



“Tsunami marine debris is a transpacific Noah’s ark for Japanese marine life, generated by an unprecedented disaster.”

Hideaki Maki, PICES Project Co-chair, Japan

For more information, visit: www.pices.int

This research was funded by the Ministry of the Environment of Japan through the North Pacific Marine Science Organization (PICES).

ADRIFT Project

ADRIFT was directed by a **Project Science Team**, with researchers from Canada, Japan and the USA, co-chaired by PICES members:

Dr. Thomas Therriault, Fisheries and Oceans Canada
Dr. Hideaki Maki, National Institute for Environmental Studies, Japan
Ms. Nancy Wallace, NOAA Marine Debris Program, USA

Project Coordinator: **Dr. Alexander Bychkov**, PICES
 Project Scientist: **Dr. Cathryn Murray**, PICES



PHOTO CAPTIONS AND CREDITS

Front Page:

A Japanese vessel washed ashore on an Oregon beach. | PHOTO CREDIT: JOHN W. CHAPMAN

Inside Fold-over Page: Clockwise from top:

1. *ADRIFT researchers on debris beach walk in Hawaii.* | PHOTO CREDIT: LIGHTSPEED DIGITAL

2. *Living plant and animal species on Japanese vessel.* | PHOTO CREDIT: JOHN W. CHAPMAN

3. *Tsunami waves washed an estimated 5 million tons of debris into the ocean.* | PHOTO CREDIT: US NAVY

4. *The North Pacific sea star, a globally-recognized marine invader.* | PHOTO CREDIT: JESSICA MILLER



ADRIFT in the Pacific

Understanding the impacts of tsunami marine debris

Great East Japan Earthquake and Tsunami

The Great East Japan Earthquake struck off Japan’s Tōhoku coast on March 11, 2011 and triggered a massive tsunami wave that surged inland across kilometres of shoreline. A magnitude of 9.1, this was the most powerful earthquake to hit Japan. More than 15,000 people tragically lost their lives, over 2,500 were reported missing, and more than 6,000 were injured.

Over a million buildings were flattened or damaged, coastal forests were washed away, and almost every item imaginable was swept from coastal cities and villages into the ocean – an estimated 5 million tons of material.

One year later, tsunami debris began arriving on the Pacific coast of North America and later, Hawai’i. The discoveries astonished researchers: two huge floating docks from Misawa, Japan, landed on Oregon and Washington beaches, and more than 150 small boats washed ashore. They were carrying hundreds of living Japanese plants and animals.

ADRIFT – Assessing Tsunami Marine Debris

In March 2014, the Japanese Ministry of the Environment generously provided funding to research the impacts of tsunami marine debris on the Pacific coast of North America and the Hawaiian Islands.

The 3-year project, ADRIFT – *Assessing the Debris-Related Impact From Tsunami* – brought together scientists from Canada, Japan and the United States through the North Pacific Marine Science Organization (PICES).

ADRIFT set out to determine:

- Where would Japanese tsunami marine debris travel in ocean currents?
- Was tsunami debris carrying non-native species from Japan to North America?
- Would these species pose a threat to North American coastal ecosystems and communities?





Floating dock carried across the ocean from Misawa, Japan.

“One dock that washed ashore looked like a floating Japanese island. It carried more than 100 Japanese species, including some that can cause big impacts.”

Cathryn Murray, PICES Marine Ecologist, Canada

Tracking Marine Invaders

For millions of years, non-native species have hitched rides on floating trees, branches and roots to raft their way across the ocean. This is not a new phenomenon, but the increase in plastic and other debris from human activities is making it easier for species to travel and potentially invade and harm native ecosystems.

While large amounts of marine debris are afloat at sea, researchers rarely know where the debris is from, when it entered the ocean, or how long it took to arrive at its destination.

ADRIFT scientists had the opportunity to study ocean rafting in unprecedented conditions. Knowing that tsunami debris had been washed into the waters of Japan’s Tōhoku coast in March 2011 helped them track where this debris travelled and what it carried.

How Did Marine Debris Move in Ocean Currents?

The ADRIFT team of oceanographers worked with large-scale ocean models to connect the dots and estimate where tsunami debris was carried. For the first time, oceanographers were able to track marine debris over long distances, developing advanced techniques that increase our understanding of where things lost at sea might travel.

Other ADRIFT Discoveries

- Lightweight or floating debris such as polystyrene, a plastic packing material, was found to move rapidly and landed within a year of the tsunami. Submerged debris, on the other hand, could remain in the ocean for a very long time and become caught up in currents of the vast garbage patch of the North Pacific gyre.
- Debris traveled through the cold waters of the northern Pacific Ocean and warmer waters of the subtropical North Pacific, a fact biologists confirmed by the presence of both warm and cold water species on the debris.

“We have identified about 80 species of seaweed on marine debris and discovered that even if some of these species can be found on both sides of the Pacific, they are genetically distinct. That means seaweed arriving on debris can pose a risk of invasion.”

Hiroshi Kawai, PICES Marine Ecologist, Japan



Striped beak-fish stowed away in the hold of a Japanese fishing skiff.

“If you had asked me five years ago, if non-native species could survive open ocean crossings of multiple years from Japan to North America, I would have said probably not!”

Jim Carlton, PICES Marine Ecologist, USA



More than 300 Japanese species were discovered on debris.

What Types of Marine Debris Landed on Beaches and Shorelines?

The ADRIFT project confirmed that an unprecedented amount of marine debris from the Great Japan Tsunami washed up on North American and Hawaiian coasts. The amount of tsunami marine debris arriving was so significant, it greatly increased the overall amount of debris normally experienced on these coastlines. More is still afloat and may continue to arrive in the years to come.

Other ADRIFT Discoveries

- ADRIFT examined 650 pieces of Japanese tsunami marine debris over three years, including two huge concrete fishing docks, ripped from their moorings by tsunami waves in Misawa. A staggering number of smaller items sadly represented every aspect of Japanese life – including parts of temples, household items, and children’s toys.
- ADRIFT used beach webcams in Oregon and aerial photographic surveys of Hawai’i and British Columbia (BC) to detect how, where and how much debris washed ashore. The aerial surveys were the first comprehensive evaluations of marine debris for Hawai’i and BC – covering large, sparsely-populated coastal areas that are difficult to access.

“Hawai’i yachters sent us photos from ocean crossings, showing almost every piece of marine debris was covered with living species. This project is changing views about the ocean – demonstrating that marine debris plays an increasingly important role in ecosystems.”

Nikolai Maximenko, PICES Oceanographer, Hawai’i, USA

What Types of Species Arrived on Tsunami Debris?

More than 65 taxonomists from around the world engaged in a massive effort to identify unexpected and unusual species arriving from Japan. One major discovery challenged assumptions about ocean ecosystems: this was the first time ever that living species were recorded landing on the shores of North America from Japan carried by marine debris.

When the two Misawa docks washed ashore, they were covered with hundreds of living Japanese species and thousands of individuals. Scientists were amazed. It was assumed a coastal species could not survive in a hostile open ocean with little food, no protection from sun, and harsh marine conditions. Yet species of mussels and tiny crustaceans thrived and even reproduced at sea on marine debris – some for more than six years.

Other ADRIFT Discoveries

- More than 300 species of Japanese plants and animals were discovered on debris, including a seaweed named *Tsunamiopsis transpacificus*, one of several new species not previously known to science.
- A large number of globally-recognized marine invaders arrived – including the North Pacific sea star and Wakame kelp seaweed – but no new invasions of coastal ecosystems of North America or Hawai’i have been detected yet. ADRIFT produced a Top 10 Watch List for each region as high-risk species still pose a threat to ecosystems and continued monitoring is advised.
- Despite the large amount of debris generated, ADRIFT found that tsunami debris may present a lower risk for transporting non-native species. Greater threats may come from other forms of transport, such as commercial shipping.

ADRIFT Legacy Products

- **Museum Collection of Japanese Marine Debris Specimens**
Housed at the Royal British Columbia Museum in Victoria, British Columbia, Canada. Available for scientists worldwide – A comprehensive permanent collection of thousands of specimens from Japanese tsunami marine debris objects that landed in North America and Hawai’i.
- **The PICES Japanese Tsunami Marine Debris (JTMD) Database**
Available through the Smithsonian Institution online portal NEMESIS. Provides detailed information for more than 250 marine debris species, contributing to a better understanding of how species move and the traits of successful invaders.
- **Archival Collection of Aerial Photographs and Data Layers for British Columbia and the Hawai’ian Islands**
Available online through the British Columbia Provincial Government and Hawai’i’s Department of Land and Natural Resources (see PICES website).



ADRIFT researchers examined hundreds of debris items.