

Marine Algae arriving on JTMD (Japanese Tsunami Marine Debris) and their invasion threat

Principal Investigators

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Carried across the North Pacific on currents from Japan, marine debris from the The Great Tōhoku Earthquake and Tsunami of 2011 has frequently arrived on the west coast of Canada, USA and Hawaii laden with Japanese marine algae and invertebrates. The algal species are often healthy and reproductive, and many could recruit to invade these shores. In order to recognize the invasion threat of these JTMD algal species to North America and Hawaii, we are carrying out the following multi-part project:

- (1) We are collecting and examining all of the algae arriving on JTMD in order to:
 - a. Identify & voucher the species using both morphological and molecular methods
 - b. Score the species for fertility (if they are actively reproductive)
 - c. Document the frequency or % occurrence of each species on the debris
 - d. Determine their seasonality and also longevity on debris
 - e. Use the literature to determine the global distribution or residency of each JTMD species revealing:
 - (a) those species that are known only from the NW Pacific, known from both the NE and NW Pacific, or known to be widespread (cryptogenic); (b) those species that are known invaders; and also (c) those species that already occur in the NE Pacific.
- (2) For the JTMD algal species already present in the NE Pacific, we are:
 - a. Determining their state-wide and site specific distributions so that these occurrences are not confused with new invasions;
 - b. Comparing the molecular structure of the North American species with those of the identical JTMD species in order to reveal differences for use as indicators of new invasions
- (3) For detecting new invasions from JTMD, we are using our JTMD algal species lists to:
 - a. Visually search for the larger JTMD species in habitats in WA and OR that are likely to be invaded (floating docks, bays and rocky sites near abundant debris landings);
 - b. Collect, microscopically examine, and sequence material from these habitats that is likely to contain the smaller JTMD species;
 - c. Screen publications, pre-existing lists, databases and herbarium records for JTMD species already present
 - d. Compile a distributional database of these known occurrences for on-going use in assessing both new and prior invasions along our coast.
- (4) Lastly, we will prepare a photographic guide to the algal species found on JTMD.

To date, algal material has been collected from 29 JTMD items that have been collected and/or made available to our project for analysis. The items have ranged from the Agate Beach, Oregon floating dock in June 2012, to Panga fishing boats and lumber in 2013 & 2014, and, most recently, to plastic totes in December 2014 and January 2015. In total, 66 algal species have been identified from these JTMD, including 40% brown algae, 17% green, and 33% red algae. This dominance of brown algae differs considerably from the Oregon algal checklist where red algae dominate the flora at 60% and brown algae consist of only 20% of the species. About 33% of all of the surviving species occurred on only one of the various debris item. Only 8% occurred on 10 or more items, and these widespread-on-debris species were all early successional forms (e.g., *Feldmannia mitchelliae* and *Petalonia fascia*). On debris, we did see a seasonal change in the group proportions: green algae and blue-green bacteria increased in the winter while brown and red algae decreased.

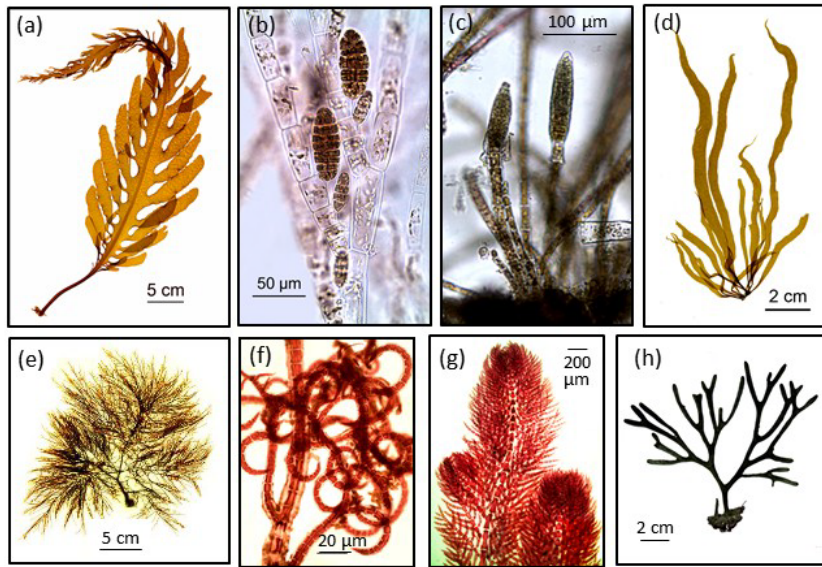
About 80% of the debris algal species were found to be reproductive on arrival, displaying active spore and gamete release. Increasing nutrients on reaching shore could have stimulated this occurrence. Another reason seemed to be that the greatest proportion of the algal species on JTMD were ephemeral (53%) and opportunistic/early successional forms (76%), both groups typified by species that reproduce rapidly, grow quickly and invade new habitats. Ephemeral species are also capable of producing many generations per year, a feature that enables their populations to bounce back from a wide variety of environmental stresses such as those they might have encountered at sea.

Our global distribution study of the 66 algal species on JTMD revealed that 36 species (55%) are cryptogenic (of unknown origin), 23 (34%) are Asian only or known Asian exports, and 7 (10%) occur both in the NE and NW Pacific. By reviewing publications, web-posted data, checklists and personal data, we have also been able to determine that 41 JTMD species (62%) are already resident in the NE Pacific due to natural dispersal or earlier invasions. Of these 41 species, only half (20 species) are present in Oregon. We are now in the process of determining the sites along the coast where these JTMD & NE Pacific co-occurring species are most common in order to characterize the habitats and collect material for our genetic study.

Currently, we are targeting the bays in southern Washington where numerous debris items have landed. To date, our collections have revealed that 23 of 77 species in Willapa Bay, WA and 20 of 122 species in Grays Harbor, WA are also species that occur on JTMD. We have begun to analyze the genes of these species and have already found a species that will be useful as a genetic indicator of JTMD invasion in the species that are already here. In *Petalonia fascia* the genetic structure of the mitochondrial Cox 3 gene in NE Pacific vs. JTMD species differs by more than 20 base pairs.

The 66 marine algal species found on JTMD may indeed invade the North American flora. Water temperatures in the NE Pacific are within the range of those in the tsunami region of Japan, and most of the species were reproductive on arrival. The 25 species not yet present in the NE Pacific certainly pose the greatest threat to our native species, but the 41 species that are on JTMD and already here will also have some influence as they could interbreed with native populations and modify the genetic population structure (haplotypes). Perhaps even more indicative of the invasion potential from JTMD are the 6 JTMD algal species that have been included on the Global and/or Mediterranean Worst Invasive Species lists: *Undaria pinnatifida*, *Codium fragile* subsp. *fragile*, *Grateloupia turuturu*, *Anthithamnion nipponicum*, *Polysiphonia morrowii*, and *Desmarestia viridis*. All except *P. morrowii* are already known in California.

Some Marine Algae on JTMD



(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*