Effect of Marine Debris Caused by the Great Tsunami of 2011

The Great East Earthquake in Japan on March 11, 2011 created a massive tsunami, which washed about 5 million tons of debris into the Pacific Ocean (Ministry of the Environment [MoE], Japan, 2012). The Government of Japan estimates that 70% of that debris sank close to shore, leaving 1.5 million tons floating in the North Pacific with the potential to arrive on Canadian and American coastlines. In fact, debris continues to arrive four years after the event and is expected to carry on for years. The unprecedented amount of debris and the associated fouling species are of particular concern.

A 3-year PICES project, funded by the Ministry of the Environment of Japan, seeks to assess the impact of Japanese Tsunami Marine Debris (JTMD) on ecosystems of the west coast of North America and Hawaii through three research themes:

1. Surveillance and monitoring for JTMD landfall and accumulation,
2. Modeling JTMD movement to estimate/forecast the amount, pathways and timelines of its arrival on the west coast of North America and in Hawaii, and
3. Assessing the risk and potential impacts from JTMD, including associated invasive species.

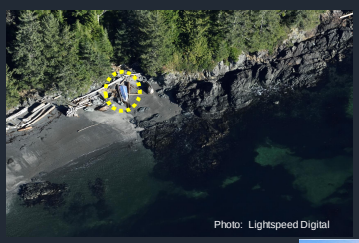
Surveillance and Monitoring

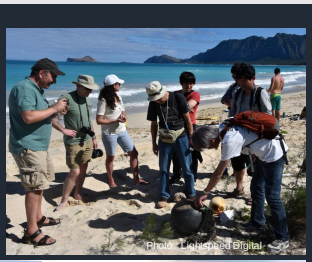
Atsuhiko Isobe, Hirofumi Hinata, Shin'ichiro Kako, Tomoya Kataoka, and Cathryn Clarke Murray

Aerial surveys are cost-effective ways to monitor the vast coastlines where debris may be accumulating to identify hot spots. Over 150 small boats have been washed up on North American and Hawaiian beaches, many of which were confirmed to have been lost during the tsunami. Aerial surveys have been conducted on the outer coast of British Columbia, Canada (see photo at right) and will next be conducted in the Hawaiian Islands.

Beach monitoring for debris has been on-going for the past fourteen years at over 160 sites in North America and Hawaii (NOAA Marine Debris Program). This research data has been analysed and shows an immense ~860% increase in marine debris influx to the coast of Washington, USA since the Great Tsunami of 2011 occurred.

Webcam monitoring is an established method to identify quantities, variation over time and types of debris washed ashore, and a trial installation is operating in Oregon, USA.

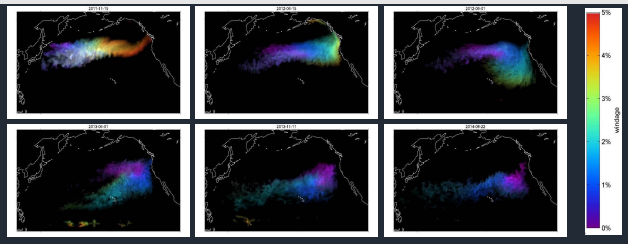




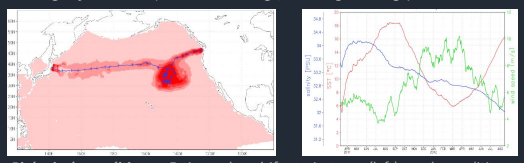
Looking for marine debris: *Aerial surveys look for JTMD and small boats (yellow) on remote beaches of Alaska and British Columbia (above).*

Government and citizen science beach surveys monitor incoming debris in an attempt to quantify and categorize marine debris (above right).

Webcam monitoring of debris flux at a site near Newport, Oregon, USA (right).



Predicting debris drift: *Motion of JTMD in SCUD model simulations from 2011-2014. Colors indicate windage of the debris (blue = low windage, red = high windage).*



Biological conditions: *Estimated drift trajectory (left) and conditions experienced by species living on debris items (right): wind speed (green), sea surface salinity (blue) and sea surface temperature (red).*

Modeling Movement of Tsunami Debris

Nikolai Maximenko, Amy MacFadyen, and Masafumi Kamachi

A suite of numerical models (SCUD model by Univ. Hawaii, GNOME model by NOAA, and SAE-GELN model by JAEA) was used to assess the movement of different types of debris under effects of ocean currents and atmospheric winds. The models successfully reproduced propagation of JTMD across the North Pacific and its arrival on the North American and Hawaiian coasts (see figures above left).

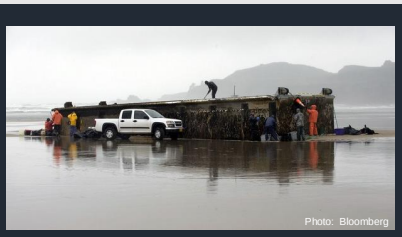
The models are being used to estimate the probable trajectory of JTMD items arriving at different times (see figures below left) in order to assess the range of oceanographic conditions to which the debris item was exposed along the probable path. The method is based on a combination of forward and reverse modeling and interpretation of tracer concentration as a probability density function for a particle location. Information about the drift trajectory combined with oceanographic information, such as ocean temperature, salinity, and wind speed, can then be compared with the limits of survivability for the species found on the item.

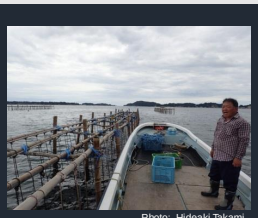
Risks from Invasive Species

James Carlton, Jessica Miller, John Chapman, Jonathan Geller, Gregory Ruiz, Gayle Hansen, Hiroshi Kawai, Thomas Therriault and Cathryn Clarke Murray

Species of Japanese origin attached to debris have the potential to impact ecosystems on the west coast of North America and Hawaii. Surveys of sites where these high-profile JTMD items landed are in progress to monitor for establishment and spread of tsunami-debris associated species.

More than 300 living Japanese biofouling species (invertebrates, algae and fish) have been identified on 330 debris objects landing in North America and Hawaii and a large number of these species are not yet present on these coastlines. Some, such as the large barnacle *Megabalanus rosa* (photo at right), are well-known invasive species elsewhere around the world. The endoparasitic hydroid *Eutima japonica* (known to cause shellfish mortalities), and the pathogenic protist *Haplosporidium* have been detected in mussels on debris items. Samples from existing and new debris items continue to be processed using both traditional taxonomy and genetic methods. Results are being used in a screening-level risk assessment to evaluate the risk these species associated with JTMD could pose to coastal ecosystems.

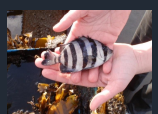


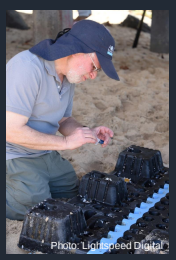


Debris Hitchhikers: *A surprising number of Japanese coastal species have been found live on debris washed up, such as the large floating dock on an Oregon beach (above).*

Field surveys for fouling species are underway in Japan (above right), North America, and Hawaii (bottom right).

Stowaways on debris include striped beakfish Oplegnathus fasciatus *(middle) and acorn barnacle* Megabalanus rosa *(bottom left).*





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