas is labor-intensive, costly, and subject to the risk and delays inherent to diving. To enhance safety and reduce costs, the Navy partnered with NIWC Pacific and U.S. Army Corps of Engineers Development and Research Center (USACE ERDC) to demonstrate the use of an autonomous, long-range, semi-submersible technology known as SubSeaSail to collect data heretofore impractical to collect using divers or other conventional techniques. The technology demonstration included deployment in open, coastal deep water and in relatively shallow bays around Vieques, while exhibiting the platform designed to support remote sampling devices and other environmental sensors. Results of the field demonstration are currently being evaluated for potential full-scale application to support underwater munitions characterization and remediation at sites across the country.



Figure 9. SubSeaSail, an autonomous semi-submersible capable of collecting critical scientific data, being field-tested in a Vieques bay containing thousands of munitions on and beneath the seafloor.

Innovative Virtual Community Involvement Program amid Global Pandemic

– One of the Environmental Restoration Program Team priorities is to ensure the Vieques community is engaged in the cleanup process. The global Coronavirus

(COVID-19) pandemic presented a new and unique challenge of ensuring the community remains actively involved in the cleanup despite the historic restrictions imposed on in-person interaction. In response, the Navy designed and implemented “virtual” platforms that have allowed for continued public engagement while ensuring compliance with Federal and Commonwealth restrictions.

Restoration Advisory Board (RAB) and public meetings, two of the primary mechanisms for two-way dialogue about the cleanup, continued throughout 2020 and 2021 using a virtual platform format and content that are comparable to those of traditional meetings whereby stakeholder agencies and community members share information, provide comments, and ask questions in a real-time, interactive manner. In addition, because pandemic-related restrictions did not allow for in-person interviews for the 2021 Community Involvement Plan update, the Navy developed a detailed questionnaire, mailed and emailed the questionnaire to all Vieques residents, announced the availability of the questionnaire via social media and the Navy’s Vieques public website, and conducted two month-long online public survey events to solicit feedback. Evidence that this multi-media approach was successful was the receipt of filled questionnaires from 132 Vieques residents, business owners, civic organizations, public and elected officials, community leaders, and members of environmental groups that provided insightful feedback on the community outreach program, including recommendations for continued enhancements.