EFFECTS OF MARINE DEBRIS CAUSED BY THE GREAT TSUNAMI OF 2011

HIDEAKI MAKI, THOMAS THERRIAULT, NANCY WALLACE, ALEX BYCHKOV AND CATHRYN CLARKE MURRAY

SILVER SPRING, MARYLAND, USA
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PICES

GREAT EAST JAPAN EARTHQUAKE AND TSUNAMI

On March 11, 2011, an earthquake with a magnitude 9.0 hit the country of Japan and triggered a tsunami with waves up to 130 feet over 200 miles of land.

Photo credit: National Geographic

PERSPECTIVES

Funded by the Japanese Ministry of Environment

TSUNAMI DEBRIS

An estimated 5 million tonnes of debris was washed away and began drifting east across the Pacific Ocean.

Photo credit: U.S. Navy

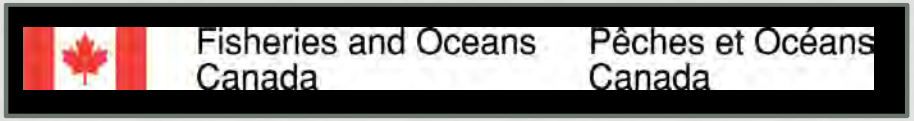
Photo credit: Bloomberg

NORTH PACIFIC MARINE SCIENCE ORGANIZATION (PICES)

An intergovernmental scientific organization, established in 1992 to promote and coordinate marine research in the northern North Pacific and adjacent seas. Its present members are Canada, Japan, People's Republic of China, Republic of Korea, the Russian Federation, and the United States of America.

PROJECT CO-CHAIRS

- Hideaki Maki, NIES
- Thomas Therriault, DFO
- Nancy Wallace, NOAA



PROJECT RESEARCH TEAM

- Ehime University
- Kagoshima University
- Kobe University
- Kyushu University
- Japan Meteorological Agency
- Japan Agency for Marine-Earth Science Technology
- National Institute for Land and Infrastructure Management
- Toho University
- Fisheries Research Agency
- Oregon State University
- Moss Landing Marine Laboratory
- Smithsonian Environmental Research Center
- University of Hawaii at Manoa
- Williams College and Mystic Seaport

PROJECT RESEARCH TEAM

RESEARCH THEMES

1. **Modelling**
2. Surveillance and Monitoring
3. Risk from Invasive Species

Modeling Movement of Tsunami Debris

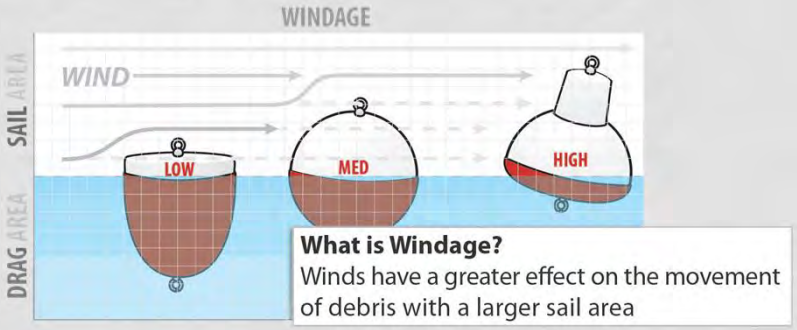
- Develop forecasts of JTMD distributions and timelines of its arrival on the US/Canada West Coast and in Hawaii
- Calibrate models using available observational reports
- Produce maps of probable geographical distribution of JTMD

Photo credit: U.S. Navy

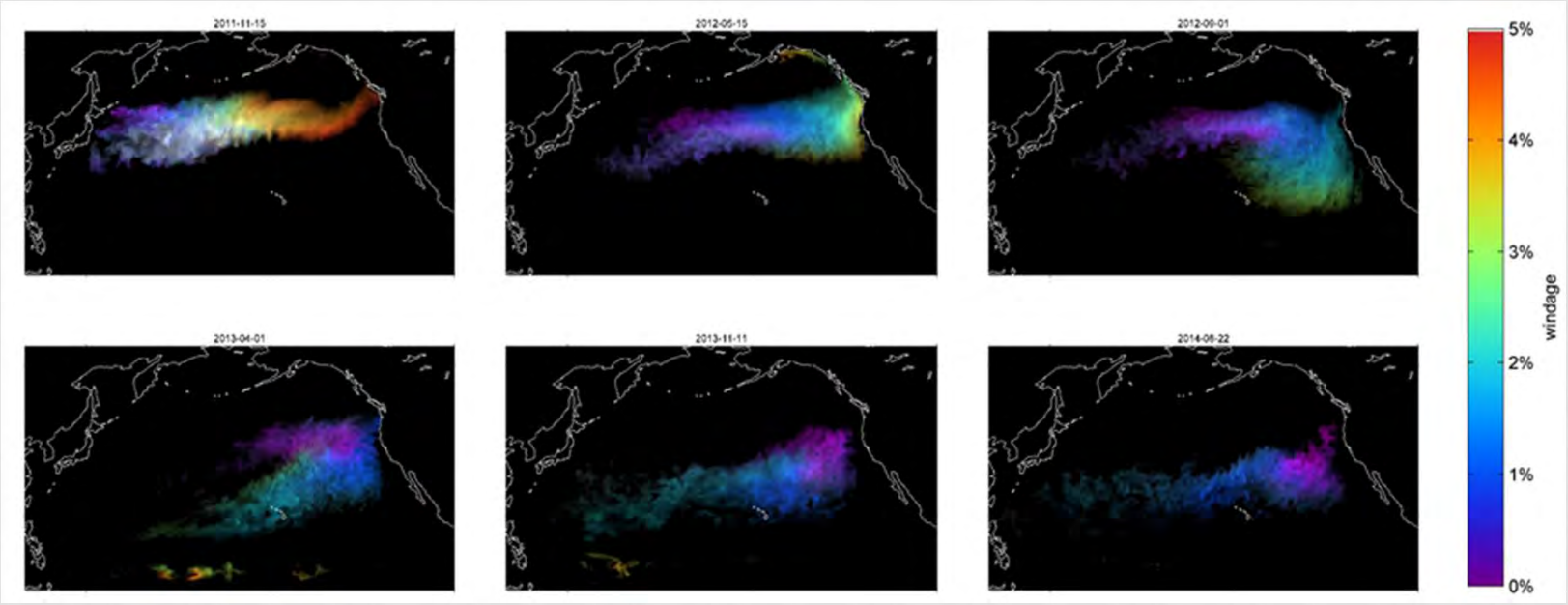
Modeling Movement of Tsunami Debris

Three models of the debris field were developed and refined:

- SCUD model – University of Hawaii
- GNOME model – NOAA
- Particle model – JAEA SAEGELN



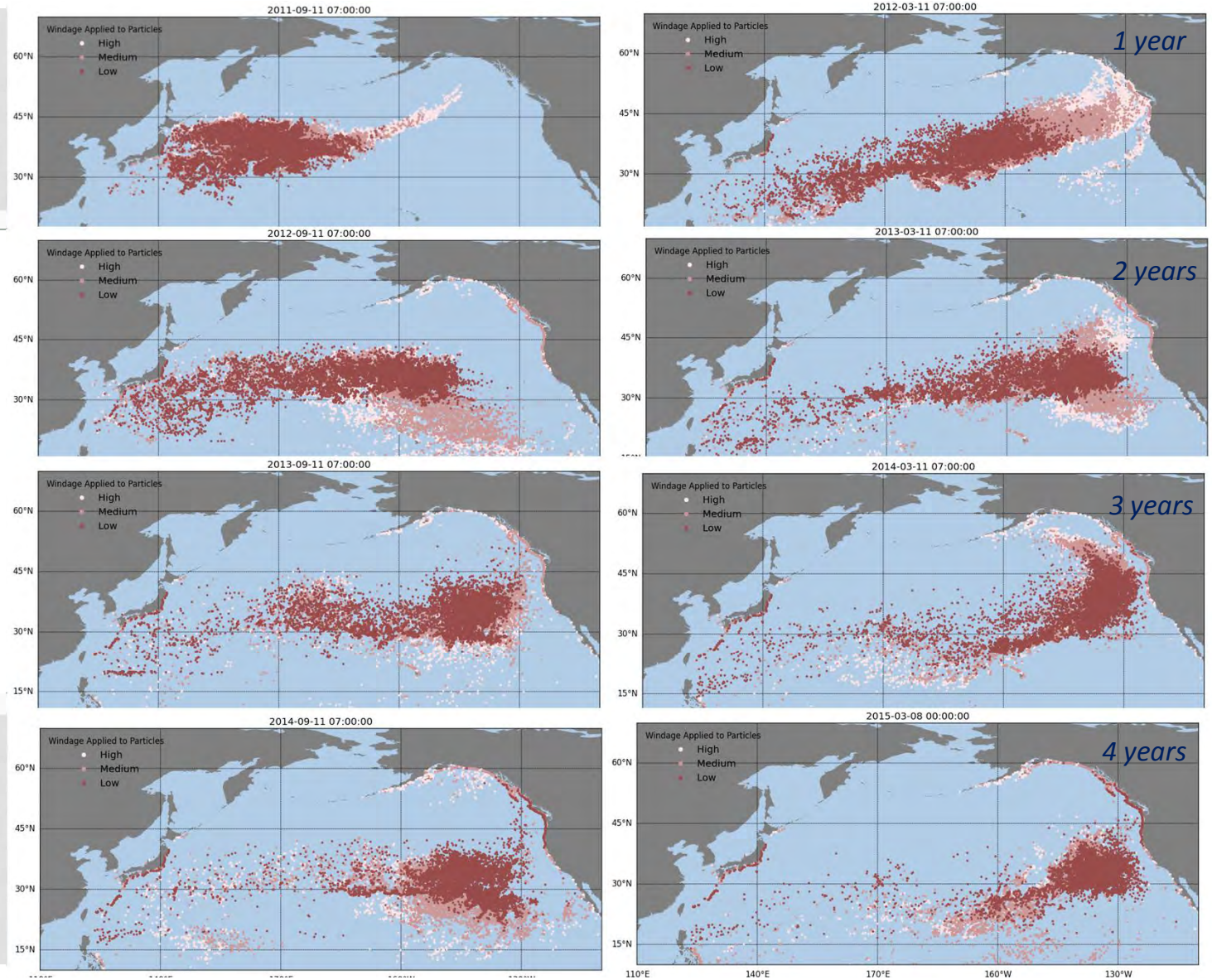
University of Hawaii: SCUD model



Motion of JTMD in SCUD model simulations. Colors indicate windage of the debris. Shown are maps, corresponding to November 15, 2011, May 15, 2012, September 1, 2012, April 1, 2013, November 11, 2013, and August 22, 2014.

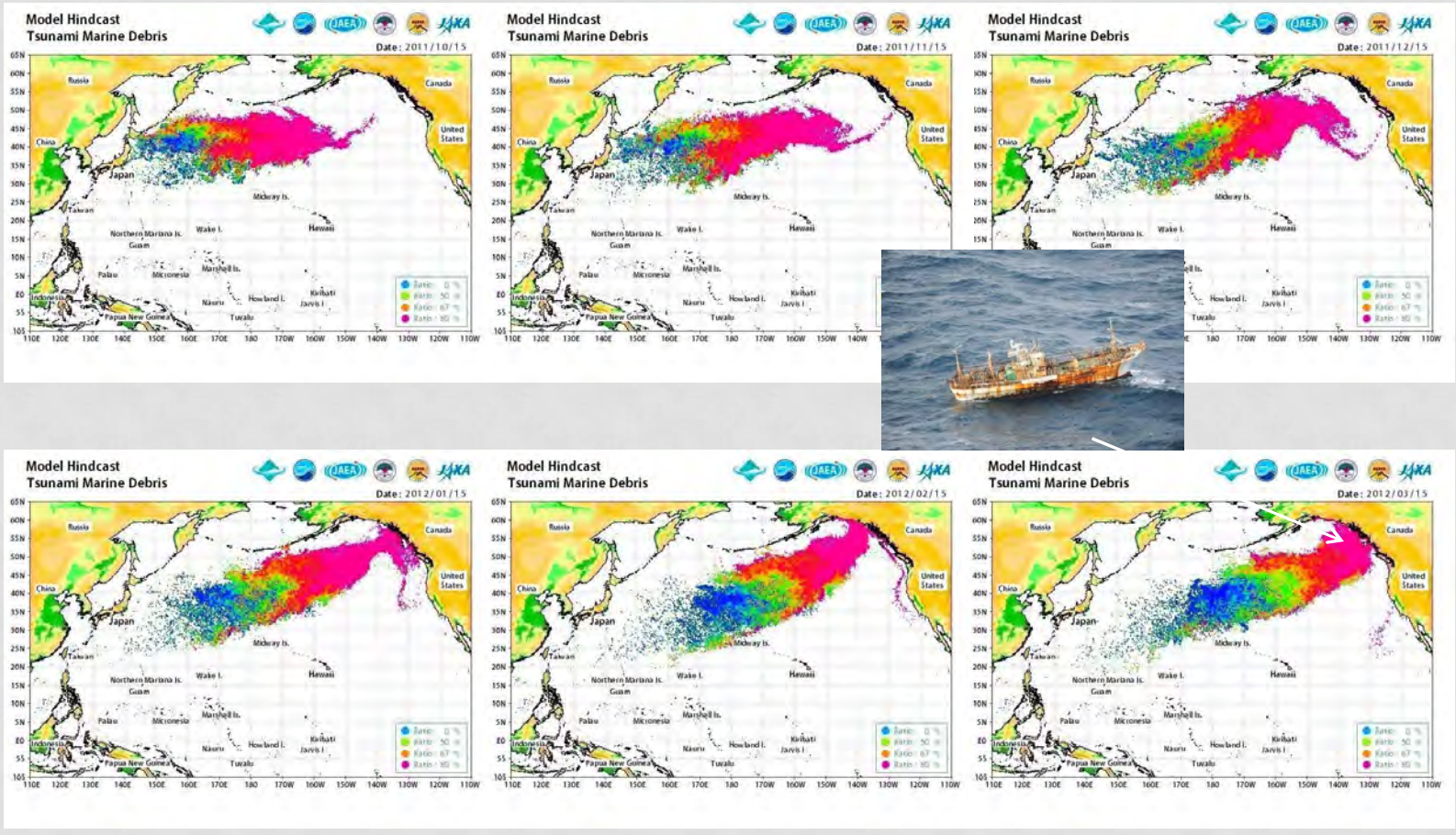
Nikolai Maximenko, UH

NOAA: GNOME model



Amy MacFadyen, NOAA

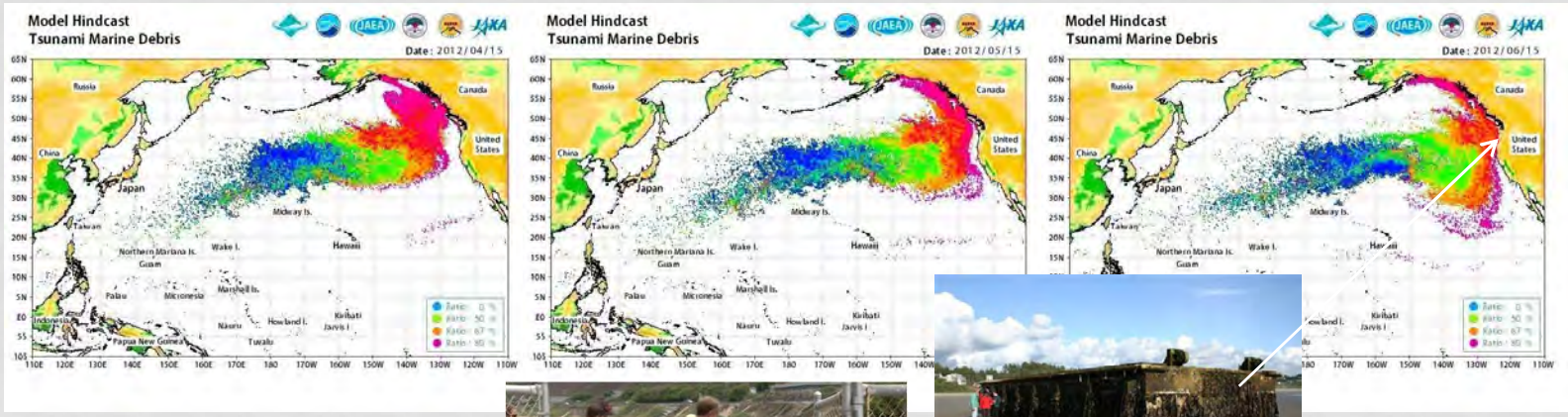
JAEA SEAGELN Model

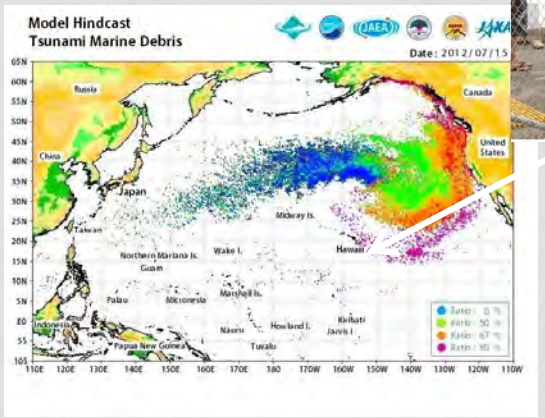


Oct. 2011 ～ March 2012

Japanese Government

JAEA SEAGELN Model

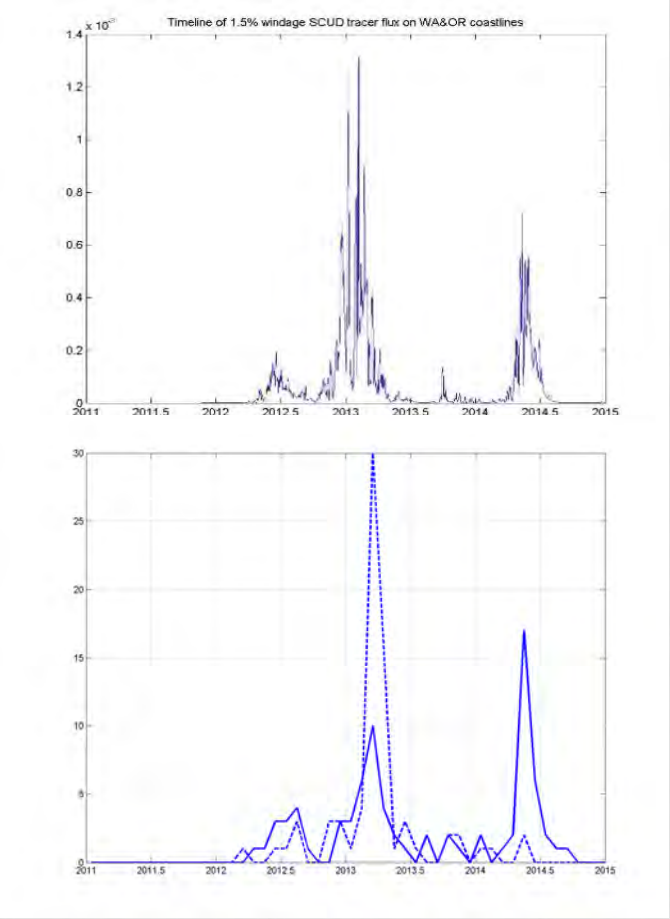




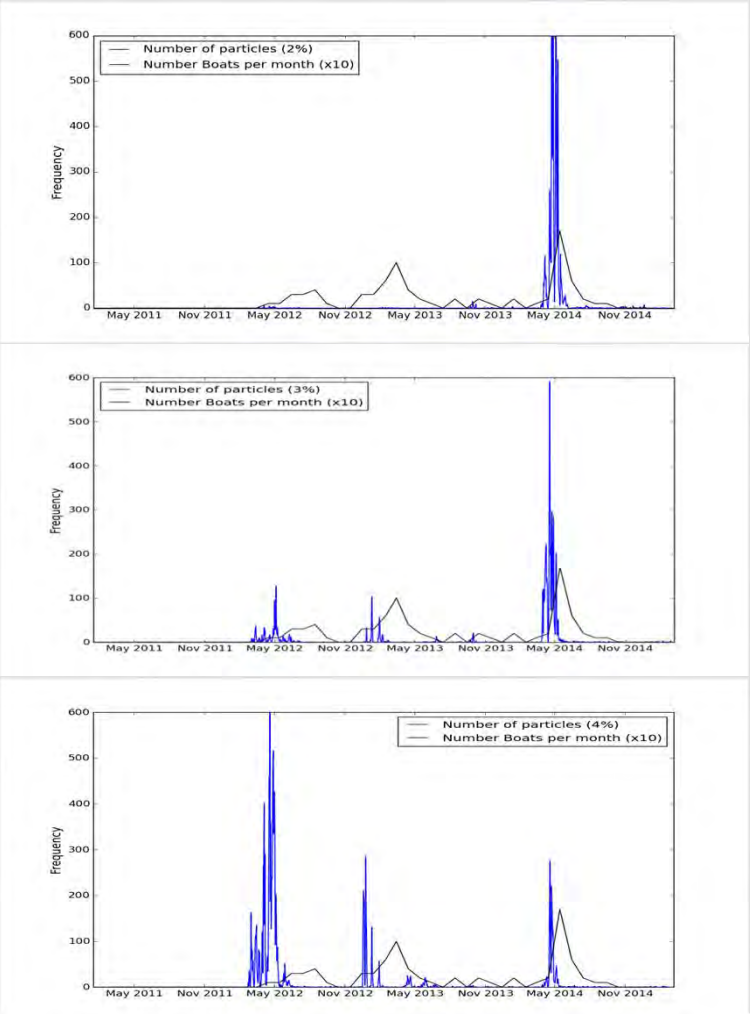
（Apr. 2012 ～ July 2012）

Japanese Government

Model predictions match observations in WA & OR



GNOME



RESEARCH THEMES

1. Modelling
2. **Surveillance and Monitoring**
3. Risk from Invasive Species

Surveillance

Goals:

1. To search for large debris items (vessels, skiffs, docks)

2. To identify hot spots of debris accumulation

British Columbia Aerial Surveys

- Oblique, overlapping photographs
- Small aircraft
- Post-processing:
  Tag images for debris items
  Qualitative rankings

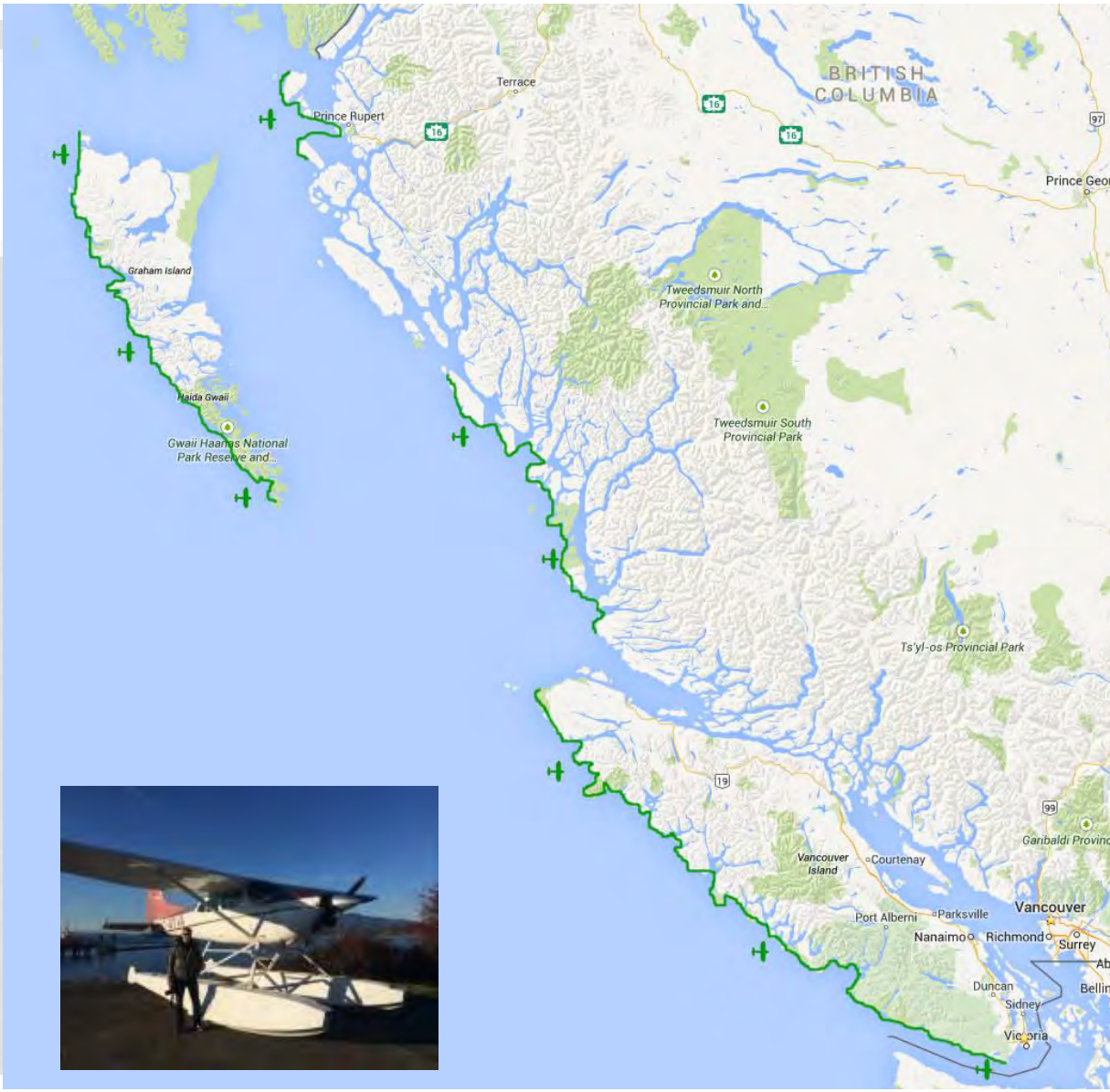


Photo credit: Lightspeed Digital

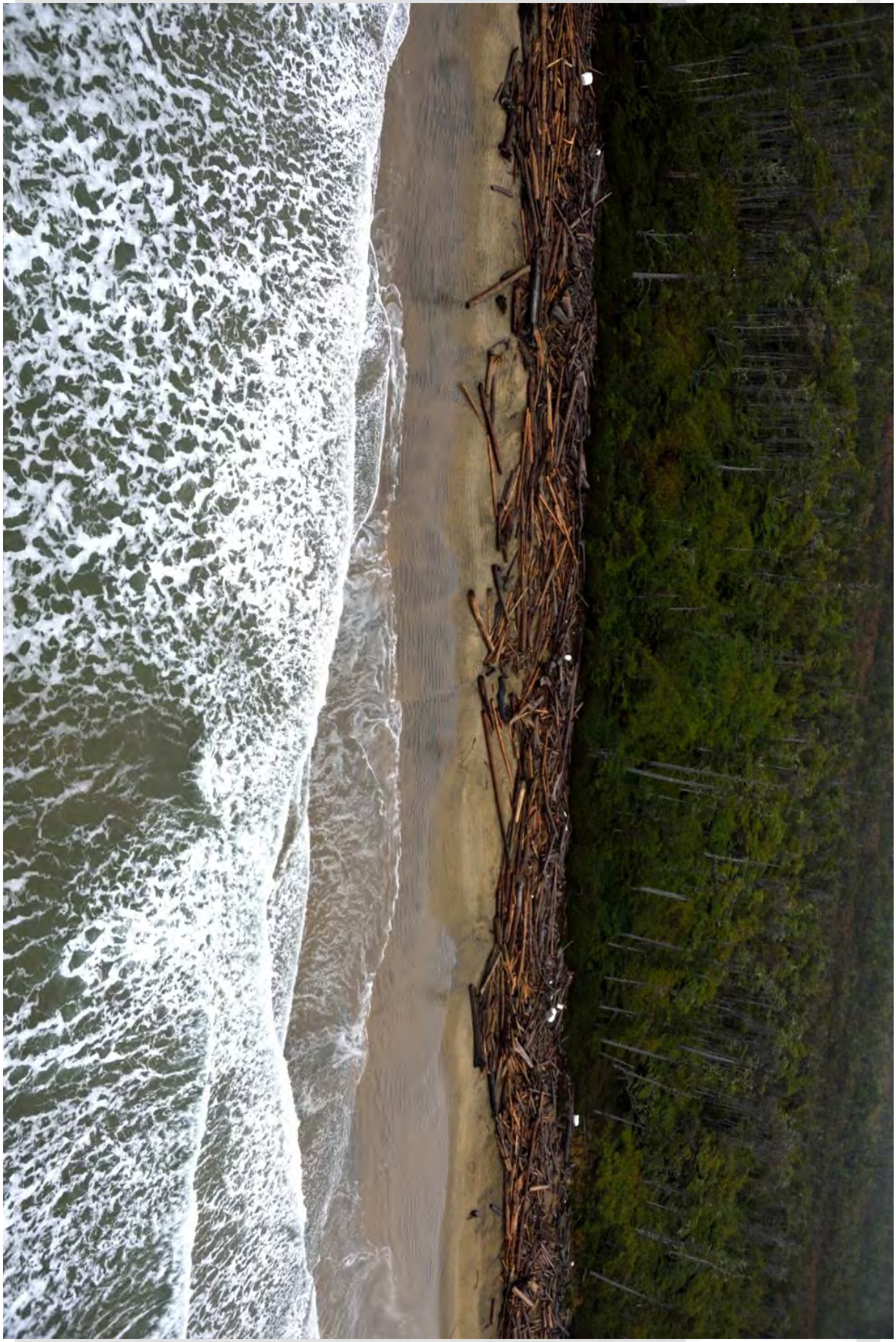


Photo credit: Lightspeed Digital

Photo credit: Lightspeed Digital

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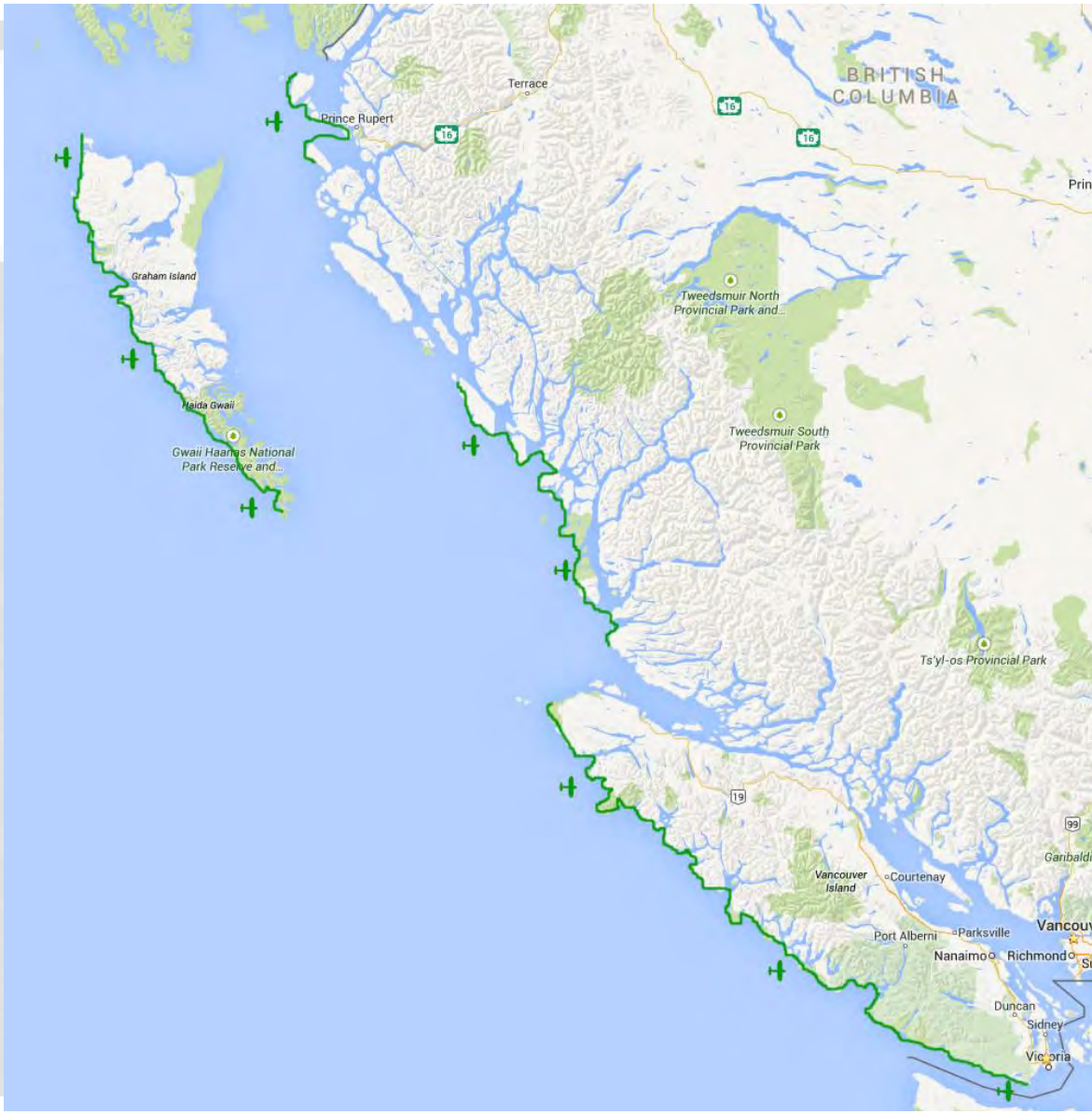
Aerial Surveys

North - High windage
Central – skiffs, large items
South – skiffs, less debris



Monitoring

1. Quantify the amount, distribution and timing of debris landfall
2. Estimate debris landfall attributable to the 2011 tsunami

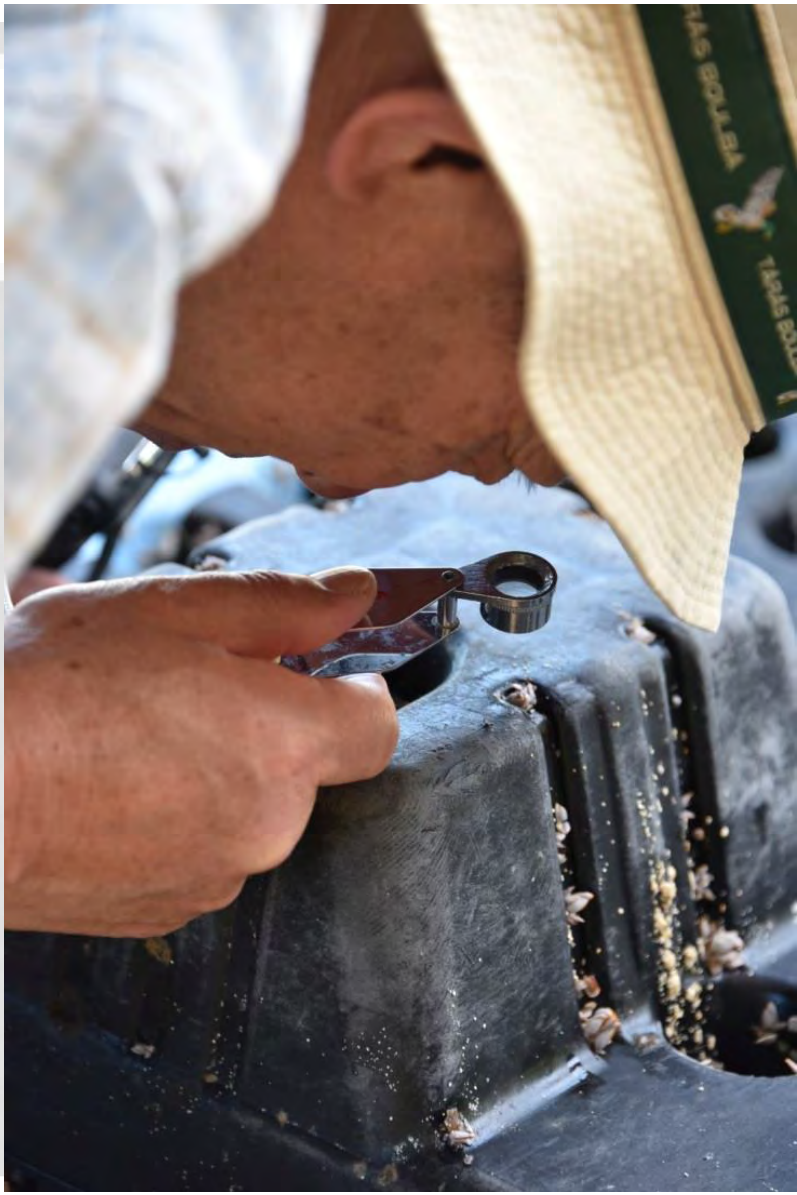


Photo credit: Lightspeed Digital

Beach Debris Data Sources

1. NOAA Beach Monitoring – debris accumulation surveys
2. OCNMS beach surveys

Photo credit: Lightspeed Digital

NOAA Beach Monitoring Surveys

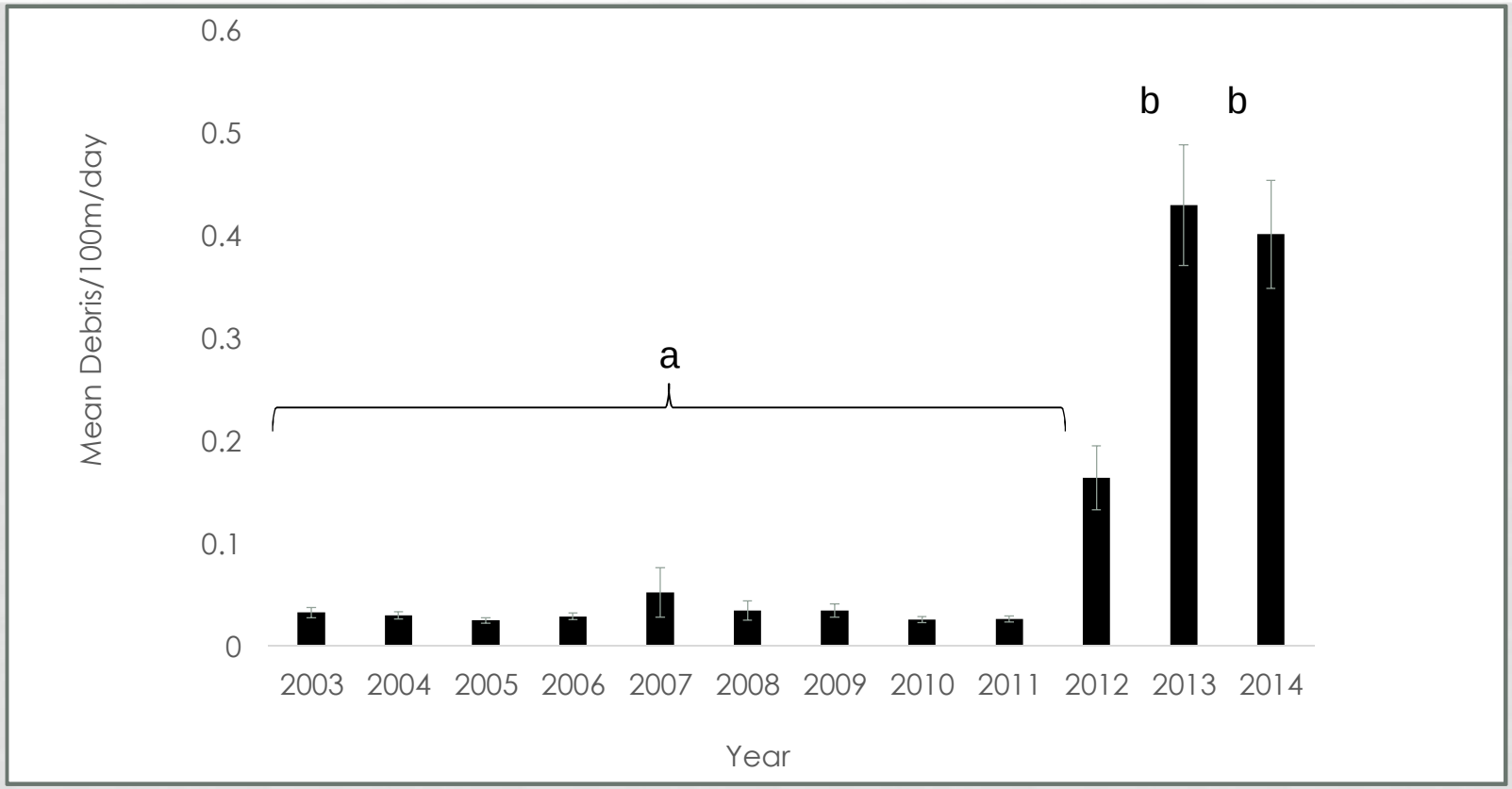
Debris accumulation monitoring

- Over 800 surveys
- More than 120 sites in AK, WA, OR, CA, HI
- 2011-present

Olympic Coast National Marine Sanctuary (OCNMS)

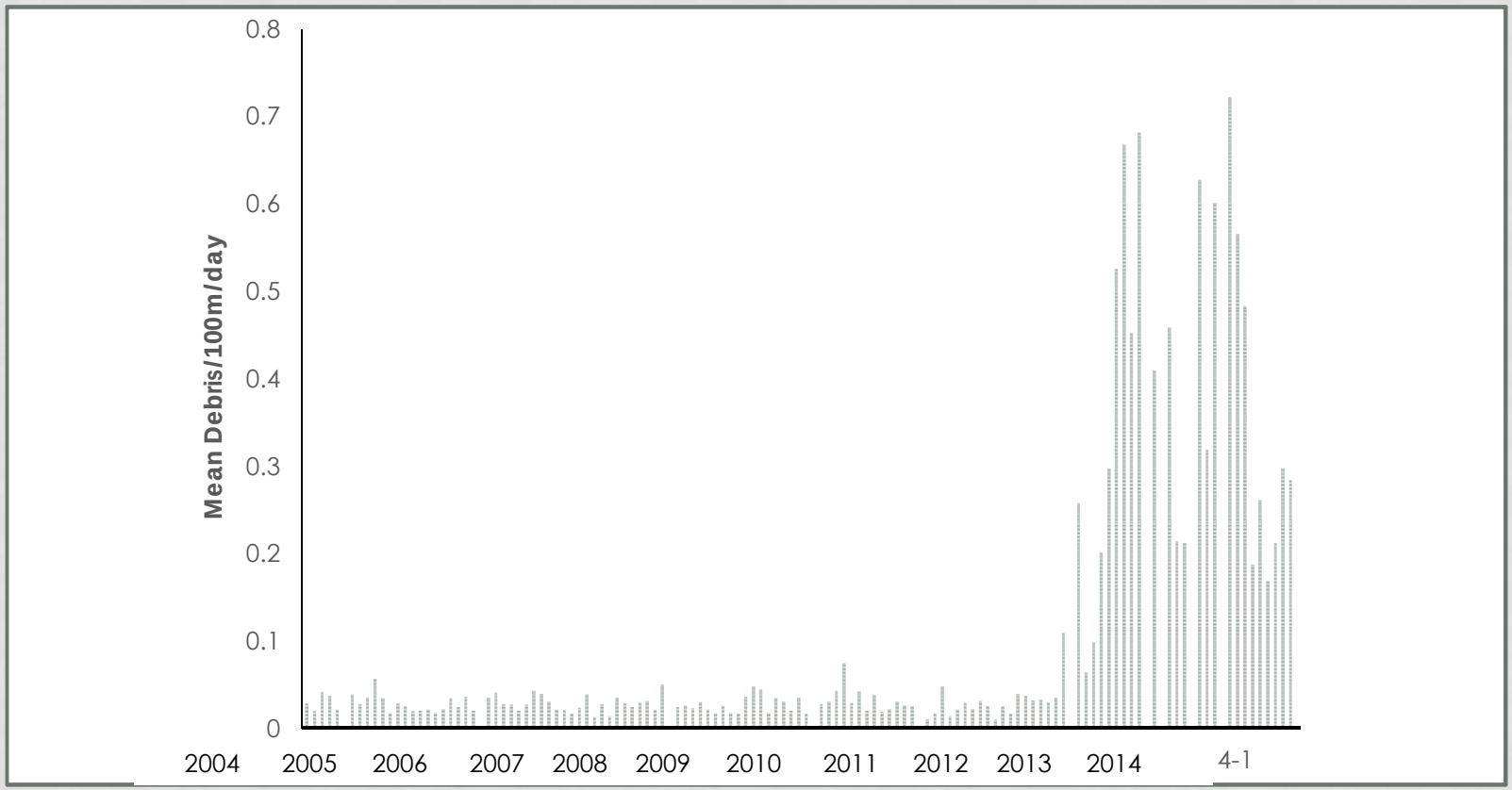
- Washington State
- 2001-2011
- 47 beaches
- 11 sites match post-2012 survey
- Different methodology – indicator items

Significantly More Debris Post-Tsunami



OCNMS, NOAA data

Ten-Fold Increase in Debris Over Baseline Levels



OCNMS, NOAA data

RESEARCH THEMES

1. Modelling
2. Surveillance and Monitoring
3. **Risk from Invasive Species**

Invasive Species

- Beyond the debris itself, there is the threat of associated invasive species
- A unique vector of invasion and an intriguing natural history event

Photo credit: Lightspeed Digital

Characterize and Evaluate the Risk of Invasion

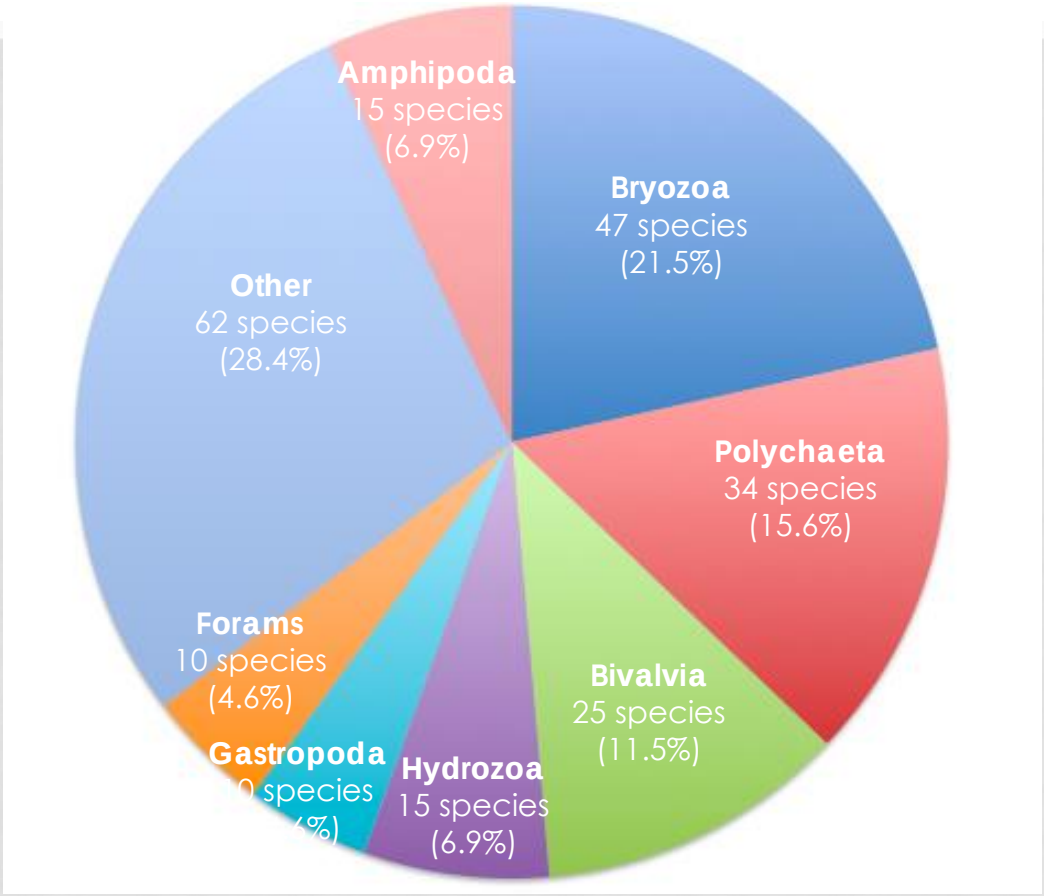
- Uptake of species by tsunami debris
- Survival during transit across the North Pacific
- Establishment potential in coastal waters (North America and Hawaii)
- Potential spread
- Impact of invasions

Almost 300 Debris Items Sampled

Location	Number of Items	Percentage
Alaska	7	2.4
BC	15	5.1
Wash	50	16.9
Oregon	160	54.0
California	6	2.0
Hawaiian Archipelago	58	19.6

Jim Carlton, MWC

288 Japanese Species Present



Nearly 75% of diversity represented by 4 major groups:

Bryozoa (47) 21.6%
Crustacea (40) 18.3%
Mollusca (38) 17.4%
Annelida (34) 15.6%

Jim Carlton, MWC

Japanese Seastars found on JTMD

Asterias amurensis
Pier from Misawa, Japan
June 2012 in Oregon

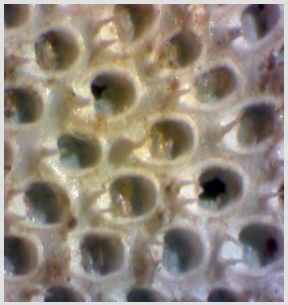
Patiria pectinifera
Skiff - May 2014 in Oregon

Aphelasterias japonica
Skiff - February 2013 in Oregon

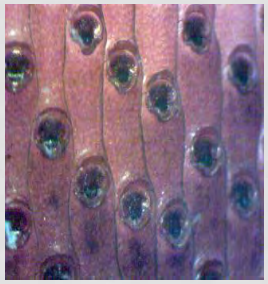
Jim Carlton, MWC

Japanese and oceanic bryozoans

Japanese Species

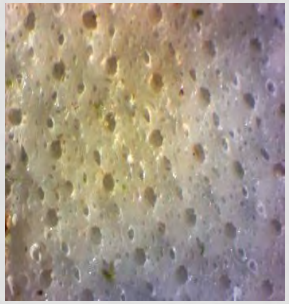


Arbocuspis bellula

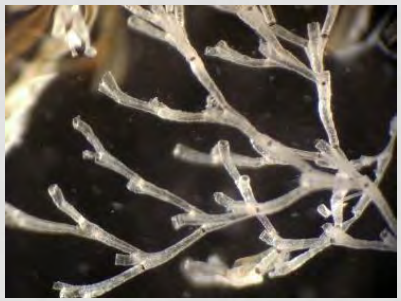


Watersipora sp.

Lichenopora radiata



Exochella sp.

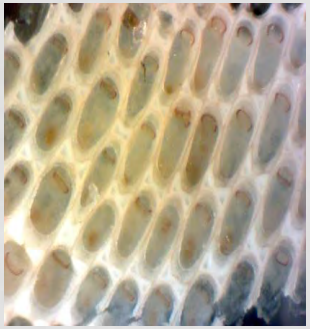


Filicrisia sp.

Aetea truncata

Oceanic Species

Jellyella eburnea



Jellyella tuberculata

… and many others

Jim Carlton, MWC

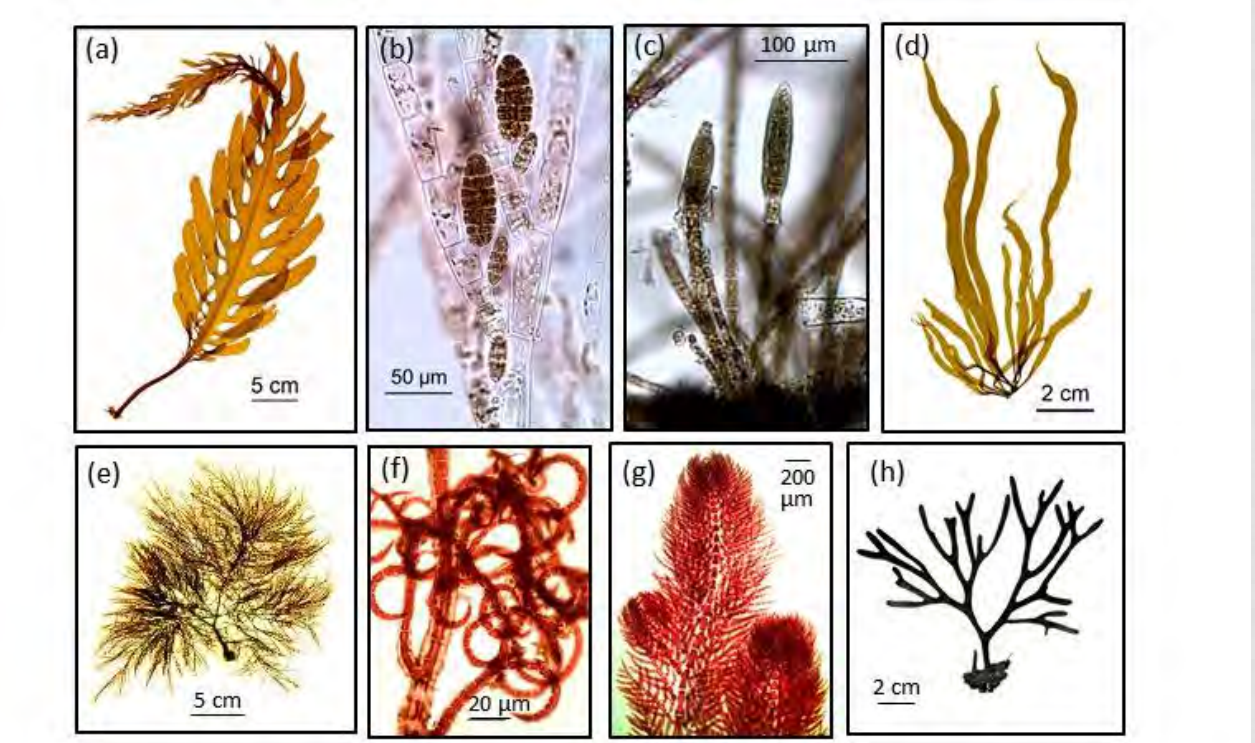
Shipworms found in tsunami lumber

Six species of shipworms (marine bivalve mollusks) have been found in Japanese post-and-beam timber

Global invasion histories

Jim Carlton, MWC

Over 70 species of marine algae



(a) *Undaria pinnatifida*, (b) *Feldmannia mitchelliae*, (c) *Kuckuckia kylinii*, (d) *Petalonia fascia*, (e) *Desmarestia viridis*, (f) *Polysiphonia morrowii*, (g) *Antithamnion nipponicum*, (h) *Codium fragile* subsp. *fragile*

Gayle Hansen, OSU

Parasites & Pathogens are of concern

Parasitic hydroid in mussels from debris

- Å ***Eutima*** was detected on 4 JTMD objects 2.5% prevalence on the 4 objects
- Å High intensity of infection (100s-1000s per host)

Photo credit: CBC

Gregory Ruiz, SERC

Mussels were growing larger as they drifted

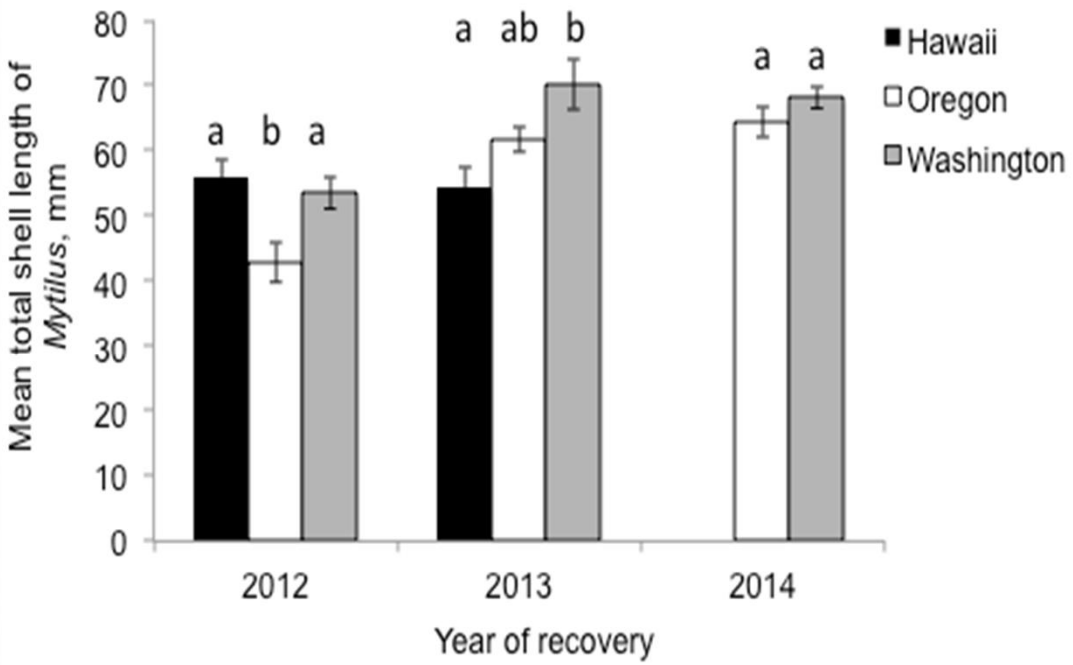
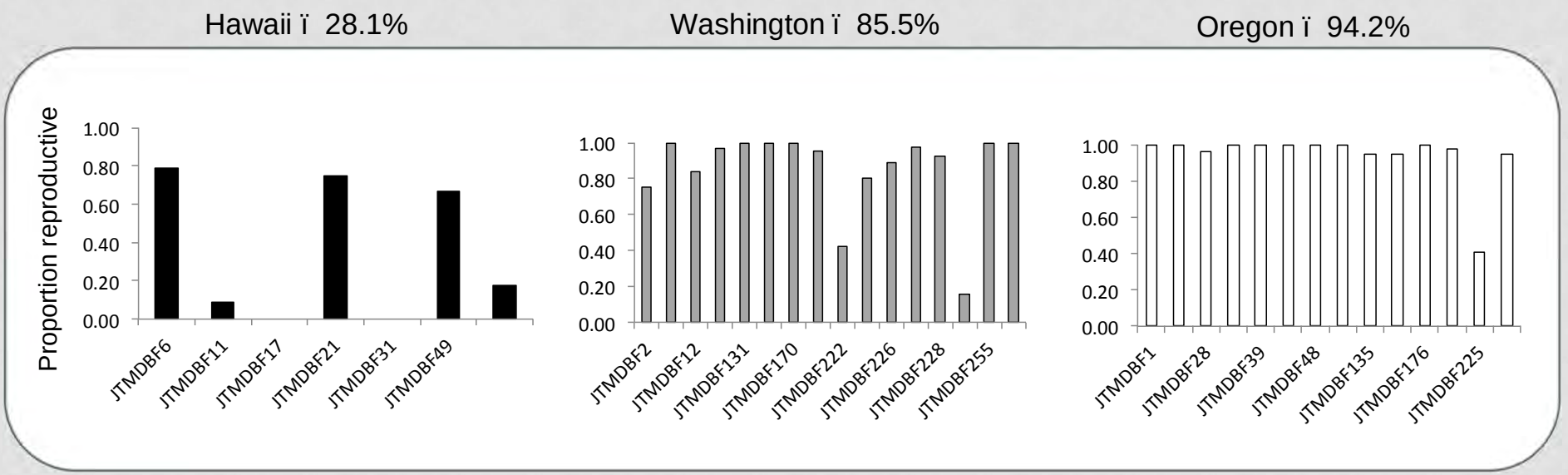


Figure 2. Mean length (±2 SE) of *Mytilus* recovered on JTMD. Letters indicate groups that are statistically similar within years.

Jessica Miller, OSU

Mussels were reproductive when they arrived



Jessica Miller, OSU

One possible introduction detected

Striped knifejaw fish

Photo credit: Oregon State University

Future Directions

- Identification of hot spots of JTMD landfall
- Detection of JTMD species in North America and Hawaii
- Risk assessments for JTMD species
- Risk assessment for the JTMD vector

THANK YOU

Photo credit: Oregon Dept. Parks and Recreation