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.
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.
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
Three models of the debris field were developed and refined:

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

Modeling Movement of Tsunami Debris

Nikolai Maximenko, UH
NOAA: GNOME model

Amy MacFadyen, NOAA
JAEA SEAG ELN Model

Oct. 2011 ~ March 2012

Japanese Government
JAEA SEAGELN Model

(Apr. 2012 ~ July 2012)

Japanese Government
Model predictions match observations in WA & OR
RESEARCH THEMES

1. Modelling
2. **Surveillance and Monitoring**
3. Risk from Invasive Species
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
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
Beach Debris Data Sources

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

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of Items</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Alaska</td>
<td>7</td>
<td>2.4</td>
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<tr>
<td>BC</td>
<td>15</td>
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<tr>
<td>Wash</td>
<td>50</td>
<td>16.9</td>
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<tr>
<td>Oregon</td>
<td>160</td>
<td>54.0</td>
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<tr>
<td>California</td>
<td>6</td>
<td>2.0</td>
</tr>
<tr>
<td>Hawaiian Archipelago</td>
<td>58</td>
<td>19.6</td>
</tr>
</tbody>
</table>

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

*Aphelasterias japonica*
Skiff - February 2013 in Oregon

*Patiria pectinifera*
Skiff - May 2014 in Oregon

Jim Carlton, MWC
Japanese and oceanic bryozoans

**Japanese Species**

- Arbocuspis bellula
- Watersipora sp.
- Lichenopora radiata

**Oceanic Species**

- Jellyella ebumea
- Jellyella tuberculata
- Exochella sp.
- Filicrisia sp.
- Aetea truncata

... 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) Falmannia mitchelliae, (c) Kuckuckia kylini, (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

- *Eutima* was detected on 4 JTMD objects. 2.5% prevalence on the 4 objects
- 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 ($\pm 2$ SE) of *Mytilus* recovered on JTMD. Letters indicate groups that are statistically similar within years.

Jessica Miller, OSU
Mussels were reproductive when they arrived

Hawaii 28.1%  Washington 85.5%  Oregon 94.2%

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