2016 New Year Symposium on Marine Litter
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University of Marine Science and Technology, January 23-24, 2016

Synthesis of marine debris modeling and observations: recent progress in understanding and applications

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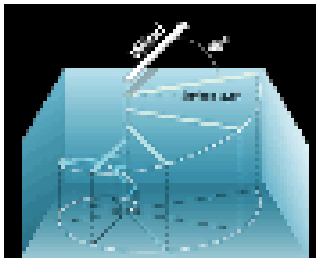
- University of Hawaii: Kin Lik Wang, Christina Curto
- NOAA: Nir Barnea, Peter Murphy, and Lexter Tapawan
- many contributors to the dataset.

Drift Models of marine debris

Velocity of drifter = Velocity of the ocean surface current + Velocity relative to water parcel

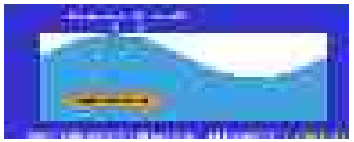
Geostrophic currents (non-local dynamics)

Wind-controlled currents



Direct wind force

Interaction with wind waves (Stokes drift in a linear case)



Today surface currents are not well measured and not well simulated.

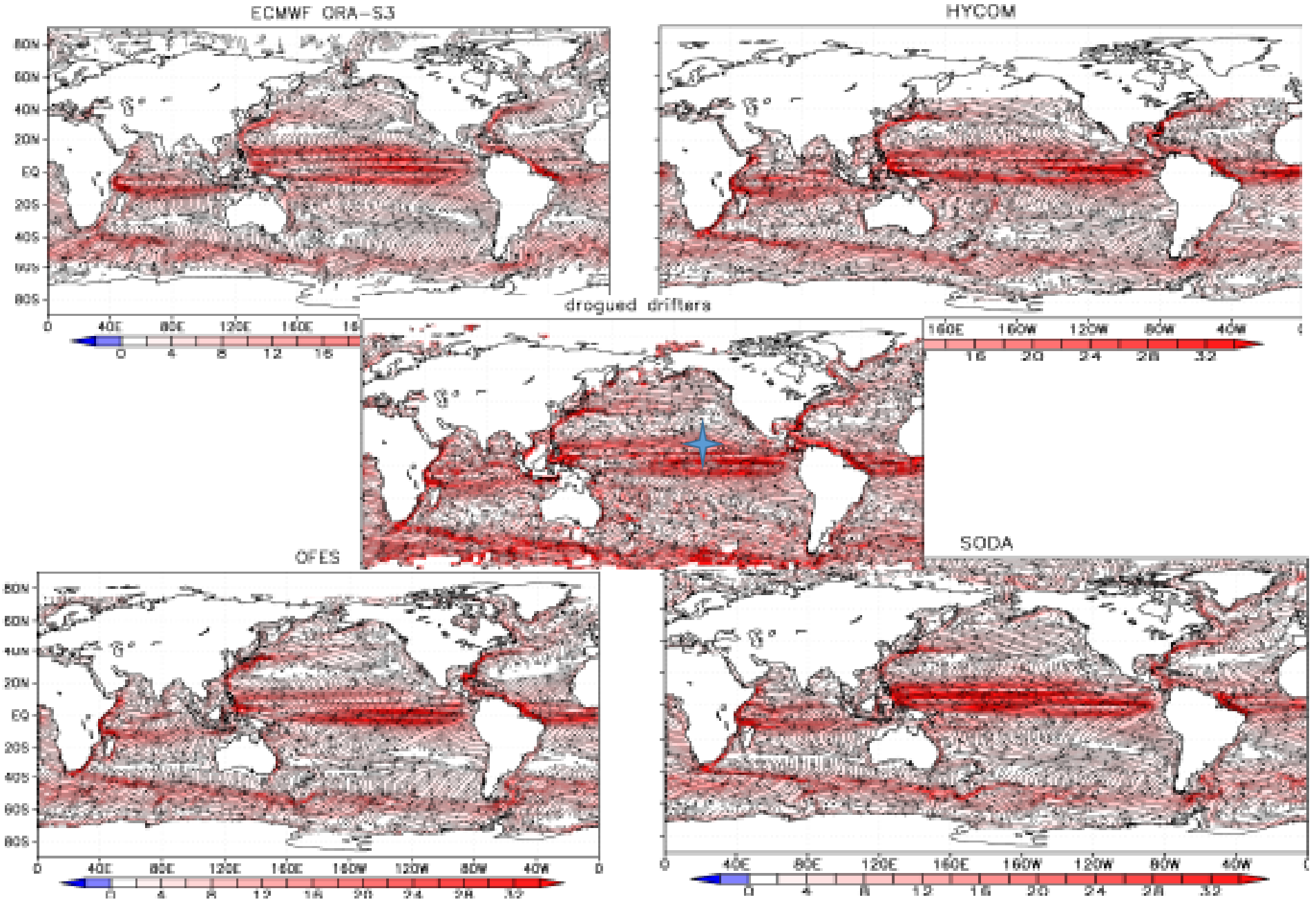
Combination of wind force and wind waves amplifies wind drift

Practical formula:

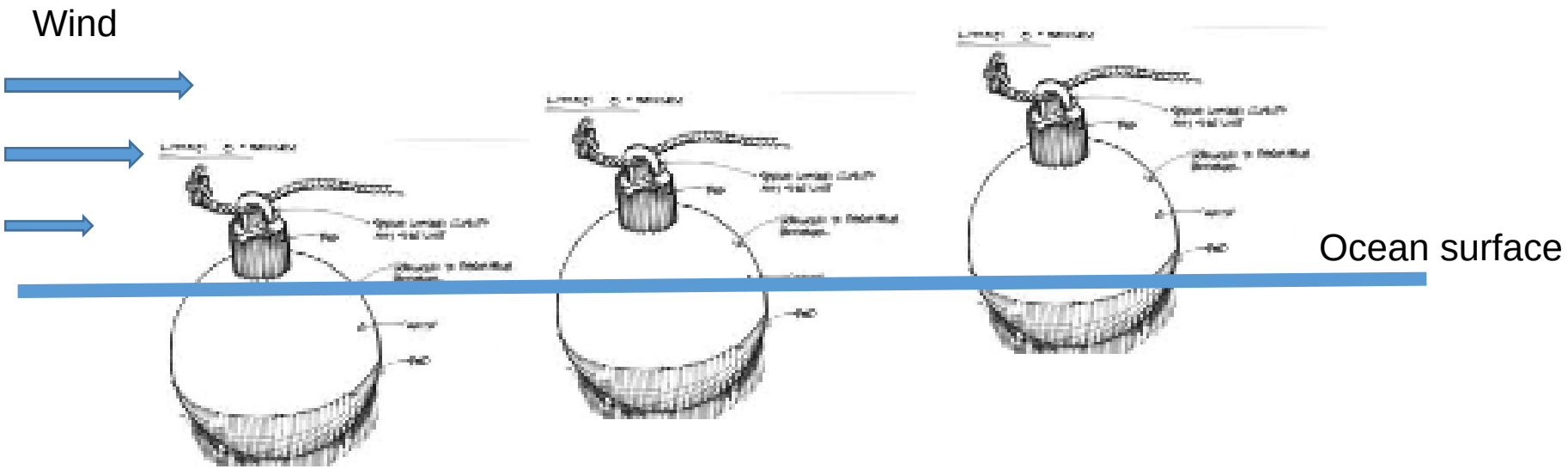
Drift = Current (from models) + A(windage)*Wind (from satellites or models)

Same object may dynamically correspond to different windages in different models

Time-mean currents at 15 meters level in different models



Windage



Low windage,
object sitting deep in water

Photo: Charles Moore

Medium windage,
object sitting half in water

Photo: Randal Reeves

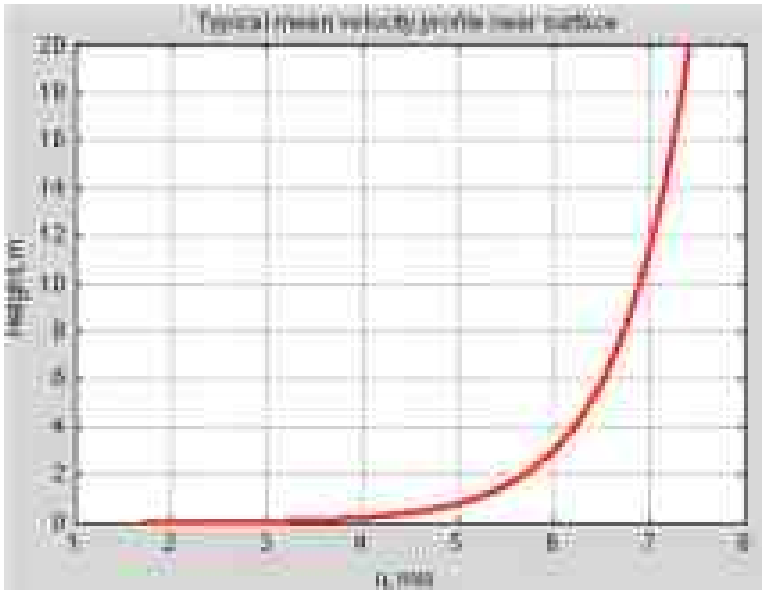
High windage,
object sitting high on water

Photo: S/V “Tregoning”

For example 5% windage means an object is moving with the current + 5% wind speed

Windage - simple?

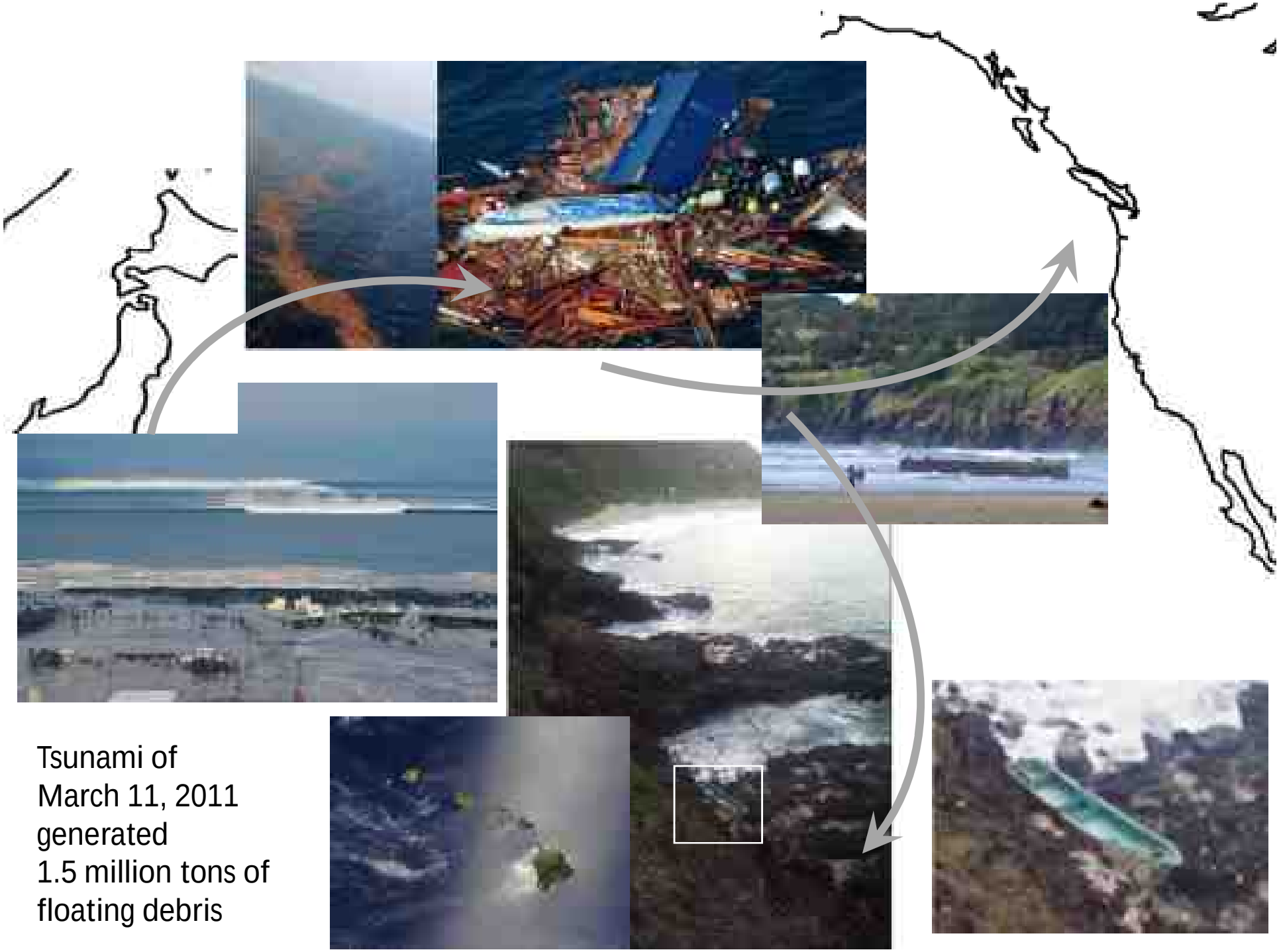
Surface wind vertical profile



Ocean surface wind = 10m height

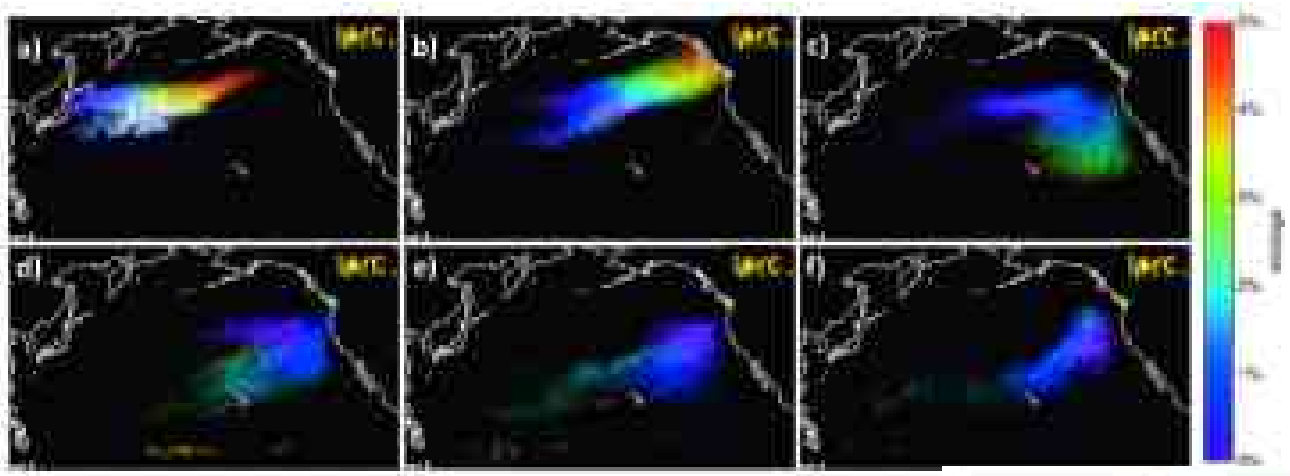
Source: http://www.wikiwand.com/en/Wind_wave

Sea Surface

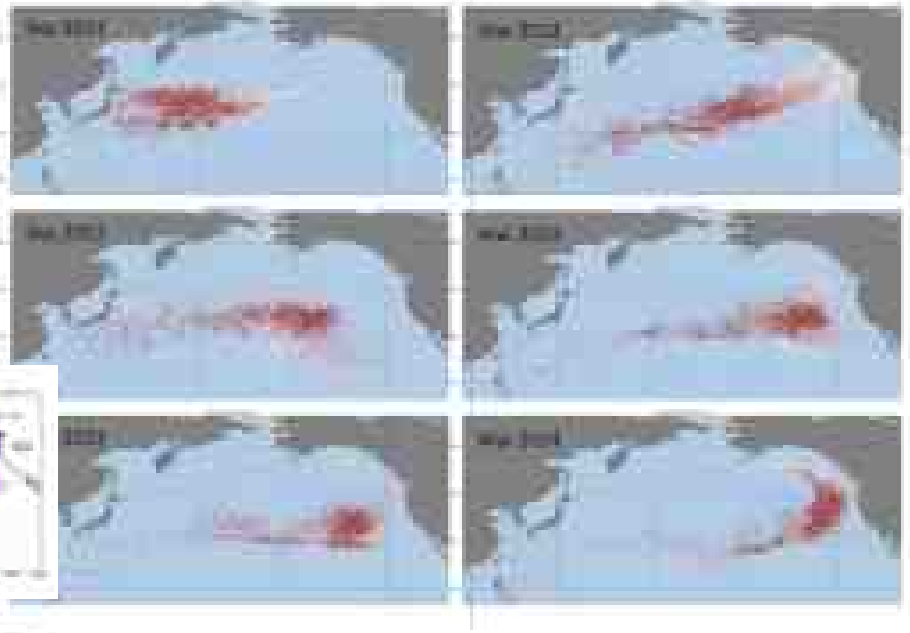


Tsunami of
March 11, 2011
generated
1.5 million tons of
floating debris

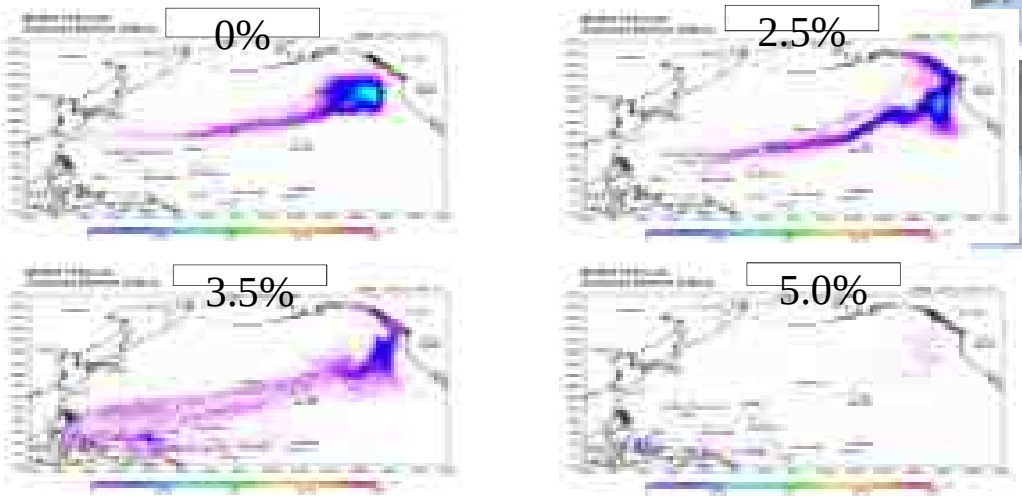
Model simulations used in the ADRIFT project



Motion of JTMD in SCUD model simulations. Colors indicate windage of the debris. Shown are maps for (a) September 1, 2011, (b) March 1, 2012, (c) September 1, 2012, (d) March 1, 2013, (e) September 1, 2013, and (f) March 1, 2014.

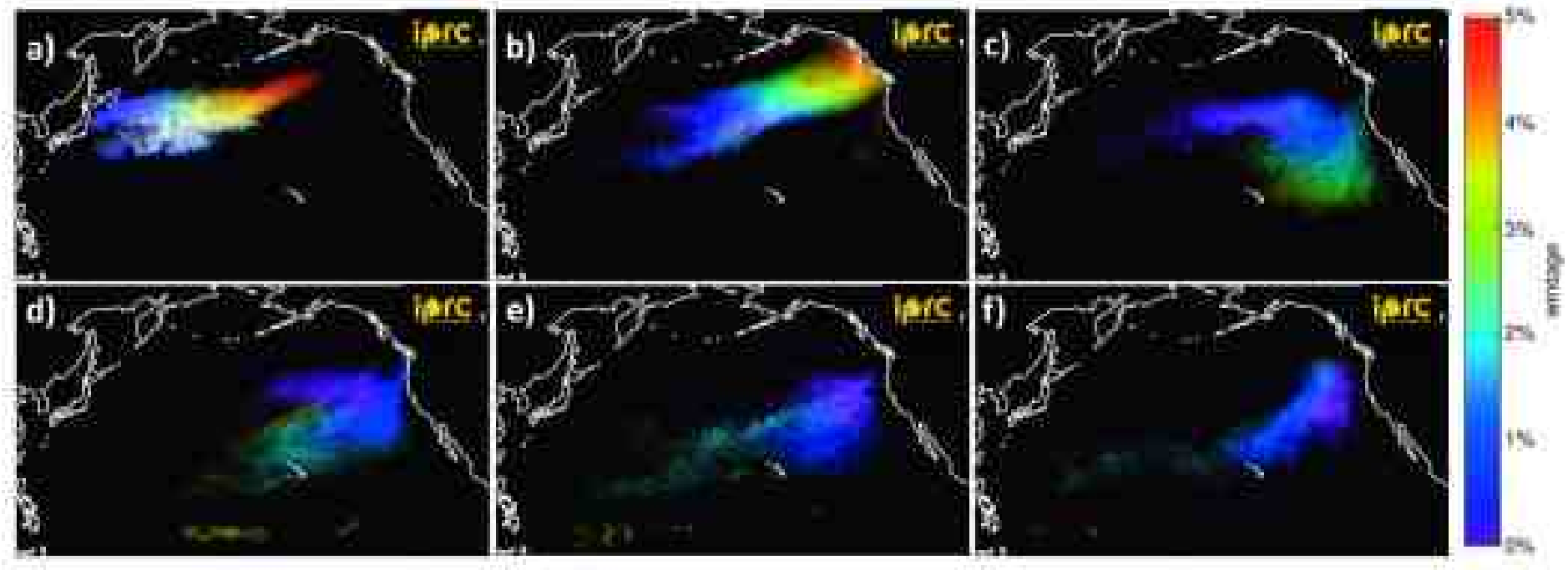


April 15, 2013 distributions of SEA-GEARN/MOVE-K7 model particles for four values of windage: 0, 2.5, 3.5, and 5%. Colors indicate concentration of particles on a computational grid.



GNOME modeled particles simulate the movement of tsunami debris of varying types – from high windage objects like styrofoam (white) to low-windage objects like wood (red). These six panels show the distribution of the model particles every 6 months from September 2011 (6 months post-tsunami; top left) to March 2014 (3 years post-tsunami; bottom right).

Debris with different windages do not only move at different speeds –
– they have different destinations



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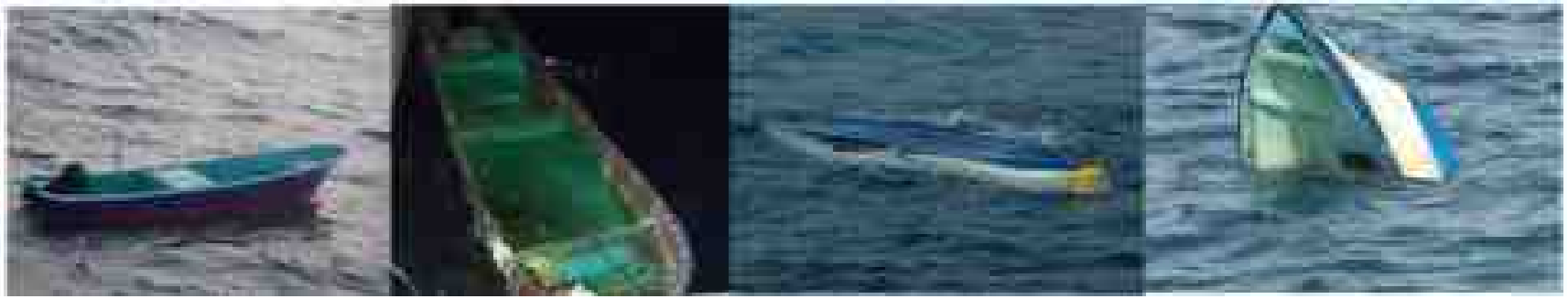
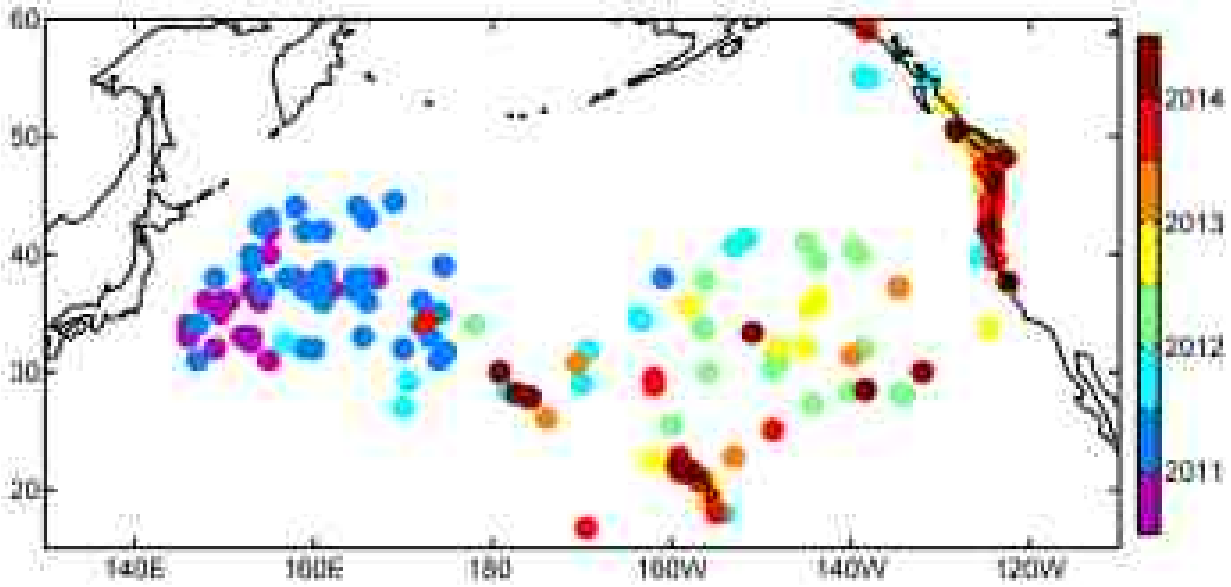
Examples of potential tsunami marine debris from or near Hawaii

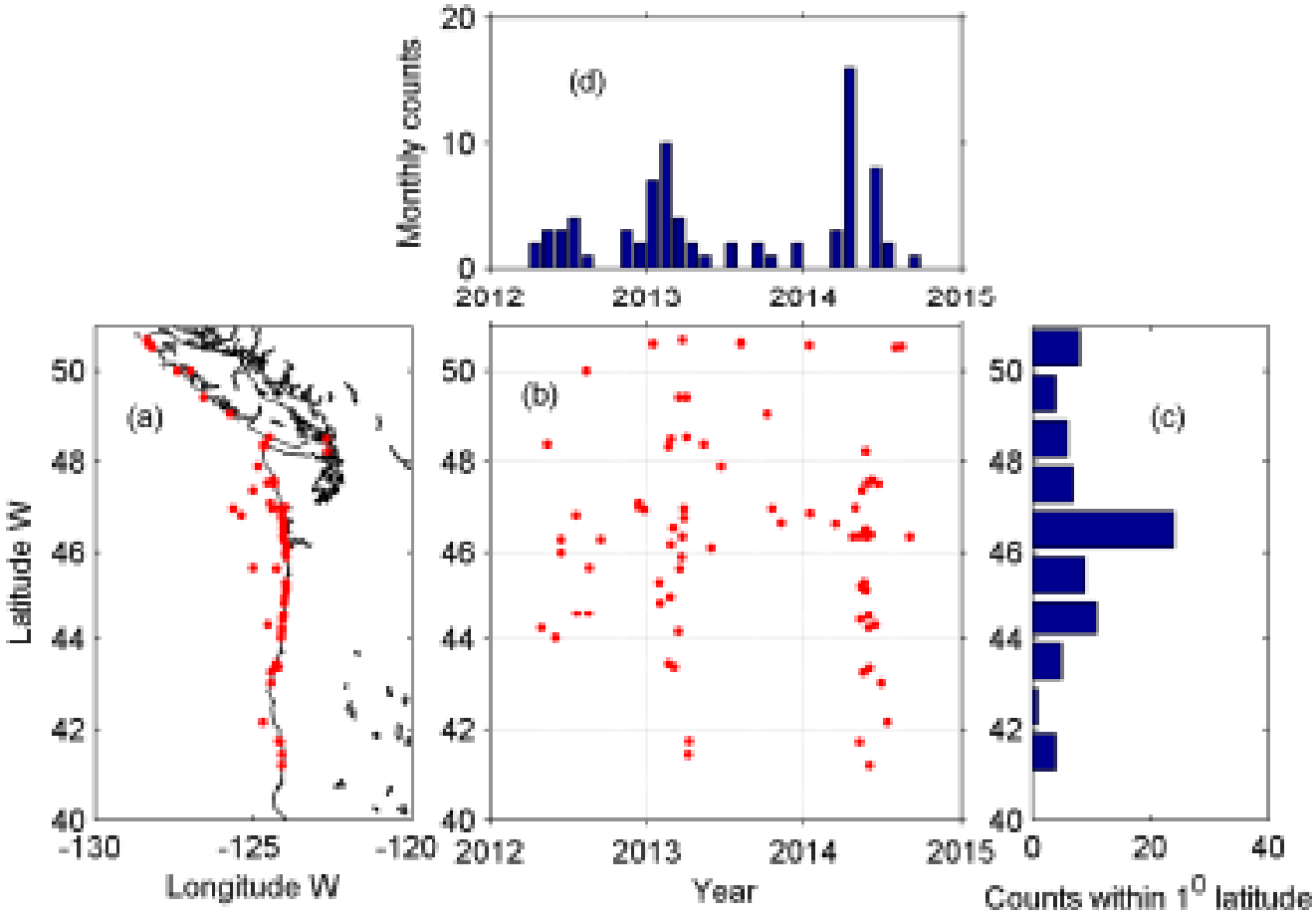
To reduce uncertainties due to unknown windage parameter let’s focus on a particular type of items: boats and skiffs



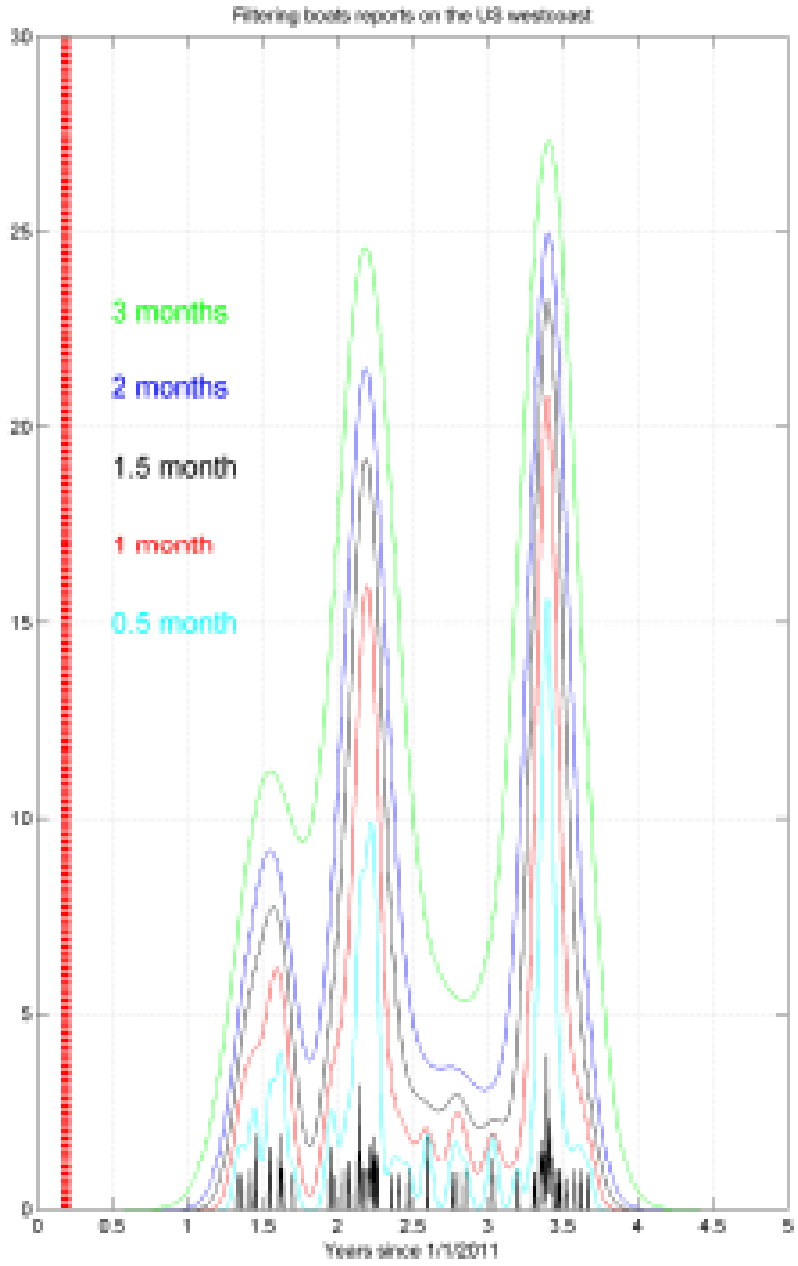


277 reported locations of boats/skiffs/ships and (colors) times of the reports. Color bar spans January 2011–December 2014 and labeled ticks mark central moments of the years.

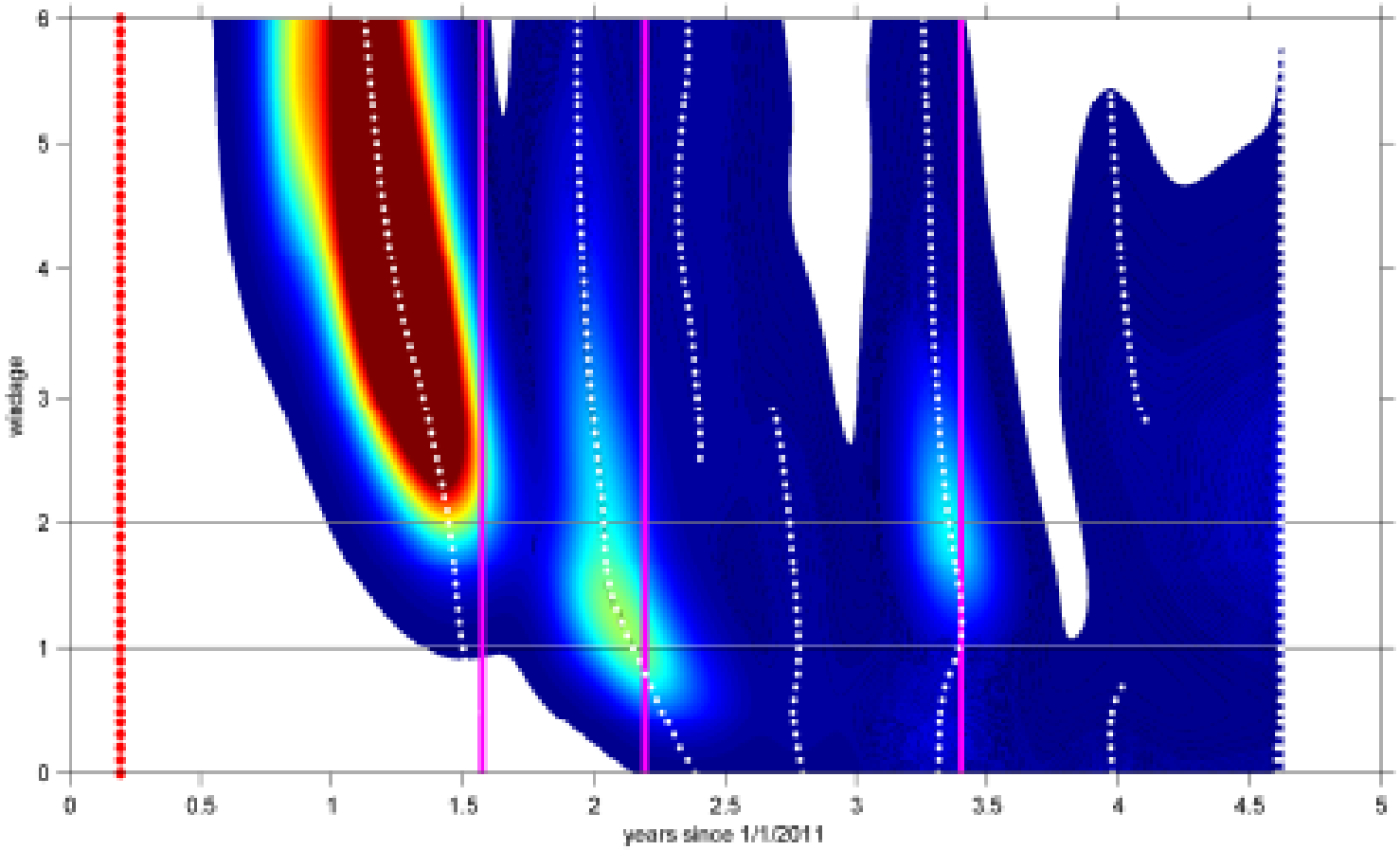
Problem is that “clean” regions are never reported.



Latitude-time distribution of 79 boat reports on the US/Canada west coast



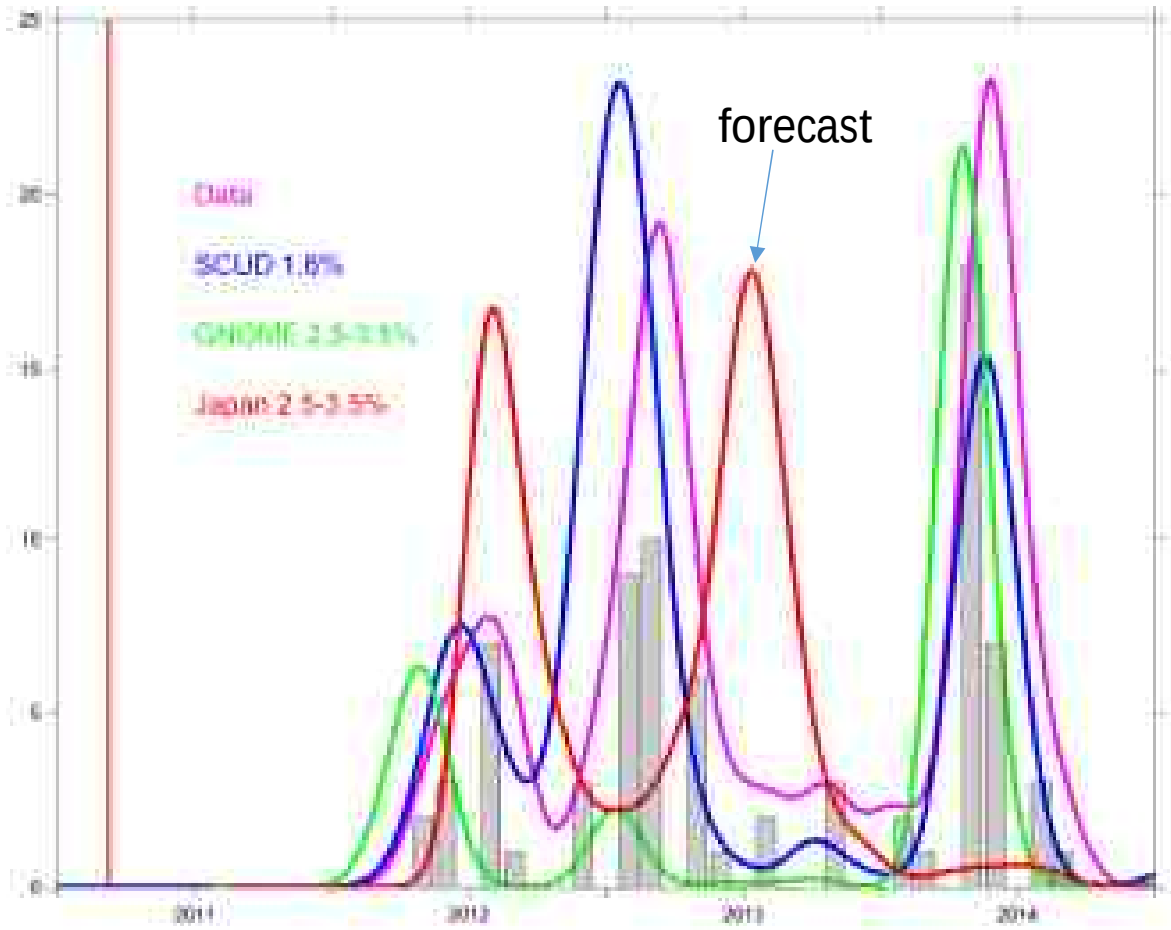
Monthly boat reports from the US/Canada west coast and smoothed indices.



2011 2012 2013 2014

Timelines of SCUD model fluxes on the US/Canada west coast for a range of windages.

Low-pass filtered in time.



Monthly counts of boats on the U.S./Canada west coast (gray bars) and low-pass filtered timelines of boat fluxes in observations (magenta) and model experiments with different windages: 1.6% for SCUD (blue) and 2.5–3.5% averages for GNOME (green) and SEA-GEARN/MOVE-K7 (red). Vertical red line marks March 11, 2011. Units on y-axis are boat counts for monthly reports and conventional for other timelines.

Conclusions based on model-data comparison

1. All three models capture peaks in JTMD flux on the US/Canada west coast but not all reproduce successfully magnitudes of the peaks.

2. IPRC model, providing best correspondence, suggests that:
- About 1000 boats were originally released by the 2011 tsunami.

Consistent with this estimate, on November 16, 2011, the Japan Coast Guard detected 506 skiffs/vessels, drifting off the devastated shoreline.

- Approximately 700 boats are still floating in the “garbage patch”
and will continue washing ashore in the next several years.

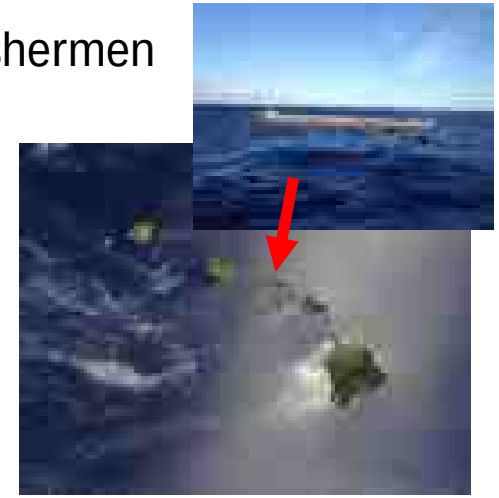
But how useful are data and models in case of a single item?

Four 66-feet Misawa dock,
washed off shore Mar 11, 2011

Apr 5, 2013:
Olympic Coast

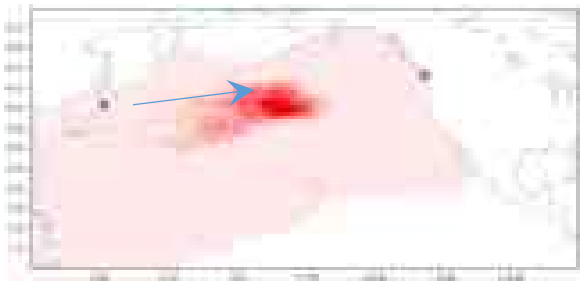
Jun 5, 2012:
Agate Beach, OR

Sep 17-19, 2012:
repeatedly reported by fishermen
north of Molokai.
Not found by the USCG.

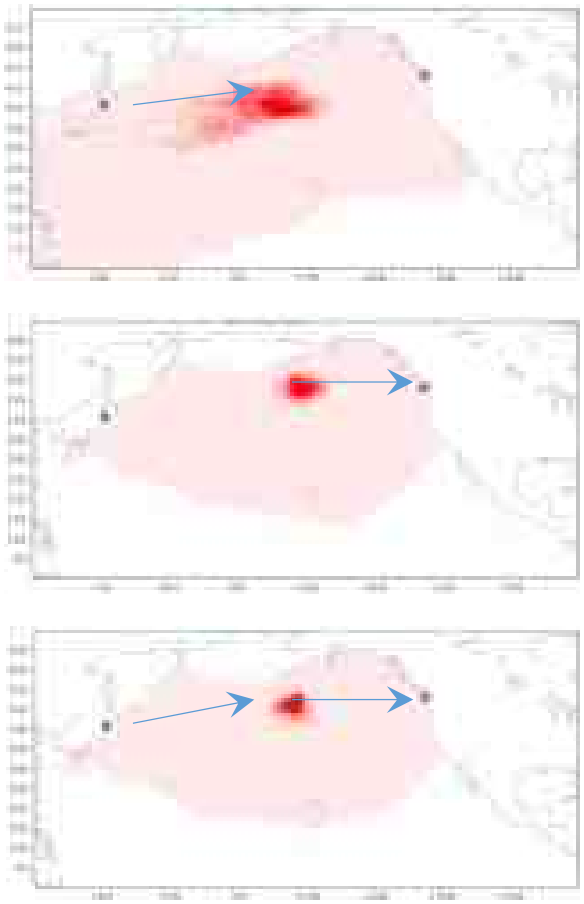


Dock #4 was never reported

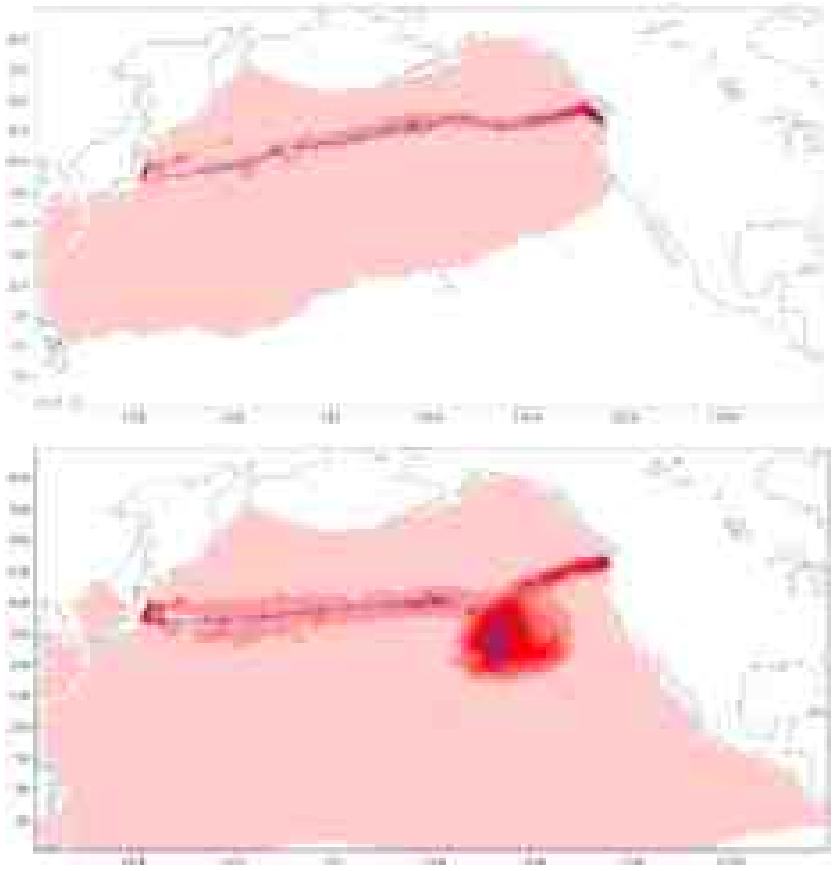
But how useful are data and models in case of a single item?



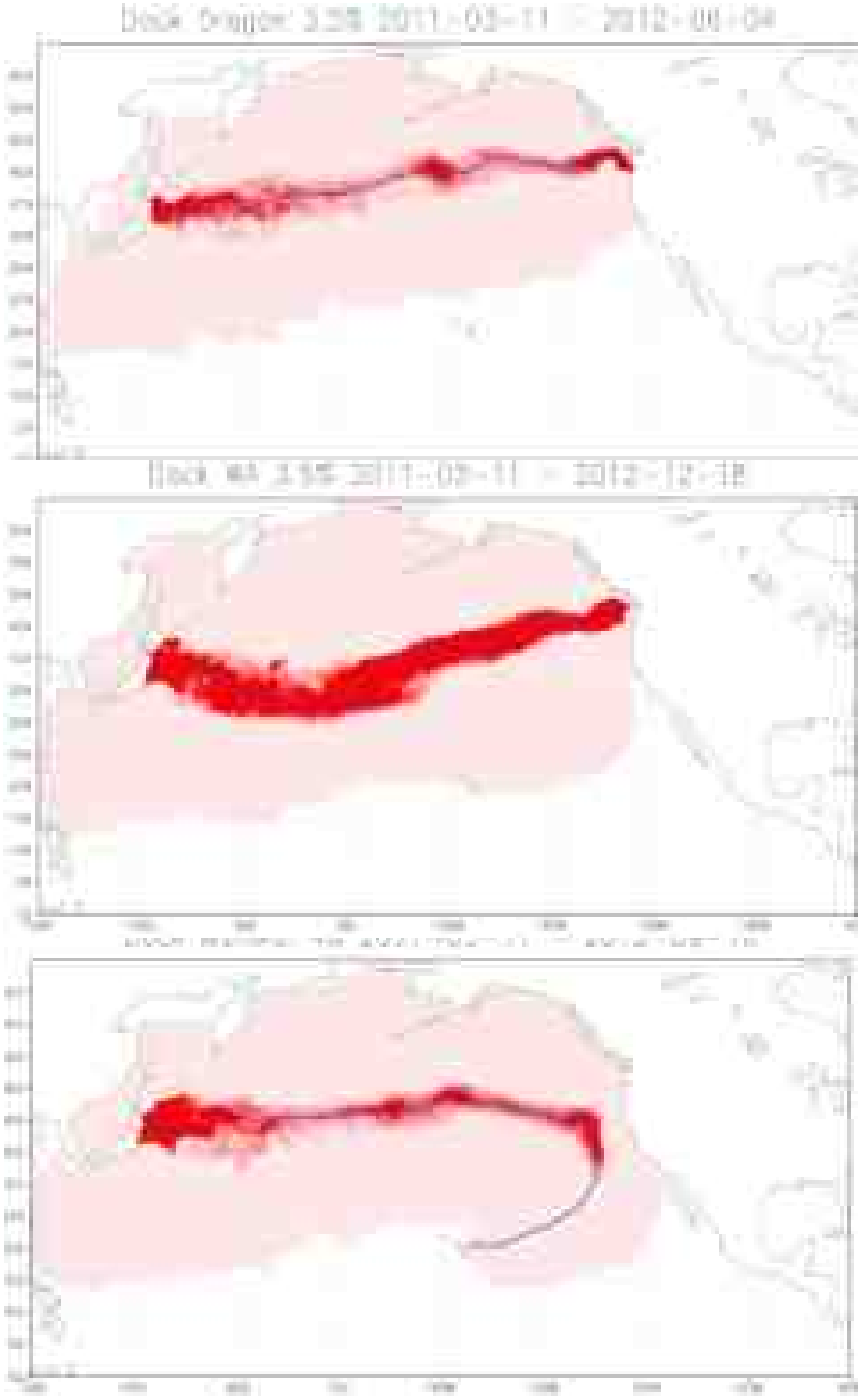
IPRC study of the drift of potential debris from MH370 is based on a new technique developed to estimate most probable pathways of floating object between known origin and destination



PDF's of particle locations on January 1, 2012 for the particles that: (left) started from Japan on Mar 11, 2011, (left bottom) ended in Washington state on Aug 15, 2012, and (below) started from Japan on Mar 11, 2011 and ended in Washington state on Aug 15, 2012. Note how fixing start and end points (blue dots on the maps) and times reduced uncertainty at intermediate times).



Probable pathways of two particle with the same start points and start time (Japan, March 11, 2011) but arriving on the Washington coastline nearly two years apart (August 15, 2012 and May 15, 2014). Saturated red colors show locations visited by the particles at higher probability. Blue lines connect most probable locations on monthly maps. Note that slower particle takes more southern route and spends significant time in the “garbage patch” area.



Misawa docks found:

In Oregon

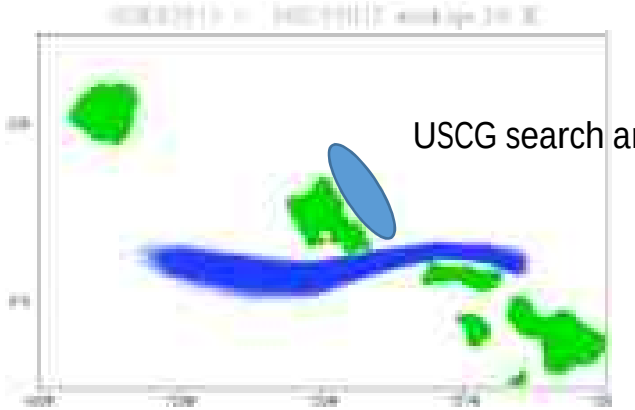
In Washington

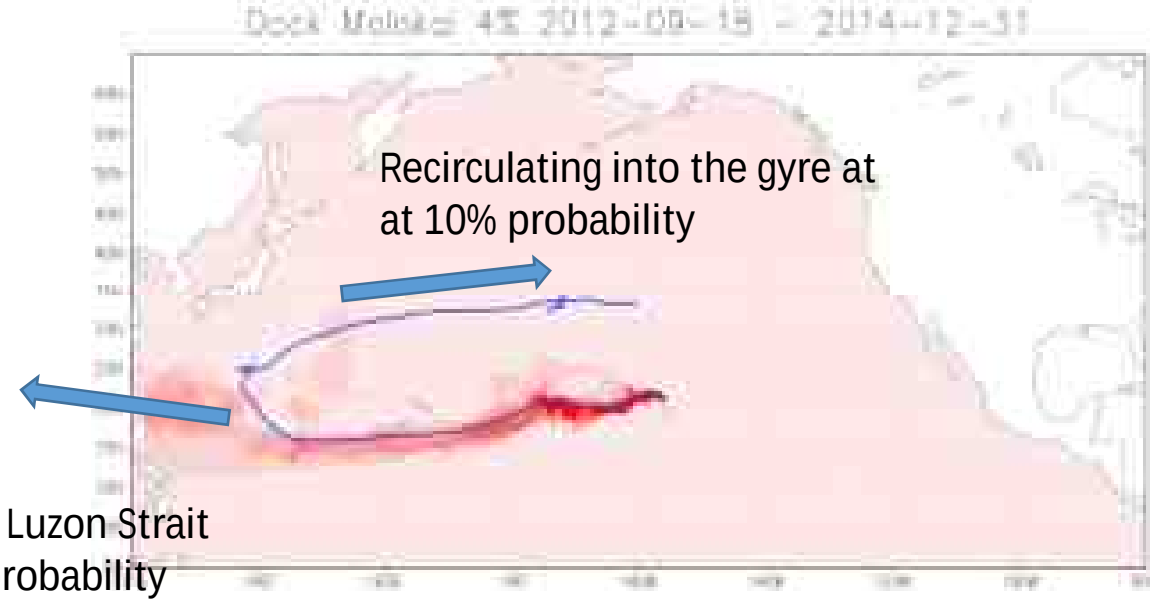
North of Molokai

Dozens of Asian species were found on all kinds of debris arriving in the North America and Hawaii, some have a potential of becoming invasive species.

Japan Ministry of Environment sponsors a project, assessing risks to the US/Canada ecosystems from species, colonizing tsunami marine debris. The ADRIFT project is managed by PICES (North Pacific Marine Science Organization) and is now in year 2.
Modeling team includes UH, NOAA, and MRI.

Fate of Molokai dock





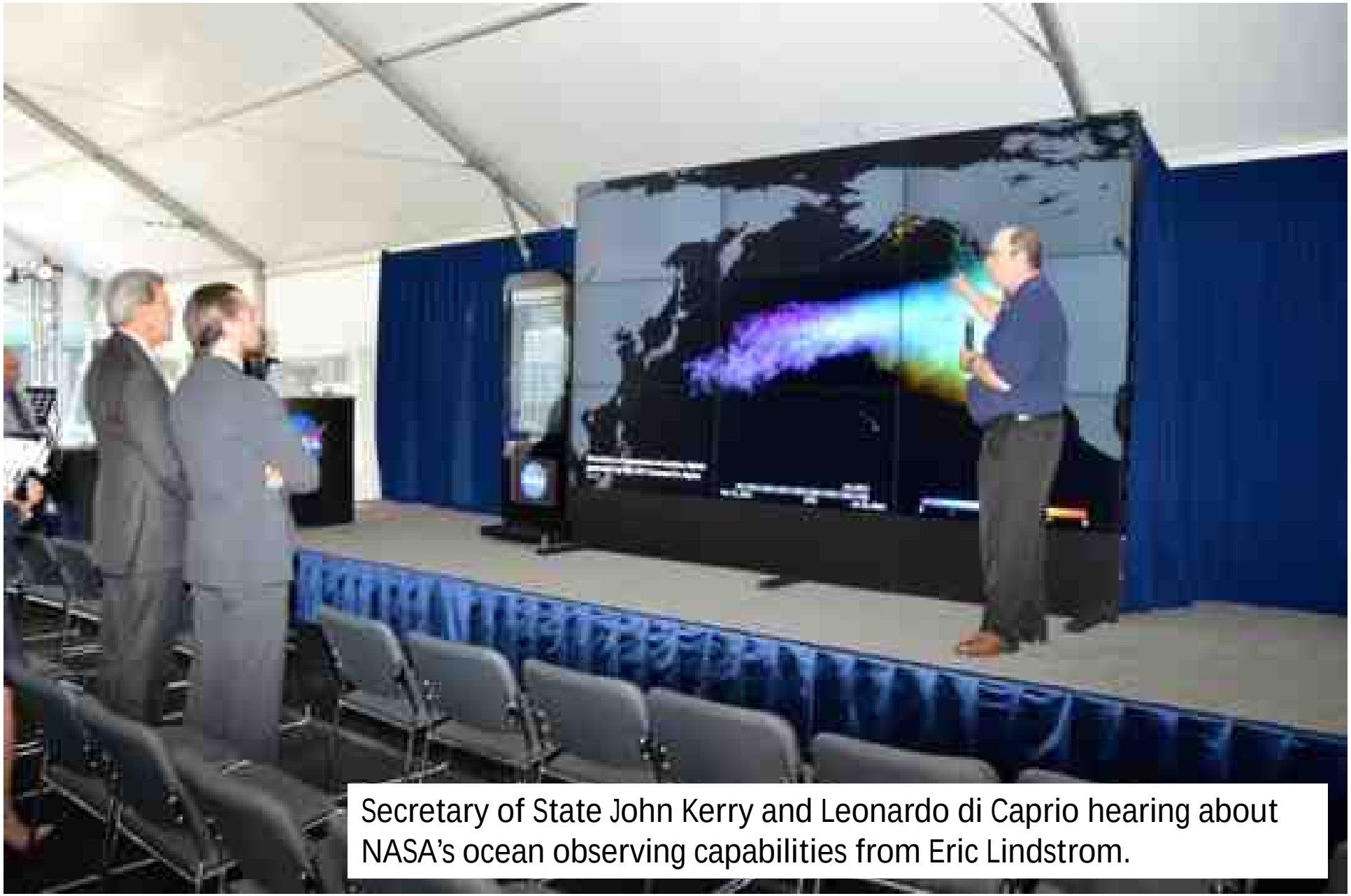

Debris problem becomes obvious
requires urgent use of all our resources,
including most advanced technologies
indosurflife.com

Workshop on Mission Concepts for Marine Debris Sensing

19 (Tuesday) - 21 (Thursday) January 2016
East-West Center of the University of Hawaii at Manoa, Honolulu, Hawaii

The accumulation and impacts in the ocean of marine debris generated by anthropogenic activities and aggravated by natural disasters are of growing concern, yet our existing data collection systems are rudimentary and cannot answer even fundamental questions. This is partly due to the diversity of the debris and the vastness of the ocean that complicate observations.

NASA is sponsoring a three-day workshop to review existing and emerging technologies that could be capable to remotely survey the state of marine debris in the ocean and on land. The workshop brings together oceanographers, technologists, and experts in marine debris. An important outcome of the workshop is expected to be a white paper that will be circulated among NASA and other relevant organizations and that could lay the foundation for a possible future NASA mission focusing on marine debris.



Secretary of State John Kerry and Leonardo di Caprio hearing about NASA's ocean observing capabilities from Eric Lindstrom.

Steps necessary to take marine debris under control

- Reduce the source
- Create the marine debris observing system
- Understand marine debris life cycle
- Identify impacts
- Make it valuable