NORTH PACIFIC MARINE SCIENCE ORGANIZATION (PICES)
PROJECT ON *"EFFECTS OF MARINE DEBRIS CAUSED BY THE GREAT TSUNAMI OF 2011"*

Year 2 Final Report

1. PROJECT INFORMATION

Title:	Hawaiian Islands Marine Debris Aerial Imagery Survey
Award period	June 1, 2015 –January 31, 2016
Amount of funding	$85,000 CAD
Report submission date	March 24, 2016
Lead Author of Report*	Brian Neilson

Principal Investigator(s), Co-Principal Investigators and Recipient Organization(s):

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2. EXECUTIVE SUMMARY

The Hawaiian Islands have been a major landing site for marine debris from the Great Japanese Tsunami of 2011. The debris has served as a rafting mechanism for non-native species to the Hawaiian Islands. Managers and researchers are monitoring marine debris landing sites for the presence of non-native species. As part of the effort to identify Japanese tsunami marine debris (JTMD) on the Hawaiian Islands, a remote sensing firm, Resource Mapping Hawaii, was contracted to collect imagery of approximately 2,000 km of coastline. The imagery was then analyzed using remote sensing techniques to locate, categorize, and quantify marine debris in the main Hawaiian Islands in a separate PICES project.

3. PROGRESS SUMMARY

a. Describe original proposed research and planned outputs

The main Hawaiian Islands have been a major landing site for marine debris caused from the Great Tsunami of 2011. To date, 235 suspected JTMD items have been recovered as recently as January 2016. Thirty of these suspected JTMD items were confirmed by the Japanese consulate. It was also confirmed that marine debris is a vector for alien species rafting, with 79 alien species identified on suspected JTMD from Hawaiian shores and coastal waters.

In order to help characterize the potential ecological consequence of tsunami debris, it is important to understand and quantify where the debris is accumulating and the type of debris. Given the vast extent and remoteness of coastlines in the Hawaiian Islands, large-scale surveillance efforts are needed to identify these accumulations. Aerial imagery allows for rapid qualitative and quantitative assessments at this scale. This

technique was also shown to be effective in Alaska and British Columbia. The project was conducted in two phases:

Phase 1 – Aerial image survey: image collection and processing
Phase 2 – Aerial image analysis for marine debris

This report covers Phase 1 of the project with the following objectives:

- Collect imagery of the shorelines of the main Hawaiian Islands;
- Process the imagery into an ortho-mosaic that is ArcGIS ready for marine debris analysis.

Aerial Image Data Collection

A remote sensing firm, Resource Mapping Hawai'i (RMH), was contracted by the Hawaii Department of Land and Natural Resources (DLNR) to conduct aerial image surveys of the coastlines of the main eight Hawaiian Islands. RMH collected high-resolution (2 cm/pixel) photos in natural color (RGB) from August to November 2015 (Table 1). RMH used a fixed wing Cessna 206 and an IDM600 mapping system to capture the imagery (Fig. 1). Flight plans were based on weather conditions (cloud cover, tailwinds, downdrafts, and turbulence) and shoreline topography to maximize image quality and minimize safety risks. High-resolution aerial imagery required flying slow and low to the ground. Therefore, areas of rugged terrain such as steep cliffs and complex coastlines posed challenges to maintain steady flight lines, speed and altitude. Flight plans were determined using a USGS digital elevation model (10 m DEM). In addition to weather concerns, RMH was limited by airspace restrictions around airports and military bases. As a result, there were some gaps in the imagery, but approximately 98% of shorelines were captured. While the amount of land and ocean included in the imagery was variable, at least one third of the imagery swath was land above the tide line.

Imagery flights were conducted at approximately 2000 ft (610 m) above ground level (AGL) to achieve a target ground sampling distance (GSD) of 2 cm, and covered a swath width between 200-300 m perpendicular to the shoreline. A groundspeed of 90 kts was used to ensure a consistent overlap of 60% between photos. Icaros Navigation software was used to navigate flight lines. A Navstar GPS was used for positioning and a 3-axis gyro-stabilized gimbal with an inertial measurement unit (IMU) was used to maintain a three-DSLR camera array within 4 degrees of crab, pitch and roll angles. Imagery surveys were planned during the mid-morning or late afternoon hours to ensure adequate lighting conditions and avoid shadows with sun angles greater than or equal to 30 degrees. Intermittent clouds (and resulting shadows) posed some challenges to maintaining consistent exposures, requiring the camera operator to make occasional manual adjustments to aperture and ISO settings.

Table 1 *Aerial survey areas, coastline length and survey dates.*

Island	Coastline length (Miles/Km)	Survey dates
O'ahu	237/381	9/24/15
Kaua'i	125/201	10/6/15
Moloka'i	119/191	9/23/15
Maui	192/308	9/7/15
Big Island	397/638	8/7/15, 8/8/15, 8/9/15, 9/1/15
Ni'ihau	52/83	10/6/15
Lana'i	58/93	9/9/15
Kaho'olawe	43/69	11/28/15
Total	1,276 miles/2,053 km	11 flight days

Fig. 1 RMH's Cessna 206 and IDM mapping system for image capture.

Image Processing

Image processing was done using IPS 4.0, a photogrammetry software by Icaros, Inc. for ortho-rectification, aerial triangulation and mosaicking. The raw images were corrected for distortions using data from GPS, elevation, IMU and camera calibration. Matching features in overlapping photos were identified *via* automated feature extraction, and then the images were merged into mosaic tiles as GeoTIFF files under 2 GB each for easy access and viewing in ArcGIS (Fig. 2). Standard aerial triangulation was used to produce triangulated blocks with internal root mean squared errors (RMSE) values of less than 1 pixel for each island unit. The positional accuracy was determined to be within 2cm RMSE.

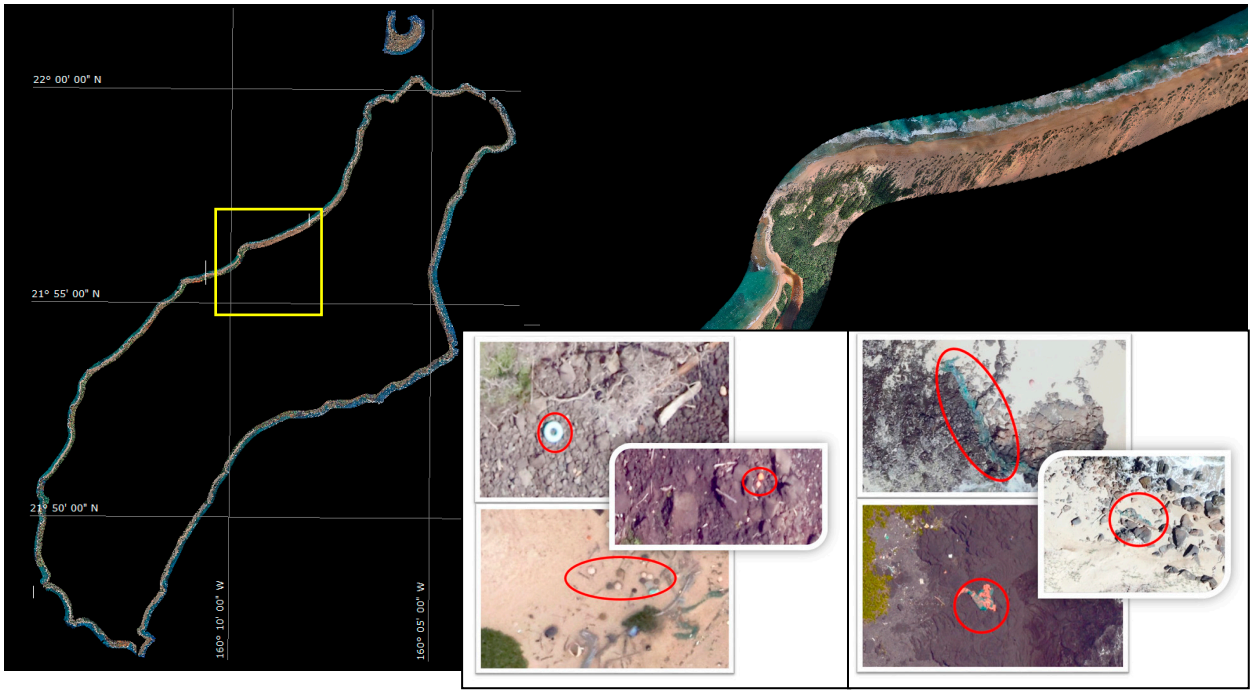

Fig. 2 Example image mosaic of the Hawaiian Island of Ni'ihau (left), zoom in of the shoreline imagery of Niihau (top right) and examples of imagery and marine debris located on Niihau (bottom right).

b. **Describe progress**

c. Describe any concerns you may have about your project's progress

This project was completed on schedule.

d. Completed and planned publications

We are working to publish the image analysis phase of this project.

e. Poster and oral presentations at scientific conferences or seminars

This project will be presented at the 13th International Coral Reef Symposium to be held June 19–24, 2016, in Honolulu, Hawai'i, USA (http://coralreefs.org/conferences-and-workshops/13th-international-coral-reef-symposium-hawaii/).

4. PROGRESS STATUS

This project was completed in January 2016.