

Pacific Islands Fisheries Science Center

2018 Marine Debris Removal and Assessment in the Northwestern Hawaiian Islands



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Introduction

The Papahānaumokuākea Marine National Monument (PMNM) includes all of the Northwestern Hawaiian Islands (NWHI) and encompasses 1,508,870 km² (582,578 mi²) of the Pacific Ocean. Within the boundaries of the monument lie coral reefs, atolls, shoals, and seamounts, including 70% of all shallow-water coral reef habitats (<200 m) in the United States. The PMNM was named a World Heritage site in 2010 by the 34th session of the World Heritage Committee in recognition of its cultural and natural values (World Heritage Committee 2010). The extensive coral reefs found in the PMNM are home to more than 7,000 marine species, one-quarter of which are found only in the Hawaiian Archipelago (PMNM Webmaster 2019). Many of the islands and shallow-water environments in the PMNM are important habitats for rare species, such as the green sea turtle (listed as threatened under the U.S. Endangered Species Act) and Hawaiian monk seal (listed as endangered under the International Union for Conservation of Nature Red List and as endangered under the U.S. Endangered Species Act). The PMNM contains only 15 km² of emergent land, but 14 million seabirds representing 22 species use this land as breeding and nesting grounds (PMNM Webmaster 2019). Land areas provide a home for four species of birds found nowhere else in the world, including one of the world’s most endangered ducks—the Laysan duck (PMNM Webmaster 2019).

The PMNM is centrally located within the world’s largest ocean gyre, the North Pacific Gyre (Figure 1). This gyre is a system of clockwise rotating ocean currents between 8°N and 50°N latitude which extends across approximately 20 million km² (7.7 million mi²) of ocean (Karl 1999). Marine debris (including plastics and derelict fishing gear) originating from across the North Pacific Rim is often entrained and then concentrated within this gyre. The Hawaiian Islands are located just south of the gyre’s convergence zone, resulting in the islands and atolls of the NWHI being particularly prone to marine debris accumulation.



Figure 1. Papahānaumokuākea Marine National Monument and the Hawaiian Archipelago within the North Pacific Gyre.

Project Background

At least 52 metric tons (115,000 lb) of derelict fishing gear (DFG) is estimated to accumulate on the shallow coral reefs of the PMNM each year (Dameron et al. 2007). Since 1996, the NOAA Pacific Islands Fisheries Science Center (PIFSC) and agency partners have conducted ship-based, large-scale removal of DFG and plastics from the reefs and shorelines of PMNM in order to mitigate the entanglement and ingestion threats to protected wildlife as well as damage to coral reefs. Impacted species include the endangered Hawaiian monk seal, threatened green sea turtle,



Figure 2. Annual and cumulative weight of marine debris removed by PIFSC from the Northwestern Hawaiian Islands, 1996–2018.



and numerous avian species. For example, between 1982 and 2019, 404 Hawaiian monk seals were recorded as becoming entangled in DFG in the PMNM. Of the estimated 1,400 remaining Hawaiian monk seals, an estimated 32% of them are alive today due to marine debris disentanglement, rehabilitation efforts, and cleanups (Harting et al. 2014). Since the NWHI marine debris removal project began, PIFSC and agency partners have been successful in removing 923 metric tons (2 million lb) of DFG and plastics—the equivalent weight of 30 adult humpback whales—from the sensitive environment of the PMNM (Figure 2).

In-Water Debris Removal

Two methods are utilized for the in-water survey and removal of DFG: towboarding and snorkel surveys. Free-dive towboarding, also known as manta tow, allows for rapid visual surveys in shallow water (<30 ft) and maximum area coverage. This unique method requires divers to use breath-holding techniques while being towed behind a 17–19 ft inflatable boat at 1–2 knots across fringing or barrier reefs. Snorkel (swim) surveys are primarily used within atoll lagoons around reticulated reefs or in areas which are too shallow or intricate to conduct towboard operations effectively. In both methods, divers conduct surveys until DFG is visually located entangled on the reef. Once located, net location (latitude and longitude), net characteristic (type, length, width, height, depth, foul level, coral growth) and habitat characterization data are collected, and divers cut the DFG free from the substrate while minimizing impact to the entangled coral and surrounding reef habitat. Once the DFG is free from the reef, it is loaded by hand into the inflatable boats for transport to the ship.

Shoreline Debris Removal

The shorelines of the PMNM are depositories for buoyant ocean plastics and DFG. This debris can pose an ingestion hazard (Schuyler et al. 2014), entanglement/entrapment hazard (Harting et al. 2014), and may impact hatching success on marine turtle nesting beaches (Triessnig et al. 2012).

Shoreline accumulation has been studied at Midway Atoll since 2013. To expand the spatial extent of that study, shorelines at five additional islands were added in 2018: Kure Atoll, Pearl and Hermes Atoll, Lisianski Island, Laysan Island, and French Frigate Shoals. This work was done in partnership with NOAA PIFSC’s Protected Species Division (PSD) Hawaiian Monk Seal Research Program (HMSRP). The shorelines of these islands were divided into 300 m segments stratified by directional aspect and randomly selected for survey and removal of marine debris. A total of twenty-five 300 m segments were cleaned across those five islands. Each segment was surveyed and cleaned of all DFG and plastics greater than 10 cm in size. Debris items were sorted and tallied by debris type, and survey area was tracked and calculated using GPS and geographic information system (GIS) software.

Plastic Fragments	33,508
Buoys & Floats	10,593
Bottle Caps	9,591
Oyster Aquaculture Spacers	7,797
Beverage Bottles	3,603
Nets & Net Fragments	2,575
Slippers & Shoes	1,964
Toothbrush & Personal Care Items	1,320
Eel Cone Traps	716
Cigarette Lighters	687
Plastic Toys	432
Plastic Baskets	342



Table 1. Tallies of marine debris items removed from the shorelines of the NWHI in 2018.

2018 Mission

In September 2018, a team of scientists and divers led by the NOAA PIFSC conducted a large-scale mission to survey and remove marine debris from the islands and atolls of the PMNM. Over the course of 41 days, two ships, and a shore-based mission, the team was able to successfully remove over 74 metric tons (164,013 lb) of derelict fishing gear, plastic, and other marine debris from the shallow (<30 ft) coral reefs and shoreline environments. The mission from September 19 to October 30, 2018, consisted of three legs:

1. In-water removal of DFG from Pearl and Hermes Atoll aboard NOAA Ship *Oscar Elton Sette*: September 19–October 11.

Over the course of ten operational days, a team of 18 divers and one UAS (unmanned aerial systems) pilot surveyed the lagoon of Pearl and Hermes Atoll. A total of 23,362 kg (51,504 lb) of DFG was removed from the shallow reefs. During that time, a total area of 2.23 km² of reef was surveyed and cleaned; 1.99 km² was surveyed via snorkel methods, and 0.24 km² was surveyed via towboarding methods (Figure 3).

2. In-water and shoreline removal of DFG, plastics, and other debris from Midway Atoll: October 5–25, 2018.

A team of 15 staff disembarked the NOAA Ship *Oscar Elton Sette* at Midway Atoll to conduct a land-based mission to survey and remove shoreline and in-water debris. The result of the Midway effort yielded 28,685 kg (63,240 lb) of DFG, plastics, and other debris removed. A total area of 1.35 km² of reef and 0.41 km² of shoreline were surveyed and cleaned.



NOAA Ship *Oscar Elton Sette*

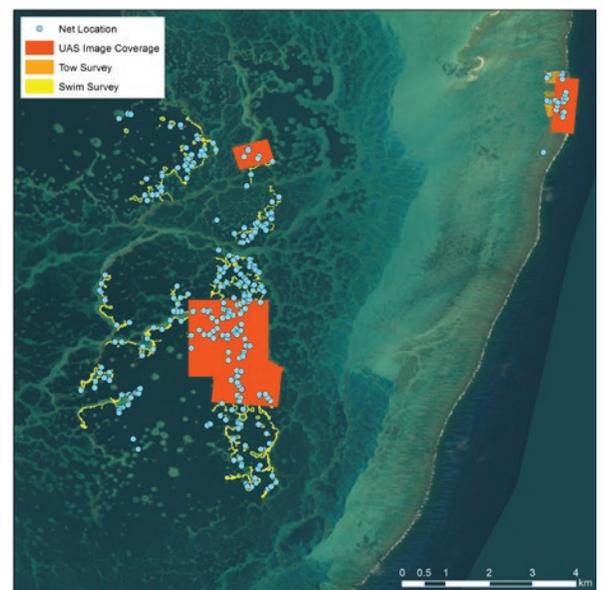


Figure 3. Spatial distribution of swim, towboard, and UAS surveys at Pearl and Hermes Atoll during Leg 1 of the 2018 Marine Debris Project.

3. Shoreline removal of DFG, plastics, and other debris from Kure Atoll, Pearl and Hermes Atoll, Lisianski Island, Laysan Island and French Frigate Shoals aboard M/V *Imua*: October 13–30, 2018.

A team of ten staff embarked chartered vessel M/V *Imua* at Midway Atoll to survey and remove debris from the shorelines of five islands and atolls within the PMNM. Over the course of 12 operational days, a total of 22,348 kg (49,269 lb) of marine debris was removed from those shoreline environments. Of the 12 days, one was spent at Kure Atoll, three at Pearl and Hermes Atoll, three at Lisianski Island, three at Laysan Island, and two at French Frigate Shoals. Of the 22,348 kg (49,269 lb) of marine debris removed, 12,908 kg (28,457 lb) was DFG and 9,440 kg (20,812 lb) was plastic and other debris. The amounts of debris removed from each of the five islands and atolls are shown in (Figure 4).

The 2018 effort focused on the removal of DFG and plastics from the PMNM, but also included several ancillary marine debris research objectives:

Structure-from-Motion (SfM) Benthic Impact Pilot Study

For many years, marine debris removal divers have qualitatively observed derelict fishing gear (DFG) causing damage to coral reefs by breaking, shading, and abrading live coral colonies. During the 2018 removal effort, data were collected using Structure-from-Motion (SfM) technology in an effort to quantify this impact to the benthos. SfM is a modern photogrammetry method that uses overlapping sequences of 2-dimensional photographs to produce a 3-dimensional digital model. The resulting point cloud and mosaic image allow accurate measurement of features and provide a detailed 3-D visual representation of a large area in a single image.

DFG removal sites within the lagoon at Pearl and Hermes Atoll were surveyed using SfM methods with two objectives: (1) to quantify ecological impacts as a result of derelict fishing net interaction with coral reefs and (2) to establish a baseline from which future recovery and/or successional changes in the coral reef benthic community could be examined as a result of derelict net removal.

Nets were located during swim surveys and selected for SfM if the net was interacting with coral or hard substrate and the depth of the net was within 1–3 m of the surface. At each selected net removal location,



M/V *Imua*

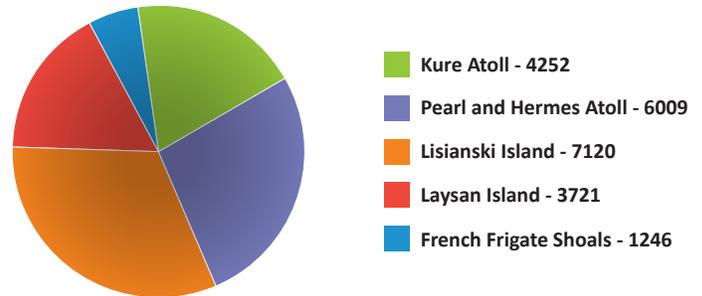


Figure 4. Proportion of debris removed from five surveyed islands and atolls during Leg 3 of the 2018 Marine Debris Project. Values in black are the weight (kg) of debris removed.

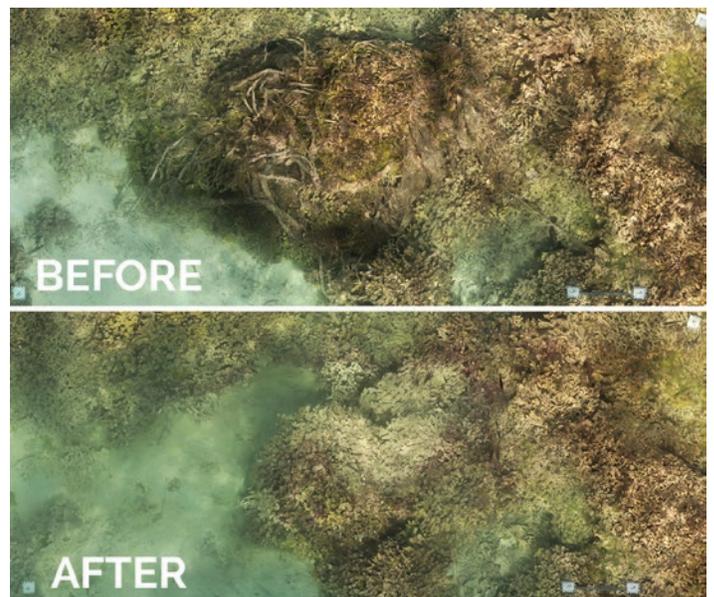


Figure 5. Before and after net removal at an impact site at Pearl and Hermes Atoll.

a 3 m × 3 m plot was established over the center of the net. The site location was physically marked and recorded so that the plot can be surveyed again in the future. An SfM survey was completed at each site before net removal, after removal, and at a nearby control site (Figure 5). A total of 21 net removal sites and 24 control sites were photographed. Analysis of this imagery began in 2019 to determine benthic habitat characterization and coral condition in areas with and without derelict nets. The goal of this study is to successfully measure negative impact caused to coral reefs by nets according to size and weight.

Unmanned Aerial System (UAS) DFG Detection Pilot Study

In an effort to explore the feasibility of using a UAS (commonly referred to as a drone) to detect DFG from above, a project was created in collaboration with the University of Hawaii Applied Research Lab UAS Program. The objective of this project is to evaluate the efficiency and accuracy of aerial DFG detection surveys in comparison to traditional in-water (towboard and snorkel) surveys. UAS surveys were conducted in locations prior to in-situ surveys and debris removal efforts. Using a fixed wing vertical takeoff and landing Flightwave Edge model aircraft, nine flights were flown over the lagoon of Pearl and Hermes. Mapping-quality imagery was collected at 60 m altitude (determined most effective altitude for resolving DFG), using both infrared (IR) and red-green-blue (RGB) sensors (Figure 6). A total area of 3.39 km² of potential DFG habitat was mapped using the UAS in less than 10 cm resolution. Future analyses will compare the count and location of nets between the aerial and in situ surveys to determine whether UAS surveys will be integrated into future DFG removal efforts.

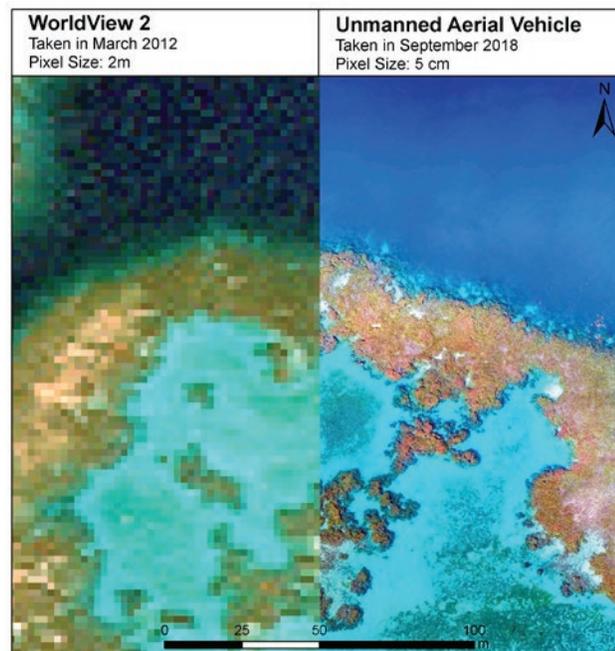


Figure 6. Imagery captured by satellite vs. UAS at Pearl and Hermes Atoll.

Satellite Tracking of DFG Pilot Study

Derelict fishing nets are often partially buoyant, with sections of the net entangled in the shallow reef substrate while other sections remain afloat. Little is known about whether this buoyancy impacts net movement and the number of interactions a single net can inflict on various coral reefs within a reef system. In 2018, a pilot study which used satellite tracking buoys to monitor net movement over time was initiated. Six derelict fishing nets were located via visual survey in the northeastern region of Pearl and Hermes Atoll and left in place for the purpose of satellite tracking. These nets were at least 75% buoyant and had a minimum in-water volume of 0.5 m³. A satellite tracking buoy, which can position and track information of its exact location at any given time remotely, via the internet, was attached to each of the six nets. The movement of these nets within the atoll will be tracked over the course of 2018–2020 in order to provide more insight into the movement patterns of DFG and the number of reef interactions a single net can be expected to have over time. The deployment locations and initial movements can be seen in (Figure 7).

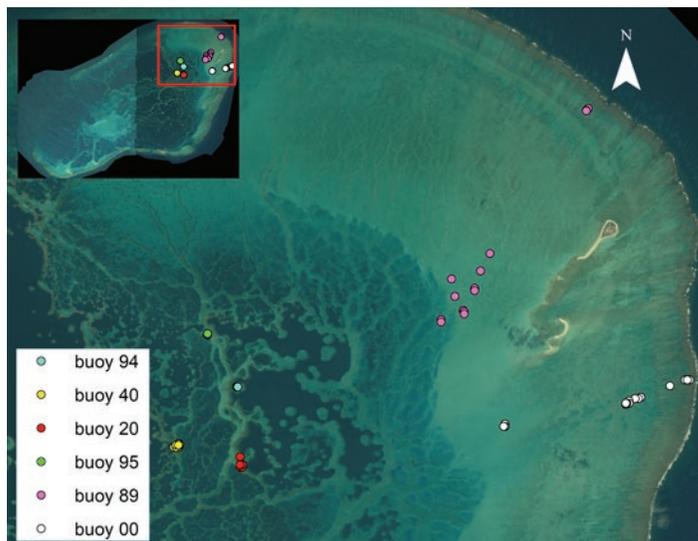


Figure 7. Spatial distribution and movement of satellite buoys deployed on nets at Pearl and Hermes Atoll during Leg 1 of the 2018 Marine Debris Project.

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Project Partners

NOAA National Marine Fisheries Service (NMFS)

- Pacific Islands Fisheries Science Center (PIFSC)
- Ecosystem Sciences Division (ESD)
- Protected Species Division (PSD)
- Restoration Center (RC)
- Damage Assessment Remediation and Restoration Program (DARRP)

NOAA National Ocean Service (NOS)

- Office of Response and Restoration (ORR)
- Marine Debris Program (MDP)
- Office of National Marine Sanctuaries (ONMS)
- Papahānaumokuākea Marine National Monument (PMNM)

University of Hawaii at Manoa

- School of Ocean and Earth Science and Technology (SOEST)
- Joint Institute for Marine and Atmospheric Research (JIMAR)

National Fish and Wildlife Foundation (NFWF)

Fishing for Energy Partnership

Hawaiis Nets-to-Energy Program

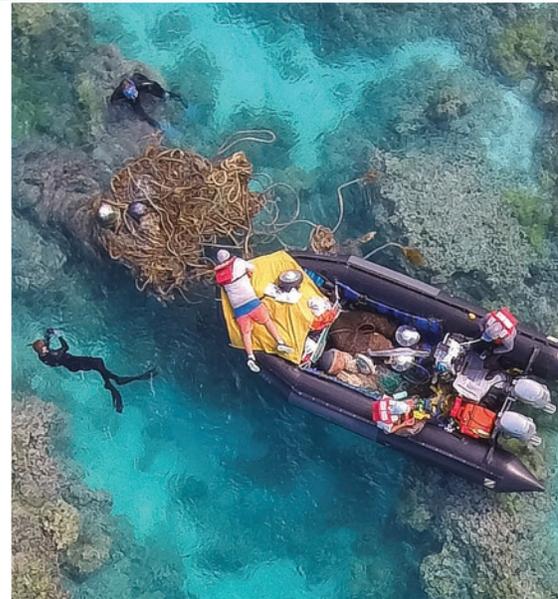
- Schnitzer Steel Industries, Inc.
- Covanta Honolulu / Honolulu Program of Waste Energy Recovery (H-POWER)

U.S. Fish and Wildlife Services (USFWS)

- Midway Atoll National Wildlife Refuge

National Marine Sanctuaries Foundation (NMSF)

SatLink Global





Summary

Marine debris and derelict fishing gear affect the entire Hawaiian Archipelago and all the people and wildlife living in it. Whether entangling marine animals (seals, turtles, whales, fish, and invertebrates) or adversely impacting corals as large, derelict fishing nets roll across reefs, marine debris is a detriment to fragile coral reef ecosystems—some of the most biologically diverse and economically valuable ecosystems on earth (Bryant et al. 1997).

Fortunately, we can each do our part to help protect our marine environment and ocean wildlife from the effects of marine debris. From recycling and reusing materials to participating in local beach cleanups, working together, we can make a difference. NOAA PIFSC and our project partners are proud to continue our long tradition of leading marine debris removal missions from the protected waters and shores of the Papahānaumokuākea Marine National Monument.



U.S. Secretary of Commerce
Wilbur L. Ross, Jr.

Acting Under Secretary of Commerce
for Oceans and Atmosphere
Dr. Neil Jacobs

Assistant Administrator for Fisheries
Chris Oliver

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www.fisheries.noaa.gov

National Marine
Fisheries Service
Pacific Islands Fisheries Science Center
1845 Wasp Boulevard
Honolulu, HI 96818

