Tracking marine debris generated by the March 11, 2011 tsunami using numerical models and observational reports

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March 11, 2011 tsunami in Japan
Debris, drifting offshore after tsunami

Courtesy of US Navy
Use of drifting buoys to study pathways of marine debris

There are ~15,000 trajectories, collected since 1979
Status of the Global Drifter Program array on January 2, 2012
(co-lead by L. Centurioni (SIO) and R. Lumpkin (NOAA/AOML))

January 2, 2012

(M. Pazos and R. Lumpkin)
To remedy the bias we developed a probabilistic model

All pairs of 6-hourly drifter fixes are used to calculate the probability function for the drifter to move between bins \((x,y)\) and \((X,Y)\) in \(\delta t\) time.

\[ p(X,Y|x,y; \delta t) = P(X-x,Y-y|x,y; \delta t) \]

Choice of scale:
- spatial grid: \(\delta x=\delta y=0.5^0\)
- temporal increment \(\delta t = 5\) days ( \(V\delta t >> \delta x\) )
Differences between years and importance of real-time modeling (as opposed to statistical modeling)
Satellite-measured sea level anomaly (AVISO)

IPRC mean dynamic ocean topography (APDRC)

Satellite-measured ocean surface wind (QuikSCAT & ASCAT)

SCUD - Surface CUrrents from Diagnostic model

SCUD is essentially a drift model, tuned using collocated data from satellites and trajectories of drifting buoys.

SCUD offers a practical solution without full understanding of complex physics of the ocean-atmosphere boundary layer.

SCUD products are on nearly global ¼-degree grid and updated daily. The dataset starts from August 1, 1999, forced by QuikSCAT winds. In November 2009, after the death of QuikSCAT, SCUD is seamlessly transitioned to ASCAT scatterometer vector wind data.
“Would be now location” of model debris, released on March 11 of year:

2011

2000

2005

2008
Model trajectories from Japan to Midway area of the debris, if March 11 tsunami happened in 2000

Trajectories starting 11–MAR–2000
Model flux of March 11 tsunami debris on Midway in different years
Daily public updates are available at [http://iprc.soest.hawaii.edu/users/hafner/PUBLIC/TSUNAMI_DEBRIS](http://iprc.soest.hawaii.edu/users/hafner/PUBLIC/TSUNAMI_DEBRIS)
“Pallada” found tsunami debris where SCUD predicted

Small fishing boat, registered in Fukushima Prefecture

Observed maximum density of debris
December 2011 expedition, organized by the University of Hawaii, Ocean Recovery Alliance, and Scripps Institution of Oceanography studied structure of currents, protecting Midway and other Hawaiian Islands.
Daily public updates are available at [http://iprc.soest.hawaii.edu/users/hafner/PUBLIC/TSUNAMI_DEBRIS](http://iprc.soest.hawaii.edu/users/hafner/PUBLIC/TSUNAMI_DEBRIS)
Effect of direct wind force (windage)
Heterogeneity of tsunami debris
Applications: pathways of marine debris
Pathways of tsunami debris

Windage: 0% 2% 4% 5%
Amount of tsunami debris in the ocean

Windage: 0% 2% 4% 5%

19 JUN 2012
Models verification using observations
Fishing boat “DAI-GO KOURYOU-MARU”

4’x5’ concrete dock

Reported by Randall Reeves, S/B “Murre” June 27-28, 2012 north of Hawaii
Fishing boat
Reported by Marcus Eriksen,
S/B “Sea Dragon”
June 22, 2012
Northwest of Midway
Reports of potential tsunami debris, collected by the NOAA Marine Debris Program and partners

This map includes all debris reported to NOAA as possible tsunami debris since December 2011. Confirmed sightings (red triangles) indicate objects that were identified and traced back to the tsunami impact area. Potential sightings (yellow circles) indicate objects that may be linked to the tsunami, based on location, type, and markings, but that may not have the unique identifiers necessary, such as a serial number or contact information, to confirm its origin.

Marine debris is an everyday problem, and not all debris found on U.S. shorelines is from Japan. It is important to note that potential sightings may not be from the tsunami impact area, but items lost or abandoned before or after the tsunami from sources around the Pacific Rim. For more information regarding tsunami marine debris from Japan please visit: http://marine.debris.noaa.gov/tsunami/debris
Tsunami debris in Hawaii
Sep 18, 2012 – the first object on Oahu Confirmed as Tsunami debris
A skiff lost during March 11, 2011 and recently salvaged by a fisherman in Hawaii
US/Canada west coast

Fishing floats washed up by the tsunami in Hadenya Port on Shizugawa Bay, Minamisanriku, Japan. Photo adapted by C.Ebbesmeyer from Jim Seida, msnbc.com

Washington, December 2011
Source: C.Ebbesmeyer

At least 100 oyster buoys were reported on the US west coast by January 2012

Hilo, Big Island of Hawaii, June 2012

Kamilo, Big Island of Hawaii
Reported by Megan Lamson
July 14, 2012

Hawaii

June 2012 – report of s/b “Tregoning” north of Oahu

Kure Atol Northwest Hawaiian Islands
Reported by Scott Godwin
August 2012

August 2012 – oyster buoy reported by Carl Berg on Kauai

September 2012 – oyster buoy reported by Cynthia Vanderlip in Turtle Bay, Oahu
Debris of unidentified origin
Unidentified 3m x 6m object washed ashore at Na’alehu (Big Island of Hawaii) in October 2012
Example of operational applications of SCUD: tracking individual objects

50-foot dock reported Sep 19-21 by fishermen north of Maui and Molokai and never found since then. SCUD suggests that it’s drifted south between Oahu and Molokai and now is on its way back to Asia.

Similar dock landed on the Oregon coastline in June 2012.