

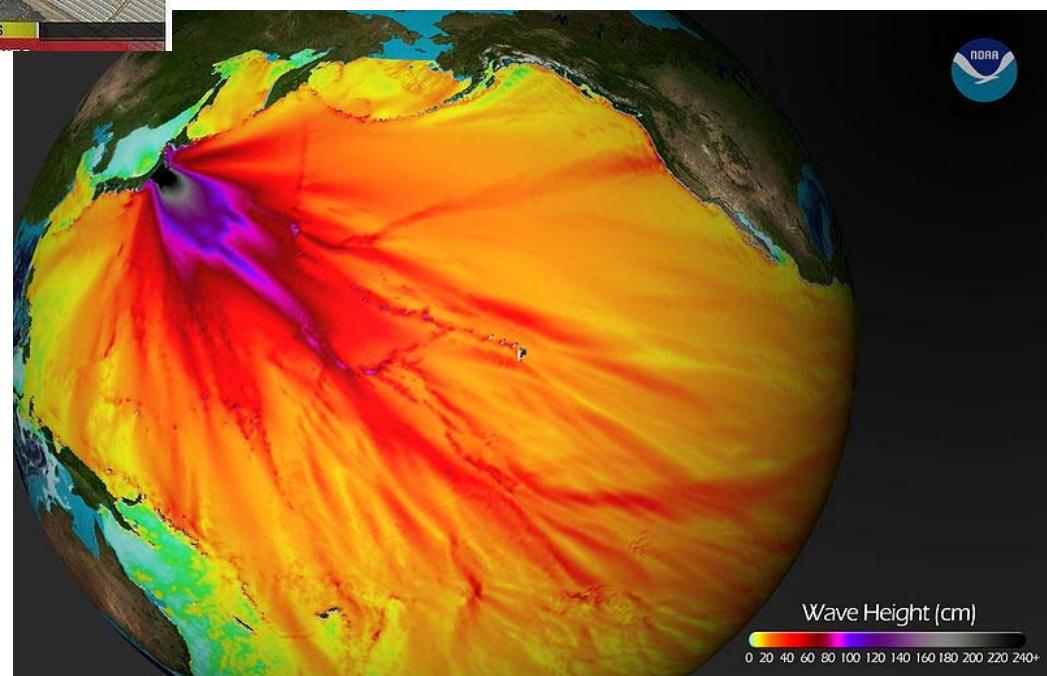
# “Waves” of Tsunami debris: Effect of the windage

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Workshop on Mission Concepts of Marine Debris

19-21 January 2016, East West Center, University of Hawaii at Manoa, Honolulu,  
Hawaii

# Japanese Tsunami 11 March 2011



# Massive amount of debris generated

Estimates of the amount about 1-2 million tons of debris



Courtesy of US Navy

# Massive amount of debris generated



Courtesy of US Navy

Deposited on land

Sunk down to the ocean bottom

Floating in the ocean



Courtesy of US Navy

## Ofunato – March 2011



Courtesy of Robin Bond

## Ofunato – March 2011



Courtesy of Robin Bond

## Ofunato – March 2011



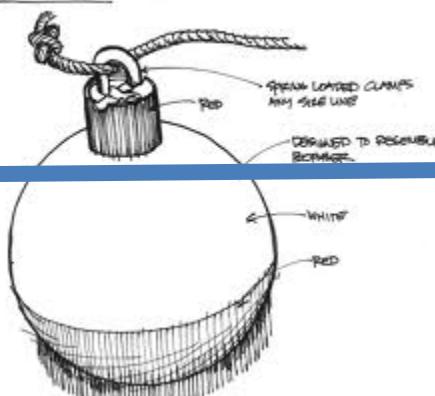
Courtesy of Robin Bond



Courtesy of US Navy

# Windage

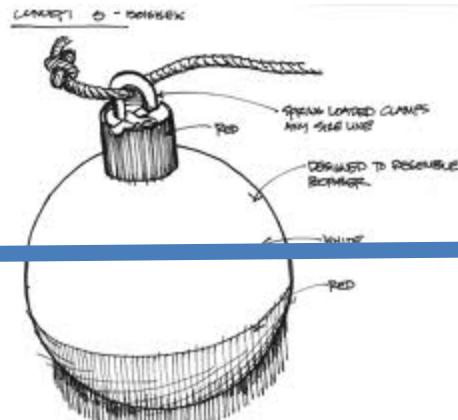
Wind



**Low windage,  
object sitting deep in water**



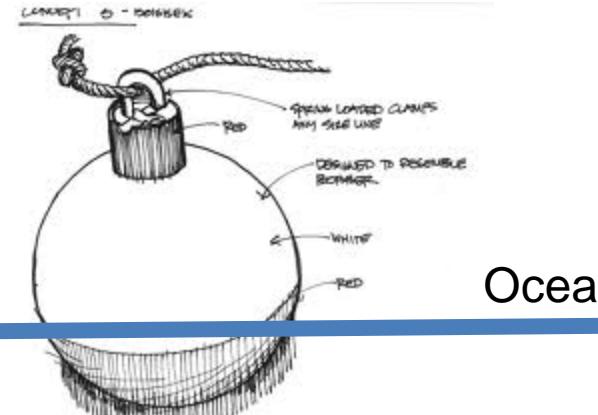
Photo: Charles Moore



**Medium windage,  
object sitting half in water**



Photo: Randal Reeves



Ocean surface

**High windage,  
object sitting high on water**

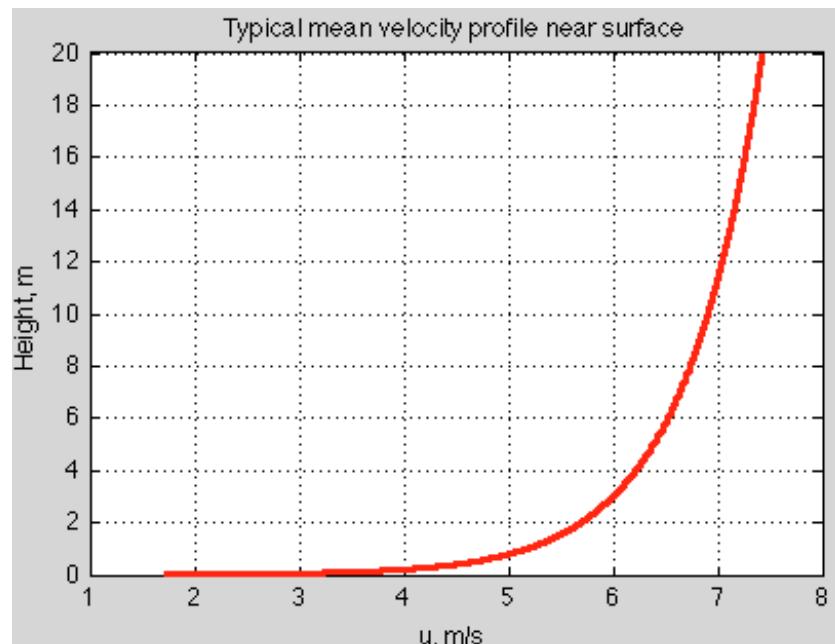


Photo: S/V "Tregoning"

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

# Windage - simple?

## Surface wind vertical profile



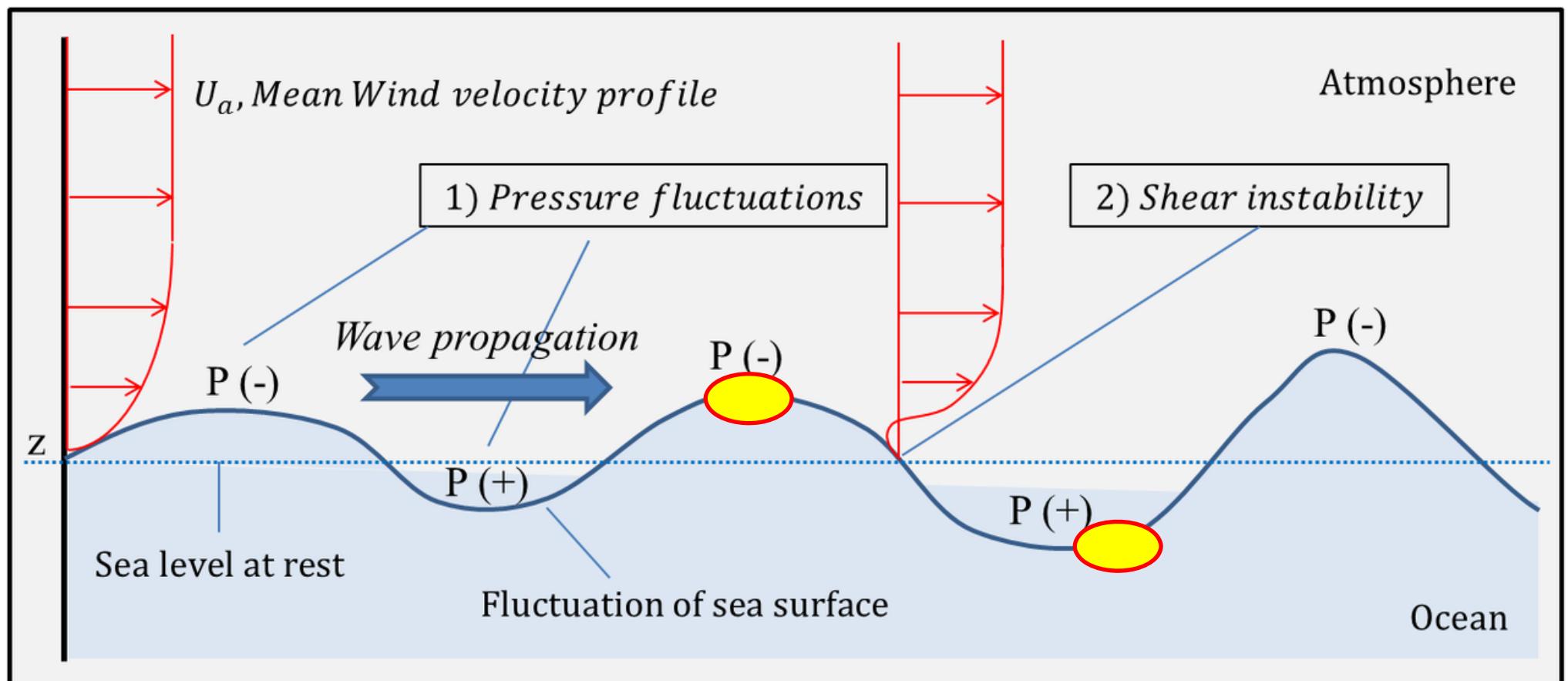
Ocean surface wind = 10m height



Sea Surface



# Windage - simple?



Source: [http://www.wikiwand.com/en/Wind\\_wave](http://www.wikiwand.com/en/Wind_wave)

# Windage - simple?

Similar boat type in various floating positions => Different effective windages.



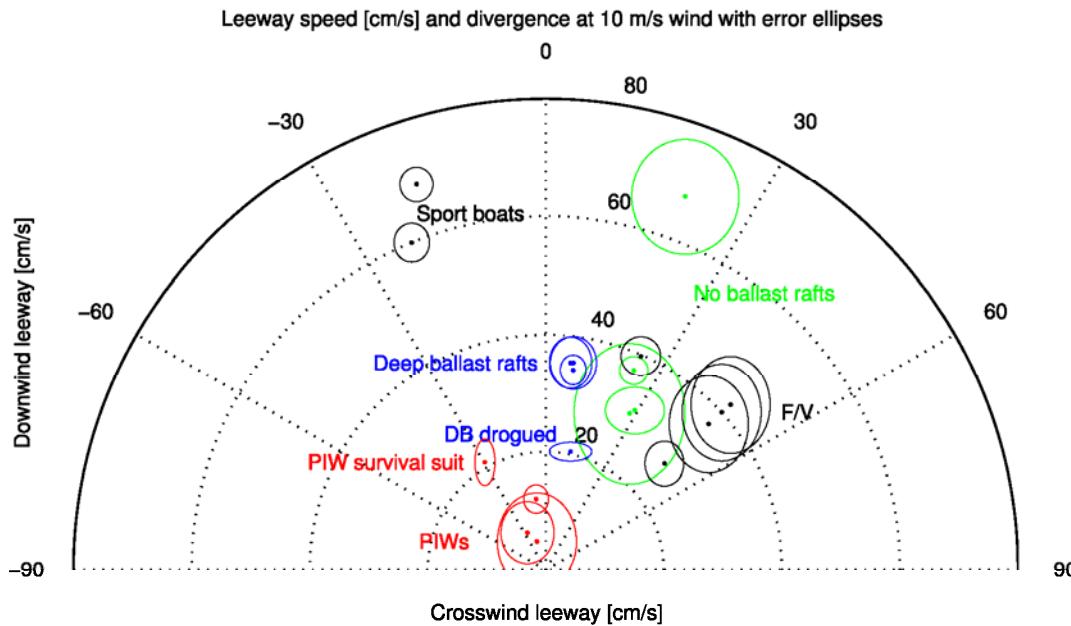
80ft “island” Floats and lines all tied and anchored.

July 2014 -33.37.849 138.07.326



Source: Capt. Charles Moore Algalita

# Windage - simple?



**Fig. 1.** Distribution of selected object categories in the two-dimensional leeway-space. The downwind (vertical axis) and crosswind (horizontal axis) leeway of selected leeway categories at 10 m/s wind speed is shown. The distance from the origin indicates leeway speed (cm/s) while the angle relative to the vertical indicates the object's divergence from the wind direction (wind blowing upwards along second axis). The ellipses show crosswind and downwind error. Categories are placed in the left and right quadrant for readability. Deep ballast rafts (DB, marked blue) and the person in water (PIW) in survival suit (red) are objects studied with the direct method. The older unballasted life rafts (green) and fishing vessels (F/V, black) were studied earlier using the indirect method. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Source: Brevik, et al., Wind-induced drift of objects at sea: The leeway field method. Applied Ocean Research 2011

**Windage can be a problematic variable. However, in a simple form it can quite sufficiently describe the motion of tsunami debris across the North Pacific Ocean.**

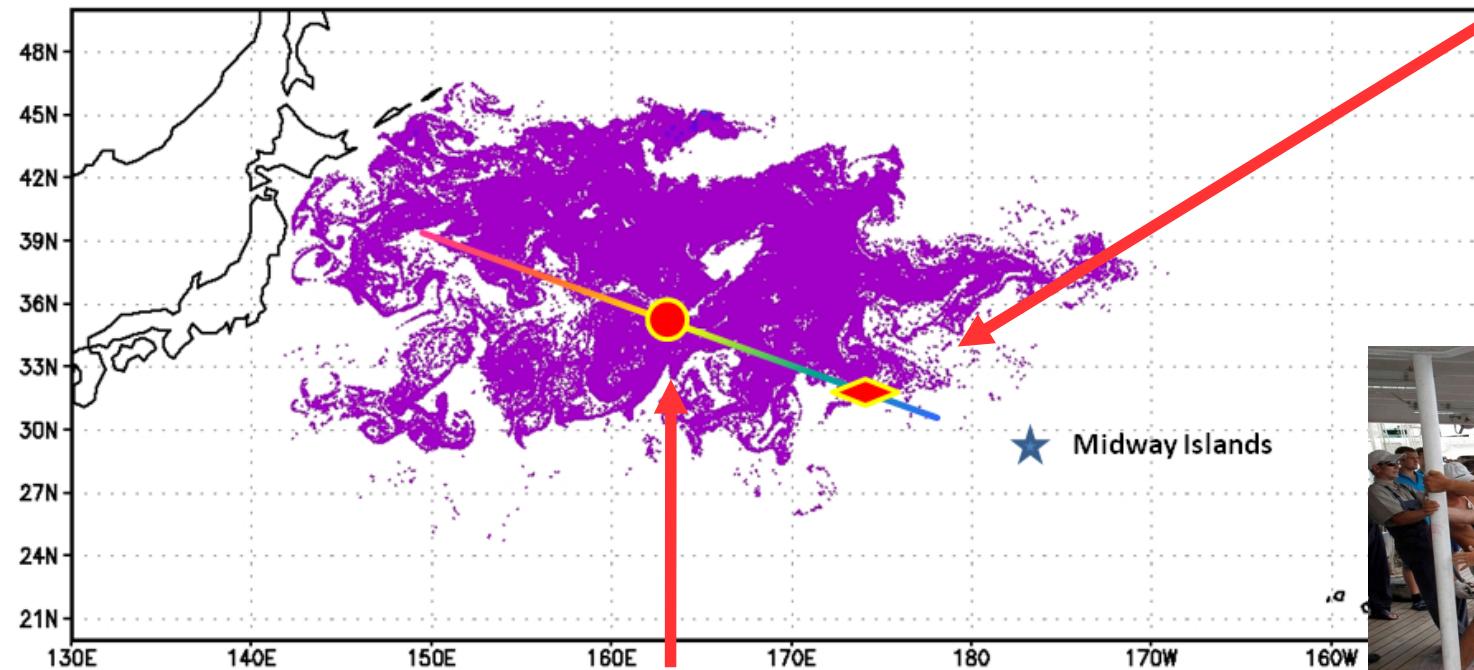
# Actual Observations !

“Pallada” found tsunami debris where SCUD predicted

Small fishing boat, registered in Fukushima Prefecture



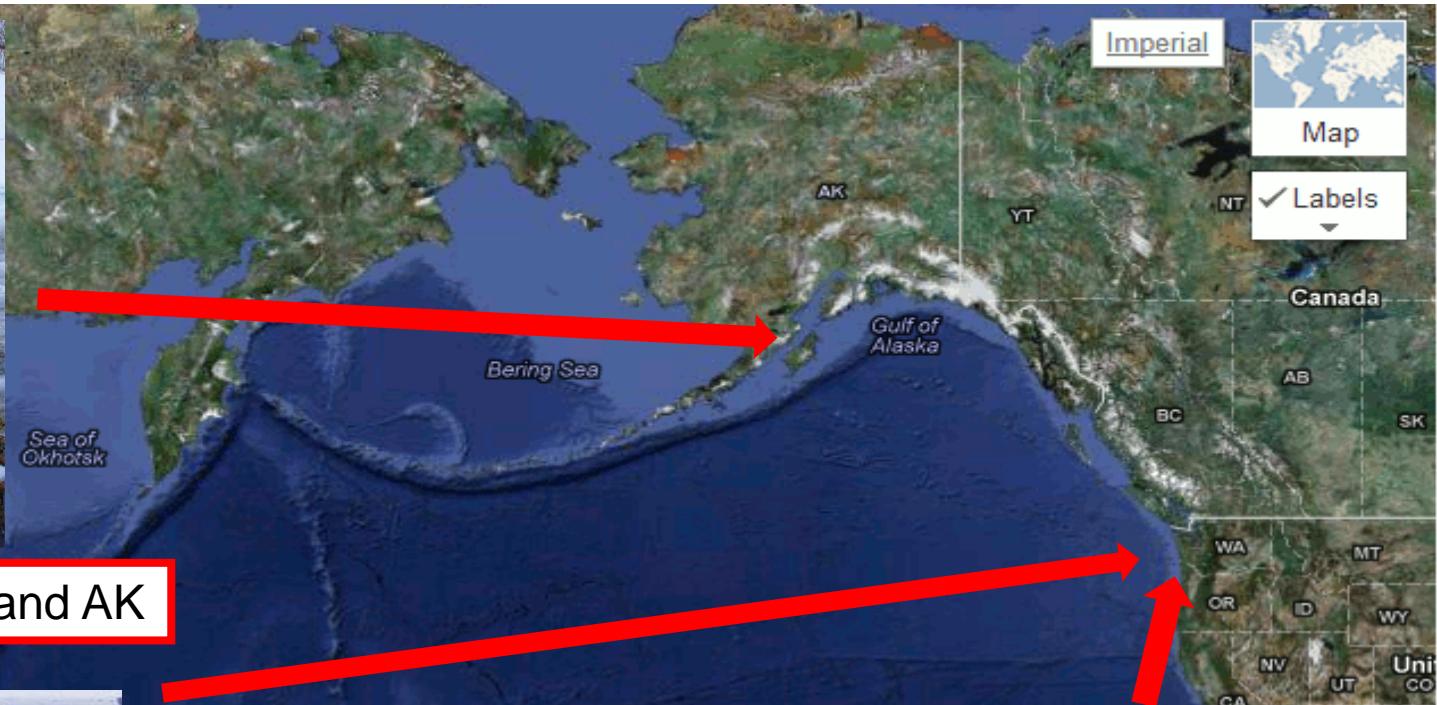
00Z25SEP2011



Observed maximum  
density of debris



# Actual Observations West Coast of N. America



20 Dec 2011 Whale Island AK



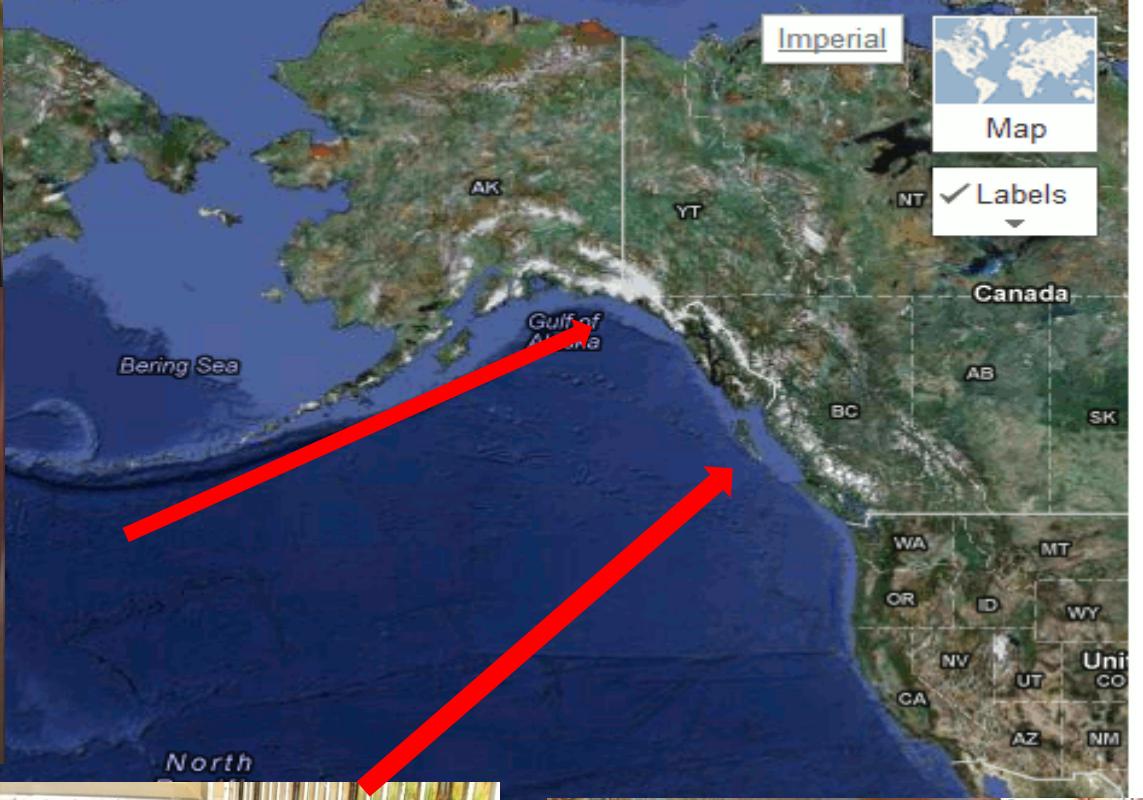
Early December 2011 Vancouver Island WA



Mid December 2011 Olympic Peninsula WA  
Photo courtesy of Curtis Ebbesmeyer

# Actual Observations

## North Pacific Ocean



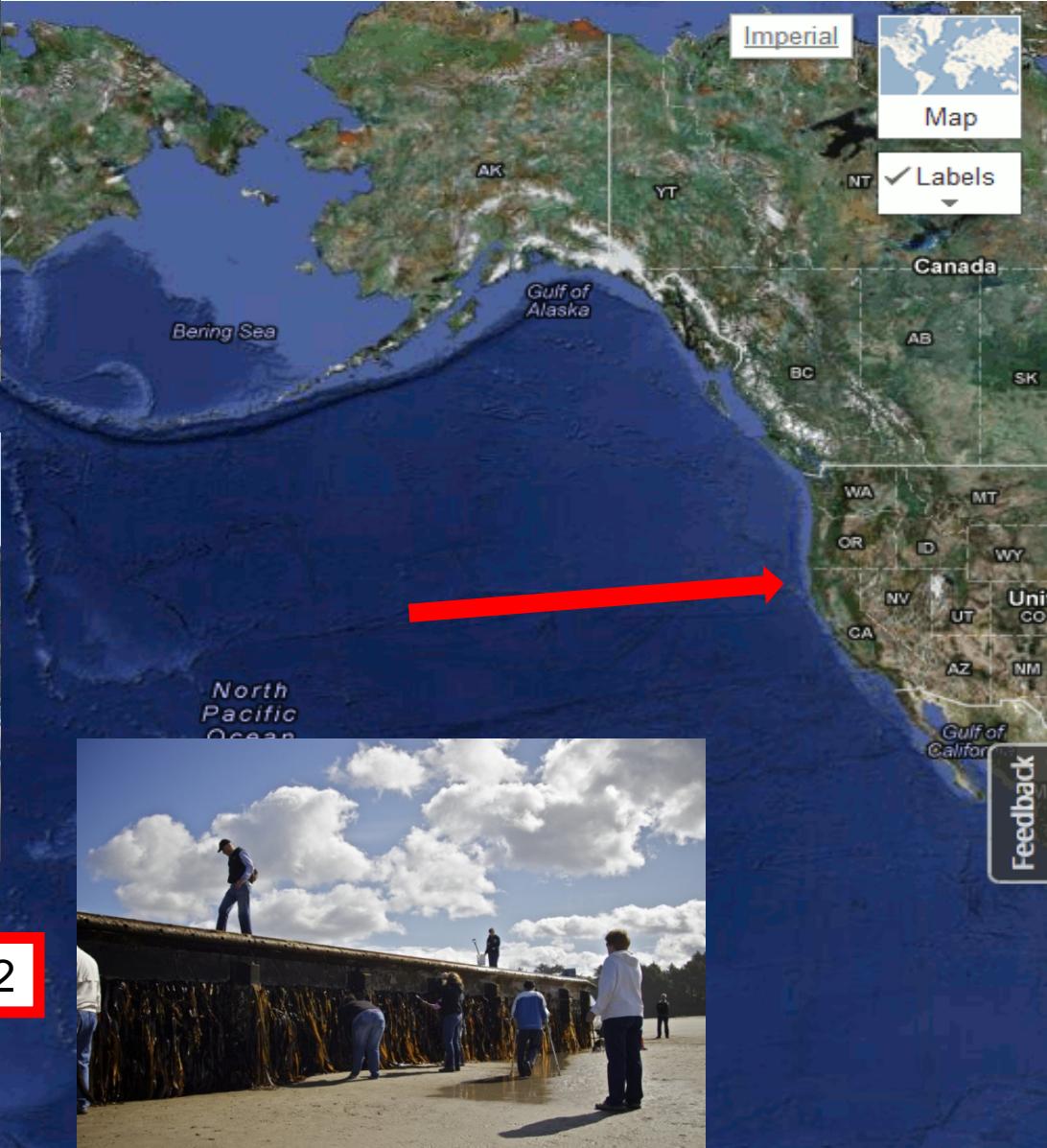
# Actual Observations West Coast of N. America

The image is a composite of two parts. On the left is a photograph of a fishing vessel, likely a trawler, sailing on choppy, blue ocean waters. On the right is a satellite map of the West Coast of North America, spanning from the Bering Sea down to the Gulf of California. The map shows landmasses in green and brown, and the ocean in shades of blue. A red arrow points from the map towards the fishing vessel. The map includes labels for various regions and countries: AK (Alaska), YT (Yukon), NT (Nunavut), AB (Alberta), SK (Saskatchewan), BC (British Columbia), WA (Washington), MT (Montana), ID (Idaho), OR (Oregon), CA (California), HI (Hawaii), and AZ (Arizona). It also shows the Gulf of Alaska and the Gulf of California. A legend in the top right corner indicates 'Imperial' (selected), 'Map' (unchecked), 'Labels' (checked), and 'Feedback' (unchecked). A photo credit 'Photo: Department of National Defense' is visible at the bottom of the map section.

Photo: Department of National Defense

20 March 2012 150 nm south off Queen Charlotte Islands BC

# Actual Observations West Coast of N. America



# Actual Observations

## West Coast of N. America

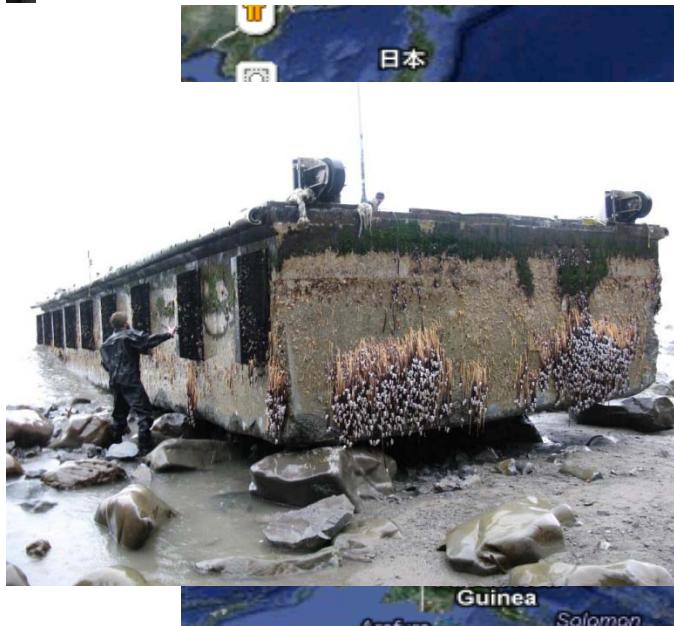
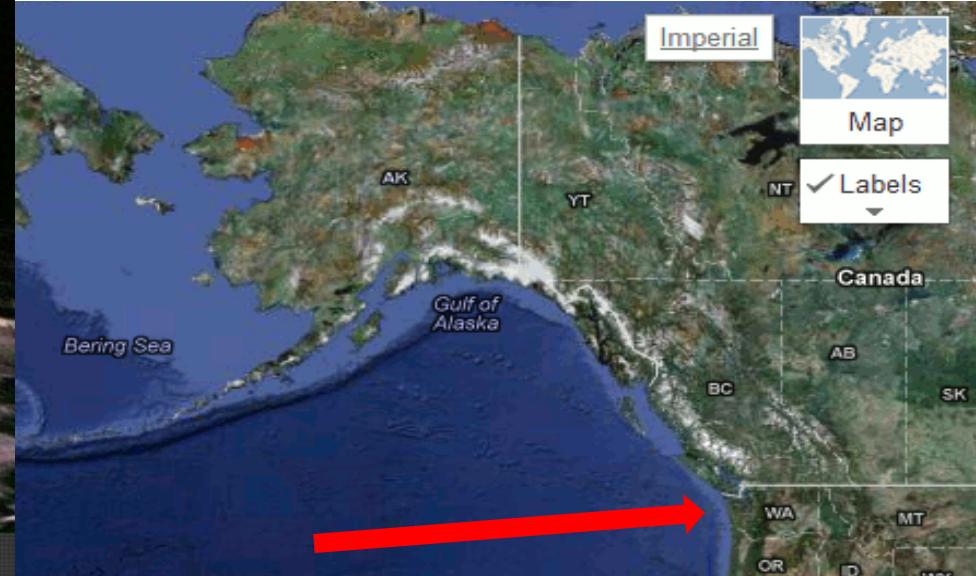
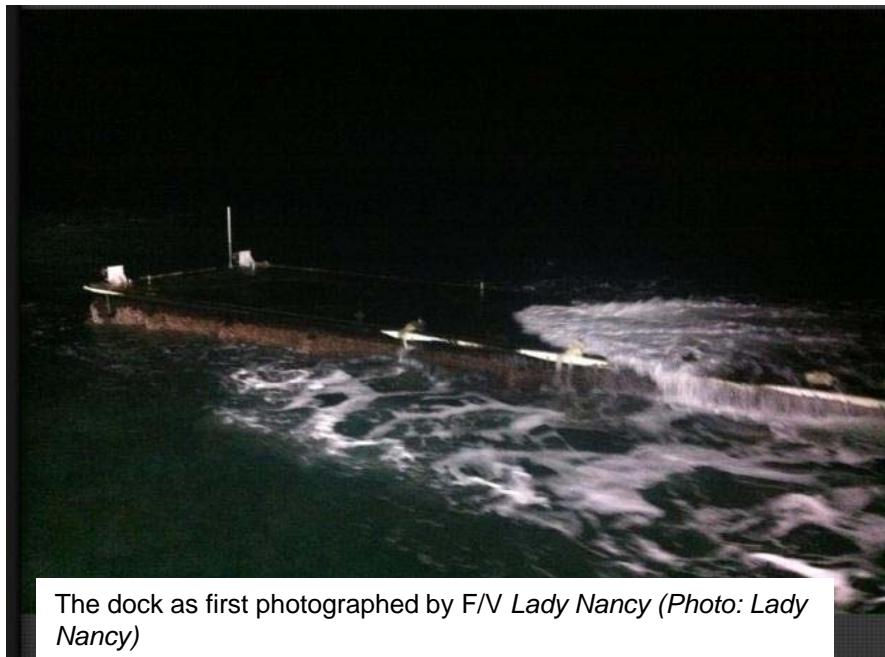
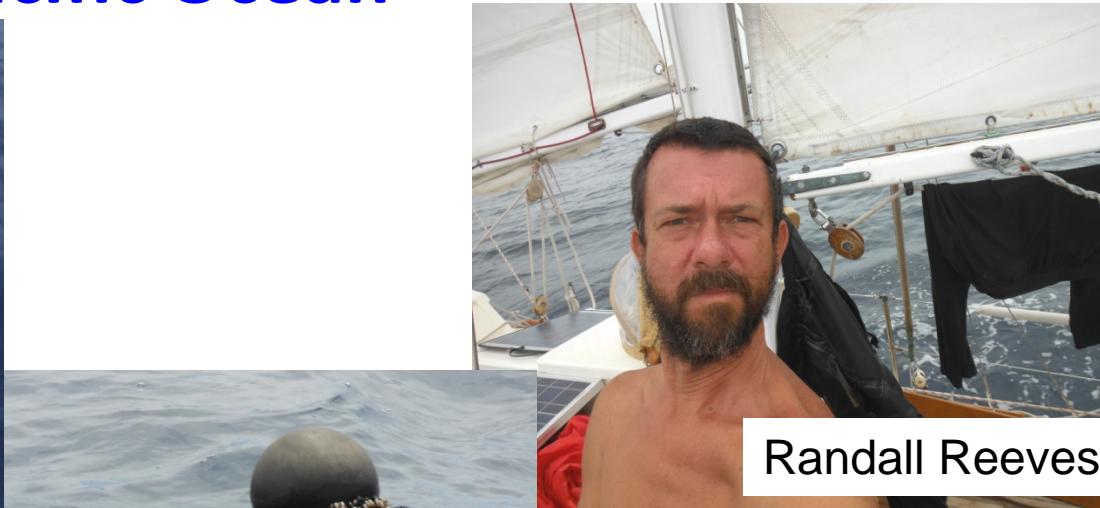


Figure 4: Dock found by USCG on December. 18 (Photo: USCG)

Washington December 2012

# Actual Observations

## North Pacific Ocean



# Actual Observations

## North Pacific Ocean



# Actual Observations

## Hawaii shores



Hilo, Big Island of Hawaii , June 2012



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



**August 19, 2012 –oyster  
buoy reported by Carl Berg  
off Kilauea Point, Kauai**

**September 3, 2012 –oyster  
buoy reported by  
Cynthia Vanderlipin Turtle  
Bay, Oahu**

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



Kure Atoll Northwest Hawaiian  
Islands Reported by Scott Godwin  
August 2012

# Actual Observations

## Hawaii shores



18 Sept. 2012 ,Y.K Suisan Co., Ltd

# Actual Observations

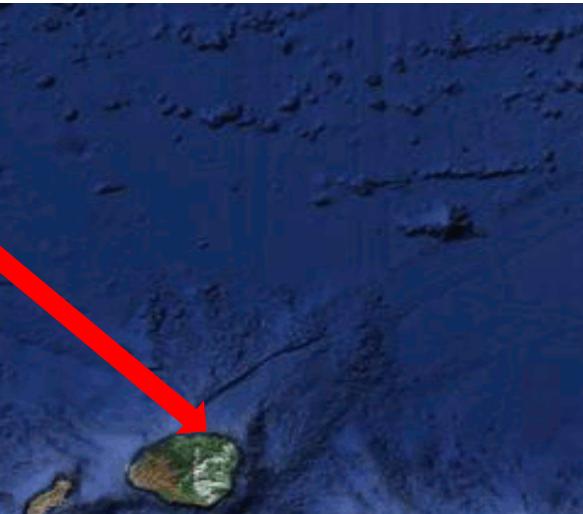
## Hawaii shores



24-28 Sept. 2012 gasoline tanks Molokai

# Actual Observations

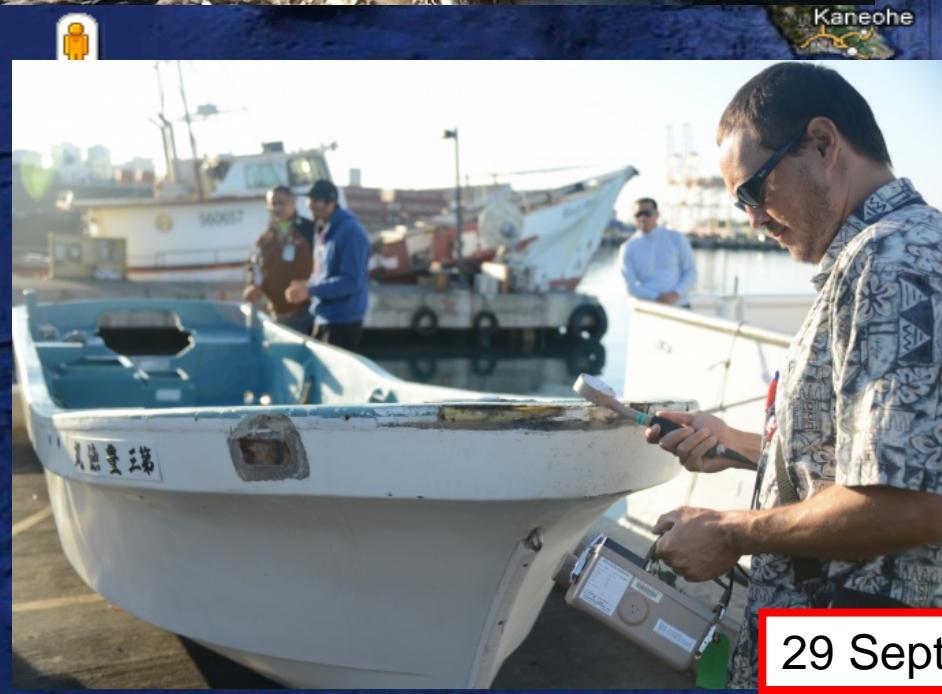
## Hawaii sho



24-26 Sept. 2012 Japanese light bulbs Hanalei, Kawaihae Har

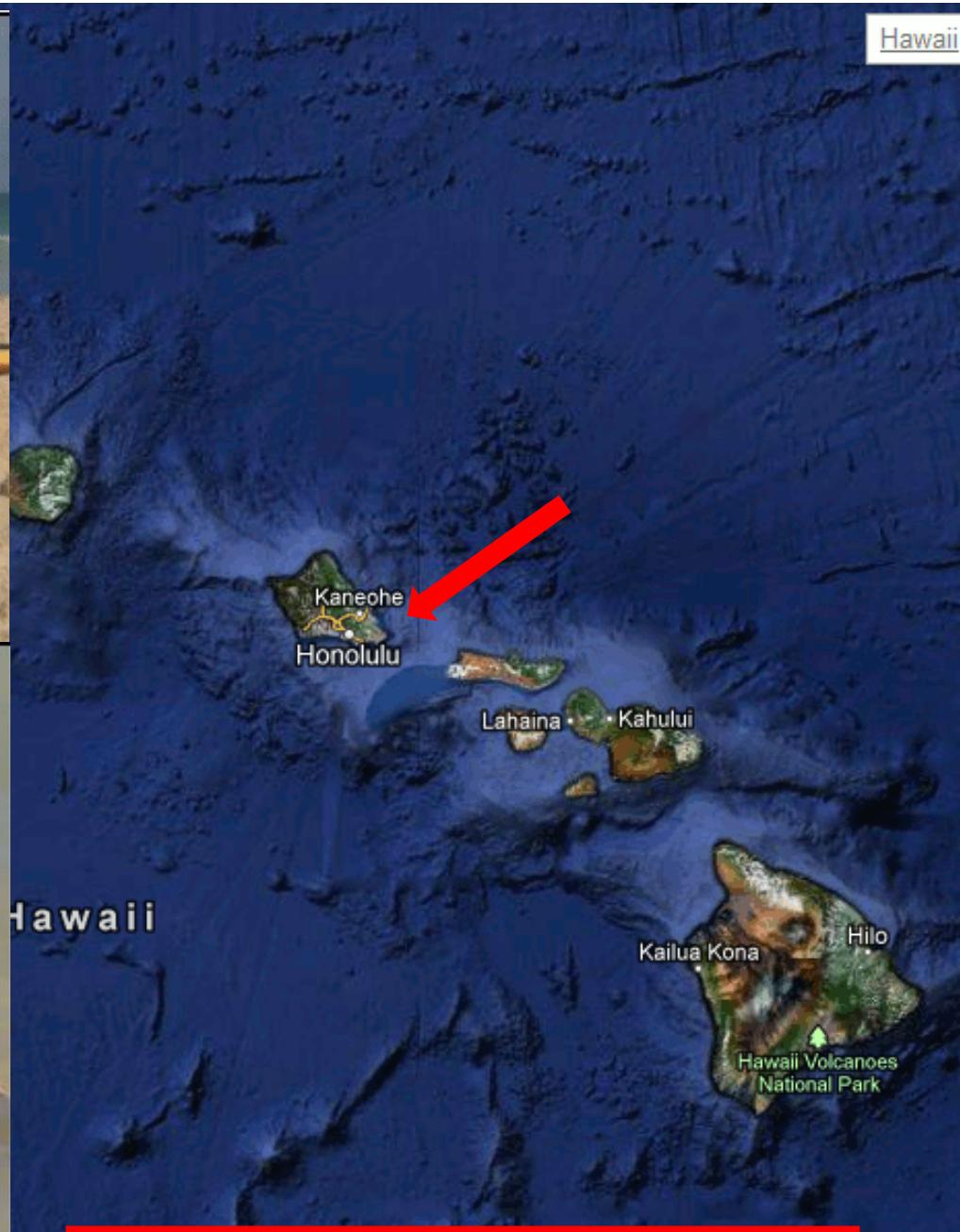
# Actual Observations

## Hawaii shores



29 Sept. 2012 skiff boat 700 nm N. of Molokai

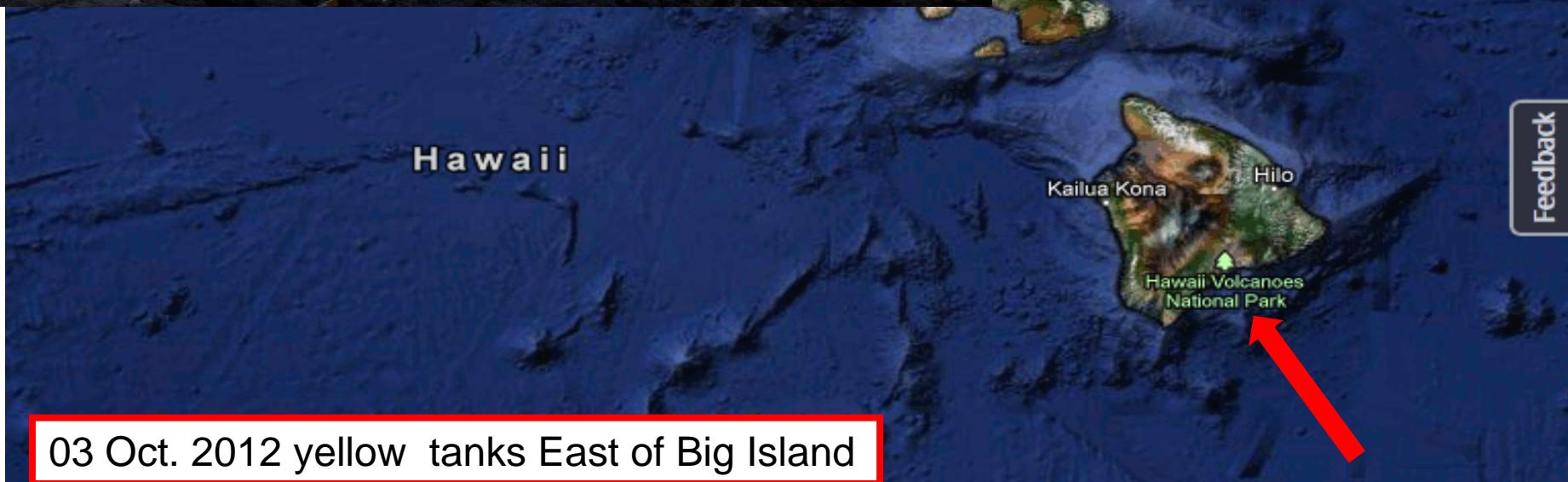
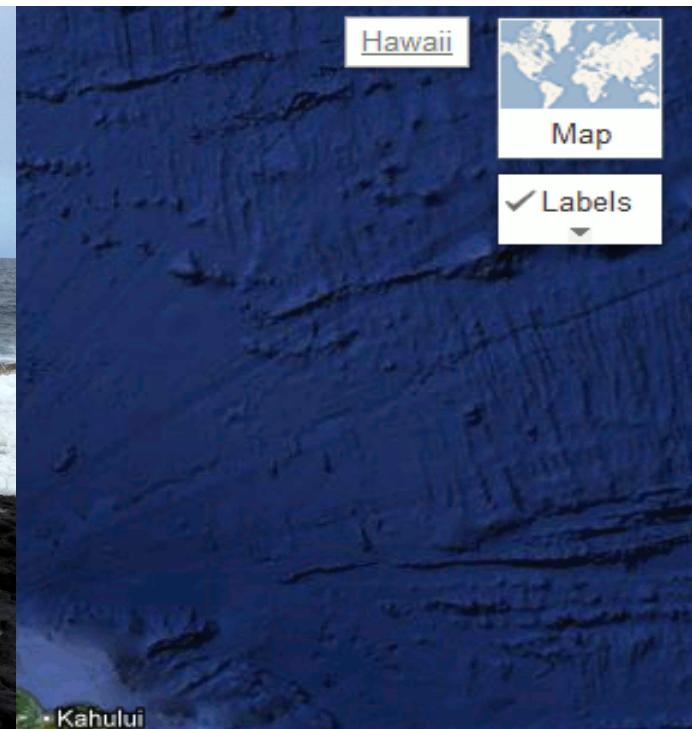
# Actual Observations



30 Sept .2012 Asahi beer crate Oahu

# Actual Observations

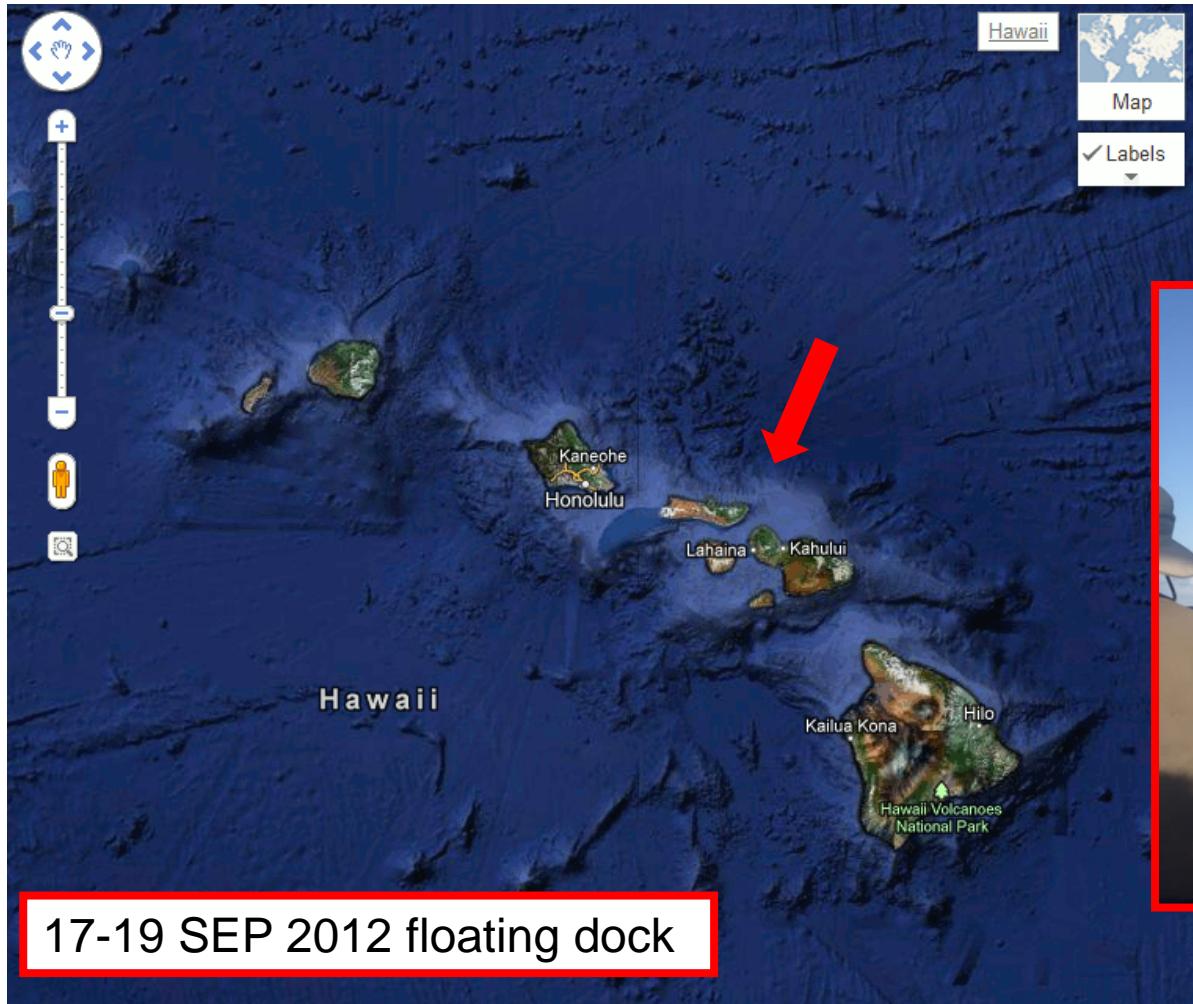
## Hawaii shores



03 Oct. 2012 yellow tanks East of Big Island

# Actual Observations

## Hawaii shores



# Actual Observations Hawaii shores



Nov. 2012 Kahuku Golf Club coast, Oahu



Nov. 2012 Kahana Bay, Oahu



Dec. 2012 Punaluu, Oahu



Jan 2013 Hanauma Bay, Oahu



Feedback

Jan 2013 Waialua, North Shore, Oahu

# Actual Observations Hawaii shores



Feb. 2013 Makapuu, Oahu



Jul 2013 Malaekahana, Oahu



Feb. 2013 Kahuku, Oahu



Feedback

Aug 2013 Turtle Bay, Oahu

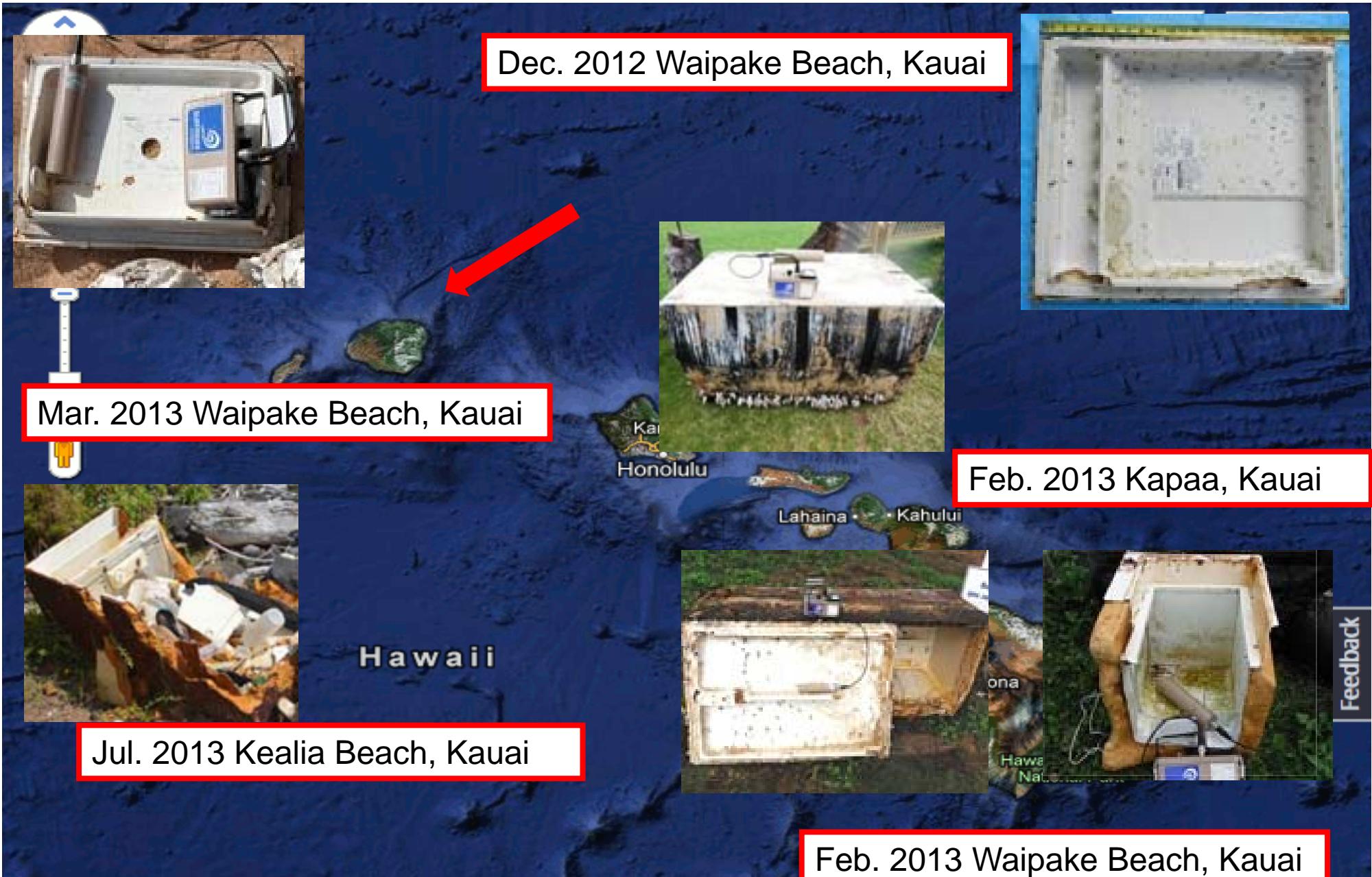


Mar. 2013 Kahuku, Oahu

Sep 2013 Lanikai, Oahu



# Actual Observations Hawaii shores



# Actual Observations Hawaii shores

Aerial map of Hawaii showing shorelines and major cities like Honolulu, Lahaina, Kahului, Kailua-Kona, Hilo, and Kona. Three inset photos show marine debris: a wooden structure on a beach in Kauai, a large metal object on a beach in Kauai, and a piece of debris in a grassy area on Oahu.

Sep. 2013 North of Donkey Beach, Kauai

Aug. 2013 Kapaa, Kauai

Aug. 2013 Waipouli, Kauai

Hawaii

Map

Labels

Feedback

# Actual Observations Hawaii shores wood

The image shows a map of the Hawaiian Islands with three inset photographs illustrating actual observations of washed-up wood.

- Dec. 2013 Shipwreck Beach,, Kauai**: An inset photo of a large, dark piece of wood washed up on a sandy beach. A red arrow points from this label to the Kauai island area on the map.
- Nov. 2013 Kahuku, Oahu**: An inset photo of a long, dark piece of wood lying on a sandy beach. A red arrow points from this label to the Oahu island area on the map.
- Sep. 2013 Kamilo, Big Island**: An inset photo of a person standing next to a large, light-colored wooden structure (possibly a washed-up hull or frame) on a rocky shore. A red arrow points from this label to the Big Island area on the map.

Map features visible include:

- A world map in the top right corner labeled "Hawaii".
- A legend in the top right corner with options for "Map" and "Labels".
- A "Feedback" button in the bottom right corner.
- City labels: Kaneohe, Honolulu, Lahaina, Kahului, Kailua Kona, Hilo, and Hawaii Volcanoes National Park.
- Geographic features: The main island of Hawaii, Maui, Lanai, and Oahu.

# Actual Observations Hawaii shores wood



# Actual Observations Hawaii shores wood

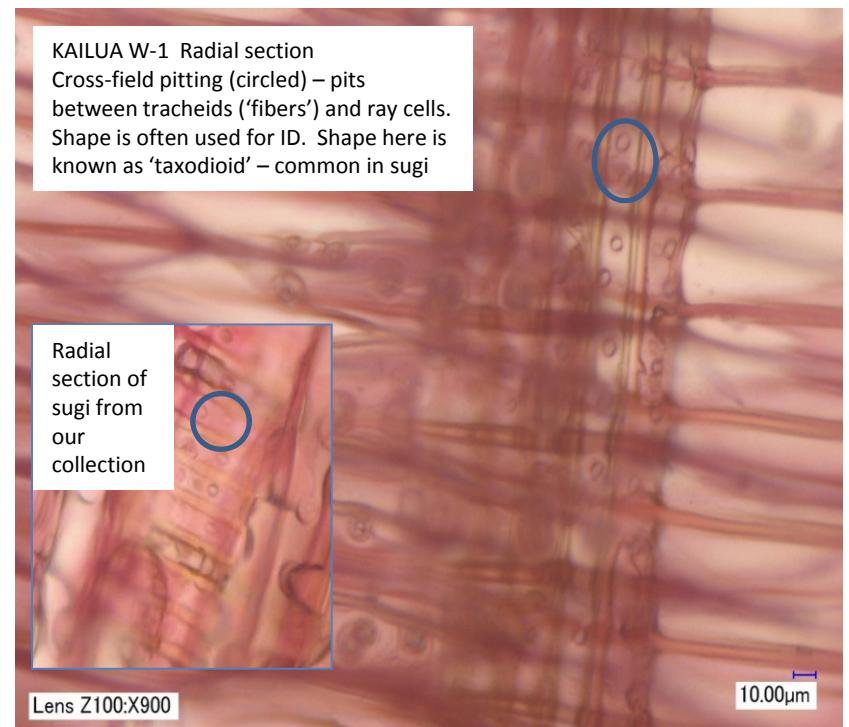
Origin: most likely Japan

tenon and mortise construction

many pieces of timber of Japanese cedar “sugi”

Also timing and large number of driftwood indicate origin from 2011 tsunami in Japan.

DNA analysis is pending



Scott Leavengood (Oregon State Univ.)  
David Stallcop (Vanport International Inc.)

# Actual Observations Hawaii shores

## Changing composition in time

### Observations

AUG-SEP 2012

time

### Model



Buoys, bulbs,  
canisters,  
container



MAR-APR 2013

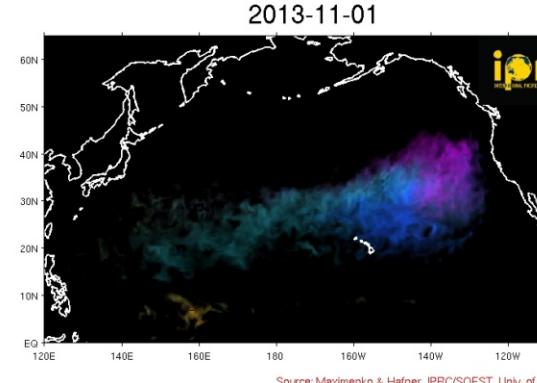
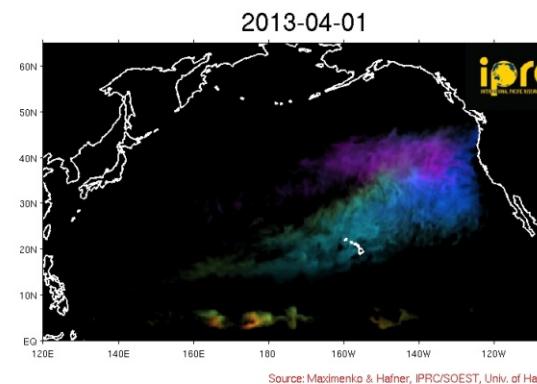
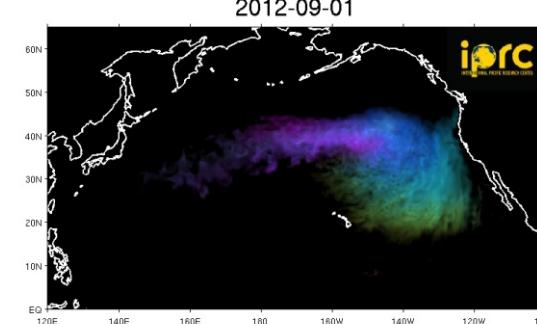
Buoys, pallet,  
fridge, boat



OCT-DEC 2013/2014

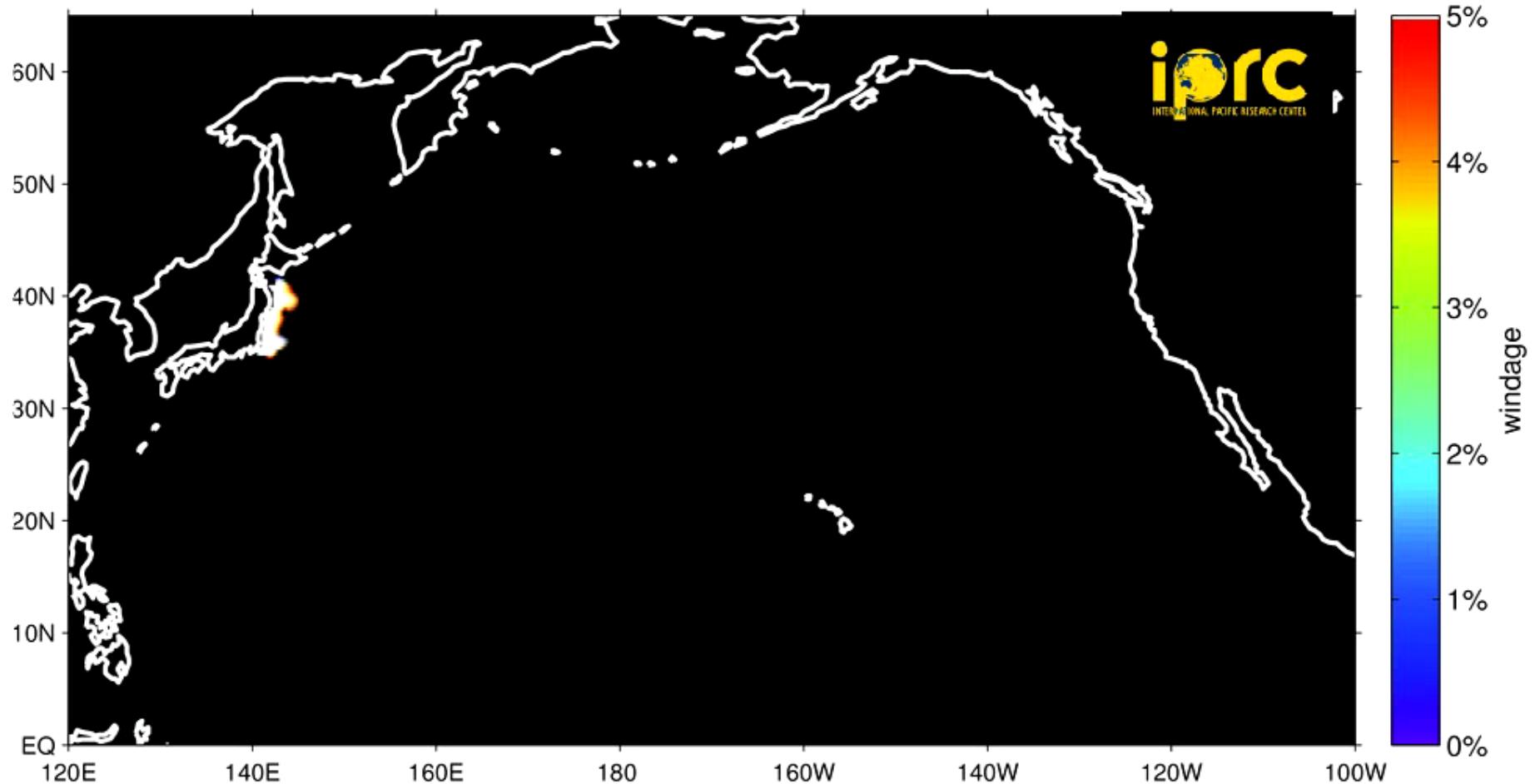


Buoy, gas cylinder,  
Timber beams,  
Processed wood,  
Wood poles  
Tree trunks  
Total number 52



# Modeling how objects from the Japan tsunami drift across North Pacific?

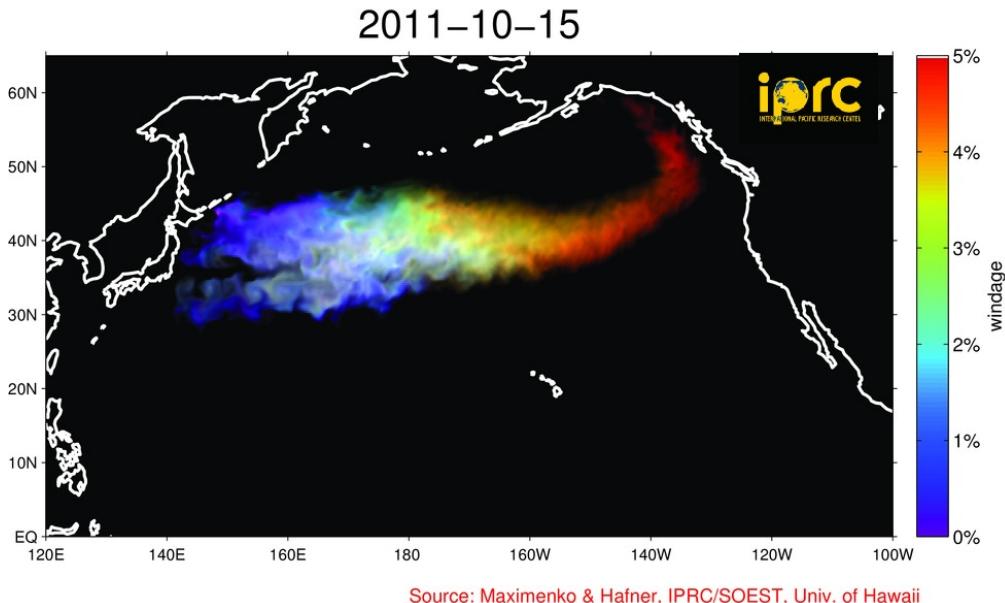
2011-03-11



Source: Maximenko & Hafner, IPRC/SOEST, Univ. of Hawaii

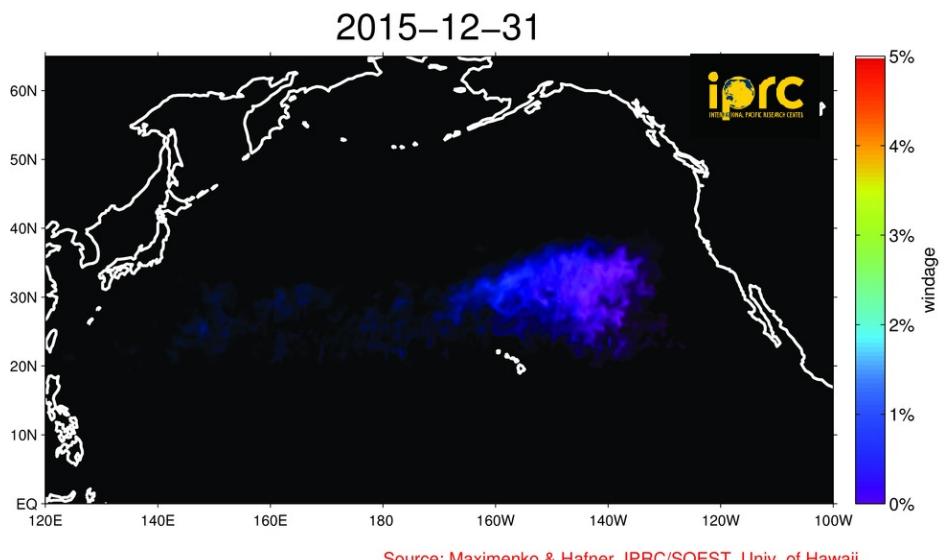
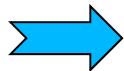
Using satellite data with scientific computer model we can estimate the drift of tsunami debris across the North Pacific Ocean.

The effect of wind on transport and final destination of tsunami debris is seen in the observations. Also it is simulated by the IPRC drift model.



High windage type of debris destined to coast.

Low windage type of debris accumulates in the North Pacific Garbage Patch



Thank you !