PICES MOE Project Meeting Summary Report
July 30 to Aug 1, 2014
NOAA Sandpoint Campus, Seattle, USA

PICES MOE Project Overview

- The impact of tsunami debris generated by the 2011 Great Earthquake of Japan on the coastal ecosystems of North America
- PICES working group 21 – invasive species WG
- Also funding through the Japanese gift money to the states/province; those proposals are on hold while this group allocates money
- $1 million per year for 3 years; contingent on satisfactory progress each year; funds committed but not secured for three years, money can be carried over to next year
- Three areas of focus for Year 1 (April 2014-March 2015): 1) Modeling of marine debris transport, 2), Transport of invasive species on debris, and 3) Monitoring and response to debris

Modeling of Marine Debris Transport: Current and Proposed Activities

Current Activities

Large-scale Modeling

Amy MacFadyen (NOAA Office of Response and Restoration, Emergency Response Division)
NOAA runs an oil spill model GNOME (based on HYCOM currents and wind) and uses the model to do a hindcast for a range of windage values (windage parameter describes how much the debris catches the wind). They used a US Coast Guard database that was meant for search and rescue. The model is useful in looking at trends and seasonality but quantifying how much each State/Province would get is a more difficult task. There needs to be a more careful sensitivity analysis of the model; for example, on precise distribution of locations of debris sources. There has been some work done for marine debris in general but predicting local-scale debris collection areas requires an expensive, fine-scale coastal model. Yet another, different model (does not currently exist) would be required to address invasive species transport once they get into the surf zone.

Nikolai Maximenko (International Pacific Research Center, University of Hawaii)
Models reflect the state of knowledge and require observations for adequate selection of model parameters (such as windage, sources and sinks of debris). Stochastic ocean mixing reduces predictability of tracer trajectories with time and observations are needed to reduce model uncertainties. Currently, there is a gap between observations of debris and models. Observations are scarce and do not reflect the actual composition and full range of properties of objects, released by the tsunami. As a consequence, models have to deal with very approximate estimates of debris proportions with different windages.

The complexity of the problem is most severe on small scales but is much reduced on the large, ocean basin scale, where ocean dynamics are well understood and circulations of the ocean and atmosphere are accurately monitored with satellites. Downscaling models to nearshore requires a huge amount of effort, not only computer power but also enhanced (and currently non-existent) high-resolution forcing (wind stress, heat and fresh water fluxes, etc). On a larger scale debris dynamics is predictable: for example the windward side of Hawaiian Islands is affected more than the leeward side, Alaska tends to receive a lot of Styrofoam, and microplastics collect in subtropical oceans. However, local dynamics is much harder to explain: for example, the most famous "dirty" beach, Kamilo, is located close to the South Point of the Big Island of Hawaii, the leeward side. Trajectories of thousands of standardized satellite-tracked drifting buoys distributed around all oceans provide unique information about pathways of low-windage marine debris. However, long-term measurements of other, more common types of marine debris are missing and their motion may significantly deviate from predictions of those models calibrated using drifter data.

According to model simulations, high windage debris from Japan was moving faster than lower windage and hit the North American coast first, followed by medium and low windage debris. While most of high-windage debris (such as oyster buoys) ended on the US/Canada west coast, part of medium windage (such as boats) recirculated toward Hawaii. The majority of low windage debris (such as lumber) drifted to the area of the North Pacific Garbage Patch, located between California and Hawaii. This patch is the area of convergence of surface currents, sustained by seasonally varying winds, normally releasing debris from the patch to the west coast and Hawaiian beaches in winter-spring seasons. Tsunami debris reports from Hawaii were organized into a public webpage illustrating waves of similar debris types: refrigerators, tires, gas cylinders, wood, etc. Recently appearing low windage types are hard to observe in the water and can be a navigation hazard. There are puzzling observations of different fouling levels on similar objects.

Question from the group: can you run the model with different sized debris? Different windage values? Answer: Yes, this could be done; in fact our models are already run for a range of set windages. The problem is how to determine windage of a particular type of debris. Also, there is drag from increasing biofouling, soaking, breaking, deterioration (e.g., deterioration of the wood eaten by shipworms) which may require time-varying windage in model experiments. These changes need to be based on the best knowledge that we have.

Fine Resolution Modeling

Fine-scale modeling could help to identify hotspots of debris landing and would be useful for tasks of invasive species monitoring and prevention. In Washington State, debris sighting coordinates are sent to NOAA and attempts are made to predict where that debris would land so that rapid response resources can be deployed. Such local models are available only in a small number of regions. They can be nested within the basin-scale drift models and used to provide boundary conditions but this work would require significant resources from the project. Alternatively, because intensity of inflow of debris seems to be correlated over large scales (hundreds to thousands of miles), "hot spots" can be identified using historical reports from various interest groups (beachcombing, cleanup, drift seeds, etc.) while the timeline of debris landfall can be derived from coarser-resolution models.

Modeling Discussion

- Could we make use of Local Ecological Knowledge? Engage the locals to find out which beaches collect debris in general.
- Shoreline cleanups are being done but can we correct for effort? More shoreline surveys have been done in places near population centers so we don't know as much about remote, pristine places.
- Could we leverage larval transport models, like those with drift cards for *Spartina* and green crab?
- How do we differentiate between general debris and 2011 tsunami debris? E.g., debris found in June 2011 on the beach of the Pacific Missile Range Facility (western Kauai) was likely the debris, collected for long time on some remote beach or atoll, and re-floated by the 2011 tsunami.
- Are we going to look at local circulation patterns that would retain invasive species that are washed off debris that has made landfall?
- Would we expect differences between marine debris hotspots and JTMD hotspots? Do we assume that JTMD is functionally similar to marine debris? Are there unique characteristics that are of interest? In contrast to other marine debris, we know the date of entry, it is a larger magnitude/volume of debris than normal (large pulse), weird items (with differing drag/windage)

such as refrigerators, some already fouled by coastal organisms.

Invasive Species Research and Risk Assessment

Current Activities

James T. Carlton (Mystic-Williams College)
Co-PI with on Sea Grant and NSF-funded projects on the biology of tsunami debris, with Jessica Miller and John Chapman (Oregon State University), Jonathan Geller (Moss Landing Marine Laboratory) and Gregory Ruiz (Portland State University / Smithsonian Institution). To date, preserved samples from debris objects have been sent to OSU (Miller/Chapman) or Williams-Mystic (Carlton).

To date, 240 JTMD objects have been intercepted, including 27 Japanese skiffs which landed in WA/OR in a 6 week period from April to June 2014. More than 220 taxa have been found alive, the team expects that the total number will go over 300 with further analysis. Jessica Miller's research has focused on estimating life history of *Mytilus* from shell chemistry. Isotope analysis can differentiate between coastal residency and open ocean; Ba/Ca spikes are the result of coastal residency because coastal waters are rich in barium. Invasion with tsunami debris is considered to be a distinct possibility given the number and abundance of living species that have landed in North America and Hawaii. Some species, such as caprellid amphipods and marine insects, have passed through several generations during multi-year rafting. The team has developed a rafting model which has been populated by examples from the JTMD debris species: stages of the model include departure, loss, enhancement, arrival.

Research priorities for the NSF team working on marine invasion are 1) Rapid response sampling of debris and, 2) Processing of biological samples (field work, taxonomy, molecular)

Gayle Hansen (Oregon State University, USA)
Collaborating with Hiroshi Kawai and Takeaki Hanyuda (Kobe University, Japan) on identifying marine algae on JTMD in OR/WA. Start-up funds were provided by Oregon Sea Grant.

In OR/WA, 24 JTMD items were available for algal sampling. Comprehensive collections were made from each debris item, and the algal species were sorted, vouchered and identified. To date, 62 algal species have been found on JTMD. Initial identifications were based on morphology, but absolute confirmation of the more problematic species employed genetic sequencing at Kobe University (27 species). Of the 62 identified species, 49 were actively reproductive. Ephemeral and early successional forms (those that reproduce rapidly and colonize easily) were the most abundant and widespread on debris. Using AlgaeBase.com, the species were coded for their worldwide distribution: 7 were known from both sides of the North Pacific, 22 were found to be Asian only or know Asian invaders, and 33 were globally widespread. Six species were on the Global and/or Mediterranean Invasive Species lists – *Undaria pinnatifida, Codium fragile* subsp. *fragile*, *Grateloupia turuturu, Anthithamnion nipponicum, Polysiphonia morrowii*, and *Desmarestia viridis*.

Research priorities for the algal team include: (1) Completion of species determinations and publication of the species list, (2) Photographic documentation of the species, (3) Detecting new JTMD invasions and documenting the current (historical) site-specific distribution of JTMD algal species already in OR & WA, (4) Detecting unique Japanese haplotypes among these resident (in OR & WA) JTMD species – in order to help us recognize current and past invasions.

Invasion discussion

What is the type of debris with highest invasion risk? Floating docks, skiffs? Things already floating in coastal waters and already fouled. Would these things be low windage or high windage?

In order to assess invasion potential of debris-associated species we need to survey sites where tsunami debris arrived to check for establishment. Are there species baselines in these areas? How can you tell that it wasn't already there? How can you tell that what you find is from JTMD and not from some other vector? Molecular techniques and whole community sequencing could be useful. Compare JTMD sites and non-debris sites? Given the state of the modeling, how do we identify the non-debris sites? Completeness of baselines will be site-specific and taxon-specific. Some coastal sites have long baselines and the presence/absence of larger taxa will thus be more accurately assessed.

Invasion potential of species:
What is the invasion potential of novel species/novel genotypes? Are there any with serious impact potential?
Which exotic species should be on a target list for searching?

- Need to know the biodiversity of what has arrived thus far and what is continuing to arrive
- Need to continue with a robust program to assess biodiversity, chemistry, genetics; continued analysis of existing samples and future arrivals
- Focus on the long-term survivors that are still alive and arriving after 3 years

Therefore, we need to work up the material we have, and conduct additional real time surveys to collect additional material as new debris comes in. Longer-term, look in the environment for the species we already know have arrived (morphologically and genetically) and use general environmental samples to look for others (genomics and meta-genomics). A few other areas to focus on: Transoceanic survival, Individual species, Landing, Environmental matching, Parasites & Diseases (e.g. hydroid in mussels)

Most of the discussion so far has focused on detection and identification - the exposure/likelihood axis of the risk assessment. We haven't yet looked at the impact/consequence axis.

Surveillance and Monitoring: Current and Proposed Activities

Current Activities

Atsuhiko Isobe (Kyushu University) – marine debris monitoring in Japan
There have been various pieces of debris monitoring research in Japan. A balloon with digital camera attached was towed like a kite, camera remotely controlled from the ground. Georeferencing using 1m2 markers. Change images to lightness maps to calculate area of litter. Weigh debris from 10 x 1m^2 quadrats.

Webcam monitoring has been conducted in Japan. The team set webcams on 10 beaches along the coasts, images open to the public, solar-powered, records one image every 90 minutes. Image processing is used to separate anthropogenic from natural debris. Researchers found that amount of debris varied with time (winds) so estimates will depend on the timing of sampling. Mark-recapture of marine debris (Kataoka et al 2013 MPB), on that beach had an average residence time of 200 days.

A potential webcam project on the North American side needs local coordinator to choose sites. Equipment purchase and image processing would be done in Japan and provided to researchers in North America. The project would need information to decide which sites are good candidates. Ideally, internet access at the site would be available but could use satellite to upload images. Anthropogenic wood is not currently considered in the image processing, as is it wouldn't distinguish natural and anthropogenic (lumber).

There are three types of monitoring methods to consider:

1) Aerial photography – efficient for quantifying large areas but only a snapshot
2) Webcams – efficient for time series but local scale
3) Beach survey – efficient for invasive species detection but difficult to estimate totals

All three components together could be used to estimate total marine debris brought to coast and a measure of vector potential for invasive species by marine debris.

Nancy Wallace (NOAA Marine Debris Program)
Marine Debris Program website: www.md-map.net. The total number of debris monitoring sites is 164; 41 sites in British Columbia. Three levels of monitoring survey sources:

1) Rigorous surveys within WA and CAL sanctuaries (2 sites)
2) Some funding to interested local groups, like Surfriders, for equipment
3) General public

Two survey types: one is the “standing stock” where they sample but don’t remove debris. The second survey type is “accumulation rate” survey. The data from both surveys are maintained in a central monitoring database held by NOAA, access is available to all groups. There is some money for QA/QC, but no analysis so far. One power analysis on how much sampling is required to detect policy changes, such as plastic bag bans. Data available are debris count data, types of debris and relative proportions of debris types. Note that there have been no monthly surveys in Alaska; some sites did monthly surveys within the field season, some sites had surveys going back to the 1980s (another division of NOAA using a different protocol). Presence of fouling is not collected as part of the monitoring protocol; but it can be modified to capture other types of data (e.g. they modified the WA surveys to look for a particular type of fishing gear). In addition, NOAA maintains the Disaster Debris reporting site. There are over 2000 records in the database.

Peter Murphy (NOAA) – Alaska coordinator
The State of Alaska conducted aerial surveys to qualitatively assess debris hot spots. The first survey was conducted July-Aug 2012 using a small aircraft, shooting oblique images with a GPS enabled handheld still camera resulting in ~8000 photos. The photos are not ortho-rectified. The contractor ranked the each photo’s debris density (0-5 scale) in post-processing. NOAA did the follow up georeferencing and mapping in house. The rankings were translated into 1mile/5 mile segments using averages and the resulting maps show hotspots of debris. The photos and rankings are available online in the Environmental. Response Management Application (ERMA).
http://www.arcgis.com/home/webmap/viewer.html?webmap=8ac40a055c5349b19e20cf84fdbeacf0
The 2012 survey was not a continuous survey as in traditional mapping exercises. There were more photos in areas with high debris. The 2012 aerial survey will be repeated in 2014, weather dependent.

Additional debris data sources: Citizen science targeted at objects/beaches of interest “tsunami week” has resulted in stratified sampling. Some city staff clean up and record what they remove. Fishing fleets have eyes on the ocean and can respond to large objects with aerial survey. As mentioned previously, the NOAA monitoring database is available upon request and staff can direct us toward those records with high data quality. An analysis of existing images could also be completed.

Surveillance Discussion

- How large do the debris objects have to be identifiable in the aerial photos? Objects down to the size of a milk jug could be detected, if it is visible, the post-processing could be tuned to look for fouled skiffs in the photos.
- Alaska and British Columbia need aerial surveys for large objects, but they would be less useful in the more populated southern states of interest (WA/OR).
- What is the impact of debris itself, outside of alien invasive species (AIS) risk? Stakeholders are concerned about styrofoam and juvenile salmon. NOAA and National Marine Fisheries Service (NMFS) commissioned studies looking at whether juvenile salmon consume foam and what chemicals would be in salmon as a result.

Overall Group Discussion

Debris data: There is existing data from NOAA monitoring data, aerial surveys, and existing webcams. Environment Canada debris surveys done for Scott Islands. BC. There are a couple of papers from them, but there doesn't seem to be much tsunami debris accumulating there
A synthesis of existing data needs to be conducted and then the group can decide on surveys/webcams/etc.

Debris sampling: We could explore opportunities to sample debris objects at sea. The group could conduct a survey of the Pacific garbage patch, opportunistic surveys with cargo ships or mount webcam on ships. NOAA has some at-sea observations data. Hazards to navigation reports are relayed to Coast Guard in WA; there has been some delay with the reporting in Hawaii. Outreach to recreational and commercial vessels has been done (advisories and signs) and there have been some reports from air pilots on debris sightings. Collaboration with Charles Moore is a possibility. Trackers could be deployed on existing debris or a tracker could be modified so that it has the same windage as the debris types we are discussing.

Surveillance: Look for other large objects in the north (BC and Alaska), look for incoming material, look at the biota on those objects, behavior of the objects. Are large objects greater risk of invasion than multiple small objects?

Modeling: focus on vessels/skiffs as a specific type of debris; play with biofouling rate as a parameter; look for skiffs specifically in the aerial surveys, hindcast vs. forecast modelling of arrival/volume/type of debris

Additional research: rate of degradation of lumber is research area of interest. The lumber already in possession could be used to estimate it. Ucluelet, BC, is having a lot of Japanese-origin lumber right now and it could prove to be a useful parameter for modeling. We also need to take a closer look at the biofouling parameter, potential measurements and its use in the models.

Prioritization of Projects to be Undertaken

Priorities for Year 1 (Fiscal year ends March 31 2015):

- Modeling for prediction of arrival events
- Aerial surveys- new survey for BC, some data mining of the AL images
- Ability to respond to new debris coming in
- Dealing with biological material on the debris

Modeling
- Redo the analysis with a specific debris type, trajectories of all those identified debris with origins, run simulations using the observations from actual debris (fouling level and types of species, life history of debris), time-variant windage, rate of fouling decreasing windage.
- Surveys of oceanic debris on how much JTMD is still in the ocean
- Future projections: when to expect different waves of debris

Surveillance & Monitoring
- Analysis of existing databases – monitoring, aerial surveys, disaster debris reporting
- Aerial surveys of BC – first priority West Coast Vancouver Island, second is west coast Haida Gwaii, third is Central Coast
- Webcam surveillance – one site in North America for first year
- Field surveys – incursion response to reports of large debris (skiffs, docks, gas cylinders, etc)

Invasion Risk

- Invertebrate sampling from debris items: sample processing, taxonomy, molecular work, *Eutima* parasite as a case study.
- Algal taxonomy and molecular work
- North American parasite survey and processing
- Lumber infestation and life cycle – Nancy Treneman

Follow the Boats

A common theme through all three research areas is a focus on **vessels/skiffs** (surveillance and monitoring, modeling and invasion risk). In order to do this we need faster reports of detection of vessels. Members of the PST are already working on it, including better outreach and chain of reporting to get sightings of vessels, especially in Canada. There is a list from consulate – boats that are registered are easy to track, but those without motors probably washed off the land, no motors. It is difficult to estimate how many in total were lost. During the analysis of monitoring data, cross check to ensure all the sightings are in there; in particular check all the skiff sightings

Priorities Years 2-3

Surveys in Japan for potential species pool – Year 2
Re-survey of dock landfall sites for detection of invasion by known species – Years 2-3
Risk assessment – Years 1-2-3

Meetings and Conferences

Project Science Team (PST) Meetings

No PST meeting at PICES AGM in Korea in October 2014. PIs will all attend and meet in Yeosu, South Korea. The next PST meeting late year 1 or early year 2; potentially Feb-March 2015 somewhere on west coast of North America

Scientific Conferences

- Bioinvasions Conference in Jan 2016 (special theme session?). PICES has supported the last three conferences; a good place to highlight the project work. A good place for outputs and the timing is close to the end of the project
- There is a special session at PICES AGM in Korea on marine debris
- There is a special session at ICES on biofouling
- PICES session at AGM: deadline for proposal is end of August for following year's meeting (China)
- In 2016 the meeting will be in North America
- Either special session with all PST at one conference or fragmented presence at multiple meetings with common message

Annual Reporting

Reporting to Japanese MoE: after end of fiscal PICES has 90 days to submit financial report and progress report. PICES reporting from Project Science Team to co-leads ~1 month after end of fiscal year

Project website will be developed on the PICES webpage. This is where scientific progress reports will be housed. Can we come up with a project name?

Manuscripts/Products/Conference presentations – should be identified early and included in reporting.

High level synthesis paper on the impact of JTMD – the group should dedicate time and funding for the analysis and writing of the paper. This must occur before the end of the project timeline

Presentations to Japanese upon the conclusion of the project. Other projects from Japanese MoE required public presentations/lectures/journalist interviews/public outreach pamphlet