

Natural Selections



Department of Defense Natural Resources Program



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EELGRASS: A NATURAL PARTNER IN NAVY SUCCESS

By Jessica Curran, Navy Region Southwest, and Megan Hanna, Naval Facilities Engineering Systems Command Southwest

Scientists have long recognized eelgrass (*Zostera marina*) for its role in providing refuge for marine life, enhancing water quality, cycling nutrients, sequestering carbon dioxide, and buffering against coastal erosion. For these reasons, this humble marine plant has emerged as a critical force in supporting the Navy's mission and coastal resilience objectives.

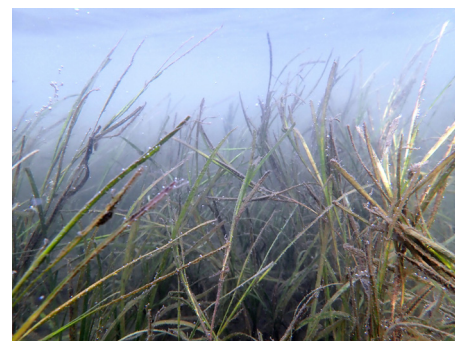


Photo of eelgrass (*Zostera marina*) in San Diego Bay. Credit: Merkel & Associates, Inc.

This plant thrives in low-energy tidal environments, such as bays and estuaries in shallow nearshore waters. San Diego Bay, the largest open water embayment in southern California, supports approximately 17% of the state's total eelgrass habitat and serves as a key naval hub. Its deep waters, extensive berthing space, and proximity to the Pacific Ocean make it an ideal, strategically important location for Navy operations and training. The port provides a gateway for maritime transportation of commercial shipping vessels and cruise liners, reinforcing San Diego's economy. Despite the densely urbanized surrounding landscape, the Bay boasts considerable biodiversity, ecosystem complexity, and habitat value. From this juxtaposition of anthropogenic and natural uses, conflict can arise at the wildlife-urban interface.

To minimize conflicts, the Navy and the Port of San Diego (Port) developed the San Diego Bay Integrated Natural Resource Management Plan (INRMP). The plan upholds a comprehensive strategy to balance the Navy and Port operational needs while preserving the Bay's diverse ecosystems, including eelgrass. Successful INRMP implementation is coordinated with natural resource partners including the National Marine Fisheries Service, U.S. Fish and Wildlife Service (FWS), and California Department of Fish and Wildlife. As part of the INRMP, the Navy supports eelgrass conservation through the Navy Eelgrass Mitigation Bank (Bank).



Eelgrass coverage in San Diego Bay. Credit: Merkel & Associates, Inc.

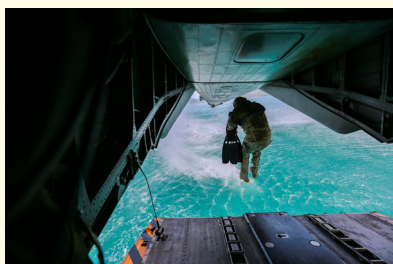
Located in San Diego Bay, the Bank is a proactive initiative facilitating Navy projects by addressing the unavoidable impacts of naval activities on eelgrass habitats. Functioning as a compensatory mitigation approach for unavoidable impacts under the Clean Water Act and Magnuson-Stevens Fishery Conservation and Management Act, the Bank allows the Navy to preemptively invest in creation and enhancement of eelgrass beds as a countermeasure to habitat loss. This investment significantly reduces mitigation costs and consultation time, allowing for timely implementation of mission-critical training and construction projects. This environmentally sustainable innovation aligns with the Navy Chief Sustainability Officer's goals, ensuring a balanced approach to maritime operations and ecosystem preservation.



MESSAGE FROM THE DOD NATURAL RESOURCES PROGRAM

By Ryan Orndorff, Director, Environmental Planning and Conservation

Welcome to the Winter 2024 Edition of *Natural Selections!* Coastal environments play a crucial role in sustaining mission-critical testing, training, and operations. For this issue of *Natural Selections*, we explore the intricate web of marine life around military installations, shedding light on the efforts of committed natural resource management staff and partners devoted to preserving these environments while fulfilling DoD's mission.



Green Berets practice helocasting into the ocean to sustain readiness near Honolulu, Hawai'i. Credit: Sergeant Jake Cox.

DoD operations on the coast and in marine environments are made possible by the critical ecosystem services provided by the marine environment, including supporting biodiversity, providing recreational services, improving water quality, preventing

erosion, sequestering carbon, and moderating extreme weather events. The significance of these services cannot be overstated, especially as we witness the burgeoning challenges posed by climate-driven impacts and ever-growing coastal populations that also affect DoD missions and installations. Rising sea levels, ocean acidification, coastal erosion, marsh migration, coral bleaching, and storm surges are not merely environmental concerns; they directly threaten the very core of our mission-critical operations.

Water quality in coastal areas has also become a focal point, impacting not only coastal and marine biodiversity, but also DoD personnel and operations. Issues such as pollution from runoff, dredging and filling impacts, harmful algal blooms, dead zones, and temperature loading are casting a shadow over the health of



Navy divers monitor the progress of transplanted corals near Naval Base Guam, March 16, 2018. Credit: Alfred A. Coffield.

marine ecosystems. These challenges demand our proactive engagement, and we are committed to addressing them head-on as stewards of our natural heritage. For example, in San Diego Bay, the Navy is focusing on eelgrass restoration to improve local water quality while enhancing mission resilience.

Our DoD Natural Resource Managers (NRMs) stand at the leading edge of innovation in coastal resilience and are leaning forward to support biodiversity. Through a series of projects highlighted in past editions, we've explored initiatives ranging from restoration of ancient Hawaiian fishponds to radio-tagging of sea turtles in the Chesapeake Bay. In this newsletter, we further explore the issues unfolding at the land-sea interface and highlight the solution-driven work to confront these challenges. We

highlight the work DoD is doing to remove invasive algae at Marine Corps Base Hawai'i, use environmental DNA to detect endangered fairy shrimp, and map local hydrology with LiDAR technology in mission-critical waterways.

We are thrilled to include several articles spotlighting some of the DoD programs' efforts towards improving coastal resilience and environmental quality, specifically the Legacy Resource Management Program, Readiness and Environmental Protection Integration (REPI) Program, Sentinel Landscapes Partnership, Southeast Regional Partnership for Planning and Sustainability (SERPPAS), and Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP).

These articles explore ongoing efforts that bolster the work of DoD's NRMs, such as the Legacy Program's initiative to create a comprehensive, nature-based solutions shoreline management

plan for Fort Eustis aimed at combating sea level rise with environmental analysis and targeted management approaches. The integration of efforts across these programs not only enables effective natural resources management, but also supports the military's mission by fostering sustainable practices within and surrounding military installations.

I hope you enjoy reading this issue of *Natural Selections* and learning more about important marine issues and how they impact the military mission. By researching marine ecosystems and championing innovative approaches, we aim not only to protect the environment but also to ensure the continued success of mission-critical operations. We work together as protectors of marine environments, adapting to change with determination and commitment, with the goal of ensuring the readiness of our military and the health of our ecosystems.

We will publish our next newsletter in Summer 2024. This newsletter will focus on invasive species. Please contact NaturalSelections@bah.com if you would like to share any DoD success stories or contribute an article.



A photo from Pacific Missile Range Facility Barking Sands, one of the 2024 REPI Challenge recipients. The project supports climate resilience while safeguarding military installations and operations through landscape-scale management and control tools.



Eelgrass provides numerous ecosystem services, including water quality enhancement. Acting as a natural filtration system, eelgrass effectively absorbs pollutants and excess nutrients, purifying the surrounding waters. This purification process is of critical importance for naval activities, as clean water is crucial to supporting the health and safety of our sailors during in-water training exercises as well as other, recreational users of the Bay.

Eelgrass also serves as a “climate champion” with its ability to capture and store dissolved carbon dioxide (CO₂). San Diego Bay’s unique joint-partnership with the Port has spurred eelgrass carbon sequestration studies at the nexus of naval and Port climate resilience actions. Recent Port studies show that the Bay’s eelgrass beds contain 170,000 metric tons of CO₂ equivalent (Mt CO₂e), amounting to the annual emission of 37,000 cars. While climate change impacts the Navy’s ability to train, the carbon sequestration capabilities of eelgrass beds support the Navy’s ongoing battle against global climate change.

Moreover, eelgrass is a valuable tool for resisting the erosive effects of storm surges that strike San Diego Bay during the winter months. Eelgrass leaves attenuate wave action and reduce sediment resuspension, while root systems anchor sediment and rhizomes can aid in self-recovery. Eelgrass bed stability is strategically important to naval bases and coastal installations, providing a natural defense against the erosive forces of tides, currents, and storms. The resilience and adaptability of eelgrass contribute to overall sustainability of coastal ecosystems, aligning with long-term interests of maintaining critical naval infrastructure in the face of climate change.

The seemingly unassuming eelgrass emerges as a critical asset in supporting various facets of the Navy’s mission. From enhancing water quality to combatting the effects of climate change, eelgrass meadows contribute to the intricate balance of coastal ecosystems and resilience. By prioritizing eelgrass conservation, the Navy strengthens its ability to operate and train effectively in San Diego Bay.

Elsewhere in this issue, the article “Living Shoreline Project at Pensacola NAS” demonstrates how aquatic vegetation can help to improve climate resilience at coastal installations, and updates from the Office of Naval Research Marine Mammal Biology Program highlight advancements that improve holistic understanding of marine ecosystems.

OFFICE OF NAVAL RESEARCH MARINE MAMMALS AND BIOLOGY PROGRAM

By Dr. Michael Weise, MMB Program Manager, and Sarah Weiss, Program Contractor



The Office of Naval Research (ONR) Marine Mammals and Biology (MMB) program encompasses basic and applied research as well as technology

development in support of the Navy’s mission. With a primary interest in the effects of sonar, the program’s efforts focus on characterizing and understanding the behavioral, ecological, physiological, and population-level impacts of sound on marine mammals.

This research falls under five main concentration areas.

Research Concentration Areas:

1. Monitoring and Detection:

This research area focuses on improving marine mammal monitoring capabilities through the development and refinement of both new and existing technologies, such as passive acoustics and infrared. Recent research includes the creation and testing of new autonomous hardware platforms and signal processing algorithms for the detection, classification, and localization of marine mammals. A key goal of the program is to expand those algorithms for use on a variety of fixed, towed, floating, and profiling platforms. A notable achievement in this field is the adaptation of autonomous ocean gliders for persistent, passive acoustic monitoring of an area for marine mammal presence and abundance. This improved technology provides timely, reliable, accurate, and actionable information, which is crucial to support effective marine mammal mitigation and monitoring.



Humpback whale (*Megaptera novaeangliae*) breaching. Credit: Greg Schorr, NMFS permit #21163

It is important to note that a key goal of ONR-sponsored technology development is to make these technologies available to the broader research and Navy communities in support of the Navy mission.

2. Integrated Ecosystem Research:

Aiming to understand the patterns and causes of the spatial and temporal variability in the distribution and abundance of marine mammals, this research area utilizes a multidisciplinary approach, employing methods like tagging, visual surveys, and acoustics. Such research on marine mammal behaviors and distributions relative to environmental features (biotic and abiotic) and prey fields is vital for developing predictive models and understanding their responses to environmental changes.

3. Sensing and Tag Development:

The MMB program has a sustained interest in the invention and early-stage development of new sensing technology with the goal of improving understanding of the behavior, distribution, and movements of marine mammals. As such, this concentration area seeks to facilitate research through the development of noninvasive attachment mechanisms for various time durations; the development of broad sensor suites into tags; and the improvement of access to sensors, tags, and attachments for the research and Navy communities.

4. Effects of Sound on Marine Life:

Research in this concentration area aims to better understand and characterize the behavioral, physiological, and potentially population-level consequences of sound exposure on marine life. Specific areas of focus include behavioral response studies, diving physiology, physiological stress responses, hearing, and population consequences of acoustic disturbance.

5. Models and Databases:

An additional key research area of the MMB program is creating models and databases as tools to support environmental compliance and informed decision making related to the effect of anthropogenic sound on marine mammals. Such recent success in this field can be seen in the development and implementation of the Animal Telemetry Network (ATN). The ATN collects data on marine mammals from numerous monitoring projects, providing researchers with map-based inventories from multiple agencies. To access this data, visit: <https://atn.ioos.us/>.

The MMB program crucially supports military operations by enabling all Navy testing and training activities in a legally responsible manner. Through ongoing research efforts, collaborative workshops, and its extensive technological advancements in marine mammal detection, monitoring, and conservation, the MMB positions itself at the forefront of marine mammal research and conservation in support of the Navy mission. To learn more about the MMB Program, visit: <https://www.nre.navy.mil/organization/departments/code-32/division-322/marine-mammals-and-biology>.

OFFSHORE SIGHTING OF TRICOLORED BAT DURING NAVY MARINE MAMMAL SURVEY



Tricolored bat lands on the boat captain 103.5 km off the North Carolina Coast. Credit: Bort Thornton, et al (2023).

While offshore bat sightings were once rare, increased survey efforts, particularly near offshore energy projects, have led to a rise in observations. In 2018, during a Navy-led offshore marine mammal

survey, a single tricolored bat (*Perimyotis subflavus*), typically found in North American forests, was observed over 60 miles off North Carolina's coast. The solo-flyer even landed on the ship captain for a closer look. This historic sighting was noted as it is likely the furthest offshore observation of a tricolored bat in history.

A recent publication in *Southeastern Naturalist* (Bort Thornton, et al) underscores the growing conflict between sea-faring bats and the offshore wind industry. As offshore wind farms increase, understanding the offshore activities of these bats, recently proposed for endangered listing due to white-nose syndrome, has become crucial. This significant sighting near a planned wind farm highlights the urgency of researching bat populations' interactions with such developments, considering the potential collision risks with turbines. Continuous study into the offshore habits of tricolored bats and other species is essential, particularly as offshore wind energy projects increase.

The marine mammal survey was part of the U.S. Navy Marine Mammal Species Monitoring Program, a program that protects the marine environment while defending national security. Over the past decade, the Navy has sponsored more than \$300 million in marine species studies worldwide. This research helps to improve methods for detecting marine species before and during training

activities while enabling better understanding of the distribution and location of important habitat areas—and, this one time, helps provide bat sighting data too!

This story was sourced from the Navy Stewards of the Sea Facebook page and a publication in *Southeastern Naturalist*. To learn more about the Navy's marine mammal monitoring and its role in supporting the Navy's mission, visit: <https://www.navy-marinespeciesmonitoring.us/>. Thornton, J.E.B., Richlen, M.E., McDonald, T.B., & Bell, J.T. (2023). "Opportunistic Offshore Sighting of a Tricolored Bat (*Perimyotis subflavus*). *Southeastern Naturalist*, 22(1), N9-N12.

NATURAL RESOURCE MANAGEMENT SPOTLIGHT: PATRICK SPACE FORCE BASE NATURAL RESOURCES TEAM

By Maggie Nave, Chief of Command for Space Launch Delta 45 Public Affairs, and Jerry Porter, Chief of Public Affairs for Space Launch Delta 45



Volunteers remove trash from a beach at CCSFS, Florida, April 21, 2022. The cleanup is conducted in April to help clear the way for nesting sea turtles and shorebirds. Credit: Senior Airman Thomas Sjoberg.

Patrick Space Force Base (PSFB) and its Space Launch Delta 45 (SLD 45) installations, in collaboration with Cape Canaveral Space Force Station (CCSFS), the Malabar Transmitter Annex, and the Jonathan Dickinson Missile Tracking Annex, support

Space Force operations that span a vast domain extending across the Southern Atlantic and into the Indian Ocean, covering 15 million square miles.

Accomplishing PSFB's space launch mission, a powerful economic driver generating an estimated \$1.3 billion annually, posed unique challenges due to the diverse natural communities housing numerous threatened and endangered species surrounding these installations. To navigate these complexities, PSFB relies on its INRMP, a tool that supports balancing environmental conservation and mission readiness. INRMPs serve as the blueprint to manage DoD's lands, waters, and airspace, addressing all the habitats and species found on an installation while providing management strategies and guidance and proactive implementation on how to conserve those habitats and species while supporting the installation's mission.

Implementation of the PSFB's INRMP, which is developed in conjunction with FWS and the Florida Fish and Wildlife Conservation Commission, involves the efforts of a dedicated Natural Resources Team (NRT) comprising DoD employees and FWS biologist partners. Despite the obstacles posed by the COVID-19 pandemic, the team rose to the challenge and continued their crucial role in safeguarding the diverse ecosystems surrounding the installations.

The NRT's leadership in managing federally listed sea turtle species is one of its shining accomplishments—running a nesting habitat protection program that has successfully hatched 480,000 sea turtle hatchlings over 37 years. Additionally, the

team addressed challenges posed by artificial lighting, which is essential for launch operations but potentially disruptive to sea turtles and their nesting abilities. Through the implementation of more than 15 Light Management Plans, the NRT ensured compliance with the Endangered Species Act (ESA). The NRT's commitment to protecting listed species extended to the rehabilitation and monitoring of the unique population of federally threatened juvenile green sea turtles (*Chelonia mydas*) residing in the Trident submarine basin at CCSFS. Collaborating with the University of Central Florida, the team secured funds to investigate the health of this population. This initiative to enhance knowledge and recovery of sea turtle populations within military operational areas aims to lessen negative interactions, offering reciprocal advantages for both the turtles and military operations.

Furthermore, the NRT SLD 45's commitment to environmental stewardship while supporting the installation's mission is demonstrated by its ongoing efforts to conserve the Florida scrub-jay (*Aphelocoma coerulescens*), the state's only endemic bird and a federally threatened species. The NRT, in partnership with external organizations, completed the 26th annual census, revealing a 40% population increase over two decades while continuing to carry out the installation's mission. To sustain scrub-jay habitats, the NRT successfully executed a prescribed burn program, achieving record burn acreage totals and exceeding INRMP goals. The team's innovative habitat management approach included the world's first utilization of thrips (insects) as a biocontrol for the invasive Brazilian pepper tree, showcasing PSFB's commitment to sustainable environmental management.

NRT efforts extend beyond the base, including community relations, conservation education, and outreach to diverse stakeholders. The NRT engaged in studies and initiatives to address environmental concerns, with topics including the impact of ghost crabs on sea turtle hatchlings, the effectiveness of clean rooms during smoke events, and the use of camera buckets for wildlife monitoring. The team's success was highlighted by the removal of tons of trash from CCSFS beaches and educational programs reaching local schools and military personnel.

In summary, these achievements led this installation to be a runner-up in the Natural Resource Conservation Large Installation category for the 2023 Secretary of Defense Environmental Awards, and they underscore the exceptional dedication and ingenuity of the NRT in balancing the demands of space launch operations with the imperative to protect and conserve diverse and sensitive ecosystems and species. Its initiatives set a benchmark for natural resource management, showcasing a harmonious coexistence between national security and environmental stewardship.



Brigadier General Wayne Monteith, Commander of the 45th Space Wing, releases a sea turtle back into the ocean, June 21, 2018, at the beaches at PSFB, Florida. Sea turtles use the beaches to make nests during parts of the year. Credit: Airman 1st Class Dalton Williams.

NAVAL AIR STATION CORPUS CHRISTI NATURAL RESOURCES MANAGER'S SWIFT WILDLIFE RESCUE

By Scott McGuire, NASCC Natural Resource Manager



Scott McGuire holding a juvenile green sea turtle that was observed by a local RV Park resident. It was one of three cold-stunned green sea turtles that were recovered and transported to the Texas Sea Turtle Stranding Coordinator at Padre Island National Seashore for rehabilitation. Credit: Rachel Houston, January 17, 2024.

Quick action from Mr. Scott McGuire helped save imperiled wildlife. A recent cold snap at Naval Air Station Corpus Christi (NASCC), led Mr. McGuire, the NASCC Natural Resources Manager, to the discovery of several cold-stunned brown boobies (*Sula leucogaster*) and green sea turtles on the NASCC beaches. His quick response transporting the lone surviving booby to the Texas Sea Life Center led to its recovery.

Along with the booby, ten sea turtles were rescued and transported to the Texas Sea Turtle Stranding Coordinator at Padre Island National Seashore for transfer to a rehabilitation facility. Saving wildlife—just another day in the life of our committed DoD NRMs!



Scott McGuire holding one of six cold-stunned brown boobies that were later taken to the Texas Sea Life Center for rehabilitation. Credit: Geoff Rothenay, January 17, 2024.

LEGACY PROGRAM PROJECT HIGHLIGHT: DEVELOPING AN INTEGRATED SHORELINE MANAGEMENT PLAN FOR FORT EUSTIS

The Legacy Resource Management Program is contributing to preserving natural and cultural heritage at Fort Eustis, Virginia. Faced with the escalating challenges of climate change, particularly sea level rise, the program is spearheading an ambitious shoreline management plan aiming to safeguard Fort Eustis' 21.6 miles of shoreline along Virginia's James River. The project began in August 2023 and is scheduled to be completed by July 2024.

Fort Eustis, originally established in 1918 for artillery training during World War I, encompasses a diverse landscape of archaeological sites, wetlands, and habitats for protected species. Over the years, the installation has meticulously collected data on shoreline erosion, revealing an alarming average loss of 0.33 meters per year around Fort Eustis.

In response, this Legacy Program-funded project is drawing upon historical data and insights from an older Shoreline Management Plan, originally established in 1997. However, unlike its predecessor, which primarily focused on hard-engineering methods like armoring shorelines, the new plan emphasizes nature-based solutions. By assessing geology, marine resources, and projected sea level rise, the project team is developing tailored strategies to mitigate erosion and enhance resilience.

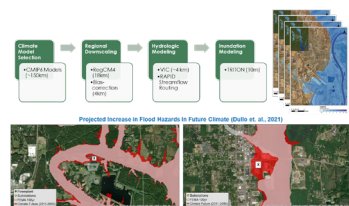
Projected sea level rise and storm surge scenarios paint a dire picture for Fort Eustis, with significant portions of the installation expected to be permanently inundated or inaccessible by 2050. Recognizing the limitations of traditional shoreline armoring in the face of rising sea levels, the project advocates for a shift toward holistic, nature-based approaches.

Rather than resisting the forces of nature, the project seeks to complement them, leveraging natural ecosystems to stabilize shorelines and minimize impacts on military operations. This forward-thinking strategy acknowledges the inevitability of sea level rise and positions Fort Eustis to adapt and thrive in a changing environment.

SERDP/ESTCP MARINE INITIATIVES

SERDP and ESTCP are critical components of DoD efforts to align environmental stewardship with military mission effectiveness. While SERDP and ESTCP focus on all aspects of the military landscape, this issue narrows the lens to highlight marine-related efforts. These initiatives drive innovation in managing climate risks, such as developing high-fidelity tools for flood prediction at military installations, enhancing underwater munitions remediation technologies for safer aquatic environments, and pioneering coral conservation methods for sustainable marine resource management. By integrating advanced science and technology, SERDP and ESTCP not only contribute to the resilience and readiness of military operations, but also play a vital role managing marine ecosystems, underscoring DoD's commitment to preserving these unique environments.

FLOOD VULNERABILITY ASSESSMENT IN A CHANGING CLIMATE FOR DOD INSTALLATIONS



A schematic of the proposed hierarchical modeling framework to generate ensemble flood inundation maps. The bottom images show an example of flood inundation maps under baseline and future climate scenarios for an arbitrary site (X) based on our previous study (Dullo, et al, 2021). The project outcomes are envisioned to generate similar maps for selected DoD installations.

By Sudershan Gangrade, PhD, and Shih-Chieh Kao, PhD, Oak Ridge National Laboratory

In response to the increasing risk of climate-induced flooding, DoD has commissioned a new high-fidelity assessment tool to improve flood prediction and military preparation for severe weather. Led by Oak Ridge National Laboratory (ORNL) and its leading national supercomputing resources, this initiative will generate high-resolution ensemble

inundation maps to guide climate resilience efforts integrating climate, hydrologic, and hydrodynamic models.

Flooding, a natural disaster with widespread impacts on society, ecosystems, and infrastructure, has become a pressing concern due to rapidly changing climate and environmental conditions. As flood risks heighten, they present unique challenges to DoD installations, where securing infrastructure is crucial for operational continuity and national security. As climate change exacerbates flood risks, traditional risk assessment methods are becoming obsolete as they do not account for this rapid change.

ORNL is developing and implementing a hierarchical modeling framework to generate high-resolution ensemble inundation maps under historic and projected climate conditions (see figure) for selected DoD installations. Enabled by high-performance computing, the framework will inform climate change-driven flood vulnerability using multiple state-of-the-art climate models from the latest Coupled Model Intercomparison Project Phase 6 effort organized by the World Climate Research Programme. The resulting high-resolution inundation maps can help identify the vulnerability of existing infrastructures under historic and future climate conditions, offering a clear picture of potential flood scenarios.

The project envisions several advancements, including the creation of a high-fidelity modeling tool based on open-source data, detailed flood inundation maps highlighting infrastructure vulnerable to climate change, and potential integration with existing risk assessment tools. The modeling framework, while essential for current DoD sites studied as part of the project, also holds the potential for scalability to other locations worldwide. The project will empower DoD decision-makers with up-to-date data, aiding in effective flood mitigation and planning strategies and ensuring climate-resilient DoD infrastructure and installations.

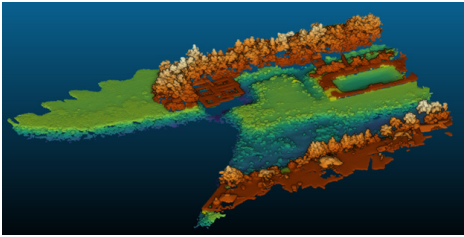
DRONE-BASED LIDAR FOR SHALLOW WATER MUNITIONS RESPONSE

By Jeffrey P. Thayer and Gerald Thompson, University of Colorado, Aerospace Engineering Sciences Department, Boulder, Colorado



LiteWave Technologies EDGE topobathy LiDAR mounted on the Skyfront Perimeter 8 drone platform.

A key focus of the SERDP Munitions Response (MR) program is the research and development of technologies for remediation of underwater unexploded ordnance (UXO). Solutions for remediating UXO need to be able to operate in shallow water (less than five meters in various aquatic environments) and where mobility might be limited. Due to this need, the MR program is refocusing on using high-resolution sensing and mapping and employing critical technologies to address the challenges in performance, access, navigation, deployment, viewing, and sensor standoff distance presented in shallow water. This shallow water environment also presents a risk to equipment and personnel due to fluctuating topography, unknown obstructions, and rough water conditions. The shallow water environment is also the most likely area where the public might encounter UXO, with exposure posing a public safety risk.



A 3D map generated from LiDAR measurements of the University of Hawai'i Applied Research Lab ESTCP site. Above-water points are colorized over a scale of brown colors with lighter brown indicative of greater altitude. Water surface points have been removed from the data set to reveal the underwater bathymetry colorized over a green-blue scale with deeper features of about 5 meters indicated by darker blue colors while light green indicates depths of about 1 meter.

a viable technique for measuring water depth and mapping large-scale subsurface terrain, traditional LiDAR bathymetry systems are cumbersome, requiring operation from manned aircraft at low resolution. Their current strengths are in covering extensive areas and deeper waters in coastal water research, nautical charting, and reconnaissance efforts. This new SERDP effort aims to advance the use of traditional bathymetric LiDAR technologies by requiring them to detect bottom located objects spanning 20–155 mm in diameter, localize them with 1-meter accuracy, within 1-meter accuracy, and classify these objects in the presence of clutter.

Unmanned aircraft system (UAS) LiDAR has many advantages for shallow-water bathymetry, including:

- Wider swath areas,
- Access to non-navigable waters,
- Frequent revisits,
- Ease and low cost of operation,
- Immediate access to the sensor system,
- Undisturbed munitions or underwater environment,
- Use of precise and proven terrestrial navigation systems, and
- The ability to operate from a variety of platforms.

The field of UAS technology has grown exponentially in recent years with ever-increasing flight durations and payload capacities. In particular, the small-UAS market—where drone, fuel, and payload combined weigh less than 55 pounds—provides agility in operations and logistics, making this capability more suited for shallow water work. Expanding small-UAS capabilities complement advances in LiDAR system miniaturization, which has evolved rapidly due to advances in photonics and solid-state lasers, thereby reducing size, weight, power, and cost. Advances in near-infrared (NIR) laser and detector technologies have increased LiDAR's use in topographic mapping, but the proliferation of terrestrial NIR LiDARs does not translate to underwater use due to the loss of NIR light underwater.

New technologies are changing the “landscape” of bathymetric measurement with a UAS-based LiDAR solution enabling measurement agility, high point density, and rapid and repeatable access in shallow waters. Leveraging advances in light wave technology, new LiDAR systems, capable of seamlessly mapping both topography and hydrography from a small-UAS platform, are being created. This new coupling of technology is capable of penetrating the water surface and determining what lies beneath, generating high-resolution, 3D maps of the seafloor.

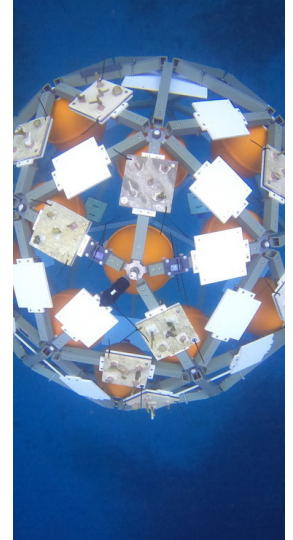
A potential emerging technology is the use of above-water Light Detection and Ranging (LiDAR) systems to map the local hydrography and detect, localize, and classify munitions lying on the sea floor. While above-water LiDAR hydrography is

Combined with the agility and payload capacities of small-UAS technologies, hydrographic 3D mapping from drone-based platforms using LiDAR has become a reality for MR program applications, adding another tool to the detection of UXO, increasing public safety, and cleaning up the environment.

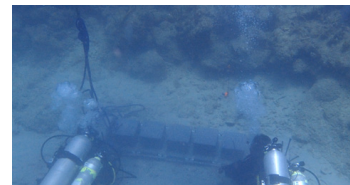
TESTING NEW METHODS TO MITIGATE IMPACTS TO CORALS

By Jessica Carilli, Naval Information Warfare Center Pacific

Numerous active and former DoD installations have coral resources growing within their submerged lands. Corals provide a number of ecosystem benefits that can support the military mission, including protecting military installations from flooding, erosion, and storm surge. Coral reef habitats and several coral species are safeguarded by U.S. laws such as the Coral Reef Conservation Act and the ESA. Military activities, such as training, construction, and refurbishment of in-water structures, or remediation, may impact these resources and can require mitigation to minimize or offset their impacts. Coral mitigation typically involves translocating a portion of the potentially impacted adult coral colonies to another benthic (ocean bottom) site. However, these translocation projects often have low long-term coral survival rates and fail to provide the rich biodiversity that is a hallmark of coral reef ecosystems.



One of the Coral Arks deployed in Vieques, Puerto Rico; this structure is eight feet in diameter and anchored in a sand patch.

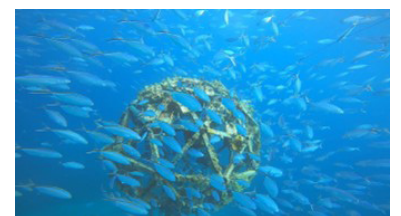


Two divers from Jacobs Engineering secure a chain of five ARMS units to the benthos adjacent to a natural reef in Vieques to accumulate reef-associated biota.

Coral Reef Arks were designed as a new approach to improve coral translocation success by providing ideal environmental conditions and habitat for translocated corals. Recognizing that corals require hard substrate and clear, clean water for optimal growth, this approach also incorporates a new

method—translocating of other reef-associated biota along with corals to these new artificial reef structures.

With funding from ESTCP (project CR20-5175), and in collaboration with the Naval Facilities Engineering Systems Command Atlantic Vieques Environmental Restoration Program, two Coral Reef Arks were deployed in Vieques, Puerto Rico in November 2021. Much like trees in a forest, corals provide three-dimensional habitat complexity, making them the most biodiverse marine ecosystems. Also like trees, corals rely on ecosystem services such as nutrient cycling and organic matter degradation from other reef-associated species.



A multitude of fish are now consistently associated with the Coral Reef Arks.

To achieve better success, the Coral Reef Arks needed to move the

right coral reef organisms along with the transplanted coral. To determine which cryptic reef organisms to transfer, one-cubic-foot Autonomous Reef Monitoring Structures (ARMS), designed to census the marine biodiversity, were deployed for a year to accumulate organisms. These were then carefully transferred to the Coral Reef Arks along with coral fragments affixed to limestone tiles. Larger coral colonies were split, so that the same coral genotypes were used for both the treatment and control groups. These “coral plates” were then translocated to the Coral Reef Arks and two benthic control sites. Coral health and growth, water quality conditions, fish biomass and diversity, algal overgrowth, and other metrics were monitored on both the Coral Reef Arks and control sites at multiple timepoints during the project.

So far, corals translocated to Coral Reef Arks have exhibited better growth and survival, experiencing less competition with turf and macroalgae, which commonly overgrow corals on many degraded reefs, compared with the control sites. The Coral Reef Arks have also developed predator-dominated fish communities, often linked with improved coral reef health, and continue to demonstrate better water quality metrics, including higher dissolved oxygen and improved virus-to-bacteria ratios compared with the control sites.

Coral Reef Arks are currently providing new habitats, improving physical conditions to encourage the survival and growth of translocated corals with reef-associated biota while apparently enhancing fish productivity. Eventually, these mini-reefs will produce larvae that drift with the currents, aiding in the repopulation of nearby natural reefs on the seafloor, furthering the survival of coral reefs and allowing the Navy to continue its national security mission.

NATURE-BASED SOLUTIONS AT TYNDALL AIR FORCE BASE

By Katie Konchar, Coastal Resilience Projects Manager, The Nature Conservancy, and Garey Payne, Acquisition Program Manager Deputy, Programs Branch, Air Force Civil Engineer Center (AFCEC) Natural Disaster Recovery

Tyndall Air Force Base (TAFB) is a cornerstone of the Air Force’s strategic framework. Its mission is to train and protect unrivaled combat power, and this imperative underscores TAFB’s critical role in fortifying the Air Force’s combat readiness and capabilities. However, TAFB’s location along the coast exposes it to the impacts of climate change, such as sea-level rise, coastal erosion, and storm surge. These environmental challenges pose significant risks to mission-critical assets, including aircraft, hangars, airstrips, control towers, and fuel distribution systems. In response, nature-based solutions (NBSs) are being explored to protect this crucial infrastructure and ensure the continuity of the military mission. The NBS approach leverages natural processes and ecosystems to address environmental, social, and economic challenges in a sustainable and beneficial manner.

On October 10, 2018, TAFB experienced devastating wind and storm-surge damage during a Category 5 hurricane. In the aftermath of this catastrophic event, the Air Force pledged to rebuild in a manner that would enhance coastal resilience at TAFB while supporting its vital mission. This enhanced rebuilding approach is in line with TAFB’s vision to become the “Installation of the Future.” Enhanced rebuilding involves elevating and strengthening key facilities, berm and seawall construction, comprehensive stormwater management, and NBSs to protect the base from storms, sea-level rise, coastal erosion, and torrential rainfall events. These measures were coordinated and integrated through a Coastal Resilience Implementation Plan.

The use of NBS at the base includes construction of three initial projects:



Garey Payne (Air Force Civil Engineer Center Natural Disaster Recovery Division) discusses the importance of the Buck Beach area with project team members: Drs. Bea Marin Diaz and Andrew Altieri (UF-CCS) and Tunch Orsoy (Jacobs). Photo credit: David Bell (Jacobs)

to coastal flooding. Adjacent habitats expected to benefit include contiguous seagrass meadows as well as salt marshes in the higher tidal elevations. Project objectives include the following: Protect approximately 1,400 feet of shoreline from erosion and attenuate wave height and energy during operational day-to-day conditions; enhance approximately 27 acres of intertidal and benthic habitat by promoting sediment accretion; and support marine species adaptation to sea-level rise.

2. The Oyster Reef Breakwater project site is in East Bay to the north of the drone runway. Critical assets driving the need for coastal resilience efforts include the drone flight line, which is subject to coastal flooding. Adjacent habitats expected to benefit include contiguous seagrass meadows as well as salt marshes in the higher tidal elevations. Project objectives include the following: Protect approximately 2,100 feet of shoreline from erosion and attenuate wave height and energy during operational day-to-day conditions; enhance approximately 32 acres of intertidal and benthic habitat by promoting sediment accretion; provide substrate for oyster settlement and sustained oyster recruitment; and support marine species adaptation to sea-level rise.



At Buck Beach, along the Gulf of Mexico shoreline of TAFB, beach and dune habitats are experiencing severe erosion, including the loss of several acres of adjacent seagrass habitat. The Submerged Shoreline Stabilization & Seagrass Restoration project aims to increase shoreline resilience by installing 3,500 feet of submerged structures and enhancing approximately 40 acres of estuarine and coastal habitat, including at least 5 acres of eroding seagrass habitat. Credit: David Bell (Jacobs).

3. The Submerged Shoreline Stabilization & Seagrass Restoration project site is in Saint Andrew Sound on the Gulf side of the TAFB peninsula. Critical issues driving the need for coastal resilience efforts include beach, dune and seagrass habitats—all of which are eroding due to exposure to more intense wave climate—and an increasing risk of coastal flooding to Highway 98 and the drone runway. Adjacent habitats expected to benefit include patchy subtidal seagrass meadows with beach areas and dunes onshore. Project objectives include the following: Protect 3,500 feet of shoreline from erosion and attenuate wave height and energy during operational day-to-day conditions; enhance 30 acres of intertidal and benthic habitat by promoting sediment accretion; directly restore up to 5 acres of eroding



NBSs currently in the planning and design phase for TAFB include the Living Shoreline, Oyster Reef Breakwater, and Submerged Shoreline Stabilization & Seagrass Restoration projects.

seagrass habitat and protect existing seagrass meadows; and support marine species adaptation to sea-level rise.



(From left to right) Jonathan Feldman (REPI Program), David Bell (Jacobs), Bea Marin Diaz (UF-CCS), Garey Payne (AFCEC Natural Disaster Recovery Division), Tunch Orsoy (Jacobs), and Katie Konchar (TNC) visit NBS project sites along the northern shoreline of TAFB. Credit: Andrew Altieri (UF).

The three initial NBS projects will serve as design prototypes that may be scaled-up to protect additional base assets. To advance the three initial projects and to set the stage for potential future NBS investments, the project team is:

- Drafting a Programmatic Environmental Assessment encompassing the three initial projects and their potential replication on shoreline areas, ensuring compliance with the National Environmental Policy Act and streamlining the permit process for future NBSs at TAFB;
- Modeling and engineering the three initial projects to provide vital lessons learned for the future implementation of NBSs adjacent to military installations; and
- Adopting a monitoring plan for the initial NBS projects to evaluate their performance and inform future NBS designs.

The project team includes TAFB, The Nature Conservancy (TNC), Jacobs Engineering, the University of Florida (UF) Center for Coastal Solutions (CCS), the U.S. Naval Research Laboratory, and the St. Joseph & St. Andrew Bay Estuary Program. Funding for project planning and environmental assessment work is provided by DoD REPI, a Bay County Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act (RESTORE) grant, and a National Oceanic and Atmospheric Administration award provided by the National Fish and Wildlife Foundation. Following construction in 2025, projects are expected to be models for the implementation of NBS projects on other military installations.

Projects using NBSs enhance coastal resilience, delivering significant ecological and economic benefits. This is achieved by augmenting the natural shoreline capacity to attenuate wave energy and daily erosion while promoting sediment accretion. NBSs encourage the growth of marine organisms, such as oysters, which further contribute to coastal resilience. By creating an environment conducive to vital habitats, NBSs also protect native fish and wildlife, supporting the St. Andrew Bay estuarine system and fostering various opportunities for outdoor recreation while helping to sustain and protect TAFB’s mission of providing unrivaled combat air power.

LIVING SHORELINE PROJECT AT PENSACOLA NAVAL AIR STATION

By Madison O’Toole, RESTORE Project Coordinator, Escambia County Board of County Commissioners

Established in 1914 as the first permanent Naval Air Station (NAS) in the United States, Pensacola NAS is known as the Cradle of Naval Aviation and home to the Blue Angels as well as serving as a crucial training hub for U.S. Navy, Coast Guard, and Marine Corps aviators.



Pensacola Living Shoreline Project Overview Map. Credit: Volkert, Inc.

Nestled in Pensacola Bay in northwest Florida, the NAS faces major weather events and severe shoreline erosion, which pose a continuous threat to its wastewater, electrical, transportation, and communications infrastructure, potentially imperiling its mission. As previous shoreline stabilization attempts, such as installation of rip rap, have proven unsuccessful, Escambia County has partnered with NAS Pensacola to increase coastal resilience through the implementation of NBSs with the Pensacola Living Shoreline Project. This project couples breakwater installation with habitat creation, providing short-term protection for new habitat establishment. Achieving resilience through NBSs requires a diverse suite of methods. Diversity is resiliency, and resiliency is sustainability.



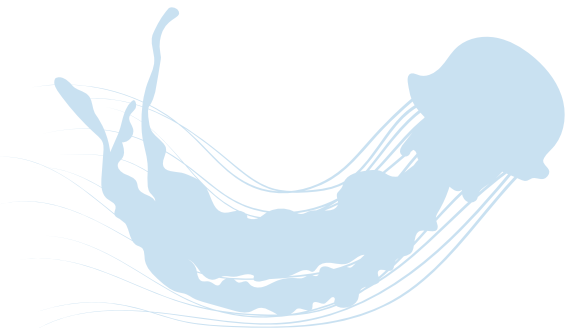
Shoreline damage along NAS Pensacola following a storm. Credit: Escambia County NRM.

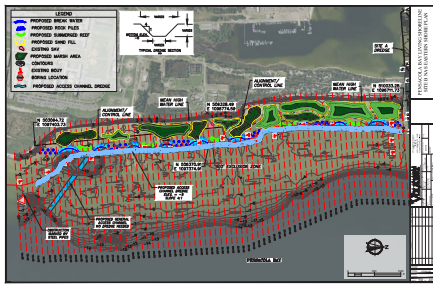
Sherman Inlet, situated along the unprotected southern shore of Pensacola NAS, has experienced over 400 feet of shoreline retreat resulting from direct exposure to Gulf waves, leaving an access road vulnerable to storm surge. Key structures to be installed at Sherman Inlet are linear breakwaters,

rock piles, and limestone submerged reefs. These structures disperse kinetic wave energy, offering protection, reducing erosion, and providing essential habitat for a wide variety of wildlife, such as snapper, grouper, crab, and shrimp.

Magazine Point, on the east coast of Pensacola NAS, has lost approximately 200 feet of shoreline since the 1960s. Structures planned for Sherman Inlet will also be applied to this site, along with submerged aquatic vegetation (SAV) and saltmarsh habitat creation. Emergent breakwaters will attenuate wave energy and prevent civilian vessels from entering the exclusion zone, providing an opportunity for habitats to become established with minimal disturbance.

White Island, located in a residential area northeast of Pensacola NAS, has experienced critical destabilization and habitat loss, necessitating sandy beach and saltmarsh restoration. Sediments will be sourced from a nearby navigational channel leading into the adjacent Bayou Grande, promoting beneficial use of dredged materials and extending the life of the site by servicing the Intracoastal Waterway, while minimizing further environmental impacts.





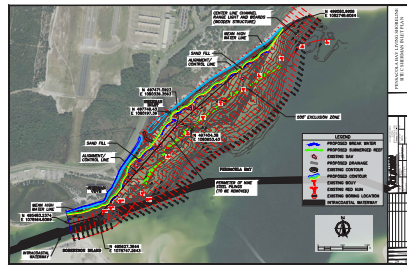
Concept plan for Magazine Point site. Credit: Volkert, Inc.

Future sea-level rise was considered in the design of these projects to ensure longevity; for example, sand platforms are engineered to roll shoreward over time, allowing for saltmarsh retreat. These projects will use a

range of concepts to maximize resiliency in every area possible.

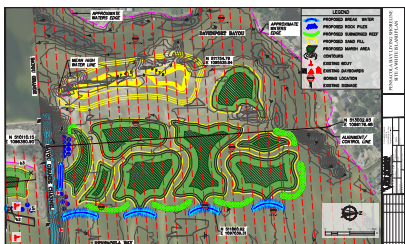
Salt marshes mitigate coastal erosion through substrate stabilization, promoting sediment accumulation, which also provides resiliency against sea-level rise. SAV, which has declined by 95% in Pensacola Bay since first measured in the 1950s, increases dissolved oxygen levels and provides essential estuarine and fish habitat, which is crucial to the commercial fish species the area is known for. SAV improves water clarity and sequesters nutrients, potentially reducing harmful algal blooms. In total, the Pensacola Living Shoreline project involves the construction of approximately 15,000 linear feet of breakwaters and the creation of 200 acres of saltmarsh and SAV habitat.

This collaborative project has been made possible through the efforts and cooperation of local, state, and federal agencies, including DoD, the National Fish and Wildlife Foundation, the Gulf Coast Ecosystem Restoration Council, the National Coastal



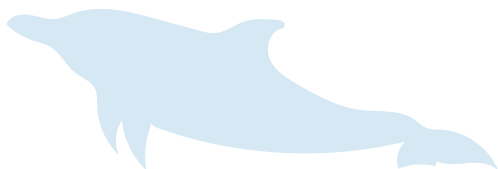
Concept plan for Sherman Inlet site. Credit: Volkert, Inc.

Resilience Fund, the Resilient Florida Grant Program, the Department of Economic Opportunity, and Escambia County. Project design was completed early 2022 and construction is anticipated to occur in 2024, pending receipt of final permits. Together, these organizations hope to implement a project that sets the standard for living shorelines in the United States, showcasing the versatility, resiliency, and effectiveness of green infrastructure and supporting ecosystem enhancement and the military mission. By enhancing the resiliency of coastal



Concept plan for White Island site. Credit: Volkert, Inc.

ecosystems, green infrastructure projects will enable the military to focus on core objectives with reduced environmental concerns and maintenance needs along with increased ecosystem and mission benefits.



SERPPAS PROTECTS MILITARY LANDS, DEFENSE COMMUNITIES, AND THE COAST

By Addie Thornton, SERPPAS Coordinator, Texas A&M Natural Resources Institute, and Hannah Sodalak, Texas A&M Natural Resources Institute

The southeastern United States is home to a large military presence and contributes to national security through the important land, sea, and air space needed for realistic training and testing. The military's influence in the Southeast extends beyond defense; it drives economic growth for many communities, manages considerable natural resources, and owns vast tracts of undeveloped land. The southeast includes several biodiversity hotspots and sustains a variety of unique and important ecosystems and industries, with the majority of land being privately owned. Because of this, numerous external factors affect the DoD mission, with issues like urban development and climate change presenting challenges that are at odds with the defense mission. To address these challenges, leaders from state environmental and natural resource agencies, DoD, and other federal agencies unified to promote a sustainable Southeast. [The Southeast Regional Partnership for Planning and Sustainability \(SERPPAS\)](#) formed in 2005 to foster better coordination among local, state, and federal stakeholders in the region.



An aerial view shows salt marsh adjacent to the runway at Naval Station Mayport in Jacksonville, Florida. Credit: Mark Bias.

Supported by DoD's REPI Program, SERPPAS emphasizes relationship-building and collaborative leadership to advance decisions that protect military missions and ecosystems by minimizing encroachment. SERPPAS has contributed to many successful collaborations, including longleaf pine restoration, prescribed fire management, and species recovery, notably of the red-cockaded woodpecker (*Leuconotopicus borealis*) and gopher tortoise (*Gopherus polyphemus*).

In light of these successes, SERPPAS is turning its focus towards coastal ecosystem collaboration. Since 2019, SERPPAS has prioritized climate adaptation and coastal resilience to support installations, communities, and ecosystems, leading to multiple regional gatherings to address shared challenges through planning and project development. A recent 2023 summit focused on the six southeast Sentinel Landscapes, with discussion of ways to enhance climate resilience through DoD policies and collaborative funding.

Furthermore, SERPPAS has partnered with the Pew Charitable Trusts to launch the [South Atlantic Salt Marsh Initiative \(SASMI\)](#), focusing on the protection of salt marshes increasingly threatened by sea-level rise and development. These tidal ecosystems buffer shorelines, coastal communities, and military installations from extreme storm events while mitigating impacts from climate



SERPPAS was awarded the 2023 Climate Adaptation Award for Natural Resources in the "Broad Partnerships" category from the Association of Fish and Wildlife Agencies. Credit: Addie Thornton.

change, sea-level rise, and flooding. SASMI brings together diverse partners to restore, conserve, and protect salt marshes and their future migration corridors for the benefit of the people, communities, military installations, and wildlife that depend on them.

The SASMI Marsh Forward Plan established a goal to enhance the long-term viability of 1 million acres of salt marshes from North Carolina to northern Florida to ensure no overall loss of the benefits these wetlands provide. SASMI and the Marsh Forward Plan were developed through region-wide collaboration, inspired largely by the highly successful America's Longleaf Restoration Initiative.

Much of SASMI's conservation work complements the objectives of the Sentinel Landscapes partnership. The South Atlantic is home to three Sentinel Landscapes and more than a dozen coastal military installations, offering abundant opportunities for REPI partners to advance conservation opportunities in salt marsh migration corridors that maintain mission operations and ensure ecological resilience.

INVASIVE ALGAE REMOVAL FOR URCHINS

By Kaley Vatalaro, Booz Allen Hamilton

The DoD REPI Program facilitates long-term, collaborative partnerships that improve resilience, preserve important habitats, and protect natural resources by supporting the sustainable and productive use of land and water resources in communities surrounding DoD facilities. As the Pacific region continues to be strategically important for national defense, REPI projects are becoming increasingly essential in promoting stewardship of cultural and natural resources in local communities. Given that most installations throughout the Pacific are coastally situated, REPI projects that focus on protecting marine environments, particularly coral reefs, have become a priority for many community partners and their neighboring installations to preserve and sustain ecosystems and the missions of those installations.



Smothering seaweed/invasive algae. Credit: DLNR DAR.



Urchins grazing. Credit: DLNR DAR.

Healthy coral reefs are integral to the resiliency of coastal communities and installations, as they enhance storm resistance by minimizing the impacts of large surf, strong currents, and storm surge. However, coral reefs throughout the Pacific islands are threatened by climate impacts and invasive aquatic species.

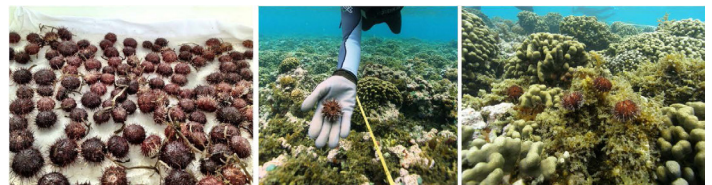
Recognizing this threat, the

State of Hawai'i Department of Land and Natural Resources (DLNR), in partnership with Marine Corps Base Hawai'i (MCBH), introduced a 2023 [REPI Challenge](#) project targeting the detection and management of high-impact invasive species in Kāne'ōhe Bay, where MCBH resides.

Invasive algae, specifically *Kappaphycus* and *Eucheuma*, pose a critical threat to coral reef biodiversity in Kāne'ōhe Bay. Known

as smothering seaweed, these species obstruct light, overgrow coral colonies, and displace indigenous fish and invertebrates. These algae have a high growth rate and reproduce through fragmentation, making them quick to spread and likely to smother nearby reefs. Following a successful large-scale effort to clear smothering seaweed using a barge-mounted vacuum device in the early 2000s, scientists recognized that the algae would continue to grow back without a viable biocontrol. In response, Native Hawaiian collector urchins, *Tripneustes gratilla*, were identified as potential solutions. They are cultured and outplanted on reefs to prevent invasive algae reestablishment through their continuous grazing. The presence of native urchins allows corals to regain access to space and light, allowing reefs to thrive. The Ānuenuē Fisheries Research Center, a DLNR Division of Aquatic Resources (DAR) facility, houses the native urchin hatchery. DAR staff collect mature urchins from the wild, the urchins spawn in captivity, and offspring are monitored prior to outplanting on reefs.

REPI funds support the expansion of native urchin culturing and release to include reefs adjacent to MCBH, covering a proposed management area of over 230 acres that will enhance DAR's statewide effort to address aquatic invasive species impacting Hawai'i's coral reef systems. Another example of REPI support is the early detection and rapid response efforts for stony coral tissue loss disease, which can be introduced by vessel traffic throughout state waters. With REPI support, DLNR continues to work with local military installations for the protection of coastal ecosystems. Joint efforts include creating a strategic response plan, facilitating a tabletop response exercise with key partners, developing a public reporting system, and campaigning to increase awareness and detection of coral diseases or die-off. All of these efforts help to allow Hawai'i's coral reef communities to continue to thrive and support the DoD installations that call the Hawaiian Islands home.



Urchin release/outplanting onto reefs. Credit: DLNR DAR.

For more information on the native urchin hatchery and DAR's efforts to treat invasive algae, [click here](#).



LEGACY PROGRAM PROJECT HIGHLIGHTS

The Legacy Resource Management Program plays a critical role in preserving natural resources while supporting the military mission. This program undertakes various projects to understand and mitigate the impact of military activities on marine environments, ensuring that DoD can carry out its mission while supporting and fulfilling its stewardship role. Key areas of focus include the assessment and conservation of threatened marine species, management of invasive aquatic plants, and use of innovative technologies like environmental DNA (eDNA) for efficient wildlife monitoring.

1. Legacy Project: MaMu-23, Study of Marbled Murrelet Diet and Forage Species Availability Within the Inland Puget Sound Waters

Point of Contact (POC): [Cynthia A. Kunz](#), Navy Region Northwest

The marbled murrelet (*Brachyramphus marmoratus*) is a small seabird that forages in the marine waters of Puget Sound and is federally listed as threatened under the ESA. Marbled murrelets are known to be present along Navy installation waterfronts and in testing and training areas throughout Puget Sound. Accomplishing Navy construction, security, testing, and in-water training activities is challenging due to the presence of these ESA-listed species. This project aims to provide data on murrelet diets and the presence of forage. Better information on the availability and consumption of marbled murrelet prey species will assist the prioritization of conservation work to raise marbled murrelet status by improving their prey base. The overarching goal of this project is to inform conservation investments made by the Navy and others, increasing the effectiveness of future projects.

2. Legacy Project: NR-16-815, Evaluation of the Biology, Ecology, and Control of Aldrovanda within a Risk Analysis Framework

POC: Rob Richardson, North Carolina State University

Waterwheel (*Aldrovanda vesiculosa*), a submersed, rootless aquatic carnivorous plant native to Europe, Asia, and Africa, has proliferated in wetlands and ponds from Virginia to New Jersey, particularly on Fort Walker (formerly known as Fort A.P. Hill). Dense growth due to its significant infestation on Fort Walker may restrict habitat for native species and interfere with the use of water resources for training exercises. Control and management of waterwheel will protect both natural resources and training activities under the military mission. This project developed risk management priorities and a literature review to guide future efforts to manage this invasive plant on DoD installations.

3. Legacy Project: NR-16-806, An Integrated Status Assessment of Freshwater Mussels on DoD Installations and Adaptive Strategies for Management and Conservation Under New and Emerging Threats

POC: [Caitlin S. Carey](#), Virginia Polytechnic Institute and State University

One of the most imperiled taxa in the world, freshwater mussels, are likely to impact resource management decisions on DoD installations in the southeastern United States due to their current or proposed ESA protection status. Understanding the status and distribution of mussels in watersheds associated

with DoD installations will contribute to the development of effective adaptive management strategies. DoD efforts included identifying emergent threats and preparing for future impacts, minimizing environmental encroachment, and mitigating impacts to mission readiness. Using an ecosystem integrated and landscape-level approach, this project compiled, reviewed, and synthesized information on freshwater mussels relevant to 13 installations in the mid-Atlantic and southeastern United States. These assessments were used to develop installation-specific mussel management plans and a comprehensive set of best management practices for mussels, which are applicable for use throughout DoD installations.

4. Legacy Project: NR-16-786, Using Environmental DNA to Improve Detection and Shorten Survey Time Frames for Endangered Fairy Shrimp

POC: [Dr. Katherine Strickler](#), Washington State University

DoD installations contain some of the most extensive and pristine vernal pools remaining in California, many of which contain federally endangered species of fairy shrimp endemic to this habitat. In southern California, intensive surveys for federally listed fairy shrimp species must be completed prior to training and construction activities on military installations, which have the potential to delay these activities for years. eDNA is a relatively new tool that can detect target organisms in soil and water samples more efficiently and accurately than conventional survey methods. This project developed eDNA methods to detect three species of fairy shrimp in soil and water samples and compared detection probabilities and costs with standard field-based methods.

5. Legacy Project: NR-15-782, eDNA-KIT: A Web-based Toolbox for Putting Environmental DNA into Practice

POC: [Dr. Katherine Strickler](#), Washington State University

eDNA is emerging as a powerful tool for producing reliable information about the presence and distribution of aquatic species; however, transfer of the technology to practitioners has not kept pace with eDNA method development. The objective of this project was to create a web-based toolbox of eDNA resources for DoD and other practitioners who are considering using eDNA techniques to manage aquatic species. This project makes eDNA tools more available and useful to DoD NRMs, enhancing decision making regarding if, when, and how to best use eDNA methods for aquatic species identification. Increased access to eDNA resources allow DoD managers to fully utilize the technology's benefits for effective management of aquatic species, potentially reducing constraints on military readiness training.

6. Legacy Project: NR-15-776, Habitat Mapping for Aquatic Species at Risk on Military Installations Using GPS-based Underwater Video

Point of Contact (POC): [Dr. Paul Ayers](#), University of Tennessee

This project involved the development of aquatic species at-risk habitat maps on military installations using GPS-based underwater video mapping and image georeferencing techniques. The Nottoway River on Fort Barfoot was continuously mapped to assess habitat for at-risk species including the Atlantic pigtoe mussel and the Roanoke logperch (*Percina rex*). Knowledge of and protection of available habitat within the installation for these two species are necessary due to the frequency of military exercises around and within the Nottoway River. This study established protocols for a DoD-wide large-scale aquatic habitat mapping approach.

Published reports and fact sheets are available on the DoD Legacy Resource Management Program DENIX website: <https://www.denix.osd.mil/legacy/>.

UPCOMING EVENTS, CONFERENCES, WORKSHOPS, AND TRAININGS

North American Wildlife and Natural Resources Conference

March 25-29, 2024

Grand Rapids, Michigan

The 89th North American Wildlife and Natural Resources Conference will bring together natural resources professionals from all sectors to exchange knowledge and best practices on issues such as endangered species, migratory birds, and landscape management through workshops and meetings. The event serves as the annual forum to set conservation policy in North America and includes conference sessions, workshops, and more than 150 separate meetings and functions.

National Military Fish and Wildlife Association (NMFWA) Annual Meeting and Training Workshop

March 25-29, 2024

Grand Rapids, Michigan

Held in conjunction with the North American Wildlife and Natural Resources Conference (above), the 41st NMFWA annual meeting and training workshop is the primary event where installation NRMNs meet to discuss key concerns and opportunities, recent policy and legislative changes, ongoing activities and recent accomplishments, and emerging issues and potential new challenges.

National American Regional Association of the International Association for Landscape Ecology Annual Meeting

April 1-5, 2024

Oklahoma City, Oklahoma

Efforts within the field of landscape ecology often blend design science, sustainability science, and creative conservation. This annual meeting brings together leaders in landscape ecology who are dedicated to preserving and protecting natural resources, including educators and practitioners in the fields of geology, ecology, biology, geography, urban and regional planning, and landscape preservation and design.

Northeast Fish and Wildlife Conference

April 21-24, 2024

Cape Cod, Massachusetts

The 79th annual Northeast Fish & Wildlife Conference, hosted by the Massachusetts Division of Fisheries & Wildlife, provides education, networking, and outreach opportunities to over 500 natural resources professionals in the fields of wildlife biology, fisheries and fisheries management, outreach and education, and law enforcement. This conference focuses on the management and protection of fish and wildlife resources primarily in the northeast.

Earth Day 2024: Planet vs. Plastics

April 22, Global

Earth Day has been celebrated worldwide since 1970. The focus of Earth Day 2024 is the reduction of plastics production and pollution. Goals of this movement include a 60% reduction in plastic production, phasing out single-use plastics, increasing public awareness on the health impacts of plastics, and more. The Earth Day toolkit provides further **resources**.

Western Black Bear Workshop

May 13-17, 2024

Jackson, Wyoming

The Western Black Bear Workshop is held every three years by the Human-Wildlife Conflicts Committee sanctioned by WAFWA. The workshop provides a forum where leading black bear managers and researchers share research results, management strategies, and emerging issues in the realms of black bear management throughout North America.

Western Association of Fish & Wildlife Agencies (WAFWA) 2024 Summer Meeting

June 2-7, 2024

Stevenson, Washington

The WAFWA biannual meetings occur in the summer and winter seasons. This summer's meeting will bring over 400 U.S. and Canadian fish and wildlife professionals together discuss shared biological, management, and land use issues. The event will attract professional fish and wildlife biologists (including commissioners and directors from over 20 states and provinces), managers, administrators, and others in fish and wildlife-related fields.

DoD Environmental Planning and Conservation (EP&C) Webinar Series

Virtual

The EP&C team hosts webinar presentations from Legacy Program project principal investigators, Natural and Cultural Resources Program partners, and other stakeholders on relevant topics for the Military Services, federal and state agencies, non-governmental organizations, and other interested groups. Webinars are held monthly via Microsoft Teams. To join the mailing list to receive notifications about these webinars, contact DoDNatRes@bah.com or DoD_CRProgram@bah.com.

Strategic Environmental Research and Development Program (SERDP) & Environmental Security Technology Certification Program (ESTCP) Webinar Series

Virtual

The SERDP and ESTCP Webinar Series promotes the transfer of innovative, cost-effective, and sustainable solutions developed through projects funded in five program areas. The webinar series targets DoD and Department of Energy practitioners, the regulatory community, and environmental researchers with the goal of providing cutting edge and practical information that is easily accessible. Most webinars will feature two 30-minute presentations and interactive question and answer sessions.

Readiness and Environmental Protection Integration (REPI) Program Webinar Series

Virtual

The REPI Webinar Series highlights best practices and provides knowledge sharing tutorials on REPI partnership efforts that support military missions, accelerate the rate of conservation, and promote military installation and community resilience.

LINKS OF INTEREST

DoD Environmental Planning and Conservation (EP&C)

DoD aims to preserve military readiness by ensuring access to 27 million acres of resources for operations. The Environmental Planning & Conservation (EP&C) portfolio supports environmental conservation, cultural stewardship, justice, and emergency planning, enhancing resilience through innovation. EP&C's coordination ensures effective management of national resources and community health, supporting the DoD's defense mission.

DoD Natural Resources Program

DoD's Natural Resources Program provides policy, guidance, and oversight to manage natural resources on approximately 27 million acres of military land, air, and water resources. Visit the Natural Resources Program website for more information on DoD's natural resources initiatives, policy updates, presentations, and links to other conservation and natural resources sites.

DoD Legacy Resource Management Program

Congress established the DoD Legacy Resource Management Program (Legacy Program) in 1990 and modified it under the Fiscal Year 1997 National Defense Authorization Act. The Legacy Program funds natural and cultural resources projects that support military readiness and enhance conservation objectives. Projects eligible for Legacy Program funding must have regional or DoD-wide significance and involve more than one Military Service; be necessary to meet legal requirements or to support military operations; be more effectively managed at the DoD level; and not be an assigned responsibility of a Military Service.

Armed Forces Pest Management Board (AFPMB)

AFPMB recommends policy, provides guidance, and coordinates the exchange of information on pest management throughout DoD. Its mission is to ensure that environmentally sound and effective programs are in place to prevent pests and disease vectors from adversely affecting natural resources and DoD operations.

Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP)

SERDP and ESTCP are independent DoD research programs that use the latest science and technology to develop innovative solutions to DoD's environmental challenges. They promote partnerships and collaboration among academia, industry, the Military Services, and other federal agencies that support military readiness, compliance with legislation and policy, and natural and cultural resources management.

Readiness and Environmental Protection Integration (REPI)

Under REPI, DoD partners with conservation organizations and state and local governments to preserve land around military installations to combat encroachment. REPI promotes innovative land conservation, which preserves the military's ability to train and test on its lands now and into the future.

Cooperative Ecosystem Studies Units (CESU) Network

DoD participates in the CESU Network, which is a national consortium of federal agencies, tribes, academia, state and local governments, and non-governmental organizations working together to provide research, technical assistance, and training

to federal agencies and their partners. The CESU Network also provides managers with the adaptive management approaches necessary to preserve installation natural and cultural resources.

DoD Wildland Fire Management

DoD manages 27 million acres across its land portfolio. These are not only mission-critical training lands, but they also support a vast natural landscape with dynamic ecosystems, valuable habitat for threatened and endangered species, as well as outdoor recreation for military personnel and local communities. The occurrence of well-managed wildland fire on the landscape plays a significant role in the structure and function of these natural systems. Website visitors can learn more about wildland fire operations on installations, explore interagency wildland fire operations, and find a list of resources for wildland fire managers.

DoD Partners in Flight (PIF)

DoD PIF consists of natural resources personnel from military installations across the United States and works collaboratively with partners throughout the Americas to conserve migratory and resident birds and their habitats. In addition, DoD PIF supports and enhances the military mission through proactive, habitat-based management strategies that help protect birds on DoD lands and maintain healthy landscapes and training lands. Visit the DoD PIF website for fact sheets, reports, and other materials with information about DoD's migratory bird conservation efforts.

DoD Partners in Amphibian and Reptile Conservation (PARC)

DoD PARC is a partnership dedicated to the conservation and management of herpetofauna (reptiles and amphibians) and their habitats on military lands. DoD PARC membership includes natural resource specialists and wildlife biologists from the Military Services, and individuals from state and federal agencies, museums, universities, and environmental consultants. Visit the DoD PARC website for information about herpetofauna management projects on DoD lands.

DoD Pollinator Initiatives

Visit this website for an overview of pollinators and why they are important to DoD. The website also contains information on how people can help protect pollinators and their habitat, including fact sheets, technical reports, and how-to guides.

DoD Invasive Species Outreach Toolkit

This toolkit has materials to help DoD NRMs communicate with agencies, organizations, and the public about invasive species issues on DoD lands. Specifically, the tool kit includes modifiable outreach materials, such as posters, brochures, reference cards, and a PowerPoint presentation.

Conserving Biodiversity on Military Lands: A Guide for Natural Resource Managers

The DoD Biodiversity Handbook contains a thorough introduction to biodiversity and how it is essential to support the military mission. It also details the scientific, legal, policy, and natural resources management contexts for biodiversity conservation on DoD lands, and includes 10 case studies with practical advice from DoD NRMs.



DOD NATURAL RESOURCES PROGRAM

Enabling the Mission, Defending the Resources

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Natural Selections

Natural Selections is published by Booz Allen Hamilton with funding awarded by the DoD Legacy Resource Management Program under Washington Headquarters Services contract number HQ0034-20-F-0574. All written information contained in *Natural Selections* is public and not copyrighted.

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