Studying Military Expended Materials in the Marine Environment

NESDI & ESTCP Projects Assess Impact of Materials, Develop Biodegradable Substitute

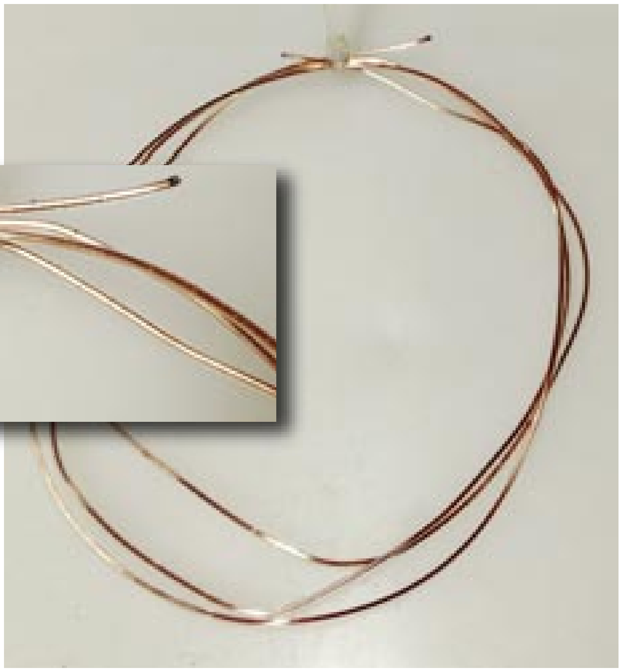
TWO PROJECTS ARE studying the potential environmental impacts of Military Expended Materials (MEM) including copper guidance wire and sonobuoy decelerators (parachutes), and evaluating the use of biodegradable alternatives for those parachutes.

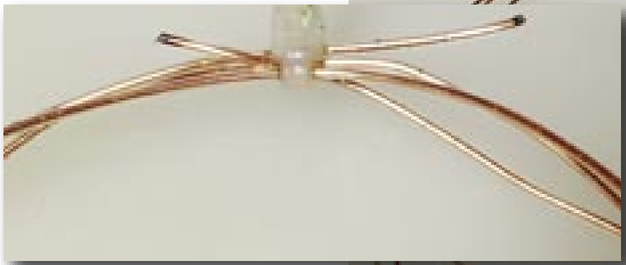
MEM are defined as munitions, items, devices, equipment, and materials which are uniquely military in nature and are used and expended in the conduct of the military training and testing missions. Examples include sonobuoys, flares, chaff, drones, targets, weights, and guidance wires. These items may result in a chemical or physical hazard to marine life. To promote environmental stewardship, a better understanding of the potential environmental impacts of these materials is needed.

Personnel from the Space and Naval Warfare Systems Command—Systems Center Pacific (SSC Pacific) in San Diego, CA with funding provided by the Navy Environmental Sustainability Development to Integration (NESDI) program, have identified and provided an in-depth analysis of two MEM items. These two items, copper-based torpedo guidance wire and nylon sonobuoy parachutes, were chosen based on data gaps identified by experts from the Navy's range community. The Department of Defense's (DoD) Environmental Security Technology Certification Program (ESTCP) has funded a multi-agency project to evaluate the use of biodegradable sonobuoy parachutes as a replacement to the traditional nylon parachutes.

Copper-based Torpedo Guidance Wire

The conceptual approach used in this NESDI study was to identify potential environmental impact pathways from torpedo guidance wire to the marine environment and to





Copper torpedo guidance wire with plastic coating intact after 45 days.

INSET: After 45 days, only the tips of the copper wire experienced any corrosion.

evaluate each pathway through empirically derived data and/or peer-reviewed literature. The study approach focused on site-specific environmental characteristics and marine species relevant to the training areas where copper guidance wire is used.

The potential risks (or stressors) identified for torpedo guidance wire were both chemical (leached copper) and physical (entanglement hazard). A series of experiments and analyses were carried out to evaluate the various stressors. These included experiments to quantify copper leach rate over time and under various degrees of plastic coating degradation, mechanisms of coating degradation, toxicity testing, guidance wire sinking rate, and breaking strength. Additionally, a simple copper dispersion model was developed to predict water column and sediment concentrations. A list of known marine mammals and sea turtles identified in the Navy testing range areas was assembled and analyzed with respect to diving and foraging behavior to assess the potential for entanglement.

The evaluation of copper leached into the marine environment as a potential stressor suggests that there is no negative impact to the water column, sediments, and organisms living within these environments. Predicted water column and sediment copper concentrations are below the water quality criteria, sediment guidelines, and predicted toxicity endpoints.

Evaluation of the guidance wire as a potential physical stressor suggests that there is an extremely low entanglement potential for animals found within the range areas. The physical characteristics of the wire (breaking strength and reluctance to looping or coiling) and sea floor habitat types,

The Basics About ESTCP

ESTCP IS DoD'S environmental technology demonstration and validation program. The program was established in 1995 to promote the transfer of innovative technologies that have successfully established proof of concept to field or production use. ESTCP demonstrations collect cost and performance data to overcome the barriers to employ an innovative technology because of concerns regarding technical or programmatic risk.

The program's goal is to identify and demonstrate the most promising innovative and cost-effective technologies and methods that address DoD's high-priority environmental requirements. Projects conduct formal demonstrations at DoD facilities and sites in operational settings to document and validate improved performance and cost savings. To ensure the demonstrated technologies have a real impact, ESTCP collaborates with end users and regulators throughout the development and execution of each demonstration. Transition challenges are overcome with rigorous and well-documented demonstrations that provide the information needed by all stakeholders for acceptance of the technology.

ESTCP issues an annual solicitation for proposals from the Federal government, academia, and industry and employs a competitive selection process to ensure that ESTCP funds high-quality demonstrations. ESTCP requires each project to develop a formal test and evaluation plan. Demonstration results are subject to rigorous technical reviews to ensure that the conclusions are accurate and well supported by data.

ESTCP is managed by a Director and Deputy Director, five Program Managers, and a Financial Officer. The ESTCP office is co-located with the Strategic Environmental Research and Development Program (SERDP) in Alexandria, VA. In this joint program structure, the management staff has insight into the entire range of scientific and technical issues associated with an environmental problem, from basic research questions through implementation. ESTCP relies on the technical skills offered by the participating Services serving on its technical committees to assist in the technical aspects of program development, project selection, program monitoring, and technology transfer.

ESTCP projects are managed within the following five program areas:

1. Energy and Water
2. Environmental Restoration
3. Munitions Response
4. Resource Conservation and Climate Change
5. Weapons Systems and Platforms

For more information, visit the program's web site at www.serdp-estcp.org.

The first identified MEM, copper wire, is sometimes used to guide torpedoes such as this one.
MC1 Ricardo Danan

coupled with minimal exposure potential to marine mammals (based on diving and foraging behaviors) minimizes any potential entanglement threat. These data suggest that torpedo guidance wire does not present a significant chemical or physical hazard to the marine environment.

A technical report evaluating the guidance wire titled, "Copper Based Torpedo Guidance Wire: Applications and Environmental Considerations," has been finalized and can be obtained by contacting Brandon Swope, Principal Investigator for this NESDI study.

Nylon Sonobuoy Parachutes

Sonobuoys are acoustic transmitters deployed from aircraft during anti-submarine training. To ensure that the sonobuoy is not damaged during water entry, a nylon parachute is attached and deployed. The parachute separates from the sonobuoy following contact with the water and sinks through the water column, ultimately settling on the sea floor. To identify and evaluate potential environmental impact pathways from nylon sonobuoy parachutes, the project team used a conceptual model approach similar to that used with the copper guidance wire. Researchers focused on site-specific environmental characteristics and marine species relevant to the training areas where sonobuoy testing occurs. Potential hazards identified were entanglement, ingestion, and smothering.

The results of the evaluation suggest that sonobuoy parachutes do not present a significant physical hazard to the marine environment. The potential for entanglement, ingestion, or smothering to occur are low based on the following reasons:

- Short duration the parachute is on the surface or sinking through the water column
- Deep water depths where the parachutes come to rest
- Low numbers of parachutes deployed relative to the size of range area

A technical report titled, "Nylon Sonobuoy Parachutes: Applications and Environmental Considerations" is in final review and will be available shortly by contacting Brandon Swope.

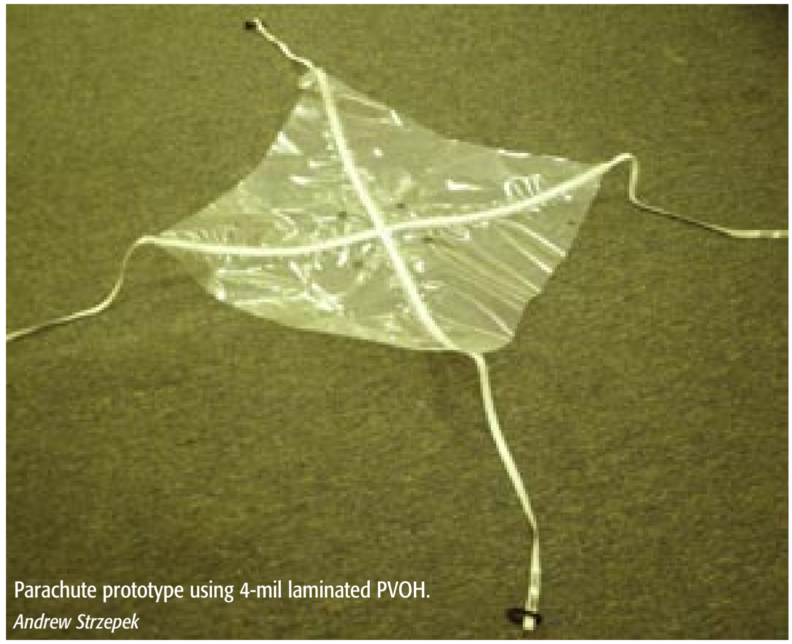
Biodegradable Sonobuoy Parachutes

Although the traditional nylon sonobuoy parachutes present minimal risk to marine life, an investigation into alternative materials has been initiated to help with overall environmental stewardship and pollution prevention measures.

A multi-agency team was funded by ESTCP to optimize a dissolving and biodegradable material for use in Navy sonobuoy parachutes. Project partners include personnel from the following organizations:

- Naval Air Warfare Center Weapons Division, China Lake, California

- Naval Air Warfare Center Aircraft Division, Patuxent River, Maryland
- Natick Soldier Research and Development Engineering Center, Natick, Massachusetts
- Space and Naval Warfare Systems Command—Systems Center Pacific
- Naval Facilities Atlantic
- Navy Region Northwest
- Naval Undersea Warfare Division, Newport, Rhode Island



Parachute prototype using 4-mil laminated PVOH.
Andrew Strzepek

First, the team developed a clear and effective testing protocol for candidate materials. Materials were identified and tested for dissolution, biodegradability, strength, and toxicity. In order for a biodegradable material to replace the traditional nylon parachute material, it must meet all current requirements and specifications. These metrics include strength, load bearing capacity, durability, shelf life requirements, and the ability to fit into the current sonobuoy housing. The material also needs to withstand a variety of weather conditions—maintaining strength during a rainstorm, yet dissolving rapidly in the marine setting to achieve the environmental goals (30 minutes in the warm water off Florida coast and 12 hours in the colder water off the northwest U.S. coast).

Two candidate materials were chosen for testing and evaluation, a polyvinyl alcohol (PVOH) film and a blend of PVOH and polyhydroxyalkanoate (PHA) materials. Several films from domestic suppliers were evaluated for tensile strength and disintegration time in both fresh and saltwater at various temperatures. Higher grades of the material had increased strength, but would neither disintegrate nor dissolve in seawater rapidly enough to meet the study goals. Ultimately, a warm-water soluble grade PVOH film (A200, Monosol Inc.) with a thickness of 50 microns (0.002 inches) was selected for prototype development. Disintegration times ranged from 50 seconds to eight minutes for freshwater, and 20 minutes to three hours for saltwater in temperatures ranging from 20 degrees to 5 degrees Celsius (68 to 41 degrees Farenheit).

During initial testing, it was determined that in order to meet the engineering requirements related to strength and

The Basics About the NESDI Program

THE NESDI PROGRAM seeks to provide solutions by demonstrating, validating and integrating innovative technologies, processes, materials, and filling knowledge gaps to minimize operational environmental risks, constraints and costs while ensuring Fleet readiness. The program accomplishes this mission through the evaluation of cost-effective technologies, processes, materials and knowledge that enhance environmental readiness of naval shore activities and ensure they can be integrated into weapons system acquisition programs.

The NESDI program is the Navy's environmental shoreside (6.4) Research, Development, Test and Evaluation program. The program is sponsored by the Chief of Naval Operations Energy and Environmental Readiness Division and managed by the Naval Facilities Engineering Command out of the Naval Facilities Engineering and Expeditionary Warfare Center in Port Hueneme, California. The program is the Navy's complement to the Department of Defense's ESTCP which conducts demonstration and validation of technologies important to the tri-Services, U.S. Environmental Protection Agency and Department of Energy.

For more information, visit the NESDI program web site at www.nesdi.navy.mil or contact Leslie Karr, the NESDI Program Manager at 805-982-1618, DSN: 551-1618 or leslie.karr@navy.mil.

Polyvinyl alcohol (PVOH) being dissolved for use in toxicity testing.
Brandon Swope

Newly designed woven PVA decelerator prototype.
Andrew Strzepek

load bearing capacity, layers of the PVOH film would need to be laminated together to achieve a greater thickness. Commercial lamination trials were successful, and rolls of 2-layer, 3-layer, and 4-layer films were developed. Various laboratory tests were then conducted on the un-laminated and laminated films. Tensile testing was carried out to determine the mechanical strength of the materials. Water exposure tests were also conducted to evaluate tensile strength during simulated rainfall. Lastly, toxicity bioassays were performed on the various films using mussel larvae, sea urchin larvae, mysid shrimp, and topsmelt.

The results of the intensive testing identified several performance gaps, ultimately concluding that the laminated PVOH film was not suitable for further field demonstration. These performance gaps include:

- Adverse affect of rain on the parachute. Half of the parachutes strength was lost during rain testing, which will likely cause the parachute to fail upon ocean entry.
- Increased stiffness of the thicker film. Increased stiffness, especially at cold temperatures, created packing issues when loading into a sonobuoy. Increased stiffness could also cause excessive opening times or failure to open.
- Lack of film permeability. Because the material blocks airflow, the initial shock following deployment results in a high degree of mechanical stress and may lead to parachute failure.
- Toxicity related to lamination process. The unlaminated PVOH showed no toxicity to all four species being tested. However, two of the more sensitive species (mussel larvae and sea urchin larvae) showed toxicity at low concentrations of the laminated material. It was

Weaving process for the new PVA parachute prototype.
Andrew Strzepek

Sonobuoys are dropped from aircraft where they parachute to the surface of the water.
MC1 Kirk Worley

determined that residual ethyl acetate from the adhesive used in lamination process was most likely the causative agent.

The testing results concluded that the initial parachute design required further development to improve strength and pliability. This led to a revised study approach utilizing the other candidate material, PHA, and a new manufacturing process. The new manufacturing tactic utilized a woven design which increased permeability and overall mechanical strength. Two smaller scale parachutes were successfully manufactured out of PHA utilizing the weaving technique. These parachutes were then evaluated during a drop test from a hovering Blackhawk helicopter. The drop height was 1,100 feet with a load of 12 pounds. The velocity at opening was determined to be 154 miles per hour (225 feet per second). The prototype canopy did not show any signs of damage and the test load did not sustain any major damage upon impact. The new woven parachute design has potential to meet all of the requirements needed for a successful nylon replacement.

After assessing the results of these efforts, ESTCP has decided to halt funding on this effort until more basic research is carried out to ensure the newly developed material is appropriate for full scale demonstration and validation. Alternate funding sources to complete the research and development are being pursued. ⚓

For More Information

FOR MORE INFORMATION on this project, visit www.serdp.org, enter “WP-201222” in the search box, and select the link for “Biodegradable Sonobuoy Decelerators.”

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