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

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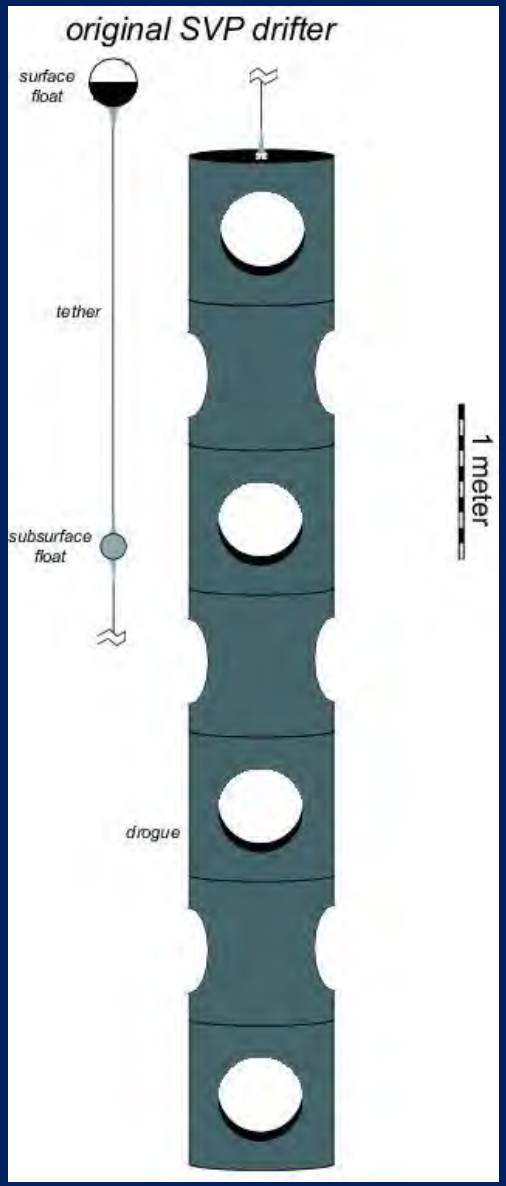
March 11, 2011 tsunami in Japan

Debris, drifting offshore after tsunami

Courtesy of US Navy

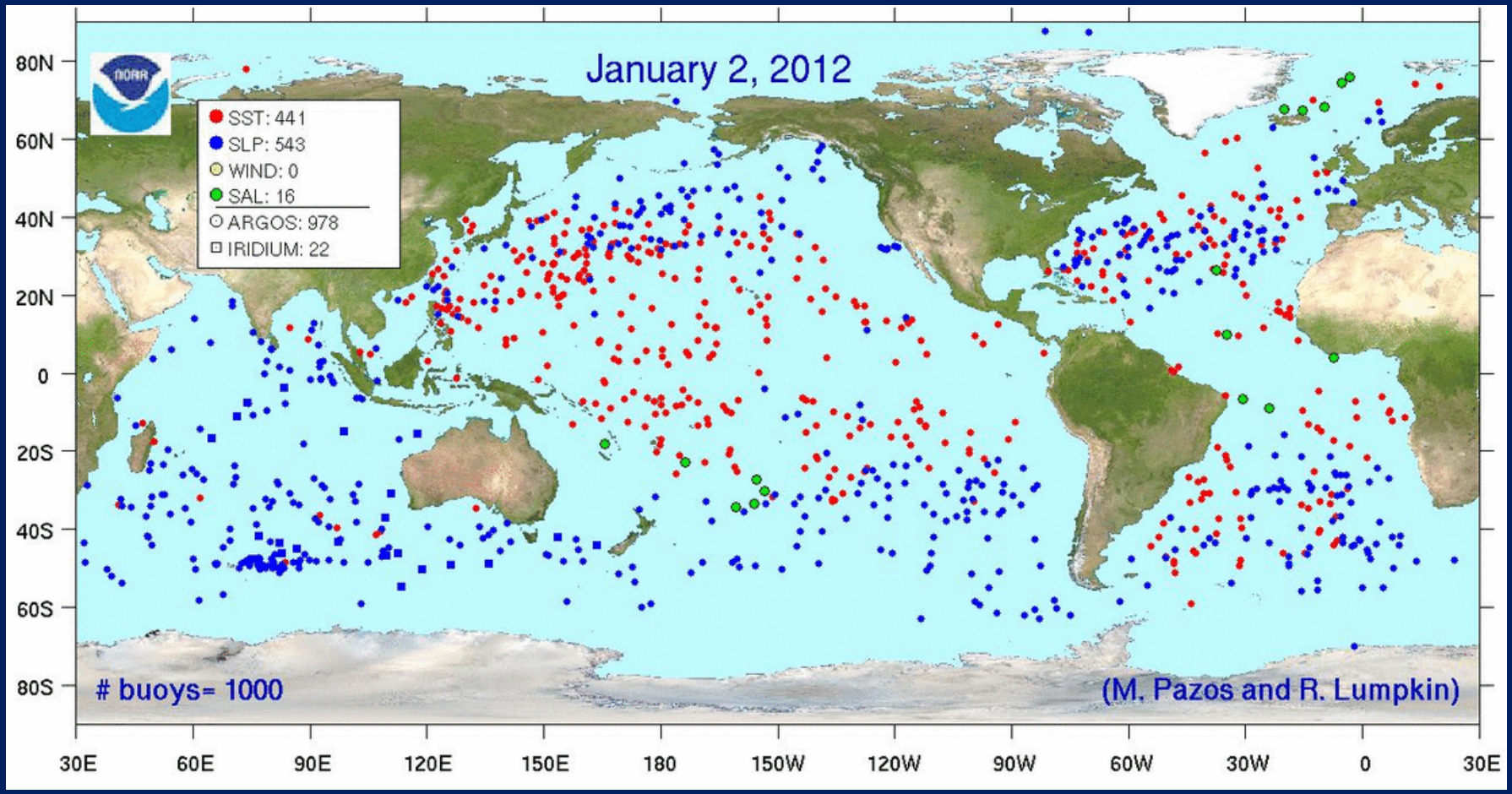
Use of drifting buoys to study pathways of marine debris



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))

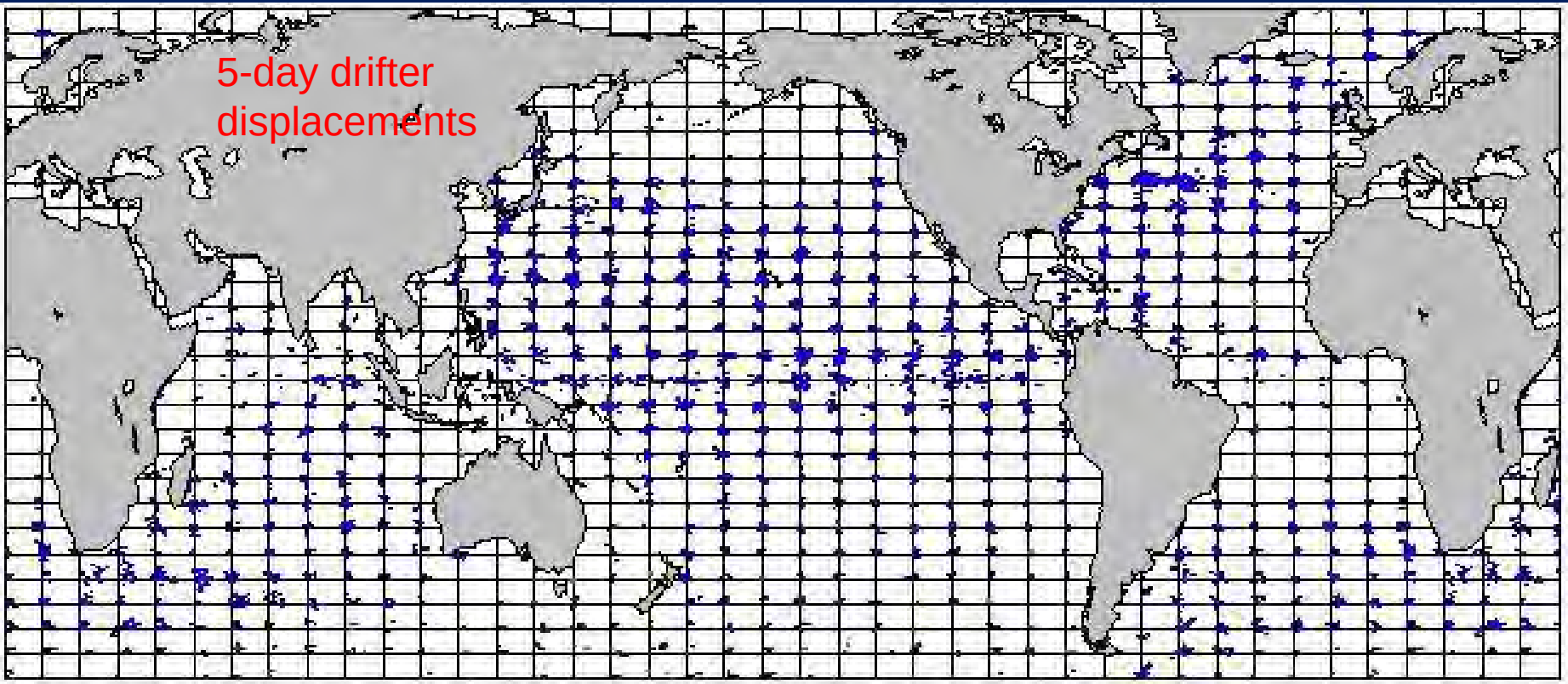


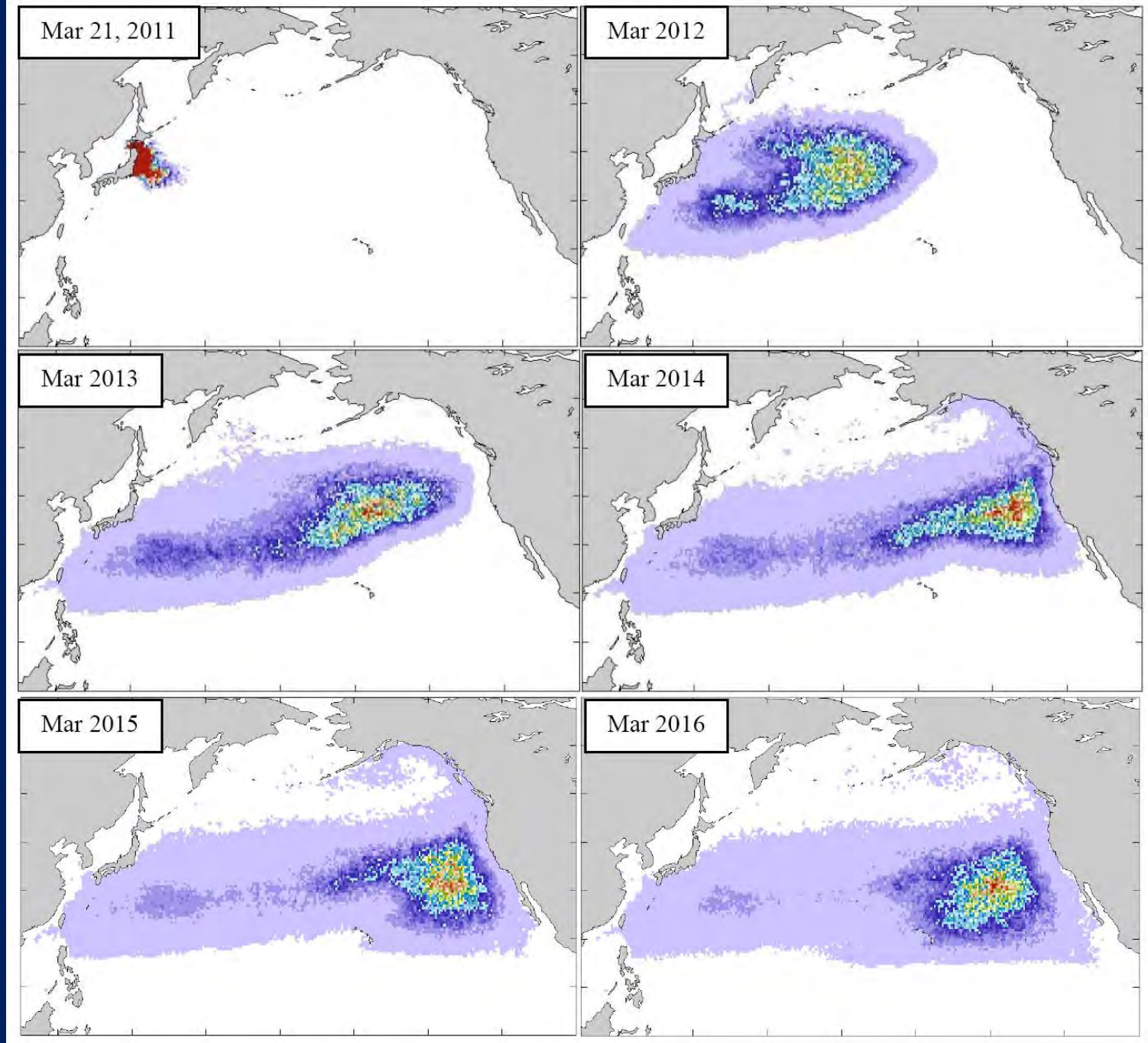
To remedy the bias we developed a probabilistic model

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 δt 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 δt = 5 days ($V \bullet \delta t >> \delta x$)

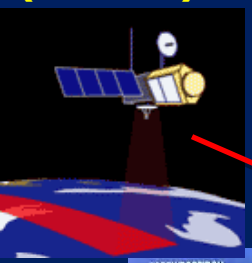



Mar 21, 2011
Mar 2012
Mar 2013
Mar 2014
Mar 2015
Mar 2016

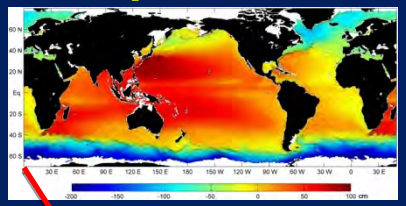
Differences between years and importance of real-time modeling (as opposed to statistical modeling)

SCUD - Surface CUrrents from Diagnostic model

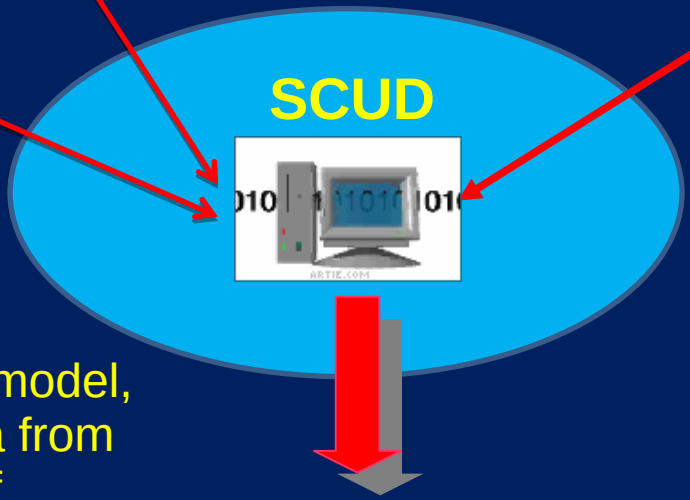
Satellite-measured sea level anomaly (AVISO)



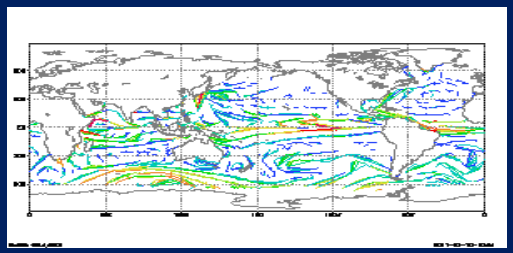
IPRC mean dynamic ocean topography (APDRC)



Satellite-measured ocean surface wind (QuikSCAT & ASCAT)



Ocean surface currents



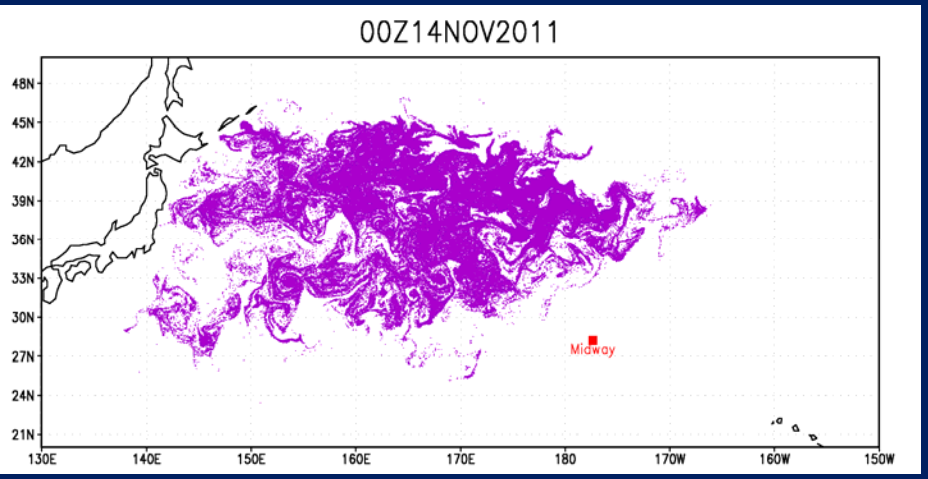
SCUD is essentially a drift model, tuned using collocated data from satellites and trajectories of drifting buoys.

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

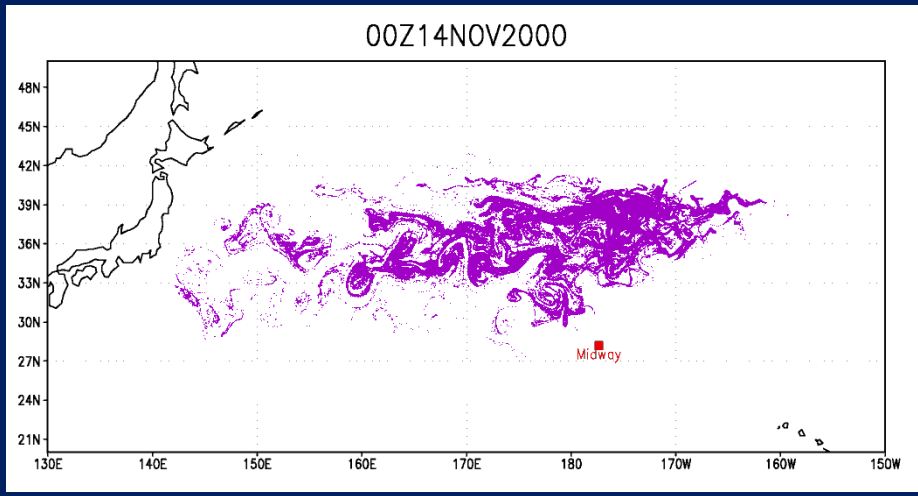
SCUD products are on nearly global ¼-degree grid and updated daily. The dataset starts from August 1, 1999, forced by QuikSCAT winds. In November 2009, after the death of QuikSCAT, SCUD is seamlessly transitioned to ASCAT scatterometer vector wind data.

“Would be now location” of model debris, released on March 11 of year:

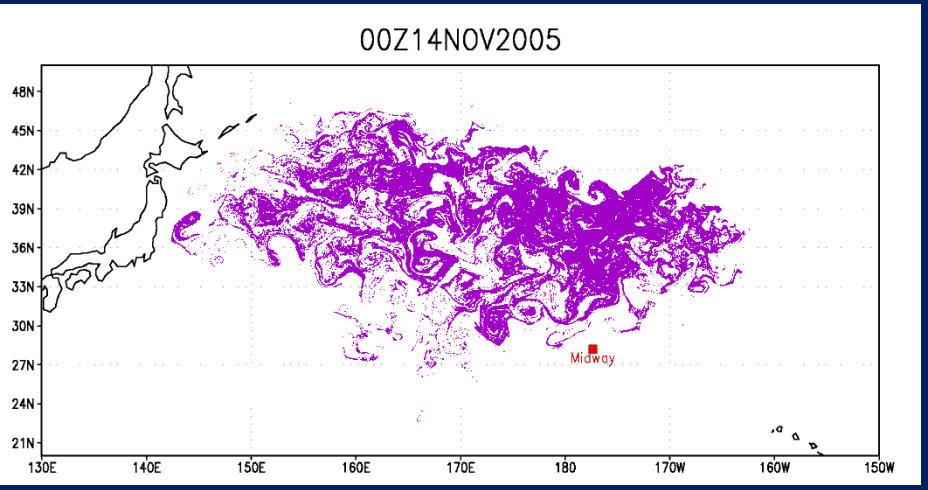
2011



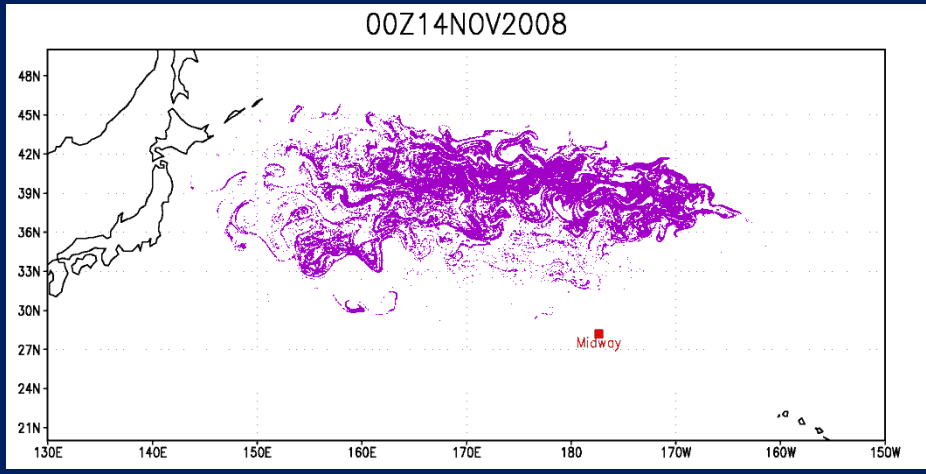
2000



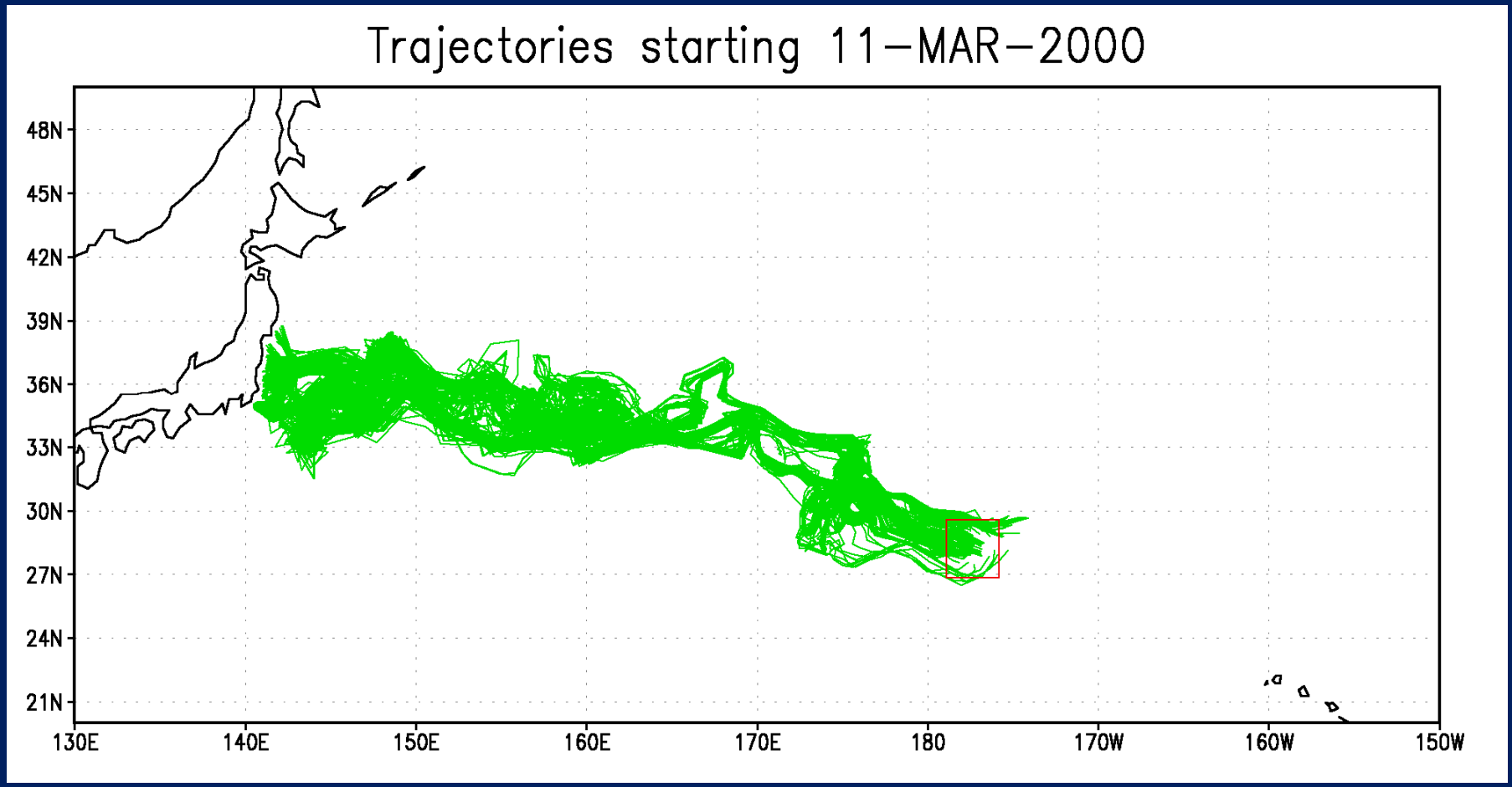
2005



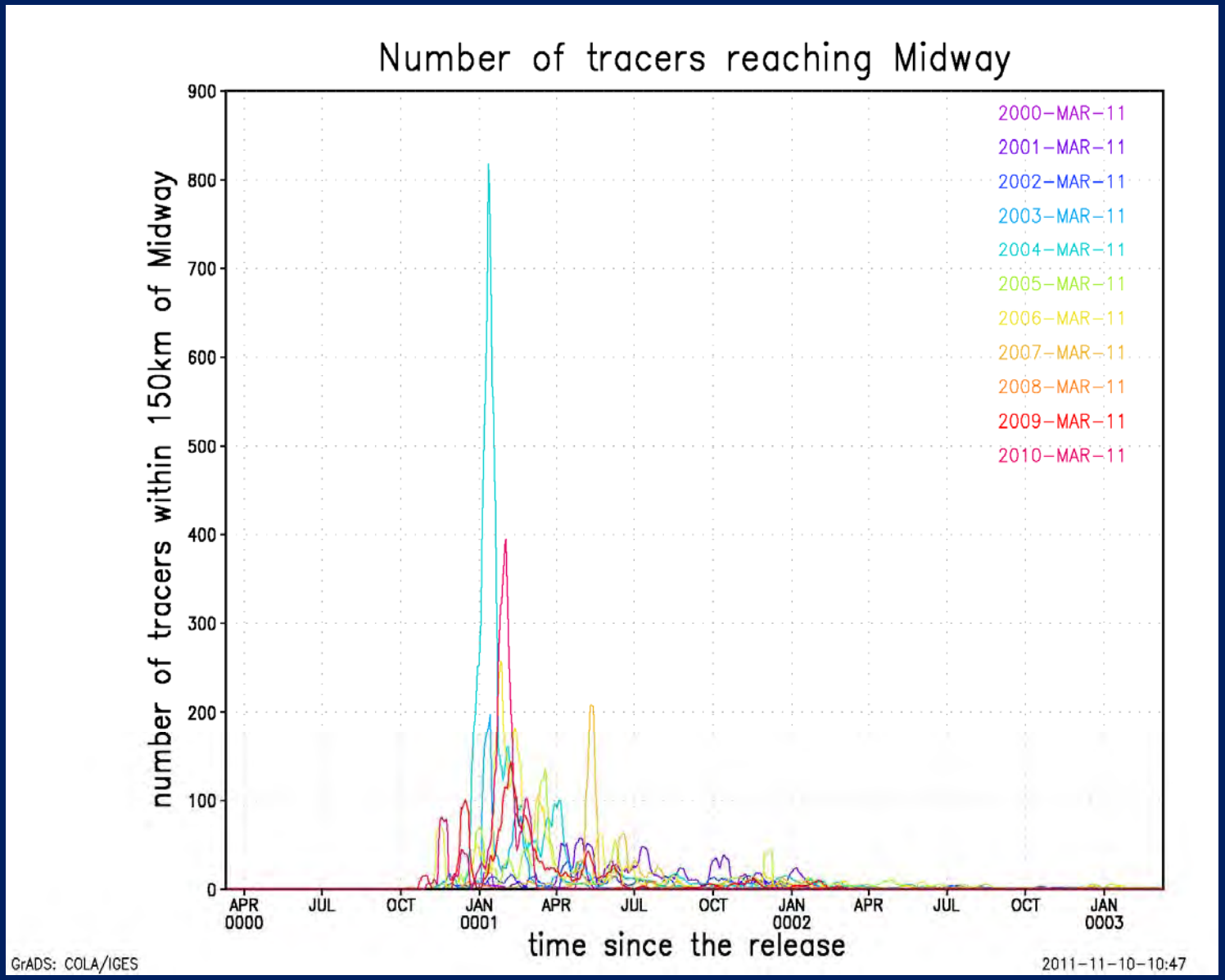
2008



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



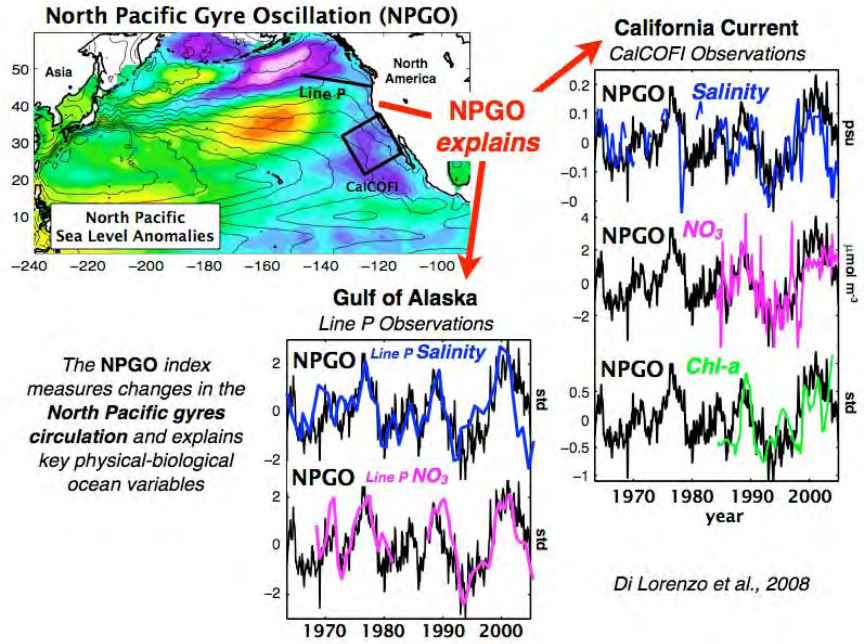
Model flux of March 11 tsunami debris on Midway in different years

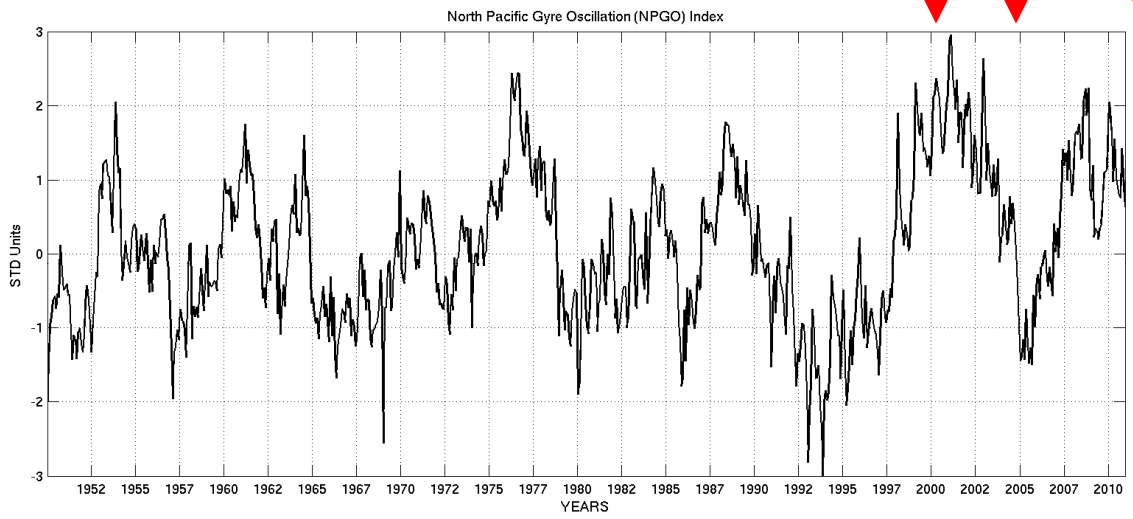


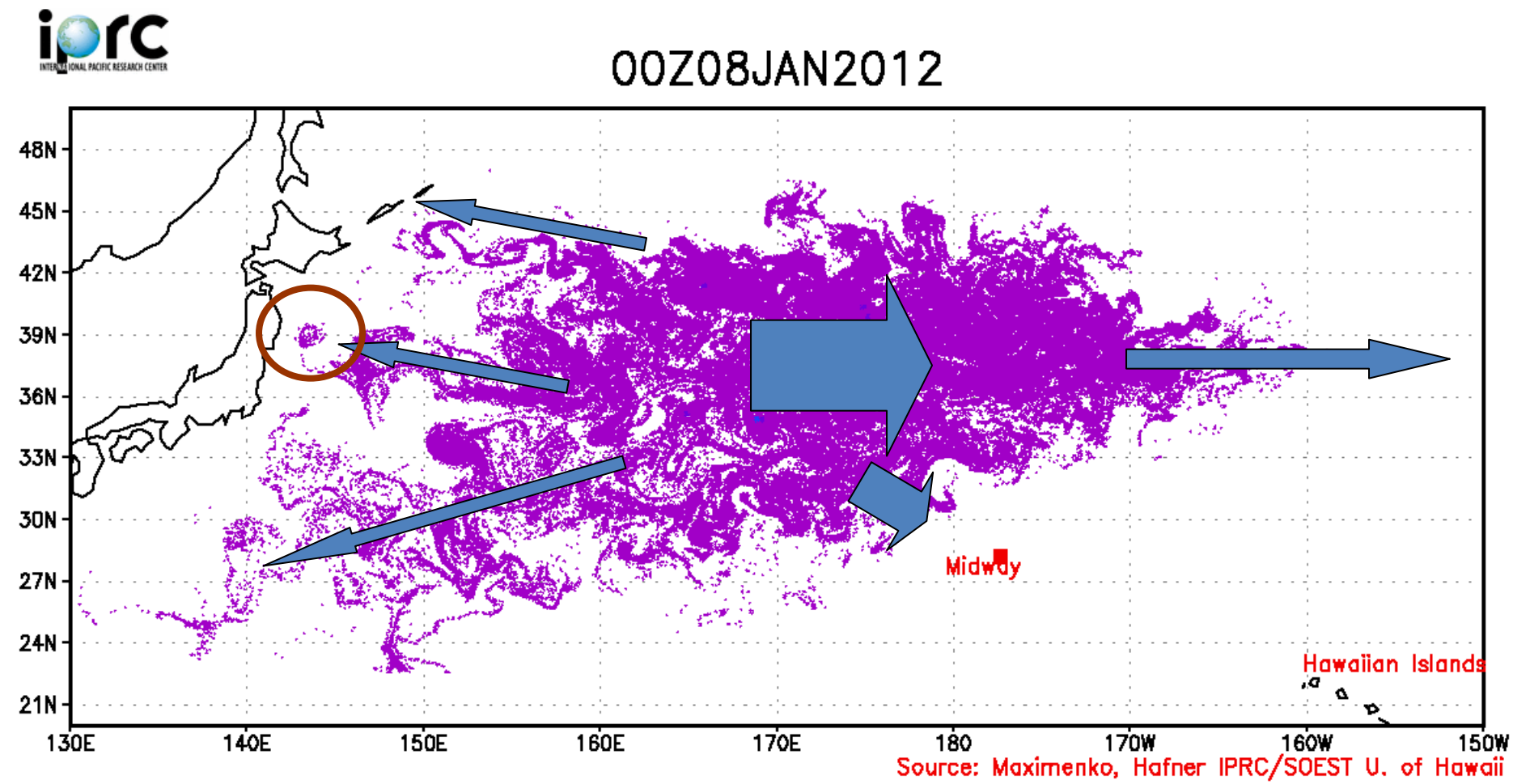
North Pacific Gyre Oscillation

Emanuele Di Lorenzo, Ph.D.

Di Lorenzo E., **Schneider** N., **Cobb** K. M., Chhak, K, Franks P. J. S., **Miller** A. J., McWilliams J. C., Bograd S. J., Arango H., Curchister E., Powell T. M. and P. Rivere, 2008: North Pacific Gyre Oscillation links ocean climate and ecosystem change. *Geophys. Res. Lett.*, 35, L08607, doi:10.1029/2007GL032838. [PDF]

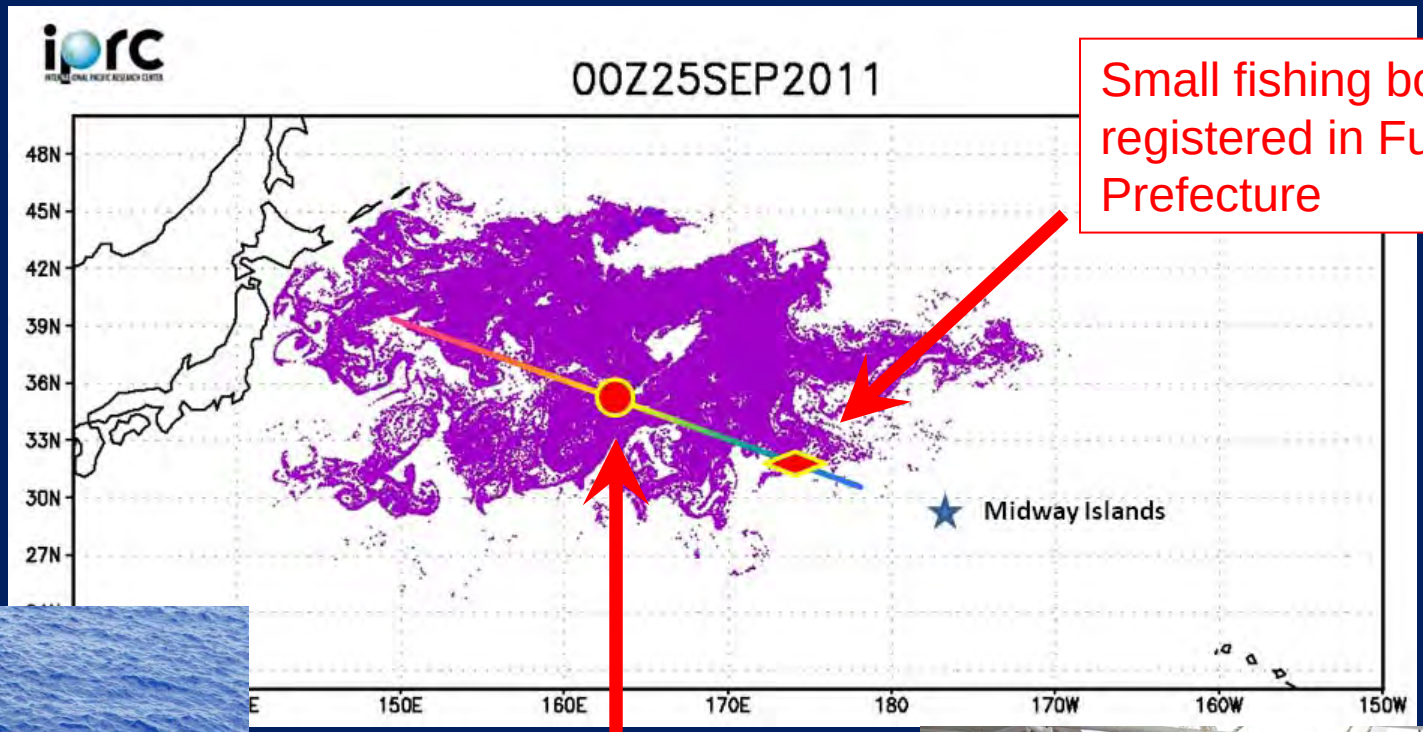






Daily public updates are available
at http://iprc.soest.hawaii.edu/users/hafner/PUBLIC/TSUNAMI_DEBRIS

“Pallada” found tsunami debris where SCUD predicted

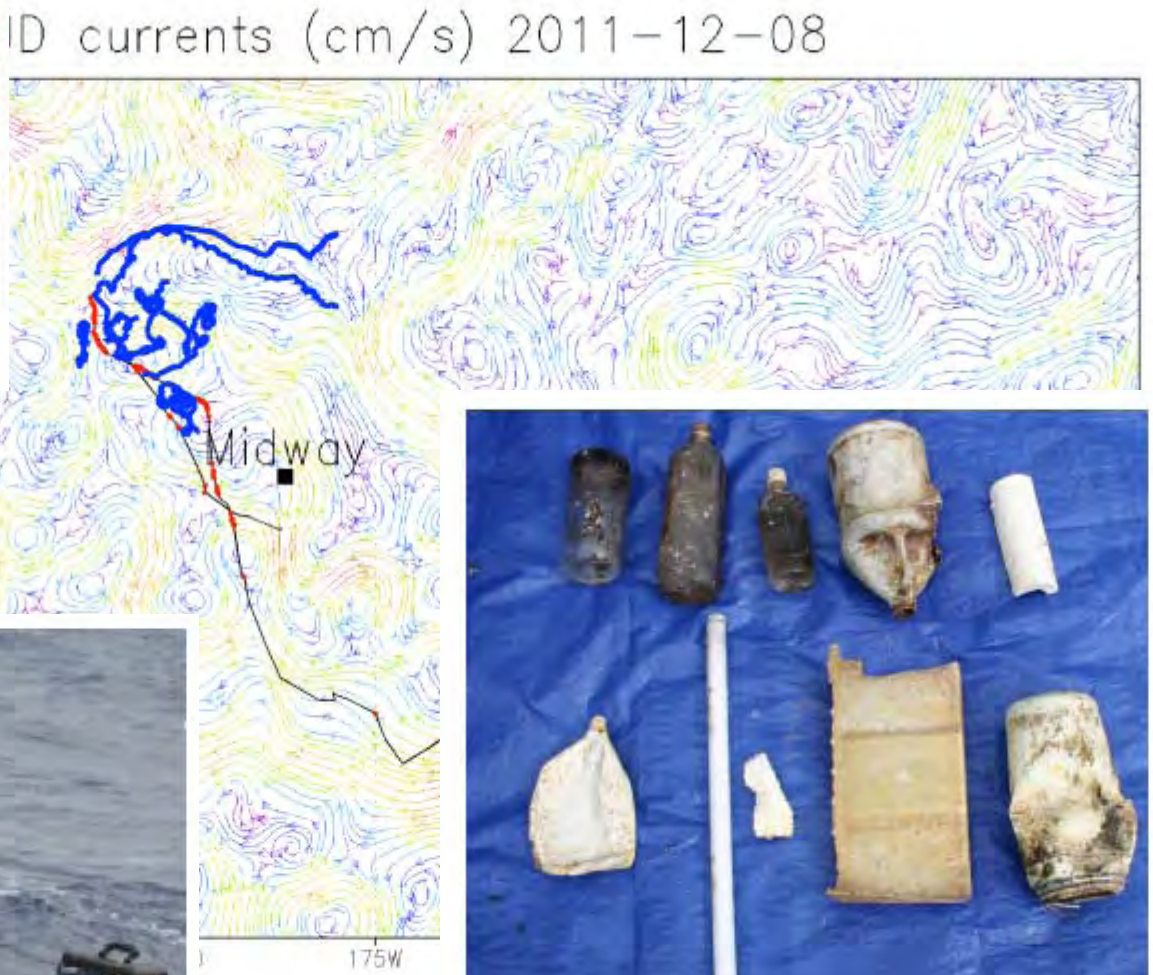


Small fishing boat, registered in Fukushima Prefecture

Observed maximum density of debris

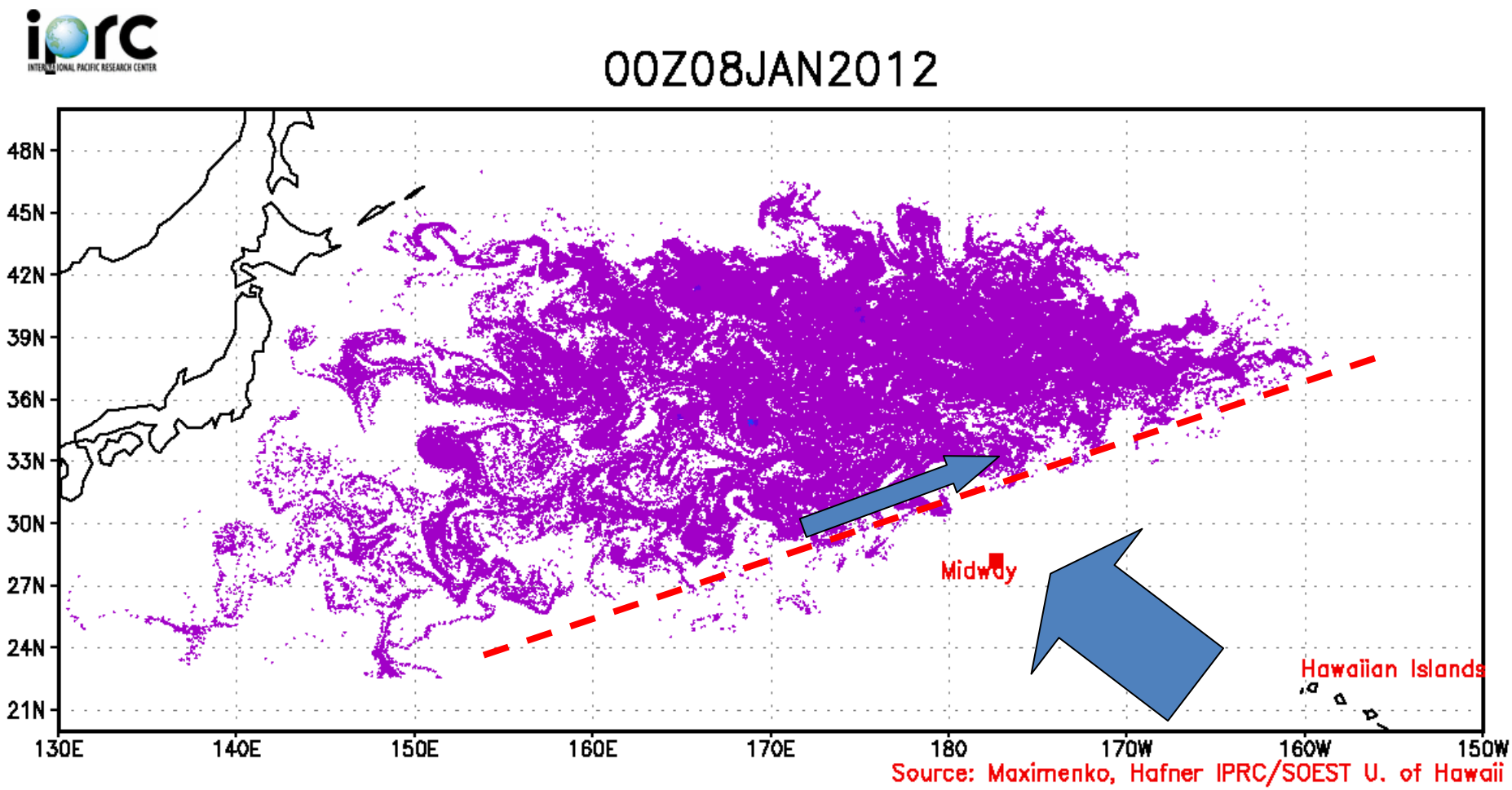
December 2011 expedition, organized by the University of Hawaii, Ocean Recovery Alliance, and Scripps Institution of Oceanography studied structure of currents, protecting Midway and other Hawaiian Islands

Numbered wooden block if found please contact hilodrifter@gmail.com



Drifting buoys deployed.

Isolated floating objects found during the expedition. They are probably not from the tsunami.



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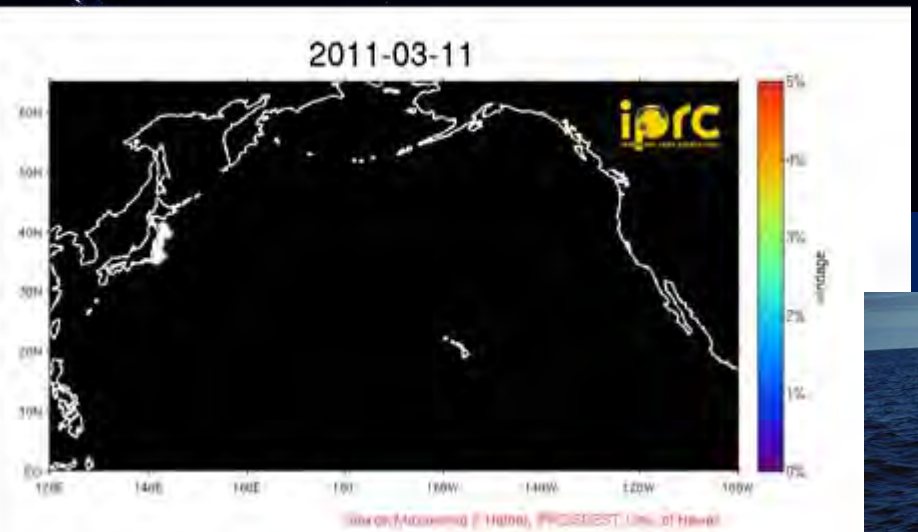
at http://iprc.soest.hawaii.edu/users/hafner/PUBLIC/TSUNAMI_DEBRIS

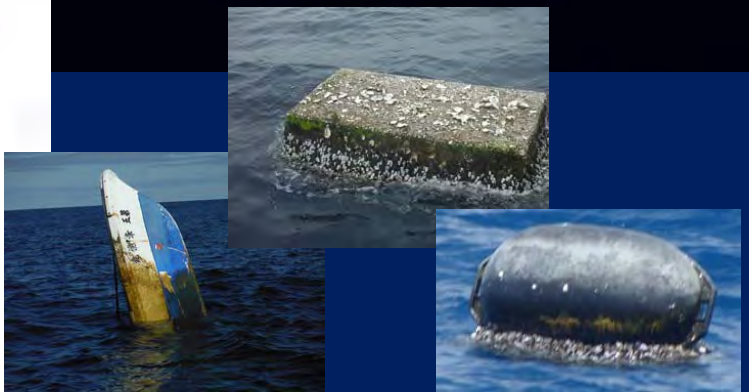
Effect of direct wind force (windage)

Heterogeneity of tsunami debris

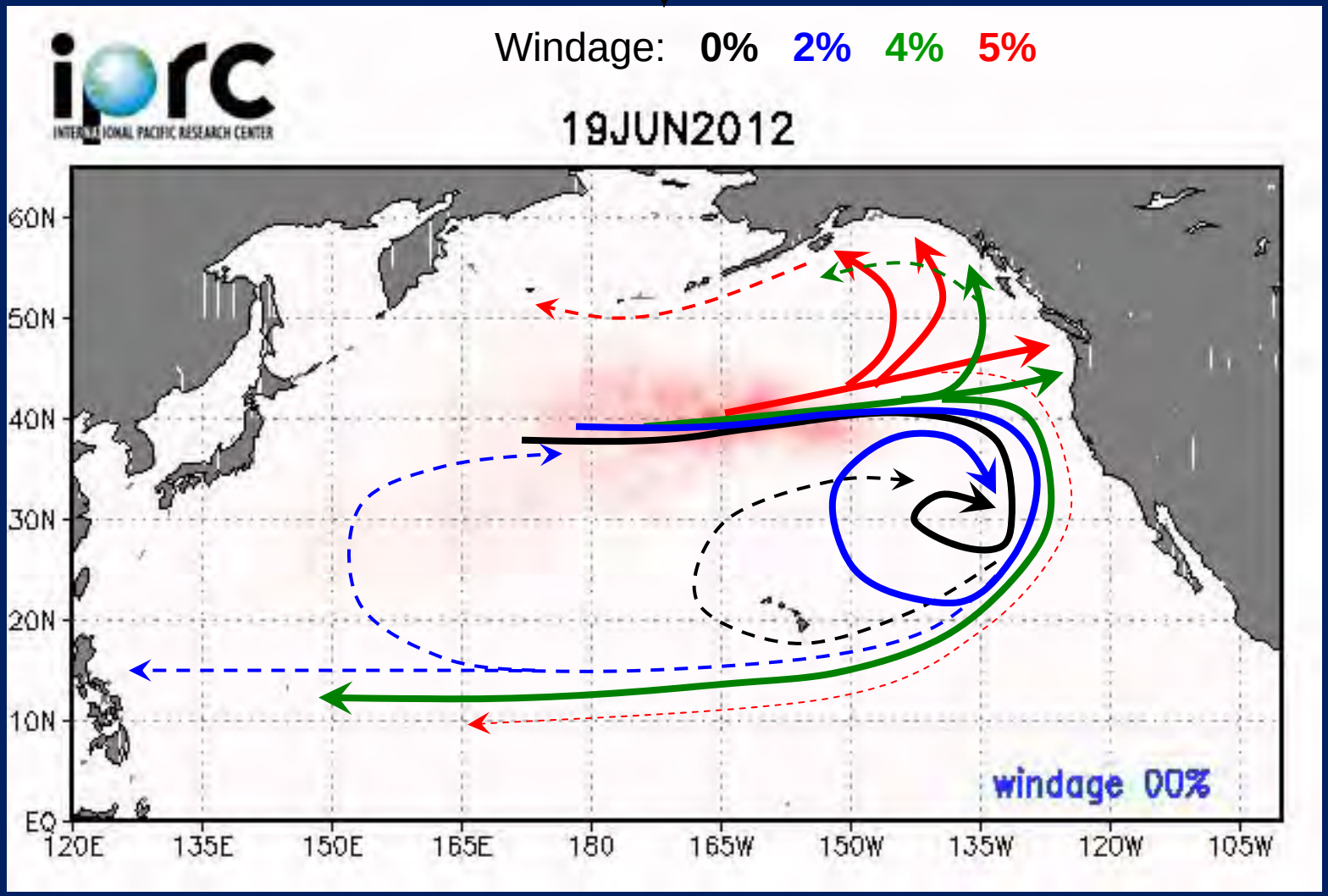
Applications: pathways of marine debris

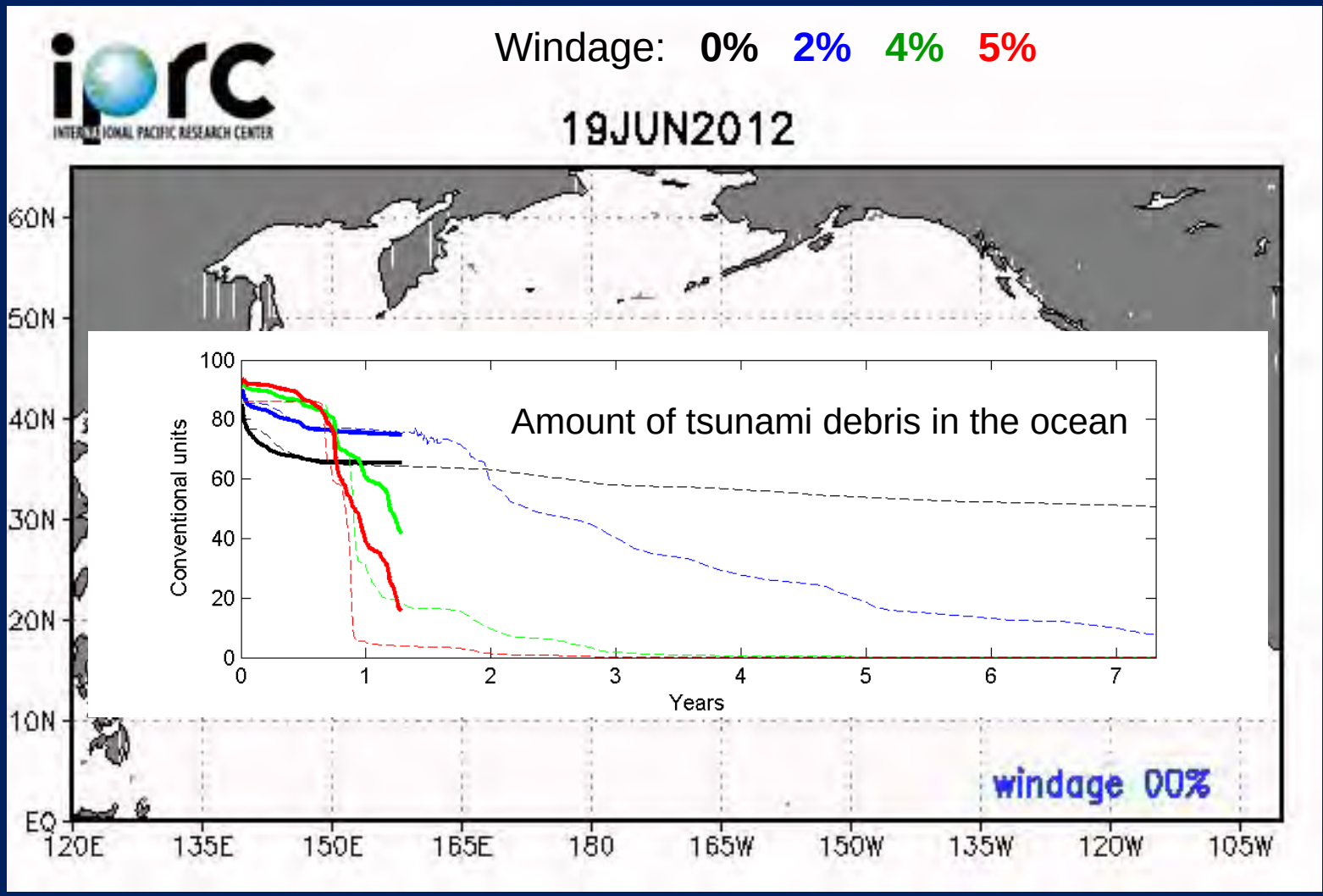
September 2012





Pathways of tsunami debris




Windage: 0% 2% 4% 5%
19JUN2012
60N
50N
40N
30N
20N
10N
EQ
120E
135E
150E
165E
180
165W
150W
135W
120W
105W
Amount of tsunami debris in the ocean
Conventional units
100
80
60
40
20
0
0
1
2
3
4
5
6
7
Years
windage 00%

Models verification using observations

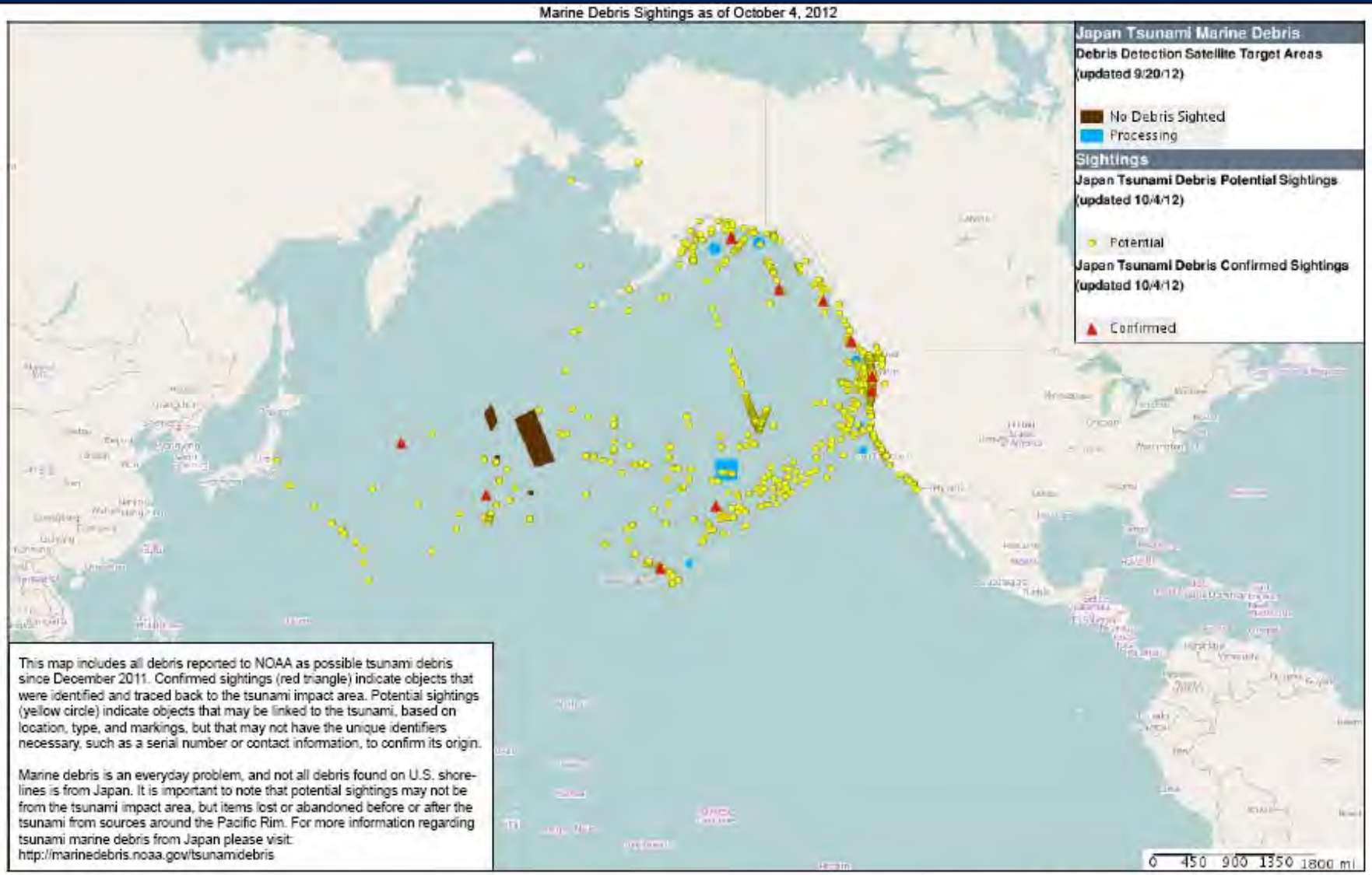
Fishing boat “DAI-GO KOURYOU-MARU”

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



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

Oyster buoy reports after 2011 tsunami

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

Hawaii

Hilo, Big Island of Hawaii , June 2012

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

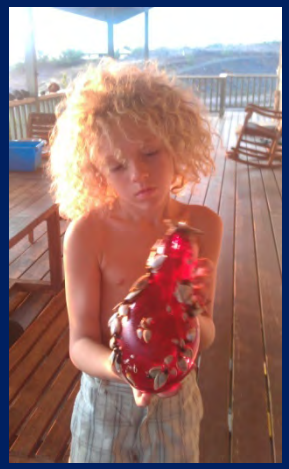
June 2012 – report of s/b "Tregoning" north of Oahu

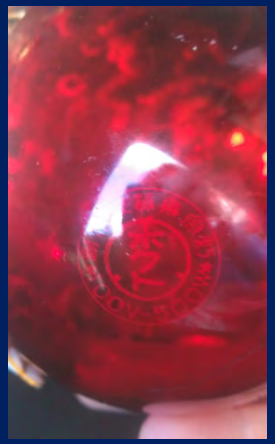
Kure Atol Northwest Hawaiian Islands
Reported by Scott Godwin
August 2012

August 2012 – oyster buoy reported by Carl Berg on Kauai

September 2012 – oyster buoy reported by Cynthia Vanderlip in Turtle Bay, Oahu

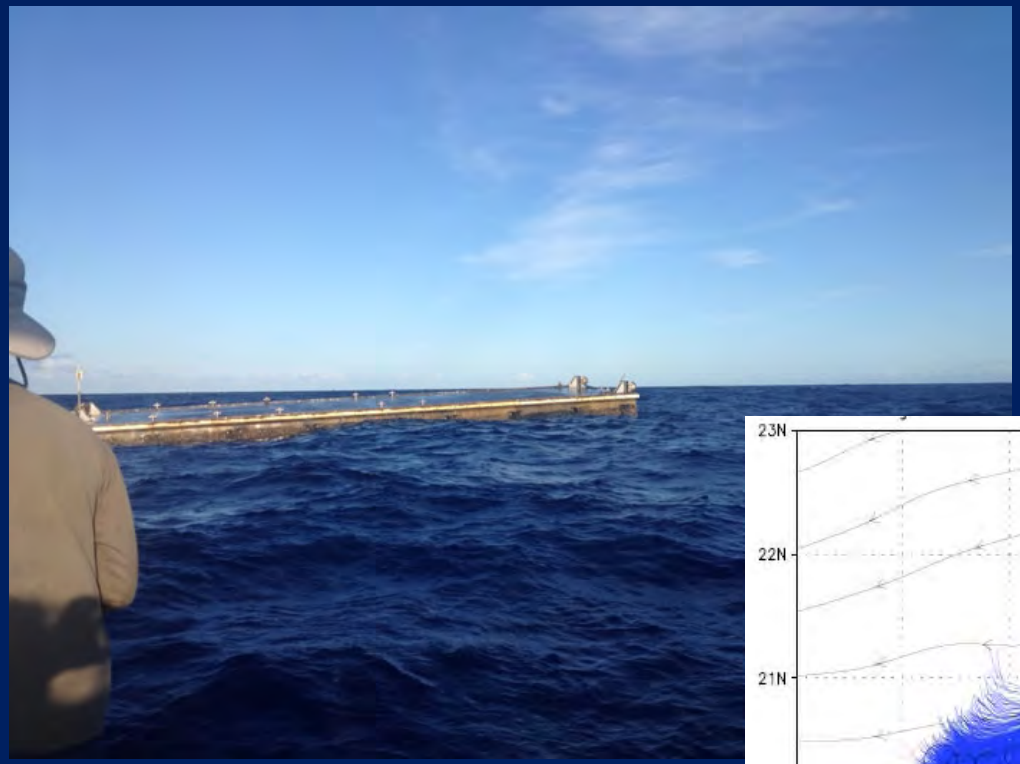
Debris of unidentified origin



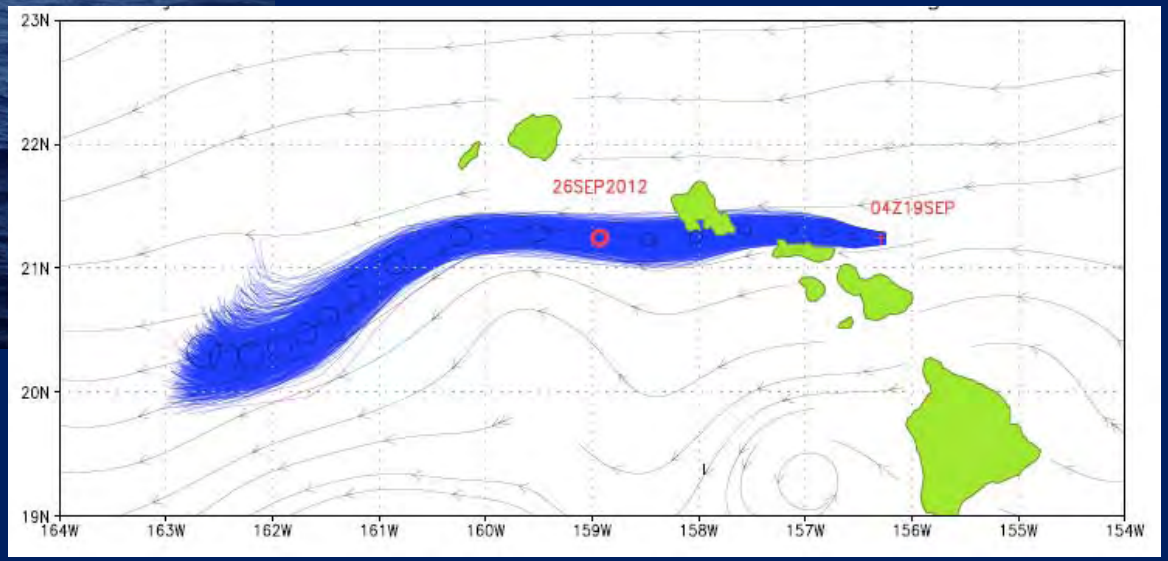


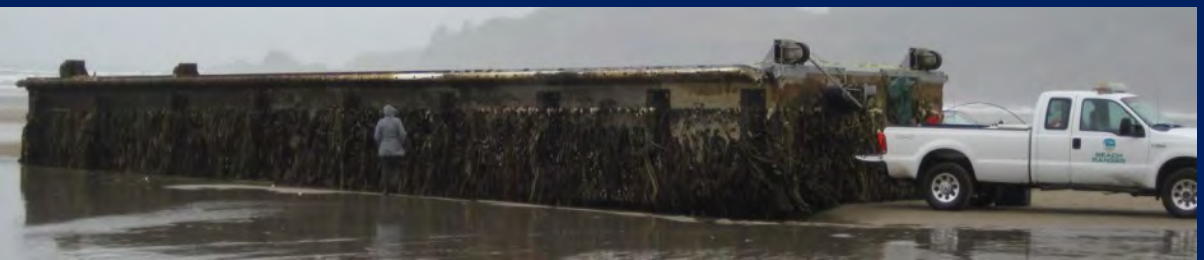
Unidentified 3m x 6m object washed ashore at Na'alehu (Big Island of Hawaii) in October 2012

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.