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Pathways, impacts and fate of marine debris generated by the 2011 tsunami in Japan, derived from a synthesis of numerical models and observational reports

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March 11, 2011 Tsunami in Japan



> 15 thousand victims
> 100,000 home destroyed





> 1.5 million tons of floating debris generated – i.e., equivalent of a full year North Pacific budget of general debris





Due to many identifiable items and nearly instantaneous release tragic tsunami of March 11, 2011 provided unique data on marine debris drift.

Massive amount of debris generated



Courtesy of US Navy

Generation of this large amount of marine debris in a single event was unprecedented event in modern history. Many objects traveled across the North Pacific and were found in remote areas.

Source distribution for model experiments

5 numerical models were used in this study:

- GNOME system, used by NOAA for oil spills. It calculates particle trajectories, using HYCOM currents and NOAA Blended Sea Winds. 400,000 particles deployed for each windage.
- MOVE/K-7/SEA-GEARN (thereafter, *MOVE*) created by a team of scientists in Japan from JAMSTEC, JAEA, JMA/MRI, and JAXA – 3DVAR from March 2011 to July 2013 followed by the forecast runs through May 2016
- FORA-WNP30 (hereafter, *FORA*) is a 4dVAR ocean re-analysis for the North Pacific over 30 years.
- SCUD IPRC diagnostic model, using satellite sea level and wind, with coefficients calibrated using trajectories of drifting buoys.
- SCUD blended with HYCOM in coastal areas (SCUD-HYCOM)

Simulations were performed in a broad windage range: 0% - 6%



SCUD - Surface CUrrents from Diagnostic model



 $V_{scud} = V_{geostr} + A \cdot Wind$, with local coefficients adjusted to best correspond to drifter velocities

Model simulations of tsunami debris drift



• Big differences between pathways of different windages suggest that different areas were affected by different types of JTMD and at different times.



Comparison between models: September 2, 2011

Comparison between models: February 28, 2013





Mean monthly debris influx of indicator items (indicator debris items/100m/day) from 2004-2015 at sites in northern Washington State (grey line)

Examples of marine debris from March 11, 2011 tsunami in Japan



Photos collected in or near Hawaii

Locations (dots) and years (colors) of 327 JTMD boat reports





Locations (dots) and years (colors) of 327 JTMD boat reports





Time-space distribution of 92 boat reports from and near the 40-51°N stretch of the US/Canada west coast.



SCUD windage, % (f) (a) 0 -GNOME windage, % • (j) (e) • 0.13 0.24 0.41 0.66 0.0001 0.0016 0.0081 0.026 0.063

Timelines of model tracer flux on the North American West Coast

SCUD

GNOME

Boat reports SCUD SCUD-HYCOM MOVE fluxes, boats/month FORA GNOME 2 -

Timelines of boat observations and model solutions for optimal windages

Model simulations of tsunami debris drift



Dissipation timeline of model tracer



- Initial number of boats is estimated ~1000.
- ~ 100 are still floating, most probably, in the garbage patch
- Boats will continue washing ashore in the next several years.



Tsunami boats continue to come, some carry Japanese species



Tsunami boat reported January 22, 2017 off Kona, Island of Hawaii. Credit: Jeffrey Milisen



New project: Physical and biological processes maintaining a unique floating ecosystem of the North Pacific garbage patch

In partnership with Smithsonian Institution, Scripps Institution of Oceanography, Applied Physics Laboratory, and Ocean Voyages Institute



The project will deploy sets of oceanographic instruments to study the hydrodynamics of various types of marine debris and collect biological samples in search for coastal species on debris floating in the garbage patch.

We are looking for at-sea partnership! Please contact us if you have field work plans in the Northeastern Pacific in 2018-2020.







THANK YOU!