

1. PROJECT INFORMATION

Title:	Surveillance and Monitoring of Tsunami Debris
Award period	September 1, 2014 to March 31, 2015
Amount of funding	\$97, 672.88
Report submission date	April 29, 2015
Lead Author of Report*	Cathryn Clarke Murray

**Although there may be only one lead author of the report, all PIs and co-PIs of the project, as identified in the approved statement of work and listed below, are responsible for the content of the Final Report in terms of completeness and accuracy.*

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

Cathryn Clarke Murray, PICES Secretariat (cmurray@pices.int)
Nancy Wallace, NOAA Marine Debris Program (nancy.wallace@noaa.gov)

2. EXECUTIVE SUMMARY

Describe the research purpose, objectives, methods, results, achievements and challenges, timelines and milestones (2-3 pages)

Characterizing the impact of debris from the 2011 Great Tōhoku Earthquake and tsunami requires an understanding of the amount, type and timing of debris landing on North American and Hawaiian coastlines. In some cases, large debris items require rapid response in order to avoid navigation hazards for maritime traffic, such as that needed for derelict fishing vessels and the large floating concrete docks. Rapid response to debris sightings is also required to obtain fresh biological samples of any species attached to debris items. Watching for new debris landings on the North American and Hawaiian coastlines as well as monitoring the landfall of tsunami debris compared to the normal influx of marine debris requires ongoing surveillance and monitoring activities.

Surveillance

Surveillance activities were undertaken in order to search for large debris items (vessels, skiffs, docks) and to identify hot spots of debris accumulation. Data gaps were identified for the surveillance of the Canadian Pacific coast. While beaches in Washington State, Oregon and California are regularly visited, cleaned and monitored, little surveillance and monitoring occurs on the remote western-facing beaches of British Columbia and Alaska at risk of tsunami-debris landfall. Aerial surveys are cost-effective ways to monitor these vast, largely uninhabited coastlines where debris may be accumulating and to identify potential “hot spots”. Aerial surveys have been conducted in Alaska to identify hot spots of debris accumulation and prioritize clean ups.

PICES contracted a local aerial photography company, Lightspeed Digital, to complete aerial surveys of British Columbia, Canada. The British Columbia survey complements aerial surveys completed by the State of Alaska in 2013 and 2014 as part of their debris response and removal activities, and uses the same survey methodology. These surveys consist of overlapping oblique photographs taken from a small plane, flying between 500m and 1000m above the beach. Post-survey processing assigned unique identifiers (tags) for specific types of debris and quantified the amount of debris on a qualitative scale from 0-5.

In October 2014, aerial surveys of British Columbian coastlines began and were completed in March 2015. The entire outer exposed coast of British Columbia (over 1500 kilometers) has been captured; on the west coast of Vancouver Island from Port Renfrew to Cape Scott, the Central Coast region, outer coast of Haida Gwaii and Chatham Sound. There are over 6,500 images of the shorelines. The surveys have located at least six skiffs and vessels as well as a number of other large debris items on remote beaches of British Columbia and provided rankings of debris accumulation for the outer coast shorelines

Conducting aerial surveys in winter is not ideal but the surveys were completed on time in spite of the conditions. Future research will focus on identifying any remaining regions that would benefit from aerial surveys, developing image analysis techniques to gain further data from aerial survey images, and hot spot analysis to direct invasive species monitoring field research.

Monitoring

Monitoring research activities aimed to quantify the amount, distribution and timing of debris landfall and estimate debris landfall attributable to the 2011 tsunami, compared to baseline amounts. Three data sources were made available to PICES to examine the influx of marine debris after the 2011 tsunami: 1) the National Oceanic and Atmospheric Administration (NOAA) shoreline monitoring surveys, 2) Olympic Coast National Marine Sanctuary (OCNMS) shoreline surveys, and 3) NOAA's disaster debris reports.

The ongoing NOAA marine debris shoreline survey is a rapid, quantitative beach survey which uses trained community volunteer organizations to collect standardized and consistent data. NOAA's current shoreline monitoring program began in 2011 and continues through the present. In the wake of the 2011 tsunami, this ongoing research provided an opportunity to analyze the amount of debris. The NOAA dataset was analyzed for trends in distribution and abundance of debris concentration and type over time and across the Pacific coast of North America and Hawaii. An additional dataset maintained by OCNMS was used to establish a baseline of marine debris influx for northern Washington State. This survey recorded marine debris indicator items and began in 2001 and continued until the new survey methodology began in 2012 which records all marine debris items.

The analysis of these two datasets first identified common sites between the two survey timelines, matched the two sets of categories (removing and combining categories as needed) and then analyzed the spatial and temporal trends in marine debris influx. There was a sharp increase in the influx of indicator debris items, from 0.03 items per 100m per day to 0.29 debris items/100m/day. This is an 867% increase in debris over that recorded in the nine year period prior to the tsunami event. The increase of all debris items, not just indicator items, cannot be calculated but the increase over the indicator baseline is almost 600,000%. Therefore the North American coastline experienced an influx of tsunami debris items that was significantly and substantially higher than the baseline amount.

After the tsunami event, there were peaks in all debris items (not just indicator items) in May 2012, early in 2013, and smaller peaks in May 2014 and late 2014. In May 2012, the mean debris influx recorded was

over 180 debris items/100m/day. Reports of disaster debris peaked in May 2012, March 2013 and May 2014 with at least one confirmed 2011 Japan tsunami debris item in each of the temporal peaks. The three peaks in debris landfall after the tsunami are similar to the peaks in disaster debris reported to NOAA and these peaks are consistent with modeling predictions.

Across the states and provinces of study, Hawaii received the most debris items over the post-tsunami study period (2012-2014). British Columbia, Canada has the second highest debris influx in this time period, driven by a few surveys in Haida Gwaii (northern BC) with high numbers of large Styrofoam pieces. Alaska had few surveys to analyze and we are investigating other data sources for this region. The incidence of large debris items (larger than 30cm) was highest in Washington State, followed by Alaska and California and the highest arrival of large items occurred in 2013 and 2014.

The congruence between the influx of marine debris documented in the shoreline surveys, the disaster debris reports and oceanographic modeling is a striking and interesting result. The analysis will be documented in a manuscript and submitted to a peer-reviewed journal in the next year. Shorelines that accumulate debris in general and tsunami debris in particular (hot spots) will be identified using the data from the aerial surveys, beach monitoring surveys and webcam monitoring and used to direct field surveys for tsunami-debris related invasive species introductions.

3. PROGRESS SUMMARY

a. Describe original proposed research and planned outputs

Provide a summary of the research you proposed to PICES and the outcomes and deliverables you planned to produce.

Surveillance: We were tasked with conducting aerial surveys of British Columbia coast, following the State of Alaska protocol in collaboration with NOAA scientists.

Monitoring: We were tasked with analyzing marine debris beach monitoring data provided by NOAA in order to document the trends in marine debris arrival in North America and Hawaii.

b. Describe progress.

Provide a narrative of your activities and accomplishments (Including samples collected, data analysis completed, etc.), being as clear and concise as possible. If no progress was achieved on a particular objective during this reporting period, state why and, if applicable, describe how you plan to address the objective in the future.

Surveillance

PICES contracted a local aerial photography company, Lightspeed Digital, to complete the aerial survey of British Columbia, Canada. In October 2014, aerial surveys of British Columbian coastlines began and were completed in March 2015. The British Columbia survey complements aerial surveys completed by the State of Alaska in 2013 and 2014 as part of their debris response and removal activities, and uses the same survey methodology. These surveys consist of overlapping oblique photographs taken from a small plane, flying between 500 and 1000 m from the beach. Post-survey processing assigns unique identifiers (tags) for specific types of debris and quantifies the amount of debris on a qualitative scale from 0-5.

Monitoring

The PICES project is analyzing the data for trends in distribution and abundance of debris concentration and type over time and across the Pacific coast of North America and Hawaii. The goal of the analysis is to characterize the signal of the tsunami debris pulse against the background of ongoing ocean and land-based debris and determine how much the tsunami debris increased or changed the influx of marine debris to North American and Hawaiian coastlines. Since 2011, over 421 surveys have been conducted at 123 sites in California, Oregon, Washington, Alaska and Hawaii as well as British Columbia, Canada.

Because the current monitoring program began in 2012, it is difficult to establish a baseline level of marine debris before the tsunami occurred. We were given access to the Olympic Coast National Marine Sanctuary (OCNMS) beach monitoring data. These surveys were carried out over a longer time series although there is a slightly different survey method that must be taken into account during the analysis. The OCNMS data ranges from 2003-2012 and there are 11 sites in common with the monitoring dataset begun in 2011.

c. Describe results.

Surveillance

The entire outer exposed coast of British Columbia (over 2,000 kilometers) has been captured, the west coast of Vancouver Island from Port Renfrew north to Cape Scott, the Central Coast region, outer coast of Haida Gwaii and Chatham Sound (Figure 1). The surveys have located a number of skiffs and a number of other large debris items on remote beaches of British Columbia. These will be cross-referenced with the disaster debris reports and other sightings. The photographs have been assigned rankings of debris accumulation for the outer coast shorelines. There are over 6,500 images of the shorelines (Figure 2) that will be made available directly to the project science team and online through an interactive map

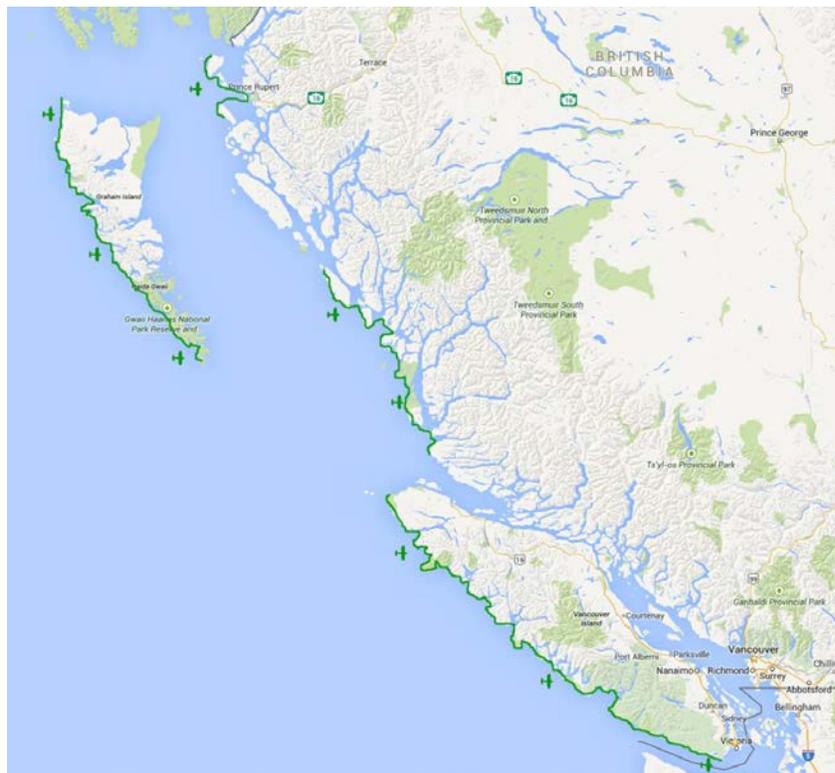


Figure 1: Aerial surveys of British Columbia, Canada (green) completed.



Figure 2: Examples of aerial survey photographs of the exposed shorelines of British Columbia, Canada.

Monitoring

The beach monitoring dataset post-2011 has a high degree of variability between sites and years so the influx of tsunami debris is difficult to detect. When adding the longer OCNMS dataset, our analyses show a sharp increase in the influx of indicator debris items, from 0.03 items per 100m per day to 0.29 debris items/100m/day. This is a 10-fold increase in debris over that recorded previous to the tsunami (Figure 3). Disaster debris reports were also analyzed for temporal variation and there were peaks in May 2012, March 2013 and May 2014. There were peaks in all debris items (not just indicator items) in May 2012, early in 2013, and smaller peaks in May 2014 and late 2014 (Figure 5a). In May 2012, the mean debris influx recorded was over 180 debris items/100m/day.

The peaks in debris landfall after the tsunami are similar to the peaks in disaster debris reported to NOAA (Figure 5) and these peaks are consistent with the modeling predictions from the University of Hawaii (N. Maximenko pers. comm.). We conclude from this analysis that the increase in debris on Washington State, Oregon and California shorelines are attributable to the 2011 tsunami and represent a minimum 10 times as much debris as baseline and as much as 6000 times more debris.

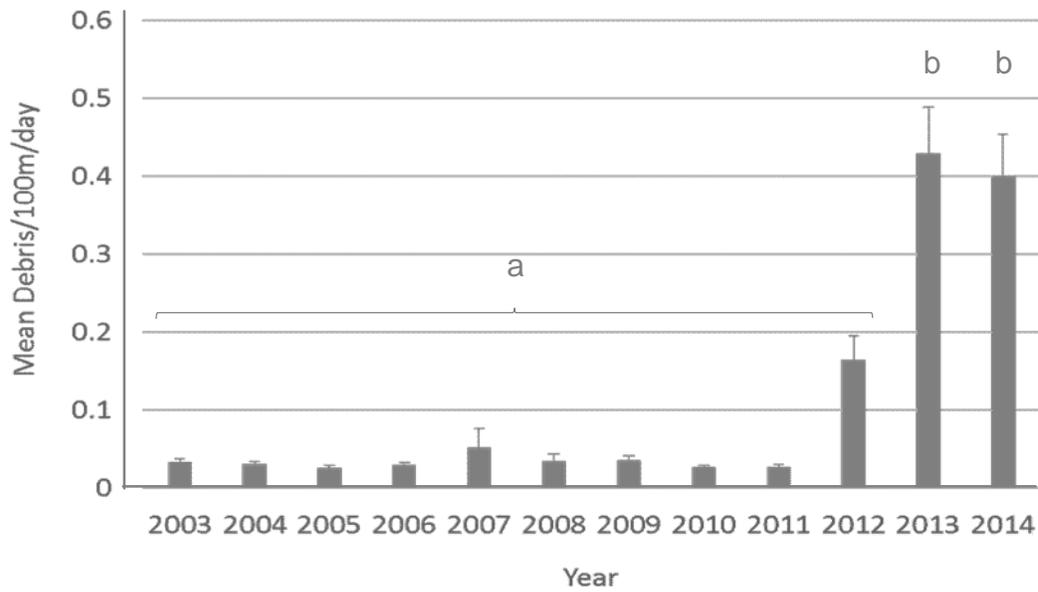


Figure 3: Increase in marine debris indicator items beginning in 2012. Letters denote statistically significant subgroups. Data from NOAA and OCNMS.

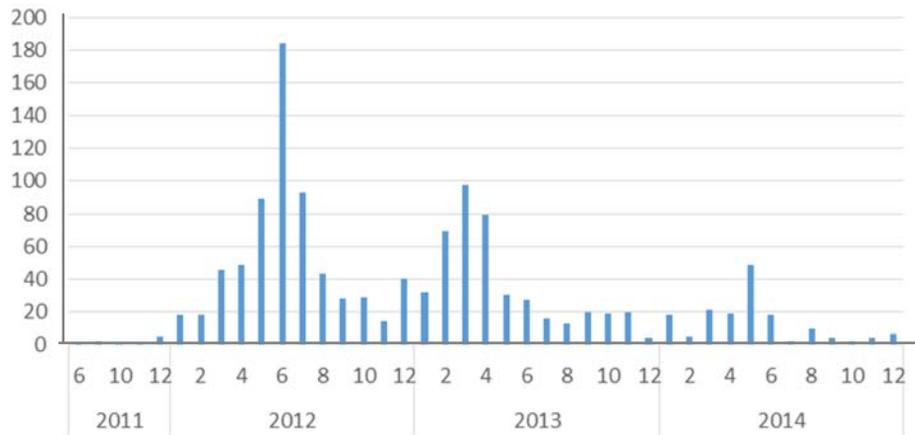


Figure 4: Number of landfall disaster debris reports (NOAA) between 2011 and 2014 for all regions (AK, BC, CA, HI, OR, and WA).

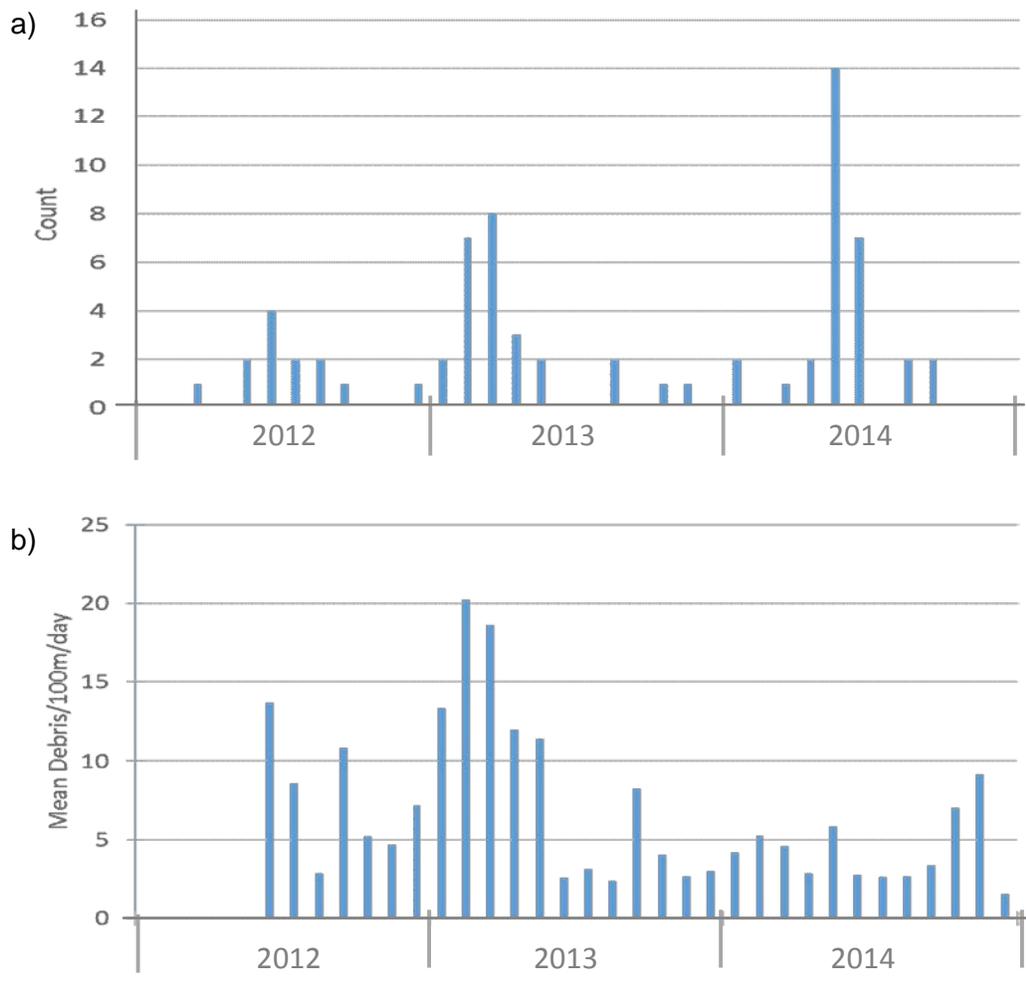


Figure 5: Corresponding temporal peaks in a) disaster debris reporting for North American landfall, and b) beach debris accumulation for Washington, Oregon and California.

d. Describe any concerns you may have about your project’s progress.

No problems were encountered during this reporting period.

e. Completed and planned publications

Clarke Murray C, Bychkov A, Therriault T, Maki H, and Wallace N. (2015) “The impact of Japanese tsunami debris on North America”. PICES Press 23(1).

Clarke Murray et al. (In preparation) “Spatial and temporal distribution of marine debris resulting from the 2011 Great Japan tsunami”

f. Poster and oral presentations at scientific conferences or seminars

Therriault T, Clarke Murray C, Wallace N, Maki H, and Bychkov A. “Effect of marine debris caused by the great tsunami of 2011” 2nd International Ocean Research Conference (IORC). Poster presentation. Barcelona, Spain, 17-21 November 2014. *Winner of best presentation award

Clarke Murray C, Wallace N. (2015) “Surveillance and Monitoring of Tsunami Marine Debris” PICES MoE Project Science Team meeting. Oral presentation. Honolulu, Hawaii, March 16-18, 2015.

g. Education and outreach

Television interview – Hawaii News Now

(<http://www.hawaiinewsnow.com/story/28525502/scientists-in-hawaii-to-study-invasive-species-on-japanese-tsunami-debris>)

4. PROGRESS STATUS

Overall progress was excellent. The aerial surveys for British Columbia were successfully completed on schedule and on budget. This will prove an important contribution to the project and the photographs will be further analyzed by Japanese colleagues to estimate percent cover of marine debris. The monitoring data analysis is largely complete and will be written as a manuscript for publication in collaboration with the monitoring contacts at NOAA and the modelling team.