Proceedings of the Japan Tsunami Marine Debris Summary Meeting

NOAA Marine Debris Program
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
Technical Memorandum NOS OR&R 50
October, 2014

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- Determines damage to natural resources from these releases.
- Protects and restores marine and coastal ecosystems, including coral reefs.
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CITE AS:
Barnea, N. et al. 2014. Proceedings of the Japan Tsunami Marine Debris Summary Meeting. U.S. Dept. of Commerce, NOAA Technical Memorandum NOS OR&R 50. Silver Spring, MD NOAA Marine Debris Program. 53 pp.

ACKNOWLEDGEMENTS:
This Technical Memorandum greatly benefited from the insight, comments, and suggestions of the JTMD Summary Meeting participants, and their contribution is greatly appreciated. Ashley Braun of NOAA OR&R greatly improved the document with expert editorial work.

Proceedings of the Japan Tsunami Marine Debris Summary Meeting

Nir Barnea[1] (ed.), Kimberly Albins [1,3], Keith Cialino [1,4], Kyle Koyanagi [1,2], Sherry Lippiatt [1,2], Peter Murphy [1,3], and Dianna Parker [1,2]

[1]National Oceanic and Atmospheric Administration
National Ocean Service
Office of Response and Restoration
NOAA Marine Debris Division
Silver Spring, MD 20910, USA

[2] IM Systems Group, Inc.
Rockville, MD 20852

[3] GENWEST Systems, Inc.
Edmonds, WA 98020

[4] Freestone Environmental Services, Inc.
Richland, Washington 99352, USA

National Oceanic and Atmospheric Administration Technical Memorandum NOS OR&R 50
September, 2014

For copies of this document, please contact:
NOAA Marine Debris Division
N/ORR, SSMC-4
1305 East-West Highway
Silver Spring, MD 20910

http://marinedebris.noaa.gov/

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Introduction
The March 11, 2011, earthquake and tsunami that devastated Japan claimed over 19,000 human lives, injured more than 6,000 people, and destroyed and damaged countless buildings. As a result of the tsunami, a portion of the debris that washed into the ocean has reached U.S. and Canadian shores since late 2011, a process that will continue over the next several years.

Three years after the disaster, the deposition of Japan tsunami marine debris (JTMD) has subsided, and agencies addressing this issue have accumulated experience, insight, skills, and lessons that are best captured and shared at this point. Accordingly, in May 2014 NOAA coordinated a meeting of the entities most involved with JTMD—federal agencies, Pacific Coast States, and Indian Tribe representatives—as well as resource managers and academic researchers who have been part of bi-weekly debrief calls, to summarize the main activities to date, derive lessons learned, and make recommendations for responding to future severe marine debris events.

The JTMD Summary Meeting started with short background presentations, followed by focused discussions in three workgroups: Response, Science, and Communications. Workgroup discussions were facilitated and directed by a series of guiding questions. Note takers captured input from attendees, which was used to generate these proceedings.

Background
On March 11, 2011, an earthquake with a magnitude of 9.0 struck the country of Japan, triggering a tsunami with waves up to 130–feet high that inundated more than 200 square miles of land. As the tsunami receded from land, it washed much of what was in the inundation zone back into the ocean. Heavier materials sank closer to shore, while buoyant materials went on to make up the debris fields initially captured by satellite imagery and aerial photos of the waters surrounding Japan immediately after the tsunami. In the months that followed the tsunami, it became apparent that the untold amount of property lost was to become a marine debris issue not just for Japan, but also for its neighbors across the Pacific, the United States and Canada.

Actions Taken
The section below summarizes the main actions taken in response to the deposition of JTMD on U.S. shores. It is brief and not comprehensive, serving as a reminder rather than a thorough description. For more information, please refer to the websites provided in Appendix 1.

Hazard Notifications
Shortly after the tsunami event, U.S. Coast Guard and NOAA assessed the status of the floating debris and agreed that hazards to navigation existed and could be substantial. As a result, NOAA worked with the U.S. Department of Transportation's Maritime Administration to place ocean-going vessels on alert, and asked partners across shipping, science, fishing, and recreational fleets who regularly travel the Pacific Ocean to report back any significant sightings of marine debris. This information was disseminated to shipping fleets (through the World Ocean Council), commercial and recreational fishing vessels, scientific expeditions, and government vessels and fleets.

At the same time, U.S. federal agencies reached out to the Government of Japan for information on items that could pose a hazard to navigation. The Japan Coast Guard provided images of floating objects, as well as reports from vessels that spotted these items in Navigation Area XI http://www1.kaiho.mlit.go.jp/jhd-E.html which is managed by Japan Coast Guard (Figure 1).

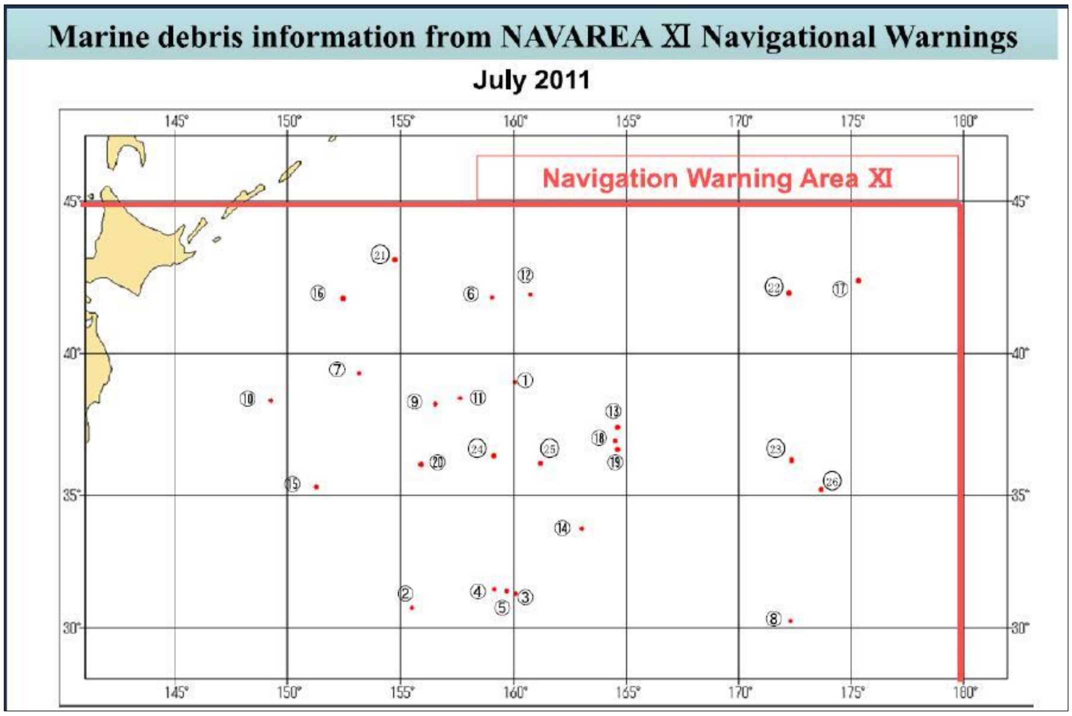

Figure 1: Marine debris items reported to NAVAREA XI, July 2011. (Japan Coast Guard)

At-Sea Detection

Immediately after the tsunami, marine debris was clearly visible from vessels, aircraft, and relatively low-resolution satellites (15–30 meters) (Figure 2). However, by mid-April of 2011, the debris had dispersed to the extent that it could no longer be detected by these satellites. As the debris dispersed and began moving across the Pacific Ocean, multiple agencies began work to detect debris on an opportunistic and targeted basis.

Opportunistic Detection

Because of the scale and inaccessibility of the detection area in the open waters of the Pacific Ocean, surveying for marine debris directly with targeted detection missions is very difficult. As such, opportunistic reports from vessels and aircrafts that were in the area of potential debris deposition were the primary source of sightings data. These reports were tracked using an email reporting system (sent to DisasterDebris@noaa.gov), through which mariners, aviators, and shoreline users could report sightings of potential tsunami debris that were later ported to online maps of sightings with confirmation status. Partners in these reports included fishing, transport, cruise, research, government/defense, and recreational vessel operators and crews, as well as shoreline citizen scientists and regional agency partners.

Targeted Detection

Starting in late 2011, the NOAA Marine Debris Program (MDP) began to work with NOAA National Environmental Satellite, Data, and Information Service (NESDIS) Satellite Analysis Branch (SAB) to collect high-resolution satellite data, using modeling results to select target areas with a reasonable expectation of elevated JTMD densities. Over time this program expanded to integrate imagery collected by the National Geospatial Intelligence Agency who provided high-resolution commercial satellite data for analysis by SAB based on MDP-identified target areas. This data includes Synthetic Aperture Radar, visual, and multi-spectral data from multiple satellite contracts, including the Worldview 2 and Geo-Eye. The analysis of these images reinforced the challenges in satellite detection of debris. The first and overarching challenge was the size of the target area, which required that high resolution imagery be focused in small areas, making a "representative" sample of the overall area impossible given resources in data and analysis time. The second challenge was the diverse nature of the debris itself, in terms of size, composition, and buoyancy. This makes tuning any one sensor to reliably focus on and identify "tsunami debris" very difficult.

Based on these identified challenges, efforts in the summer of 2012 were shifted to focus on consistent imagery collections in nearer shore areas, with the additional capability for rapid (24–72 hour), targeted imagery collections for individual objects of high priority. These consistent collections used a "persistence" method, in which images could be collected in rapid succession and compared to evaluate the persistence of the anomaly and help rule out natural phenomena.

Individual states (i.e., Alaska and Washington) also initiated dedicated shoreline aerial survey efforts in order to assess areas of highest debris concentration and prioritize cleanup operations.

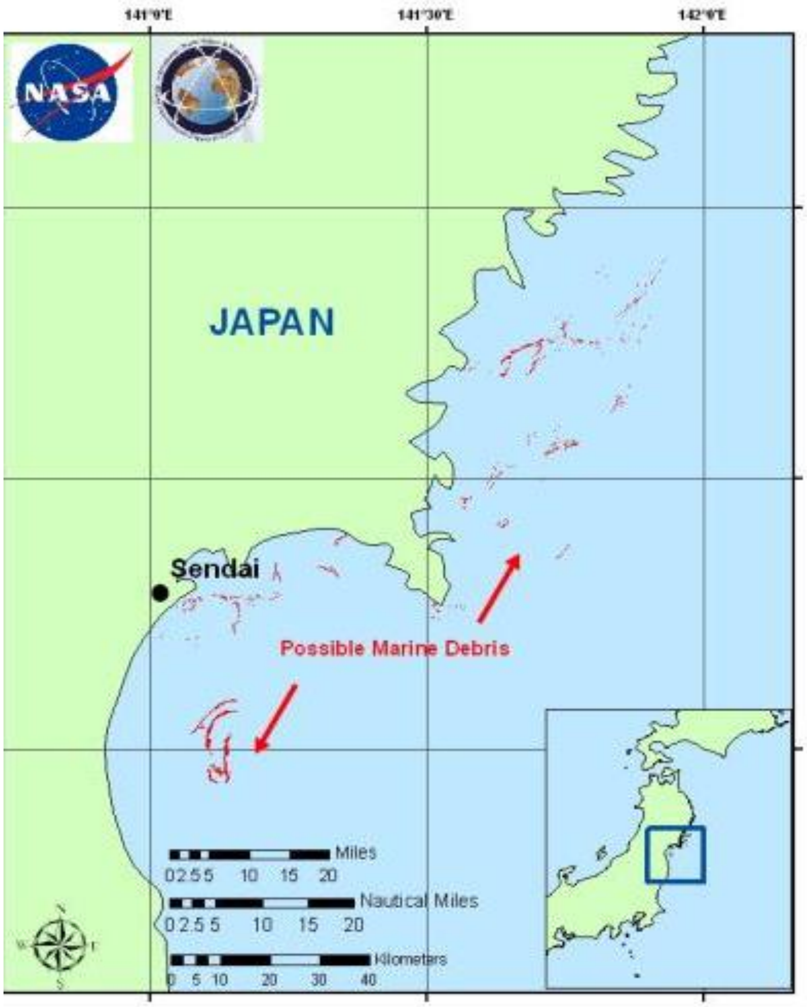

Figure 2: Satellite image from March 17, 2011,showingpossible marine debris fields in the areas off Japan's east coast. (NOAA)

Debris Modeling

In the weeks after the tsunami, as debris moved offshore, dispersed, and could no longer be detected via satellite, multiple groups began to model the movement, distribution, and arrival timelines for the marine debris released by the tsunami. The earliest of these efforts began just a few months after the event, with a limited number of modeling runs continuing through to 2014.

In December 2011, NOAA formed a subject matter expert group of modelers from across NOAA offices as well as the University of Hawaii. This group worked to share information on modeling approaches and data sources, and included the leads for the University of Hawaii's Surface Currents from a Diagnostic (SCUD) model, the NOAA Ocean Surface Current Simulator (OSCURS) model, and NOAA's General NOAA Operational Modeling Environment (GNOME) model. NOAA also coordinated information sharing with modeling teams from the government and academic communities in Japan, including multiple remote and in-person meetings to compare and share techniques and results.

The University of Hawaii International Pacific Research Center (IPRC) synthesized observations with the SCUD model to provide the framework for understanding the pathways, locations, timelines, and fate of JTMD. The University of Hawaii team began working to model JTMD in 2011, and expanded to organize voluntary debris reconnaissance missions out of Hawaii in late 2011 and early 2012. The model was successful in reproducing trajectories of individual objects, and provided results consistent with the timeline and properties of debris arriving in Hawaii. Updates to debris model outputs and other efforts were posted to the IPRC website http://iprc.soest.hawaii.edu/ and presented at conferences and other public outreach opportunities.

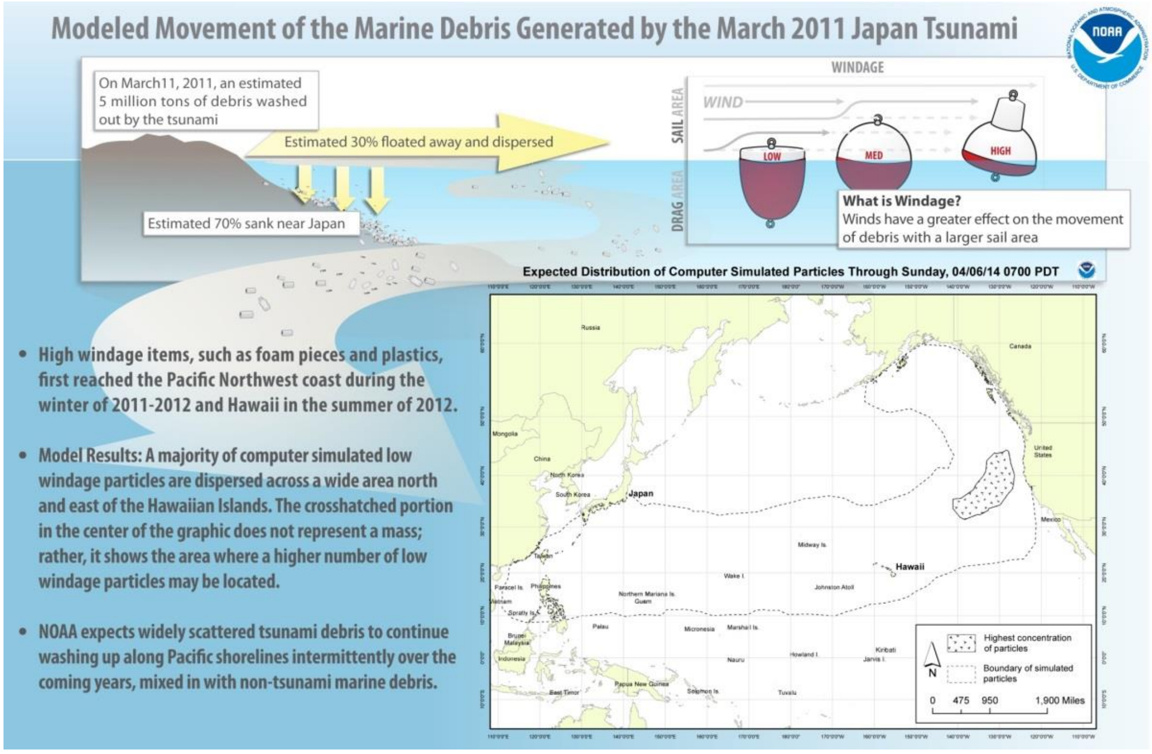

Figure 3: NOAA JTMD modeling output shared on marinedebris.noaa.gov. (NOAA)

The Japan Ministry of the Environment and the Secretariat of Headquarters for Ocean Policy established a simulation task-team consisting of Kyoto University, Japan Atomic Energy Agency, Japan Agency for Marine-Earth Science and Technology, Japan Meteorological Agency's Meteorological Research Institute, and Japan Aerospace Exploration Agency. This team conducted a hindcast drift simulation of JTMD movement from March 2011 to September 2013 using ocean current and surface wind time-series data. Later, the modeling effort expanded to a forecast run for October 2013 to June 2015. Overall, the model showed debris being transported eastward and then being spread to the north and south, arriving in North America as early as the fall of 2011. Updates to debris simulation products were shared with the U.S. Government and the general public through reports posted online.

Beginning in late 2011, the NOAA Office of Response and Restoration Emergency Response Division used the GNOME model to create a hindcast model, showing the estimated movement of tsunami debris from March 11, 2011 to the date at the time, based on ocean surface currents from the U.S. Navy's Hybrid Coordinate Ocean Model (HYCOM) and winds from NOAA's Blended Sea Wind Product. The GNOME simulation used 8,000 simulated debris particles with randomly assigned windage values based on an assessment of likely debris behavior profiles from leeway and windage studies previously performed by U.S. Coast Guard and other organizations. These model runs showed the highest windage debris arriving on the west coast of North America starting in the fall and winter spanning 2011–2012, and debris generally dispersing throughout the North Pacific Ocean over time, responding to seasonal current and wind patterns. GNOME updates were translated into a standardized visualization, which was shared through the NOAA MDP website (Figure 3) and sent to attendees of the multi-agency, bi-weekly briefing calls.

NOAA also used GNOME for short-term (72 hour) trajectory modeling of the projected path of individual objects sighted at-sea or nearshore. For example, this approach was used successfullyto forecast the area where a floating dock from Misawa, Japan, would be washed on shore after being sighted off of the Washington coast in December 2012.

Sightings and Reporting

The distribution of JTMD over the Pacific Ocean and the coastlines of the United States and Canada was widespread. In order to facilitate reporting from the public, agencies involved, and ocean-going vessels, NOAA established an email address, DisasterDebris@noaa.gov, to which any sightings at sea or on shore might be reported. In turn, those sightings were entered into a tracking database. NOAA widely shared the debris sightings e-mail address to ensure that the database would contain as much current and accurate debris tracking information as possible.

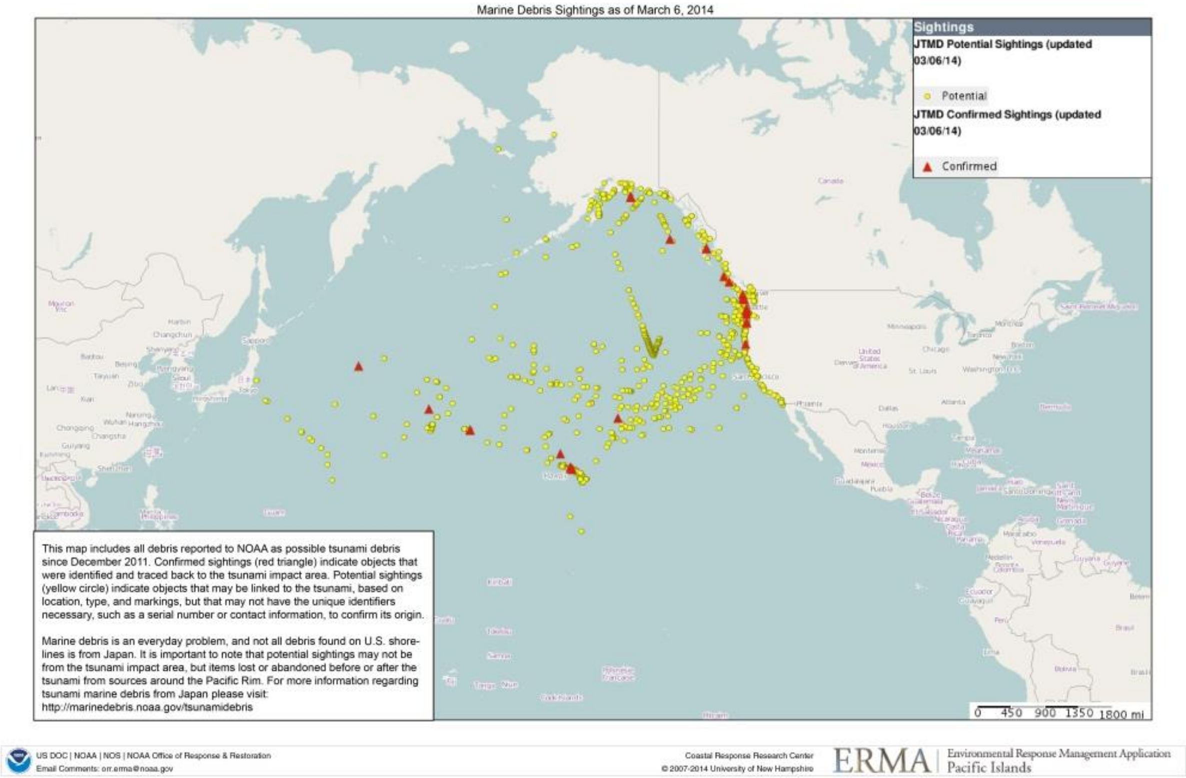

Figure 4: A map of JTMD sightings reported, as displayed in ERMA, NOAA's online mapping tool for environmental response data. (NOAA)

NOAA also uploaded sightings data into the Environmental Response Management Application (ERMA®), an online mapping tool, to display graphically the geographic distribution of debris sightings at-sea and on shore (Figure 4). Reports of hazardous materials or debris that could be a hazard to navigation were reported immediately to the U.S. Coast Guard for further action.

Some impacted U.S. states established their own dedicated toll-free phone lines to facilitate reporting of JTMD on their coasts. Collaborating with NOAA, these calls were shared and the information was captured in the JTMD tracking database. Over time, the volume of calls greatly diminished, and at the end of December 2013, Washington state decommissioned its JTMD toll-free line.

Monitoring

In early 2012, the NOAA Marine Debris Program (MDP) launched the Marine Debris Monitoring and Assessment Project (MD-MAP), which includes standardized shoreline survey techniques for both beach cleanup (accumulation) and standing-stock assessments. Briefly, the survey technique involves tallying all debris items greater than 2.5 centimeters in the longest dimension along a 100-meter long shoreline segment extending from water's edge to the back of the shoreline. There is no perfect shoreline marine debris monitoring technique that can be appropriately applied to all shoreline types along the Pacific Rim and implemented by all types of monitoring groups (e.g., trained volunteers, scientists, resource managers, school groups, etc.). The standardized NOAA monitoring techniques were designed to be as widely applicable as possible while allowing for some customization based on regional needs or debris types.

The MDP has developed partnerships for regular monitoring at sites potentially impacted by JTMD. In addition to formal monitoring partnerships with other NOAA offices and Federal agencies, the MDP has provided project oversight, an online database (www.md-map.net), and technical support to various nongovernmental organizations (NGOs) around the Pacific Rim in exchange for a commitment to survey self-selected shoreline sites on a monthly basis for a period of at least two years. The project received a lot of interest from government, NGO, and other partners and quickly grew to more than 150 shoreline sites across Alaska, Washington, Oregon, California, Hawaii, and Canada's British Columbia. Brief descriptions of monitoring programs in Alaska, British Columbia, and Washington follow and come from select partner organizations represented at the May 2014 JTMD Summary Meeting.

In Alaska, National Park Service-led monitoring has included opportunistic, aerial, and a modified NOAA marine debris shoreline survey protocol. The modified surveys include going to the second barrier along the coastline because of the seasonality of surveys and the likelihood that marine debris is located beyond the first barrier.

In British Columbia, the District of Ucluelet's Environmental and Emergency Service Department initiated a monthly accumulation monitoring site located on the west coast of Vancouver Island to help address the possible influx of tsunami driftage material. In addition, the Provincial BC Parks Department maintains a number of standing-stock survey sites.

In Washington, NOAA's Olympic Coast National Marine Sanctuary (OCNMS) initiated monthly shoreline debris monitoring as a citizen science program in 2000 using data categories developed by the U.S. Environmental Protection Agency (EPA). In the fall of 2012, OCNMS revised monitoring efforts and transitioned to NOAA's new shoreline survey methods and debris data categories. As of 2014, systematic analysis of historic and recent shoreline debris data from OCNMS has not been completed, but qualitative observations indicate distinct debris types identified with JTMD, e.g., mortise and tenon jointed lumber; large blocks of pelletized foamed plastic; large, black plastic floats; and possibly foam insulation sheet pieces (if data indicates increased quantities). Delivery of floating debris to the outer

Washington coast is episodic and associated with certain wind patterns, which will not be captured with monthly monitoring.
Coordinated debris monitoring through the MD-MAP provides concerned citizens, government partners, NGOs, and academic organizations an important means of contributing to our scientific understanding, management, and response to JTMD. MD-MAP has been used in talking points for the media, agency leadership, Congress, and other stakeholders as an example of a direct action being taken to address concerns about JTMD. Furthermore, prior to any comprehensive data analysis, having volunteer monitoring teams to reach out to for qualitative, near real-time information on the state of the coast (at specific locations) has been a great resource. One such example is the incidence of reported peaks in specific types of debris (e.g., lumber) from shoreline monitoring teams in Washington and British Columbia.

Planning

As JTMD moved across the Pacific Ocean, and especially after tsunami debris began washing up on the coast of North America, it became apparent that plans to address different scenarios could be useful. Washington state representatives, Indian Tribes, and NGOs convened in a workshop in April 2012 to draft an initial Marine Debris Response Plan for Washington, and released a first draft two months later. Oregon's plan, similar to Washington's, was drafted and released later in 2012. Both plans specified roles and responsibilities in responding to JTMD, and provided guidance on how to address overwhelming amounts of small debris, large debris onshore, large debris offshore, toxic debris, aquatic invasive species, and outreach and communication efforts. California developed a Concept of Operations Plan that followed a similar format. Hawaii developed a response framework, and Alaska focused efforts on aerial survey and prioritization of impacted areas for cleanup.

Communication and Outreach

The combination of an unprecedented event with its associated uncertainty, keen media interest, and incorrect statements released by a host of people and entities about the magnitude and composition of the Japan tsunami marine debris, all created public concern and a critical need for accurate and timely public outreach and communication. NOAA and state partners conducted more than 100 public meetings in the five impacted U.S. states (Alaska, California, Hawaii, Oregon, and Washington) to provide information available to the agencies, to address questions, and to offer opportunities for public involvement, such as reporting and cleanup.

In addition, NOAA has given more than 300 interviews on the subject of JTMD to international, national, and local media outlets, and state, academia, and NGO partners have granted many more.

The MDP maintains a dedicated Japan tsunami marine debris webpage http://marinedebris.noaa.gov/tsunamidebris/. Available on this page are the latest information on JTMD, such as frequently asked questions, updates on the response effort, and outreach materials, including a JTMD poster (Figure 5) and guidelines on JTMD handling. Impacted states also created dedicated websites and web pages, which included common links to national information sources. These online resources were especially helpful in informing the public of state-specific efforts, such as the removal of beached docks in Oregon and Washington, aerial surveys in Alaska, and debris reporting and handling in Hawaii. Aquatic invasive species experts at the impacted states, Oregon State University and Williams College developed webpages addressing the threat of aquatic invasive species from JTMD, further increasing the amount of science-based information available to the public.

To facilitate the flow of information and multi-agency coordination, the MDP hosted a bi-weekly conference call from January 2012 through March 2014, which provided the latest information and status updates related to JTMD. The MDP opened the call to all interested Federal, State, and local agencies, including partners in Canada, and the Consulate General of Japan in Seattle. The notification list exceeded 200 individuals at all levels of government, and included representatives from government agencies from all affected states.

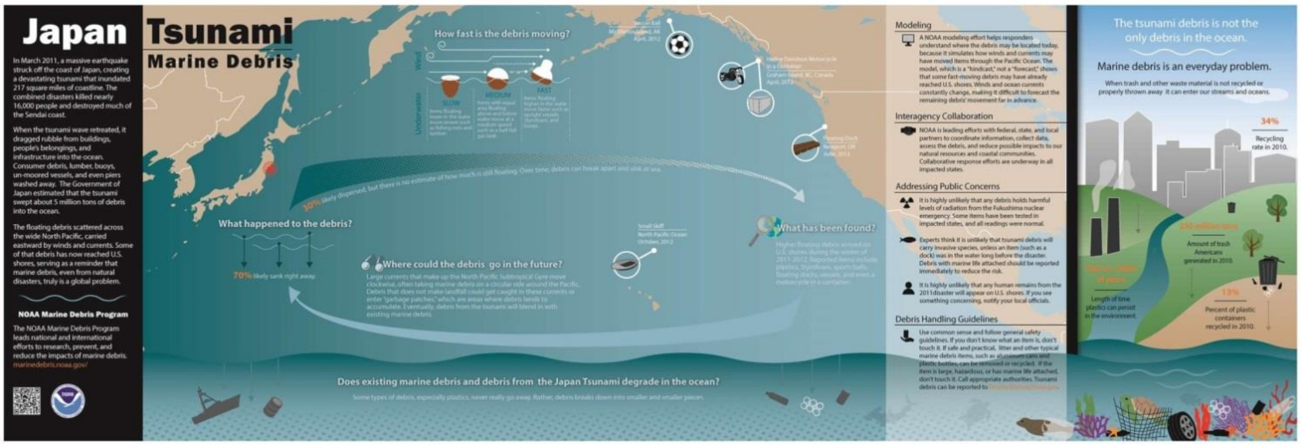

Figure 5: JTMD poster developed by NOAA for public outreach in March 2013. (NOAA)

Removal

Volunteers, including members of the general public, contribute greatly to efforts to remove marine debris from accessible beaches. On accessible beaches, small potential items of JTMD, often indistinguishable from other marine debris, have been removed mostly by volunteers. In several cases, the amounts of debris found on west coast beaches—JTMD mixed with other marine debris—proved to be more than local volunteers could handle on their own and additional resources, such as the Washington Conservation Corps in Washington state, were used to remove these items. In remote and hard-to-access locations, especially in Alaska, paid workers were employed to remove debris, as they have been used in years prior to the March, 11, 2011 tsunami event.

Removal of hazardous marine debris has a generally established protocol: After a marine debris item is reported, it is evaluated and addressed by the appropriate agency, either the state hazardous material emergency response unit, Environmental Protection Agency (EPA), or Coast Guard. Dedicated funding is available for such removal. Significant effort was made to discourage the general public from removing any item deemed hazardous. The public was asked to only mark and report these items.

Medium JTMD items, too large to be handled by one or two people, were reported to the state, Coast Guard, or NOAA, and were frequently removed by state agencies. The best examples of debris in this category are skiffs from Japan, usually between 20-30 feet long, which washed up on beaches in all five affected states and British Columbia.

Large JTMD items found on shore were relatively infrequent. The most significant examples were two of four floating docks that washed away from the port city of Misawa in northeastern Japan. One of the four docks landed on a sandy beach near Newport, Oregon, in June 2012. After removing a myriad of aquatic species, some of which were invasive, the state removed the dock at a cost of $85,000. The second dock washed up in December 2012 on a remote beach in Washington's Olympic National Park and Olympic Coast National Marine Sanctuary. After three months, the dock was cut into pieces (Figure 6) and removed by helicopters at a cost of $628,000, most of which was covered by a gift fund from Japan (totaling $5 million).

Figure 6: Cutting the Misawa floating dock that washed up at Olympic National Park, Washington, in December 2012. (NOAA)

Aquatic Invasive Species

One of the most striking findings associated with JTMD was its ability to serve as a vector for non-native aquatic species, some of which exhibit highly invasive behaviors. The arrival of the Misawa dock to Newport, Oregon, with a host of species from Japan's coastal waters (Figure 7) alerted researchers and the response community to this risk from biofouling. It also prompted experts in the field to reach out to responding agencies and the public to obtain reports and photographs of what could be non-native species, and to identify and tabulate the species. This event generated significant national and international scientific, media, public, and political interest in tsunami hazards, tsunami debris, and marine invasive species. As more JTMD washed ashore, aquatic species from Japan's coastal waters were discovered adhering not only to marine objects, such as boats, floats, and docks, where they might have resided prior to being washed away by the tsunami. These species were also found attached to items considered terrestrial, such as construction wood beams, crates, and pallets.

Learning about the potential invasive species threats and establishing consistent protocols for monitoring and responding to sightings required rapid action. The arrival of invasive species on JTMD revealed not just basic research needs (e.g., taxonomy, drift patterns, colonization substrates, risk analysis) but also critical gaps in monitoring, outreach, and communication response protocols. Some of these critical gaps were addressed by convening a workshop in August 2012, in Portland, Oregon, which gathered research, monitoring, management, policy, outreach, and communications experts from the region. At this workshop participants developed rapid response protocols published as "*Response Protocols for Biofouled Debris and Invasive Species Generated by the 2011 Japan Tsunami*." A key aspect of the biofouling protocol is the development of an ad hoc Japan Tsunami Marine Debris Taxonomic Assessment Team. This is a group of taxonomic experts familiar with North Pacific Ocean flora and fauna and willing to examine photographs of fouled debris on rapid timescales and make recommendations as to whether a management response is needed. In addition, a network of 50 to 60 taxonomists has been called on to donate further time and expertise. Four researchers — Drs. James Carlton, Jessica Miller, John Chapman, and Gayle Hansen—secured funding from the National Science Foundation and Oregon Sea Grant to study marine life arriving on tsunami-generated debris. They are gathering extensive data on species identity, population structure, reproductive condition, growth histories, genetics, and parasite or pathogen presence. Their study will also quantify how marine life showing up on JTMD varies in time and space, as well as how their diversity changes over time.

Figure 7: Removal of invasive species from the Misawa floating dock which came ashore near Newport, Oregon in June 2012. (Oregon State University)

Collaboration with the Government of Japan

The United States and Canada began working with the Government of Japan on the issue of Japan tsunami marine debris shortly after the March 11, 2011, tsunami event. Collaboration began in earnest when JTMD started washing ashore on U.S. and British Columbia beaches in January 2012. NOAA began meeting with both Japan's Embassy staff in Washington, DC, and Consulates of Japan on the West Coast. As a result, NOAA and the Government of Japan established excellent lines of communication and agreed on protocols both for confirming suspected JTMD items and for handling items of value. Through the Consulate, NOAA obtained and distributed to partners guidance on identifying Japanese vessels and a list of over 500 vessels identified offshore of Japan by the Japan Coast Guard. The government also provided guidance on and resources for identifying potentially hazardous marine debris items that may have originated from Japan.

Scientists and government representatives from the United States, Canada, and Japan convened at a science meeting in Seattle, Washington, in June 2012. At this meeting, they discussed the status of JTMD at the time; modeling, monitoring, and reporting marine debris; and future plans. After the initial meeting, modelers from Japan, led by Japan's Ministry of Environment and Kyoto University, and NOAA staff continued working together, and gathered for a second time in Seattle, Washington in February 2013 to update each other and discuss progress on modeling and predicting the movement of JTMD.

As of 2014, the productive collaboration and open communication between the governments of Japan, Canada, and the US on JTMD continues.

Funding
As JTMD began arriving on U.S. and Canadian shorelines, an important question was raised: Who will pay for the cleanup? To the degree possible, the affected states and province covered initial response and cleanup expenses, but they expressed the concern that large amounts of debris would result in massive cleanups and costs beyond their ability to deal with them.

In the summer of 2012, the NOAA Marine Debris Program allocated $250,000 in program funds and awarded $50,000 to each of the five affected states. In December 2012, the Government of Japan provided $5,000,000 in gift funds to the U.S. Government, and $1,000,000 to the Government of Canada. In the United States, $250,000 of the funding was allocated to each of the five impacted states, with the rest kept in reserve to address extraordinary JTMD events and removal costs. Part of this funding was used to remove the floating dock from Misawa, Japan, that arrived at Washington's Olympic National Park and Olympic Coast National Marine Sanctuary.

Lessons Learned and Recommendations
The main focus of the May 2014 Japan Tsunami Marine Debris (JTMD) Summary Meeting held in Seattle, Washington, was to derive lessons learned since 2011 and generate recommendations for responding to future tsunami events. This meeting's 47 participants were assigned to three break-out groups: Response, Science, and Communication. Using preparatory materials received in advanced, each participant contributed to the respective break-out group discussion, which summaries of which follow.

Science
The break-out group covering science was tasked with discussing the operational and communications challenges of scientific efforts during the Japan tsunami marine debris (JTMD) response, and defining lessons, key gaps, and potential future actions. While the scientific disciplines that have been applied to or conducted because of the JTMD issue are cross-disciplinary, break-out group time was divided into sessions on four primary topic areas:

1. Sightings and detection
2. Modeling
3. Shoreline monitoring, and
4. Biofouling and invasive species.

Each session included a very brief introduction or presentation to orient participants to the topic area, followed by a facilitated discussion. The discussion agenda followed a general format covering what was done, how it was communicated, needs and next steps, and top three points summarizing the discussion. Later in the meeting, participants broke into smaller groups within their area of expertise and spent 30 minutes synthesizing the main points of the discussion to report back to all meeting participants.

As expected, overlap and commonalities emerged among the four primary topic areas as well as with the *Communications* and *Response* break-out groups. *Science* break-out participants used sticky notes to record ideas not captured in the discussion or presentations and share them with conveners of the other two break-out groups. These questions and ideas were combined with notes from the sessions to create the proceedings which follow.

To optimize in-person discussion within this break-out group, in advance of the meeting, each participant submitted background information and summaries of actions to date, which were compiled and emailed to the group a week prior to the meeting. Participants were asked to familiarize themselves with the work that has already occurred and the areas of expertise of other participants. The background information provided by participants also is summarized in the sections which follow.

Common Themes

Throughout discussions within the *Science* break-out group and the meeting overall, several common themes emerged:

- JTMD has led to a higher level of interest in marine debris issues, which provides an opportunity to advance the state of related science and better prepare for future marine debris events.
- Funding is a consistent and significant barrier to continuing or expanding current JTMD research.
- The scientific community could improve the quality and quantity of information-sharing both among itself and with the public through collaborations to compile existing datasets, analyses and results. This could be facilitated through improved data standards and collection methods between responders, modelers, sightings trackers, the invasive species community and others.
- There is a need to educate the media as well as the public and develop better visualizations or messaging tools to enable and encourage improved communication of JTMD science. The scientific community would benefit from including information on the capabilities and value of marine debris science and the relative risk of JTMD in comparison to existing marine debris.

Sightings and Detection

Key summary points of this discussion were as follows:

1. **Standardize reporting**. Integrating common data fields, terminology, and organizational structure will increase the compatibility and ease of data sharing between reporting systems (e.g., NOAA, states, etc.) and feedback to users (e.g., public, scientists, responders).
2. **Expand at-sea observation protocol to show areas of vessel transit and areas where debris was not seen**. Adding capacity or requirements for vessels and observers to report both the overall track of their vessel or aircraft and where they did not see any debris could significantly benefit modeling and the overall knowledge base regarding debris location and concentration.
3. **Improve sightings categorization**. Identifying debris that is “consistent with” JTMD, rather than limiting categorization to the existing “confirmed” or “potential” categories, would add more detail and value to debris categorizations.
4. **Expand aerial surveying**. There is strong potential for expanding shoreline aerial surveys, but doing this would require funding. Suggested actions related to aerial surveys include exploring anomaly detection software to improve post-processing efficiency and identifying and sharing protocols for opportunistic and visual (non-photographic) aerial surveys.

Lessons and Recommendations

During the discussion, the *Science* break-out group identified multiple lessons and recommendations related to the detection of JTMD. Many of them focused on increasing opportunities for providing input to and sharing debris sightings data and detection protocols used in the field. These lessons and recommendations for detecting JTMD follow and are organized by sub-topic.

General Detection Outputs. *The Science break-out group identified several points pertinent to multiple detection techniques and products.*

- Detection of JTMD can be optimized when accompanied by a level of detail – in identification, coverage, and resolution - that can inform modeling and response. However, this expectation is unrealistic based on the diversity of debris and the size of the target area (i.e., the North Pacific Ocean).
- Identifying JTMD through change-analysis is often challenging due to the underlying gaps and limitations in knowledge of the pre-existing density of debris on some shorelines and in the open ocean.
- Opportunistic reports of individual debris sightings have notable limitations. Namely, they frequently do not report the overall track of the vessel or aircraft or areas where observers *did not* see any debris, which can be as important as noting areas where debris was seen for use in informing modeling and the overall picture of debris presence/absence.
- The awareness and common knowledge of catcher or collector beaches varies significantly by state and province. Oregon and California seem to have good qualitative understanding of where catcher beaches are located, while the degree of awareness in Washington and British Columbia is more mixed. An aerial survey in Alaska highlighted for the first time catcher beaches in a way allowing them to be compared.

Technology and Technique Limitations. *Based on the results of detection efforts, multiple limitations or challenges of detecting JTMD were linked to the underlying limitations of the detection technology or technique. These are listed below by detection platform.*

Satellite.

- The diversity in the size, shape, and composition of debris makes "tuning" satellite sensors to detect any one object at sea difficult.
- Satellite sensor resolutions at 0.5–1.5 meter per pixel—while very high for oceanographic or topographic observation—do not allow for immediate or reliable identification of widely scattered debris.
- Satellite imagery analysis bandwidth is a challenge. At 0.5–1.5 meter per pixel resolution, individual images gathered via satellite cover an area of 15 kilometers by 15 kilometers, and require significant manual analysis effort to identify potential debris anomalies.
- A gap exists for accessing satellite data between the time of the initial incident on land and later data reacquisition attempts once debris reached the open ocean. Satellite data were available under the terrestrial disaster response for one to three months, but the satellite imagery did not "follow" the debris out to sea. Once satellite requests for the debris began again in late 2011 (roughly 6 to 10 months later), the debris had dispersed to areas where detection was much more difficult.

Aerial.

- Aerial survey, even with very high quality imagery, can typically only reliably detect larger debris objects. This is especially true along shorelines, because small objects often may be under logs or vegetation.
- Shoreline aerial survey best practices should be expanded to include additional data sources. Current survey protocols focus on oblique photo surveys with manual post-processing. This can be valuable, but eliminates potential sources of data from other aircraft traffic and has high labor cost in post-processing. A more flexible and scalable protocol should be developed which can integrate opportunistic aerial surveys and direct observation reporting, with standardization to allow for better data comparison. Additionally, while current anomaly detection software likely is not compatible with marine debris data, monitoring this software for future use could allow for much more efficient post processing of aerial shoreline survey data.

Vessel.

- Debris sightings reported from vessels should be expanded to collect more information through a consistent protocol. This technique needs a consistent and easily adopted protocol to capture the vessel routes where survey or observation efforts were active, and the general approach or limitations of the survey or observation efforts. This would help provide clearer data not just on individual sightings but on debris location and movement by capturing where debris was not seen.

Reporting. *Multiple agencies and organizations—ranging from NOAA and state agencies to local NGOs and universities—maintained separate systems for reporting JTMD. Each of these had value, but they were each tailored to the specific needs or questions of the originating organization. In discussion, the group agreed that restricting organizations to one reporting system would be impractical but that increased consistency and interoperability between the systems could have multiple benefits.*

- Integrating common data fields, terminology, and organizational structure could increase the compatibility of the different reporting systems implemented by responding organizations (NOAA, impacted states, NGOs, etc.). Further standardizing data reporting can help in data coordination and integration and with communication across the active marine debris community and the public.
- NOAA's Japan tsunami marine debris categorization should be expanded to include additional categories beyond simply "potential" and "confirmed," to indicate debris objects that fit the JTMD profile (e.g., "consistent with JTMD"), even if they cannot be confirmed officially. This expansion would provide more value to the map of JTMD sightings and better capture the full picture of debris observations.

Communication. *Detection efforts and results were communicated actively to the public. However, opportunities for improving methods and messages were noted.*

- Identifying ways to more clearly and intuitively communicate ongoing detection efforts as well as their capabilities and limitations would help calibrate the public's expectations to the realities of detection efforts, as well as inform them of the breadth of related activities.
- Data sharing should be increased across reporting systems, including the NOAA MDP Sightings Tracker (via DisasterDebris@NOAA.gov). Additionally, including or emphasizing explanations of the meaning (e.g., uses and limitations) of sightings data and visualizations may improve the quality of communications to affected communities and the larger public.

Building Capacity for Future Events. Throughout the *Science* break-out session, participants noted strong interest from the public in reporting opportunistic debris sightings and the value those reports had in communication with the public and with partners. However, as noted above, limitations in the consistency of protocol, level of detail in reporting, and compatibility of various sightings data make operational or scientific application challenging.

Based on this interest, discussion of key actions for future tsunami events focused on ways to expand the consistency and robustness of opportunistic reporting protocols, tracking, and categorization. Another area of focus was the coverage and flexibility of targeted shoreline aerial surveys both to work in new areas and to integrate visual and other opportunistic survey data more easily.

Building these reporting and detection protocols and implementing them will require effort, and will be a challenge due to scarce resources, as well as the timelines required for design, approval, and outreach for public protocols. However, having the infrastructure for these data streams—such as reporting and data handling protocols as well as relationships with volunteer observation sources—in place in advance of a future event would be invaluable for providing data in the optimal format for use by the wider marine debris community.

Modeling Debris Movement

Key summary points of this discussion were as follows:

1. **Couple detection and modeling**. Improve the interactions and communication between debris modelers and those collecting or reporting debris sighting data to allow for input and advice on detection approach and data format by modelers to better inform modeling process and outputs.
2. **Expand research**. Begin and/or expand experiments with different types of objects or drifters to better understand the windage, debris degradation and colonization life cycle, and nearshore and surf-zone dynamics and how they contribute to debris movement and shoreline deposition patterns.
3. **Modeling interaction**. Improve interaction between global and coastal or regional models.

Lessons and Recommendations

During discussion, the *Science* break-out group identified several key lessons and opportunities to address them in the future through increased communication and coordination, public engagement, and research into the underlying questions that could help improve modeling outputs and operational application. These gaps, needs, and actions for improving modeling of tsunami debris follow and the overall notes are captured below, organized by sub-topic.

Data Sharing. *There was general understanding and appreciation that modeling outputs are improved with access to targeted observations that include information that can either validate or improve the parameters and starting conditions of the model simulation. While detection and sightings data collection is frequently opportunistic, increasing the coordination between modeling and detection efforts, and starting that coordination early, has the potential to improve the effectiveness of both detection and modeling efforts.*

- Improve and expand the interaction and communication between modelers and the groups managing data collection or reporting (i.e., detection and monitoring) to allow for input and advice on detection approach and outputs. This could lead to sightings and detection output data that can better inform and test model parameters.

Research and Data Needs. *Several underlying data and knowledge gaps exist that, if closed, could improve the ability of modelers to set starting conditions and debris behavior parameters. Gaps and potential actions to close them are listed below.*

- The awareness and knowledge of catcher or collector beaches varies significantly by state and province. While this gap was captured in the *Detection* break-out group, this information also is valuable for modeling, as it can help identify indicator beaches, and be integrated with shoreline monitoring efforts to provide inputs to test and inform modeling approaches.
- Additional field work and experiments with different types of objects and drifters are needed to better understand the in-situ windage and life cycle of debris as well as the nearshore and surf-zone dynamics of debris movement, deposition, and refloating. Optimally, this research should include common debris objects identified both from "background" debris and JTMD.

- Many regional models exist that include higher resolution data on winds and currents, but these models have limited spatial scope. Building improved interactions between broad-scale, basin-wide modeling approaches and these regional or nearshore coastal models could help inform and improve the resolution of modeling outputs for debris deposition in both time and space.

Communication. *Translating modeling results into clear pictures that provide intuitive information not only on the model outputs but on the underlying decisions, parameters, and limitations is a key communication challenge identified by the group. Below are several key modeling communication challenges and potential actions to address them.*

- Modeling results changed over the course of the JTMD response as the knowledge of debris types and behavior developed. This led to changes in debris arrival estimates by time and location. As knowledge and modeling results changed, the challenge was to move quickly to incorporate new information and explain how the model outputs have changed, while maintaining credibility (see Communications working group section on crisis communications).
- Participants saw potential value in creating another, more detailed version of the GNOME JTMD modeling visualization product, targeted at a scientific audience, which includes more detail than the two layers of the contour map, but also could be more readily and intuitively explained than a full particle map.
- Modeling explanations could be improved by providing more intuitive and direct information on what is included in the models and what is not included (e.g., debris types, forcing, etc.).
- Adding layers to the modeling visualization map that show the general forces that impact debris movement—currents and winds—could give the audience better context patterns in how debris generally moves over time.
- Participants noted that it was helpful for them to have information on modeling efforts outputs and status to share in their own communications and in order to both ask and answer questions. The bi-weekly JTMD stakeholder call was a specific example of this. Moving forward, having a clear sense of the plans for modeling efforts and changes to outputs will be helpful for state and regional partners.

Building Capacity for Future Events. There was consensus among participants that modeling efforts have been beneficial both in terms of public communication and in advancing the state of knowledge within the marine debris community on the speed and spread of debris after large-scale releases. Both modelers and attendees across the *Science* break-out group were interested in continuing or building on these efforts. In addition to the previously identified research needs, specific potential actions that could inform or improve modeling outputs and communication in the event of a future acute debris release event are listed below.

- Ongoing and expanded sharing of data and outputs across modeling efforts can inform future efforts for modeling both general marine debris and acute-release debris. Participants agreed that there is benefit derived from ongoing debris modeling efforts. This both builds on JTMD efforts and allows for transition and readiness for future debris events.
- For a future incident, the ideal situation would be to deploy an observing system that integrates modeling, at-sea observing, and monitoring systems to evaluate and test hypotheses and questions on debris movement and deposition as the situation develops.
- Establishing a series of auto-deployed signal drifters along the Pacific Coast in tsunami-vulnerable communities could improve future tsunami debris modeling efforts. These drifters

could be set adrift automatically in the event of a tsunami, and allow for real-time and verified measurements of debris movement based on objects with known movement behavior.

Shoreline Monitoring and Assessment

Key summary points of this discussion were as follows:

1. **Define shoreline monitoring objectives.** Standardized, coordinated shoreline monitoring is an important effort that should continue, but we need to clearly define the scientific objectives (in relation to trust resources) and identify resources to support coordination and database maintenance on a large scale.
2. **Develop modular approach**. It would be useful to review adaptations to the NOAA debris shoreline monitoring protocol with the goal of developing a modular approach to monitoring.
3. **Establish data analysis framework**. There is a need to analyze existing data and capture ways that monitoring data has been effectively used in the past to develop a framework for analysis products moving forward.

Lessons and Recommendations

During discussion, the *Science* break-out group identified key lessons and future opportunities to improve debris shoreline monitoring techniques and data analysis, and the overall notes are captured below, organized by sub-topic.

Monitoring Techniques. Participants discussed potential revisions or adaptations to the NOAA marine debris shoreline monitoring protocols. As mentioned above, some organizations have already adapted the NOAA protocol to best suit their needs and objectives. For example, Olympic Coast National Marine Sanctuary has applied background knowledge of locally significant debris types and added them to the standard datasheet developed by NOAA (the MD-MAP.net database allows users to add customized debris types). Monitoring groups may benefit from an analysis and compilation of these types of adaptations to the protocol, informing future implementation and potentially improving or increasing the efficiency of monitoring efforts. Additional suggestions for adaptations to the existing NOAA shoreline protocols follow.

- A “survey light” method could be developed to engage specific groups or individuals in a less rigorous data collection effort. Reduced standardization complicates data analysis, but given the current level of interest in marine debris, there is an opportunity to engage the public through a mobile app or other means.
- Photos and remote sensing technologies could replace or supplement traditional shoreline monitoring efforts. Large debris items potentially could be identified and quantified in aerial or webcam photos, in lieu of on-the-ground surveyors. If the technology is available and can effectively distinguish between natural and anthropogenic debris, a spectral data analysis software tool could be used to automate analysis of photos. It was recognized that aerial photography is limited to detection of large, clearly visible objects; data on smaller items or those hidden beneath logs or other debris cannot be collected with existing technologies. As image resolution improves, the post-processing time and data management requirements increase exponentially (see *Detection* discussion above). Given the current challenges, participants agreed that the potential to develop an aerial monitoring program should be considered in the future, as both technology and the capability of unmanned aircraft systems to detect debris improve. Monitoring teams could be asked to supplement survey data and periodic photos with a standard geo-referenced photo during every survey.

- Adding to the data collection requirements for shoreline monitoring teams could take advantage of "boots on the ground." One suggestion was that assessment of biofouling on debris items could be added to the NOAA protocol. As discussed in the *Invasive Species* topic section below, it is difficult to properly identify biofouling species and develop messaging or outreach materials regarding local versus non-native species. Thus, this could be overwhelming for volunteer monitoring teams to implement effectively, and may result in lower quality debris data. Highly trained surveyors may already be responsible for multiple tasks, as is the case for National Park Service and US Fish and Wildlife Service monitoring teams in remote regions of Alaska. To date, NOAA has asked monitoring partners to report any suspected non-native species on debris via the protocols outlined in the *Response Protocols for Biofouled Debris and Invasive Species* developed by experts at the June 2012 workshop in Portland, Oregon. Teams also could record the apparent aging of debris items, which would be useful information but similarly challenging to implement.

Data Analysis. Analysis of existing monitoring data is a priority moving forward. Given natural variability in the composition and concentration of marine debris at a shoreline site, and a lack of baseline data for comparison, it might be difficult to detect a significant influx of tsunami debris versus background levels of debris. Overlap between routine shoreline debris and JTMD adds to the challenge of detecting a distinct signal for JTMD, but there may be patterns or shifts in the relative abundance of different debris types. Longer-term monitoring programs that will continue to survey shorelines for years into the future will be more informative for assessing JTMD and developing a baseline prior to future debris-generating events. As survey data continues to be entered into the MD-MAP.net database, analysis will focus on spatial and temporal trends and changes in quantities and types of debris washing ashore. It will be important to combine debris data with an analysis of weather, currents, shoreline geomorphology, public access, and other factors that affect debris deposition or removal from a shoreline site.

Most MD-MAP monitoring partners selected their own survey sites based on criteria in the NOAA protocol documents, local knowledge, and logistics. Due to the nature of the site-selection process, it will be difficult to make regional or large-scale assessments of debris trends; assessments will be focused at the site level. Meeting participants noted that it would be beneficial for monitoring teams to receive a standard data analysis template to follow. Participants also acknowledged that future efforts may be more informative if sites are selected based on results of model simulations and oceanographic patterns. Currently, in the coastal zone, debris models do not provide enough detail to identify specific shorelines that tend to accumulate debris.

Building Capacity for Future Events. There was consensus among participants that shoreline monitoring and assessment provides useful data, is an excellent way to engage citizen scientists, and should continue beyond the response to the 2011 Japan tsunami–generated debris event. Monitoring will be most informative to response efforts as well as management of everyday marine debris when studies are designed with specific questions and primary objectives in mind. Examples include monitoring to evaluate baseline debris loads and to detect an influx in JTMD, or to measure the effectiveness of marine debris prevention efforts.

Products analyzing monitoring data may provide motivation for continued attention to the issue of marine debris beyond this one-time event. One suggestion for the transition of the current JTMD monitoring effort to a long-term program was to maintain a select number of high-quality monitoring sites. However, it will be challenging to obtain long-term funding to support volunteer coordination, database maintenance, and data analysis efforts. In order to build support to continue this project, resource managers need clear, objective-driven messages regarding the value of marine debris monitoring in assessing impacts to trust resources. Having an experienced and trained monitoring network in place will be invaluable for rapidly mobilizing monitoring partners during future response efforts.

Biofouled Debris and Invasive Species

Key summary points of this discussion were as follows:

1. **Coordinate science and management efforts**. Response to aquatic invasive species (AIS) requires coordinated science and management efforts, including a high level of taxonomic expertise obtained through existing relationships and donated time and services.
2. **Improve understanding of AIS risk**. Poor knowledge of relative AIS risk posed by different debris items, species, and distribution creates communications challenges and contributed to highly variable levels of state and local effort, concern, and priority.
3. **Enhance response to AIS with additional resources**. Gaps requiring additional resources include adequate sampling of debris items, sample analysis, data synthesis, risk assessment, and monitoring.

Lessons and Recommendations

During discussion, the *Science* break-out group identified key lessons related to AIS biofouling on tsunami debris and opportunities to address them in the future through better understanding of risks and better communication both between responders and scientists and between scientists and the public. The overall notes are captured below, organized by sub-topic.

Research and Monitoring to Inform Management. A number of key challenges exist related to scientific assessment of biofouled JTMD:

- There is a limited availability of knowledgeable, trained sampling personnel.
- Access to fresh samples is a logistical challenge, and is critical for algae.
- Sample storage can be a limiting factor.
- Experts were surprised to learn that the threat of AIS was not limited to debris originating from the marine environment (e.g., docks, buoys), but that terrestrial-origin debris (e.g., lumber) could also serve as a vector.
- Japan Tsunami Marine Debris Taxonomic Assessment Team decisions and recommendations need to be made quickly, even though they are not always straightforward. For example, even open-ocean gooseneck barnacles (*Lepas anatifera*) can harbor parasites and disease or cover non-native species of algae on debris.
- There is minimal data on background on levels of AIS, and ongoing monitoring for potential invasions is costly.

The assessment and sampling of JTMD and biofouling species is ongoing, and a backlog of samples needs to be analyzed and catalogued. In terms of next steps, the AIS discussion focused on the need for a comprehensive synthesis of biofouled debris documented to-date, as part of a larger risk analysis. A key desired output is information on which species, debris types, and locations pose the highest risk for invasions, and the resources (e.g., commercial shellfish operations) that may be threatened. This will require information on likely JTMD accumulation or drifting areas, debris abundance (propagule pressure), timing, species ecology, species life histories, tolerances and preferences, and habitat suitability.

A primary question is the relative risk of large, marine-origin debris that has the potential to carry more propagules and a higher diversity of species versus terrestrial debris (e.g., lumber) that is probably more abundant and less likely to be detected and removed on rapid timescales. Currently, limited resources have placed priority on larger items, due to limited capacity to address all of the small items. Funding is needed to facilitate this synthesis and risk analysis, which should include the following:

- An inventory of identified species, debris types, and locations.
- Synthesis to inform an assessment of relative risks in context with other vectors for the spread of AIS.
- Recommendations for risk management, including which debris types or locations to focus response and monitoring efforts.
- Development of products, messaging, and tools for communicating the risk of different debris types and AIS.

The initial steps for this assessment and synthesis may be best facilitated through a workshop to compile findings from the different geographical regions and reporting and response networks. Based on the current state of the science and capacity for analysis, the community needs to decide whether this effort would best be initiated in the short-term, or if it would be more effective to wait for more data to become available. If enough data currently does exist, an earlier starting point would provide more benefits to the response community in terms of where to prioritize efforts. Results will also be useful to build the case for additional funding to support additional monitoring and analysis.

Participants noted that there is currently no coordinated effort, standardized protocols, or sufficient resources in place to monitor the vast coastlines of North America for marine invasive species, and it is currently unknown if species transported by JTMD are established and reproducing. Detection of invasive species in marine environments is challenging and oftentimes may not be detected until years or even decades after the initial invasions. A rapid response while eradication is still economically possible is essential for minimizing the impacts from invasive species. In Hawaii, the Department of Land and Natural Resources has acquired funding from the Hawaii Invasive Species Council to initiate AIS monitoring surveys. As the abundance of JTMD and reported sightings inevitably decline, it may become even more challenging to initiate and defend a sustainable long-term program for monitoring invasive species.

JTMD and the associated biofouling sampling effort have provided the community with an opportunity to significantly advance current understanding of invasion biology and potentially contribute important information on the movement and behavior of marine debris. There are opportunities for linkages and collaboration between marine debris modeling efforts and biofouling assessments. With a given degree of uncertainty, models may be able to hindcast the likely path of debris across the Pacific Ocean. These modeling results could offer information on the environmental conditions encountered, which then could be related to the likelihood of colonization by different species. Further, oxygen isotopic and elemental composition of shell calcites can provide information on the growth history of mussels within distinct water masses, and potentially ground-truth modeled debris trajectories.

Communication. Developing accurate and informative communications regarding biofouled JTMD and the associated risk of spreading AIS presents many challenges. The following summarizes a number of observations made by meeting participants.

- Clear communication and information sharing between JTMD responders, scientists, monitoring teams, modelers, communicators, and the network of AIS experts is essential. Removal and response to debris often takes priority over biological sampling, but it is essential to sample as soon as possible, particularly before an item is moved off of the beach. Having AIS experts work in tandem with first responders potentially may be challenging during a debris response, but such experts could contribute to response decisions when a derelict vessel or other navigational hazard is sighted offshore (e.g., F/V *Ryou-un Maru* that was sighted and sank off of Alaska in the spring of 2012). Establishing relationships between response personnel and scientists is crucial; in many cases in Washington and Oregon, the sampling, assessment, and removal of debris (particularly skiffs) has been conducted very rapidly and effectively. However, further opportunity is present for improved coordination and documentation of how academics, state, and federal personnel work together to identify and assess JTMD and associated AIS. For example, it is not clear how many of the sightings reported to disasterdebris@noaa.gov are co-recorded in the biofouling register funded by the National Science Foundation and vice-versa.

- Accurate and clear messaging and communication tools for assessing and reporting biofouled debris have been difficult to develop. Oregon State University and Oregon Sea Grant created a field guide with photos of AIS and non-AIS species (http://bit.ly/1lerxpX), which can be a very useful tool for individuals that take the time to review it. Although the keystone of the outreach messaging is that *Lepas* is not a concern, networks continue to receive reports of *Lepas* biofouling.
- As is often the case with media reports on marine debris, misinformation has spread about JTMD and associated biofouling. It is difficult to clearly describe the current understanding of the risk associated with biofouled debris, and a limited amount of accurate information is available in the media. Meeting participants noted that there is an opportunity to establish key messaging regarding biofouled debris and AIS for the affected areas, particularly in advance of any reports of an established invasion. A key limiting factor is that a synthesis of research to-date and information on the relative risks of different species and debris types is ongoing.
- It is critically important to understand the concerns and priorities of target audiences when developing coordinated messaging about JTMD and biofouling. There was at least one report of a civilian in Hawaii that scraped biofouling off of a skiff onto the shoreline with the intention of taking ownership of the item, as well as others that have reportedly removed and consumed biofouling species. Lessons learned from these instances will help inform future communication strategies.

Building Capacity for Future Events. The JTMD response has highlighted the potential for everyday marine debris as a vector for the spread of AIS. A limited amount of research into biofouled anthropogenic debris existed prior to this event, and this experience offers an opportunity to transition the resulting momentum and level of interest into a long-term assessment of the potential for marine debris to contribute to marine invasions. Participants noted a few response-related gaps that could be addressed in the near-term in order to build on relationships between responders and the scientific community:

- Develop agreed-upon protocols for addressing AIS on large offshore items, including tactics to contain biofouling prior to scuttling or towing an item to shore.
- Incorporate the Japan Tsunami Marine Debris Taxonomic Assessment Team contacts into Area Contingency Plans or other response planning documents, in order to codify the network of taxonomists in the response arena.

Conclusion

The *Science* break-out group brought together a sample of personnel that were engaged in diverse but overlapping elements of scientific work that informed and supported the response to JTMD. As mentioned in the *Introduction*, while the expertise, training, and experience of the attendees provided different perspectives, clear consensus still emerged on several common threads that ran through each of the four topic areas. Many of these also touched on the *Response* and *Communications* areas of the JTMD response.

There are many specific needs and opportunities that were identified within each of the *Science* topic areas. One key point noted throughout the discussion was the combined opportunity and need to leverage the existing high-level of interest in JTMD toward support for research and work on the overall marine debris issue and preparation for potential future acute debris events. With ongoing effort and collaboration, the marine debris community can build off of the lessons learned from JTMD to continue advancing the state of knowledge and understanding on the abundance, impact, and means of mitigation for marine debris, regardless of the source.

Response

Participants in the *Response* break-out group were provided with the agenda for this session ahead of time and were asked to consider and list lessons learned from the 2011 Japan tsunami marine debris (JTMD) response along with recommendations for four major activities:

1. Agency roles during large-scale marine debris event
2. Planning for future large-scale marine debris response
3. Preventing hazards to navigation, and
4. Funding.

In the first of two *Response* break-out sessions at the 2014 JTMD Meeting, the group addressed the first two topics and addressed the remaining two the next day. Numerous lessons and recommendations emerged during the discussion. At the end of the second session, participants were asked to list remaining recommendations on sticky notes. The summary of the discussion, lessons, and recommendations is provided below.

Agency Roles in Marine Debris Response

The first objective was to determine which agency is responsible for which activities during a response to a large marine debris item (e.g., a floating dock), and identify resources, such as supporting agencies and cleanup groups. Participants agreed that having clear agency roles during the response to JTMD were very helpful, and that delineating agencies' roles and responsibilities for future severe marine debris events is critical. Several major issues were identified for this topic.

Defining "Response"

Marine debris poses a challenge to the response community. Spill responders are generally familiar with oil and chemical spill response, but the response to JTMD was new for most of them and needed definition. The experience responding to JTMD helped participants clarify what responding to marine debris entails.

Marine debris response is warranted when:

- The quantity of small marine debris items (which can be carried by one or two people) exceeds the capacity of local volunteers to deal with it, and additional resources are needed.
- Removal requires equipment such as a front loader and trailer, as in the case of medium-sized debris.
- Massive effort and equipment may be required to remove large marine debris on shore (e.g., dock).

- Large marine debris objects at sea pose a hazard to navigation, and require agencies to respond to address it.
- Marine debris contains hazardous material, such as gas cylinders or fuel tanks, and need a specialized response to handle and dispose of it.
- After a massive storm (e.g., Hurricanes Katrina, Sandy), large amounts of marine debris may sink nearshore, and require extensive surveying and large-scale, complex removal.
- Aquatic invasive species are present on marine debris.
- Marine debris requires prompt removal because it is abrading and otherwise damaging protected resources, such as coral reefs.

Scenarios falling into the above categories will require the response and participation of agencies beyond normal marine debris cleanup activity, which is done mostly by volunteers.

Marine Debris Response Roles and Structure

Participants agreed that while significant progress occurred during the response to JTMD, agencies' roles and overall response structure to address severe marine debris events may be improved further. Specific recommendations included the following:

- Local, state, and federal agencies need to determine the gaps in agencies' roles during response to severe marine debris events, and provide a plan to address these gaps. Examples included identifying which agency responds to a large marine debris object at sea; the role of local, state, and federal agencies in responding to a severe marine debris event; and who pays for the response activities.
- The creation of task forces to address JTMD in Washington and Oregon proved to be useful and effective in assigning roles and responsibilities to state agencies. A similar structure is recommended for federal agencies participating in a response to severe marine debris events.
- It took a while for the state and federal governments to assign a lead agency, which had an impact on the response. The lead agency for severe marine debris events should be determined and assigned in advance.
- Having an Emergency Management Agency as the lead at the state level is effective for short-term response, but may be less effective for a response that lasts a long time. For example, in Oregon, the Oregon Parks and Recreation Department took the lead in responding to JTMD, including the removal of the Misawa dock which beached near Newport, Oregon, in June 2012.
- Participants agreed that NOAA MDP, as it is currently mandated, is not an adequate marine debris response agency. The program should be provided with the latitude, authority, and means, including funding, to respond to future severe marine debris events.
- Participants recommended examining the role of the Federal Emergency Management Agency (FEMA) during the response to a severe marine debris event. FEMA provided funding to address damage sustained by U.S. coastal communities in the immediate aftermath of the March 2011 Japan tsunami, but not for later damage from the same tsunami, in the form of two floating docks washing up on U.S. shores and requiring removal. Participants noted that current laws restrict FEMA's involvement only to efforts that fall under disaster declarations, but severe marine debris events may challenge the response community with emergencies difficult to define under current law. Regardless, even if FEMA is unable to provide assistance, participants recommended FEMA be invited to clarify if, when, and under which circumstances local or state expenses from large marine debris cleanup might be eligible for reimbursement, and to clarify FEMA's role under these circumstances.
- Likewise, participants recommended defining the role of the U.S. Army Corps of Engineers after a severe marine debris event, especially with regard to debris removal.

- Participants recommended developing guidelines for disaster proclamations for marine debris events, including potential impact from aquatic invasive species, which may have far-reaching ecological and economic consequences.
- Indian Tribes in the impacted area should be incorporated into the response structure.
- In addition to state and federal agencies, stakeholders and other players unique to marine debris incidents should be identified, along with their roles in a response. For example, volunteers and nongovernmental organizations (NGOs), such as Surfrider, contributed greatly to the cleanup of routine small debris along the west coast. A task force could determine stakeholders for large-scale marine debris events prior to an event occurring. This task force would identify participants for future response activities and these participants should receive any appropriate training.

Coordination

A recurring theme in the meeting was the critical role of collaboration and coordination. Complex and multi-faceted, the response to JTMD benefited greatly from both international collaboration and collaboration among federal agencies, states, Indian Tribes, local agencies, NGOs, academia, and other participating entities. Multi-agency collaboration on the response to JTMD may have taken longer than unilateral response, but the solutions were more comprehensive, and having buy-in from all the groups involved proved very helpful. A number of specific suggestions related to coordination were offered for future severe debris events:

- Coordination among the responding agencies should start as early as possible. A marine debris emergency response plan could facilitate early coordination.
- The Incident Command System (ICS), which works well for oil and chemical spill response, is not the appropriate coordination vehicle for response to severe marine debris events, such as JTMD. Severe marine debris events may unfold slowly and last for months, even years, but the ICS is better suited to short-term and high-intensity responses.
- Responders should consider using the Multi Agency Coordination System (MACS) as a tool to increase collaboration among agencies. This approach would involve forming a task team to identify agencies and entities to serve on the MACS during large-scale marine debris events, and identifying lead agencies to coordinate and convene the MACS.
- The NOAA bi-weekly JTMD calls were an effective communication tool that facilitated coordination and collaboration. Participants recommended using a similar format for the next multi-agency, large-scale marine debris response.
- The coordination with the Government of Japan was very effective, and should be used as a template for effective coordination and cooperation in future multi-national marine debris events.
- The response to JTMD created a network of experts as well as a response structure and protocols that should be maintained. This translates to continuing the collaborative effort within the JTMD response network and establishing a working group with appropriate stakeholders to continue the mission of marine debris awareness.

Planning for a Severe Marine Debris Event

The second objective of the *Response* break-out group was to brainstorm ideas to improve planning and coordination. This included examining two questions:

- *Is the Incident Command System (ICS) an option for a large scale marine debris response?*
- *Does each state have its own plan in place?*

Participants acknowledged that in the early phases of the response to JTMD, plans to address this unprecedented severe marine debris event did not exist. As the response to JTMD unfolded, it became clear that a one-size-fits-all plan would not adequately address the various needs, political structures, and on-the-ground conditions across five states, numerous federal agencies, Indian Tribes, NGOs, and other entities involved. As the lead federal agency, NOAA worked with the states to draft JTMD response plans that best addressed the needs of each state.

The Planning Process

A number of recommendations were offered to enhance the planning process:

- Establish a relationship among the partners responding to the severe marine debris event. Creating and maintaining connections among all the people involved enables successful planning. This could be begun by bringing together all entities for a meeting or workshop.
- Review who needs to be at the table and is not yet there, and invite them to join the planning process. Partners such as landowners, local agencies (e.g., county emergency managers), and Indian Tribes should be part of the planning process and provide input to the response plan.
- Acknowledge that planning takes resources and provide the resources needed (staff time, travel, meeting place, etc.) to facilitate the planning.
- Account for state and regional differences. A response plan that works well for one state may not work well for another.
- Allow for review and comment by all partners as the response plan is being developed.
- As with most other response plans, allow for periodic review and modification. The marine debris response plan needs to have an appropriate agency-of-contact to maintain and update the plan.
- Develop a marine debris emergency response plan in each state and at the federal level. Participants agreed that the marine debris emergency response plans already developed and signed by the governors of states affected by JTMD are a valuable resource, and should be referenced in their Area Contingency Plans.
- Share information pertinent to debris response planning on a single, centralized website. NOAA should consider taking the lead in developing this resource.
- Build relationships and strengthen communication between NOAA Marine Debris Program regional coordinators and states to prepare for responding to similar severe marine debris events. Regional coordinators should provide coordination services among response agencies. Coordinators must understand the regulations that guide the actions of partners, such as states, U.S. Environmental Protection Agency, U.S. Coast Guard, and FEMA. Coordinators may need additional funding to support this expanded role.

Elements of a Debris Response Plan

Participants agreed that, in general, an effective plan to address severe marine debris events should cover a number of elements, including authority, roles and responsibilities of responding agencies, communications, and response options for marine debris of different sizes on land and at sea, as well as to hazardous marine debris. Existing plans developed to address JTMD include the above. In addition, participants recommended considering the following:

Roles and responsibilities. NOAA MDP should produce, in plain language, an outline of federal agency responsibilities, mandates, and limitations during a severe marine debris response in order to provide guidance to state and local entities.

Local response. When addressing roles and responsibilities in a response plan, planners should consider that first response usually occurs at the local level. In the plan, include the authority, roles, and responsibilities of local response entities, as well as the support they might need to be successful.

Debris at sea. Currently available marine debris response plans do not delineate clearly which agency should respond to marine debris at sea which is large enough to pose a hazard to navigation. Compile information on authorities and regulations on topics such as scuttling at sea and towing to have available to responders before and during a response.

Funding. Participants agreed that a response plan should address funding. Establish clearly what role federal agencies intend to take with regard to funding. State and local agency ability to participate may be limited in the absence of adequate funding. The marine debris response plan could include a flow chart outlining funding sources.

Communications. Communication is an integral part of the response and must be included in the marine debris response plan. To be effective, the public information officers (PIO) of the various response entities should establish and communicate the same message, and then stay on message. Response operations should support communications (e.g., provide accurate information, photos, location, etc.) and work with the PIO on crafting effective messages. Likewise, communication should support the response by providing important information to the public (e.g., what to do with different debris types) and dealing with the media and political leadership.

Additional planning tools. Develop job aids and guides to assist in responding to marine debris. Such job aids exists for oil and chemical spills and are very helpful. Examples include a job aid or checklist for notification of the relevant authorities, a standardized shoreline impact matrix to estimate marine debris coverage (light, medium, or heavy), a marine debris removal cost estimator, and marine debris handling guidelines.

Preventing Hazards to Navigation

The *Response* break-out group's third objective was to identify actions to prevent hazards to navigation from large debris.

The March 2011 Japan earthquake and tsunami resulted in many large pieces of debris with the potential to be hazards to navigation. Participants identified actions that occurred during the JTMD response that were helpful for preventing hazards to navigation from large debris. These included issuing maritime advisories from the U.S. Coast Guard and U.S. Department of Transportation Maritime Administration, mapping known floating items, outreach to local fishermen and shippers about known hazards, sharing information between governments about the locations of items, and using models to predict debris locations. Initial vessel-based survey and assessment done after a major marine debris event are a possible mechanism for incorporating preventative measures in the future.

The participants also recognized the challenges of responding to navigational hazards. During the JTMD response, an interagency team did not exist to discuss and exchange information regarding known and potential navigational hazards. In addition, regulations that require governments to identify boat owners prior to removal often hamper removal efforts. Even after owner identification, many boats do not carry insurance that could help fund their salvage and disposal. For boats that do have insurance, organizations or governments may need to fund the removal and then recover costs through insurance, while in other instances, the insurance company may provide payment prior to removal.

Stakeholders need to consider floating debris liability issues as well. Due to Coast Guard regulations, the agency is liable for the disposal of a derelict vessel if the Coast Guard tows that vessel to shore. When a floating debris item is brought to shore, aquatic invasive species may be attached to the debris and require attention. There are also issues with intentional sinking of debris, as this constitutes ocean dumping under the Marine Protection, Research, and Sanctuaries Act, also known as the Ocean Dumping Act.

Recognizing the challenges surrounding the JTMD hazards to navigation response, participants offered the following suggestions for improving future responses:

- During future responses, an interagency operational team should discuss and exchange information regarding where hazards to navigation exist, and make decisions about debris posing such hazards. This group also should determine which agency has the authority to warn recreational boaters about hazardous debris. These marine users often are unaware of maritime advisories, meaning the most effective communication method for reaching this community still needs to be determined.
- Debris response partners and others unfamiliar with issues related to navigational hazards could benefit from developing guidance documents summarizing regulations, authorities, and the process for dealing with hazardous debris.
- Participants recommended developing procedures for dealing with debris before it reaches shore. A potential vehicle for at-sea removal of debris is the U.S. Coast Guard's Basic Ordering Agreements (BOA). BOAs set removal prices with salvage companies. The Coast Guard should look into expanding these agreements nationwide.
- Placing Global Positioning System (GPS)-enabled beacons on floating debris items would enable responders to track debris items as currents carry them away from land. This location information would also help to inform modeling results. Placement of the beacons could possibly occur shortly after a severe marine debris event. These tracking beacons are often inexpensive and can last for several years with solar power.
- The participants recommended that Congress consider changes to legislation relevant to severe marine debris events and address the regulatory limits of each agency involved. For example, changes to ocean dumping regulations would enable scuttling of debris if necessary. Participants recommended the development of criteria that would help in determining whether to sink floating debris.
- Discussions also focused on alternative methods of bringing agencies together during a severe marine debris event. For example, Coast Guard and state land managers could investigate the possibility of a Memorandum of Understanding that enables the Coast Guard to tow debris to land if the state land management agency agrees to fund the removal and disposal. Participants acknowledged that there might be liability issues with this method. State and local governments could explore the creation of marine debris cooperatives. A potential model for this would be the Washington-Oregon marine firefighting cooperative. Commercial fishermen could conduct at-sea debris removal, similar to the process of using vessels of opportunity during oil spill response. There are funding and liability issues associated with this option.

Funding
The final objective of the Response break-out group was to identify which agency does pay—and which should pay—in the case of large-scale, multinational marine debris response events. In particular, the group discussed what would have happened had the Government of Japan not supplied $5 million in funding for debris response and removal efforts.

Following the beaching of Japan tsunami marine debris in the Northeast Pacific Ocean, the United States government received a gift of $5 million from the Government of Japan. The Government of Canada also received $1 million from Japan. Governments used this money in areas affected by debris generated by the 2011 tsunami. These generous gifts were instrumental in enabling the removal of debris in Hawaii, Alaska, Washington, Oregon, California, and British Columbia. In Alaska, several NGOs received funding from the state to conduct debris cleanups. In Washington, the state marine debris emergency response plan outlined a procedure for non-state landowners to request assistance from the state. The landowner would then provide oversight for any cleanup work.

Discussion by participants focused on who should pay for response during large multinational marine debris events, particularly events where a large funding source, such as the gift from Japan, is not available. Suggestions included alternative funding sources and procedures to streamline future funding allocations.

Participants recommended that local governments include the costs of marine debris in emergency response plans. The coordinating response organization should have a system for estimating the environmental and economic costs of severe marine debris events. Local, state, and federal legislatures and agencies should receive these estimates in order to inform the funding process. These response plans should also include a flow chart that outlines funding sources. For events where funding is not readily available, participants recommended that a procedure be established to determine the most significant debris. The procedure could establish significance based on the potential environmental and economic effects of the debris, as well as any additional factors determined to be relevant. In cases where focus is on the most significant debris, the government should communicate these funding decisions to the public.

Marine debris response plans should include reimbursement procedures for governments or agencies that respond to severe marine debris events prior to securing funding. The JTMD funding agreements between NOAA and the states are effective for five years. Participants recommended that future agreements should not expire. In this way, funding transfers to state governments could occur quickly following a severe marine debris event.

Participants recommended the creation of a dedicated fund to finance response to severe marine debris events. This fund would be similar to the Oil Spill Liability Trust Fund, a national fund established under the Oil Pollution of Act of 1990, which covers the cost of oil spill cleanup and damages in the event that the party responsible for the oil release is unknown or refuses to pay. Participants mentioned that other marine debris event responses, such as the responses to Hurricanes Katrina and Sandy, would have benefited from a dedicated funding source. Severe storm events are predicted to increase in severity and frequency due to climate change, making a fund like this critical.

Alternative funding sources that state and local governments could investigate include the following:

- Clean Water Act Section 319 Nonpoint Source grants.
- NOAA Community-based Marine Debris Removal grants.
- FEMA funds for emergency or disaster debris.
- Creation of state-level abandoned and derelict vessel funds.
- Cost recovery from responsible parties and/or insurance companies.
- Near-shore and intertidal cooperative agreements and grants.

Conclusion

In summary, during the discussion participants mentioned a number of factors as important for a successful response. Yet two factors were identified as the most important ones: **collaboration** and **funding**. The response to JTMD was complex and unprecedented, and collaboration among the different response entities was critical. However, even the best, most collaborative team cannot accomplish its mission without funding. The group emphasized that future response to severe marine debris events must be collaborative and must have the funding needed to carry out its tasks.

Communications

The Communications break-out group constituted representatives from the Makah Indian Tribe, federal and state agencies, and the Japan Consulate General. During the JTMD Summary Meeting, participants discussed four main areas related to communications and outreach about Japan tsunami marine debris, and concluded by developing a framework to guide communications efforts in the case of future events. The break-out session covered the following:

1. Communications needs
2. Messaging
3. Myths and rumors
4. Effective information dissemination, and
5. Building a communications plan framework.

A summary of the resulting discussion, lessons, and recommendations is provided below.

Early Communications Needs

In the first session of the *Communications* breakout group, the participants discussed early communication needs and efforts from the first six months following the disaster, roughly from March to September of 2011. The objective was to improve understanding of the importance of early communications efforts that took place during that time. They considered two key questions:

- *What were the early communications needs to prepare impacted states for the arrival of the tsunami debris?*
- *How did we address these needs and how can we improve for next time?*

Suggestions from the group generally fell into three categories, with the common theme of early action uniting them. The group felt that, had a communications team and plan been in place in advance of the 2011 Japan tsunami, it would have been easier to get out in front of the tsunami debris issue and provide quick and coordinated information to the public. However, they recognized that the tsunami debris event was unprecedented for the United States and a network was not yet in place because of the difficulty in anticipating a debris situation of this scale and nature.

Interagency Communication and Coordination

The major theme throughout this break-out session, as well as the full meeting, was interagency communication and coordination. The participants identified a need to form an interagency and stakeholder communications team quickly following the event, identify spokespersons, and create state-by-state contact lists. Such a group would have needed to regularly exchange information and create united, accurate messages for the public, media, and special audiences. By not having this team in place immediately, the media and interested stakeholders were seeking information elsewhere.

One challenge the *Communications* break-out group identified was uncertainty in the early months over whether the tsunami debris would even impact particular coastal states. This meant that, at the time, some state agencies' leadership was not supportive of responding to the issue or allocating resources to it. This prevented some states from becoming fully ingrained in budding communications efforts or knowing what resources and funding to put toward them.

An effort the group identified as useful was the NOAA Marine Debris Program–led, biweekly update calls, which began in December 2011. These interagency calls provided an opportunity for the response, science, and communications points of contact from federal and state agencies to exchange information every two weeks. Some states, in particular Washington and Oregon, eventually launched regular communication team calls within their states, but it would likely have been beneficial to create an interagency, interstate communications call similar to the larger NOAA call right away.

Identifying General Roles and Responsibilities

The Communications break-out group participants agreed that while it is important to identify roles and responsibilities within an interagency communications team, it is critical for the community as a whole to first understand operational and science roles, mandates, responsibilities, capabilities, and limitations in advance of a severe marine debris event.

In the early months after the Japan tsunami, it was difficult to form a team and begin communicating about tsunami debris because it was not clear which agencies could or would participate in a response. The "who will do what and how" was not yet defined, which created confusion and hindered communications efforts.

Preparedness and Anticipation

Building on the discussion about interagency coordination and team building, participants also felt that preparedness and the ability to anticipate problems were critical to their work. In other words, acting quickly after a major event is important, but so is having an infrastructure in place that allows you to act quickly. They decided that, in the tsunami debris case, there was a failure to recognize the risk of debris becoming a major issue or that there would be significant communication challenges surrounding rumors and misinformation. By not anticipating such issues, the organizations involved in the debris response lost control of the message, with subsequent communications being reactive instead of proactive. The group emphasized the need to have a communications plan and process in place prior to disasters occurring.

Communication Tools

In addition to a team framework, the *Communications* group identified a need to create communication tools quickly in order to get out in front of the issue. Some ideas for such tools included basic media statements—even if information was not yet available, online answers to frequently asked questions (FAQs), and active media monitoring. Not having a strong first message about the tsunami debris meant that media and outside groups set the tone for discussions of the issue. The group identified necessary communications tools, including:

- Strong, accurate talking points and messages
- A basic statement for media and websites
- One central website for information
- Frequently asked questions, and
- Media monitoring.

The participants rated how well they felt the marine debris response community executed each of the early communications needs on a scale of 0–3 (*0=did not address, 1=fair, 2=well, 3=excellent*). All agreed that, even though communications became more organized and effective as debris began hitting U.S. shores in 2012, the first six months of the effort garnered mostly 0s and 1s.

Recommendations for Future Events

During discussion, the *Communications* break-out group identified key lessons related to early communications needs surrounding tsunami debris and made the following recommendations for addressing them in the future:

- Recognize communications as a priority and make them part of the planning process.
- Have an interagency communications plan and partner contact list in place in advance.
- Begin coordination calls right away, identify resources, and prepare necessary communications tools.
- Facilitate early communications between decision-makers and partners to identify roles and responsibilities.
- Involve leadership early—including state governors and congressional members.
- Leverage existing information (e.g., joint information center protocols) that can help expedite decisions.

Messaging

In the next break-out session, the *Communications* group focused on the messages they provided to the public—either directly or via the media—and to leadership over the course of the response, rather than on actions taken. The objective of this session was to increase understanding of the challenges of messaging and ways to improve credibility with the public. They considered these questions:

- *What were the messages provided to the public and leadership and did they convey accurate, timely information?*
- *What worked about the messages and what were the challenges?*
- *How can we improve for next time?*

The group looked back on talking points, web content, and information provided to media during the response. The messages within that information addressed questions that generally fell into four categories:

1. **Nature of the Debris**. Many early questions from the public focused on the volume of tsunami debris in the ocean and what types were floating.

   Examples of messages provided:

   - "The Government of Japan estimated in March 2012 that the tsunami swept about 5 million tons of debris into the ocean and that about 70 percent sank quickly. The remaining debris was dispersed far across the North Pacific, an area of ocean roughly three times the size of the lower 48 states. Some debris has already reached U.S. and Canadian shores, and is expected to continue over the next several years. At this time, there is no way to accurately estimate how much debris is still floating—some likely sank or deteriorated."

   - "While we do not know exactly what debris is still floating at or near the ocean surface, it is likely highly buoyant materials, such as buoys and other fishing gear, lumber, plastic items of different types, drums, and possibly vessels."

2. **Science and Detection**. Similarly, many of the questions received on tsunami debris focused on debris location, where the main concentration of debris was heading, and when it would arrive. To answer these questions, those involved in the *Communications* group turned to on-going

detection efforts, including modeling, satellite searches, and information from at-sea visual observations.

Example of messages provided:

- "Marine debris is pushed through the ocean by wind and currents, and no one is able to accurately predict how winds and currents will behave far in advance. NOAA's models give us an understanding of where debris is located today, but they do not predict where debris will go in the future."

3. **Myths and Rumors**. A great deal of the communication on tsunami debris involved dispelling myths and rumors that started in part due to uncertainty over the arrival of the debris and speculation on whether it would be radioactive.

Example of messages provided:

- "The image of a massive 'flotilla' of debris headed toward U.S. shores is dramatic, but not realistic. Large debris fields spotted off the Japan coast after the disaster are now gone."

- "Radiation experts agree that it is highly unlikely that any tsunami generated marine debris will hold harmful levels of radiation from the Fukushima nuclear emergency. Some debris in West Coast states has been tested, including items known to be from the tsunami, and no radioactive contamination above normal was found. Marine debris in Hawaii has been monitored since April 2011, and no radioactive contamination above normal levels has been found."

4. **Government Efforts.** Another piece of information that the public and leadership frequently requested was how federal and state agencies were responding to the debris.

Example of messages provided:

- From NOAA: "NOAA is leading efforts with federal, state, and local partners to collect data, assess the debris, and reduce possible impacts to our natural resources and coastal communities."
- From Oregon: "A partnership of agencies and nonprofits are working with coordination help from Oregon Emergency Management and NOAA—the lead federal agency—to manage the increase in beach debris. By working together—SOLVE, Surfrider Foundation, Sea Grant, CoastWatch, Washed Ashore, U.S. Coast Guard and other federal agencies, your local counties, cities and ports, and state departments of Environmental Quality, Parks, and Fish and Wildlife—we are all pitching in to collect debris and dispose of it through recycling and landfills."

Challenges and Successes

The biggest challenge this break-out group identified with messaging was that it was difficult to clearly explain why federal and state agencies could not provide more answers about the debris. Even in situations where information was impossible to obtain, such as answering where all the debris was located at sea, audiences either were not satisfied or did not believe the messages. For example, because people believed the debris was moving across the ocean in a large mass on the ocean surface, there was a great deal of frustration over statements that debris was not visible from satellites or planes. There was difficulty explaining to non-experts the barriers involved with finding debris through satellites and that the size of the North Pacific Ocean presents a major challenge.

Similarly, the group found it challenging to highlight model results in a way that was not confusing or susceptible to misinterpretation. In some cases, the model outputs themselves became a source of rumors about a "mass" or "island" of debris crossing the ocean, because the graphic visualization of the predicted debris movement was misleading to those unfamiliar with its nuance. The resulting misunderstanding was propagated across the Internet and difficult to address.

The group agreed that once it identified local, credible experts to help reinforce the messages that dispelled myths, it was easier to counteract the claims. Reinforcing information through multiple platforms also proved successful. For example, the Makah Indian Tribe created signage on dumpsters during annual beach cleanup events, which helped dispel concerns over debris radiation.

Recommendations for Future Events

During discussion, this group identified key lessons related to messaging on tsunami debris and made the following recommendations for addressing them in the future:

- Publicly address a situation early (preferably first) so that media and the public turn to the government as a source of information.
- Emphasize actions the agency or group is taking to find answers, rather than focusing on the unknowns.
- Show empathy and clearly acknowledge concerns over potential impacts to communities.
- Thoroughly vet visual communication products—including infographics and photographs—for unintended messages before they are released to the public, and embed information that cannot be removed from them.
- Empower people with the tools they need to take action on their own—no matter how small.
- Put the problem in perspective for the general public by painting visual pictures that show the scale of the problem.
- Identify local experts to help carry messages that dispel myths.
- Repeat key messages in every public communication opportunity.
- Ensure that all stakeholders—response teams, scientists, and communicators in all impacted areas—have access to the same talking points.

Myths and Rumors

Next, the group came together specifically to discuss the myths associated with tsunami debris and how the communications team addressed them. The objective was to brainstorm the effectiveness of myth-busting to improve techniques in anticipation of the next event. They considered these questions:

- *Describe rumors and myths that arose and how we dealt with them.*
- *What worked? What didn't work?*
- *How can we improve for next time?*

The group came up with general myths or rumors that emerged initially or continued to persist among the public. These myths included the following:

- Human remains from Japan will arrive with tsunami debris.
- The debris will be radioactive.

- The debris will arrive as a large, toxic “mass” or “island,” and that it would contain cars and entire homes.
- The government has the power to take care of the whole situation but is choosing not to do anything.
- Not a myth, but a sentiment: Japan is responsible for cleaning up the debris.

The group identified two main challenges with myth busting, the first being that there is a culture within government agencies not to respond to misinformation or alarmists. In some cases, not responding to myths made them worse, because the silence was interpreted as agreement.

Another challenge was finding experts who were willing to be a spokesperson on the issue of Japan tsunami marine debris. When an agency is dealing with rumors that are outside of the realm of their expertise, there can be difficulty finding someone else who can dedicate time to speaking on the record. However, once local, credible experts came forward on issues such as radiation, the *Communications* break-out group noted that correct information more easily gained traction with the public.

While there were challenges, the group found some successes at myth-busting, including:

- **Signage.** Creating signage for public access beaches and recreational areas was a low-resource but effective way to spread information and calm fears.
- **Social media.** The group identified social media as an effective tool for quick myth-busting; it gets the information out quickly and can be spread quickly.
- **Face-to-face communications.** Meetings are ideal places for quick fact checking.
- **Context.** Painting a picture that the public can understand – for example, helping them to understand tsunami debris in the context of the larger debris problem – is helpful.
- **Showing and telling.** Instances where we showed what we were doing, rather than just saying so, helped lend credibility.

Public Sentiment: A Name Problem?

One difficulty the group identified was the misperception out in the public that all marine debris found on the West Coast comes from Japan. In fact, not every item found on our shorelines is from the tsunami. Marine debris is a persistent pollution issue, especially around the Pacific.

This misperception could have been fueled by the debris’ nickname “Japan Tsunami Marine Debris.” Linking marine debris to Japan may have left a lasting impression in beachgoers’ minds.

Recommendations for Future Events

During discussion, the *Communications* break-out group identified key lessons related to myths surrounding tsunami debris and made the following recommendations for addressing them in the future:

- Create a team specifically to anticipate and quickly address myths. Assign someone on the team with the responsibility of ensuring all stakeholders, especially those working on science and operations, have the same information.
- Secure experts to help dispel myths and alert science and operations teams that they may be expected to help address a rumor that has become the “issue of the day.”
- Find a local, trusted voice to pair up with agency scientists and help myth-bust.

Effective Information Dissemination

Next, the *Communications* break-out group discussed which methods of information dissemination were most effective during the tsunami debris response. They considered the following questions:

- *What materials and channels were the most effective ways to communicate regular information (e.g., media, fact sheets, town hall meetings, etc.)?*
- *What was missing?*

Effective Channels During JTMD Response	Discussion	Suggested Improvements
Interagency conference calls	Well-moderated, consistent interagency calls were a critical forum for information exchange.	Encourage all participants to engage actively, facilitating more of a discussion than a dialogue. Consider a separate communications call afterward.
Face-to-face meetings with stakeholder groups	These meetings provide the ability to myth-bust on the spot and lend credibility to government response.	Increase the number of meetings; dedicate more time and resources to this effort.
General facts/FAQs online	Extremely effective tool for answering media questions and providing a basic understanding.	Coordinate across all agencies on FAQs that need answering; appoint someone to ensure all FAQs remain up to date.
Joint Information Center (JIC)-type websites	Need a centralized, multi-agency website where all the latest information is hosted. "JIC" website was set up at an early date but not maintained.	After the "JIC" stops being useful, add a website redirect to send the public to a website that is maintained.
Consistent messaging and talking points	A good set of talking points are the basis for all other communications. Create these early and obtain approval from partners.	Ensure talking points are regularly updated and distributed across all agencies and groups working on the issue. Include answers to tough questions (not FAQs), anticipating how to respond if asked.
Community network email updates or listserves	Effective way to disseminate multiple layers of information. Listserves can distribute a large amount of information without first going through media.	Consider pursuing "bulletin board" style internet forums with comment threads/topics. Set up forum for email list communication (every other month) to send updates on reported sightings. Easy to provide to individual leaderships and good to show the event is ongoing.
Social media	Twitter was effective for quick myth-busting.	Have a more consistent social media strategy and coordinate among agencies. (See more below.)
Signage	Signs can help dispel myths and provide many levels of information.	
Videos	The Thank You Ocean video in California reached a lot of people, helping dispel myths. Videos can be effective.	Ensure videos contain information that will not need frequent updating. Videos are hard to take down.

Missing Elements

- A strategic, coordinated social media campaign. Certain platforms were used ad hoc.
- A boilerplate PowerPoint presentation with basic information for all stakeholders to use. This could take the place of repeated, resource-intensive, face-to-face meetings.
- Public surveys to assess public perceptions before and after communications efforts take place, in order to assess their effectiveness. This would be handled by state or local groups.
- Good photos and videos to help tell the story.

Communications Plan Framework

After the discussions on communications needs, messaging, myth busting, and effective information dissemination, the group focused attention on the next task: building a communications framework. In the months following the JTMD Summary Meeting, the NOAA Marine Debris Program plans to incorporate the comments captured in this section into the framework and build an interagency plan that can be executed when severe marine debris events occur on the West Coast. The intent of forming a plan in advance is to keep the network of communications leads in place and create long-lasting connections between organizations.

The NOAA Marine Debris Program's communications lead started off the session with a brief introduction to crisis and risk communications. The principles introduced to the group were based on the Center for Disease Control's Crisis and Emergency Risk Communication (CERC) program, which draws from lessons learned during public health emergencies, and incorporates best practices from the fields of risk and crisis communication. The manual, which provides adaptable tools and advice for communication s planning, can be found at: http://emergency.cdc.gov/cerc/pdf/CERC_2012edition.pdf.

The main principles of effective crisis communications the group considered were as follows:

- Be first.
- Be right.
- Be credible.
- Express empathy.
- Promote action.
- Show respect.

The *Communications* break-out group received an outline of an interagency communications plan (Appendix 4) and broke into smaller groups to discuss it. They received instructions to provide first, feedback on the contents of the framework and second, any missing elements or suggestions for improvement. The intention was to create a focused, accessible document that provides must-have information, allows the team to accomplish tasks quickly, mobilizes shared resources, and establishes a process and basic structure that can be adapted easily. The recommendations for the plan were as follows:

- Create a separate, adaptable framework that can be executed for short-term, focused emergency responses. This can feed into a larger plan, which should be aimed at longer-term responses.
- Clearly identify roles and responsibilities at the start of each incident and have the communications points of contact and their supervisors agree on certain tasks.
- Set up a review loop to identify which reviewers are critical and clearly lay out an information review process to reduce miscommunication regarding which agency releases what and when.
- Include a section to identify communications funding in order to prioritize activities.

- Identify a point person or team for rapid response to rumors and misinformation that includes federal, state, and local members, including tribes.
- Identify methods to proactively insert communications into science and response efforts.
- Identify backup spokespersons so there is no single point of failure when media requests come in; identify opportunities to keep spokespersons trained.
- Clearly identify which messages are for which audiences—external versus internal—and who is response for delivering the respective messages.
- Identify resources for translating information into languages other than English.

Overall Communications Lessons

At the end of the *Communications* break-out session, the group recorded overall communications lessons learned from the experience with Japan tsunami marine debris. These were the top categories:

- Have a communications plan and execute it early, recognizing that there may be a need to speak to the public before all the information is available (be first, be right, be credible).
- Dispel myths and rumors quickly with local, credible sources acting as spokespersons.
- Coordinate internally: get to know potential partners before a disaster.
- Focus efforts on effective public communication tools, such as face-to-face meetings.
- Early monitoring of media and press is essential.
- Include leadership in the communications process early and make sure they understand the resource needs throughout the response.

A List of Next Steps for the Communications Teams Following the Workshop:

- *Assess ways to continue an information exchange modeled after bi-weekly interagency calls.*
- *Find a way to maintain the network created by the JTMD response.*
- *Update current talking points to reflect the long-term outlook for JTMD (e.g., when will the "tsunami debris" become just "marine debris"?)*
- *Follow up on establishing a marine debris trust fund modeled after the Oil Spill Liability Trust Fund.*
- *Create a plan to educate science and response teams on the role of communications.*
- *Schedule follow up calls for a marine debris trust fund for emergency incidents.*

Conclusions

The Japan tsunami marine debris, a result of the tragic earthquake and tsunami that struck Japan on March 11, 2011, is an unprecedented event that has posed many challenges. While debris items, washed out to sea by the tsunami, will keep coming ashore in North America, Hawaii, and elsewhere for years to come, much has been learned on how to best conduct the science, response, and communication for this, and future such event. It is hoped that the collaborative and effective JTMD network formed to respond to this event will continue its productive work as long as necessary, and that the lessons learned and recommendations, captured during the Japan Tsunami Marine Debris Summary Meeting and presented in this document, will assist anyone responding to a severe marine debris event.

Appendix 1: Additional JTMD Information

NOAA Marine Debris Program: http://marinedebris.noaa.gov/tsunamidebris/faqs.html
Government of Japan: http://www.kantei.go.jp/jp/singi/kaiyou/hyouryuu/qanda_eng.html
Alaska: http://dec.alaska.gov/commish/tsunami-debris/
Washington: http://marinedebris.wa.gov/
Oregon: http://www.oregon.gov/OPRD/PARKS/Pages/tsunami_debris.aspx
California: http://www.coastal.ca.gov/publiced/jtmd/jtmd.html
Hawaii: http://dlnr.hawaii.gov/blog/2013/01/28/japan-tsunami-marine-debris-general-guidelines/
British Columbia: http://env.gov.bc.ca/epd/tsunami-debris/index.htm
Aquatic Nuisance Species Task Force: http://www.anstaskforce.gov/Tsunami.html
Hawaii International Pacific Research Center: http://iprc.soest.hawaii.edu/
NOAA JTMD Report to Congress, August 2013:
http://marinedebris.noaa.gov/sites/default/files/Japan_Tsunami_Marine_Debris_Report.pdf

Appendix 2: Meeting Agenda

Japan Tsunami Marine Debris Summary Meeting

NOAA Western Regional Campus, Seattle, Washington, May 13–14, 2014

AGENDA

Meeting Goal: Derive lessons learned and recommendations from the Japan tsunami marine debris (JTMD) response to-date.

Meeting Objectives:

- Share experience of JTMD challenges and actions.
- Through workgroup discussions, derive lessons learned, and provide recommendations for future such responses.
- Capture participants' input in meeting notes.
- Draft proceedings to summarize the outcome of the meeting.

Day 1: Tuesday, May 13, 2014

8:00–8:30 a.m. **Registration and Coffee**
Location: Bldg. 9 lobby

8:30–8:40 a.m. **Welcome and Overview: Nancy Wallace**
Location: Bldg 9 auditorium

8:40–10:00 a.m. **Background Presentations**
Location: Bldg 9 auditorium
Presenters:

- NOAA: Nancy Wallace
- Japan: Senior Consul Tomoko Dodo
- Alaska: Elaine Busse Floyd
- Ucluelet, BC: Karla Robison

10:00–10:15 a.m. **Break**
Location: Bldg 9 lobby

10:15 a.m.–12:15 p.m. **Background Presentations (cont.)**
Presenters:

- Washington State: Wendy Freitag
- Oregon: Steve Rumrill
- California: Bob Butchart
- Hawaii: Scott Godwin
- Modeling: Glen Watabayashi
- Aquatic invasive species: Dr. Jessica Miller

12:15–1:15 p.m. **LUNCH (on your own)**
Location: NOAA Cafeteria in building 2

1:15–4:15 p.m.	**Break-out Groups: Response, Science, and Communications** Locations: • Response: Bldg 9 rooms A and B. • Science: Bldg 1 WFM, 2nd floor conference room. • Communications: Bldg 1, WRC, 1st floor conference room.
4:15–4:45 p.m.	**Plenary: Break-out Group Report Outs** Location: Bldg 9 auditorium
4:45–5:15 p.m.	**Large Group Discussion** Location: Bldg 9 auditorium
5:15 p.m.	**ADJOURN – Optional Dinner** (Elliott Bay Brewing Co., 12537 Lake City Way NE)

Day 2: Wednesday, May 14, 2014

8:00–8:30 a.m.	**Coffee** Location: Bldg 9 lobby
8:30–8:45 a.m.	**Review of Previous Day and Today's Agenda – Nancy Wallace** Location: Bldg 9 auditorium
8:45 a.m.–12:00 p.m.	**Break-out Groups: Response, Science, and Communications (Cont)**
12:00–1:00 p.m.	**LUNCH (on your own)** NOAA Cafeteria
1:00–2:30 p.m.	**Plenary: Workgroups Report Out** Location: Bldg 9 auditorium
2:30–3:00 p.m.	**Plenary: Facilitated Discussion of Overarching Issues** Location: Bldg 9 auditorium
3:00–3:15 p.m.	**Plenary: Summary and Next Steps** Location: Bldg 9 auditorium
3:15 p.m.	**MEETING ADJOURN**

Appendix 3: List of Participants and Break-out Groups

List of Participants

Name	Organization
Albins, Kim	NOAA Marine Debris Program
Antrim, Liam	NOAA Olympic Coast National Marine Sanctuary
Barnea, Nir	NOAA Marine Debris Program
Belva, Keeley	NOAA Public Affairs
Busse Floyd, Elaine	Alaska Department of Environmental Conservation
Butchart, Bob	California Governor's Office of Emergency Services
Chan, Samuel	Oregon State University
Cialino, Keith	NOAA Marine Debris Program
Dodo, Tomoko	Consulate-General of Japan in Seattle
Doty, Travis	Consulate-General of Japan in Seattle
Freitag, Wendy	Washington Emergency Management Division
Godwin, Scott	Hawaii Papahānaumokuākea National Marine Monument
Gorgula, Sonia	Hawaii Department of Land and Natural Resources
Hafner, Jan	University of Hawaii
Hammer, Alison	NOAA Marine Debris Program
Helton, Doug	NOAA OR&R Emergency Response Division
Holley, Vernee	NOAA OR&R Business Services Group
Johnson, Louise	National Park Service Olympic National Park
Jones, Tahzay	National Park Service Alaska Regional Office
Kamachi, Masafumi	Japan Meteorological Agency
Kennedy, John	U.S. Environmental Protection Agency Region 9
Kent, Linda	Washington Department of Ecology
Kretovic, Liz	NOAA OR&R Emergency Response Division
Lippiatt, Sherry	NOAA Marine Debris Program
MacFadyen , Amy	NOAA OR&R Emergency Response Division
Marquis, Sarah	NOAA National Marine Sanctuaries
Matthews, Chuck	Washington Department of Ecology
Maximenko, Nikolai	University of Hawaii
Miller, Jessica	Oregon State University

Murphy, Peter	NOAA Marine Debris Program
Parker, Aaron	Makah Indian Tribe
Parker, Dianna	NOAA Marine Debris Program
Parker, Ryan	Oregon Parks and Recreation Department
Pleus, Allen	Washington Department of Fish and Wildlife
Robison, Karla	British Columbia Ucluelet District
Rumrill, Steve	Oregon Department of Fish and Wildlife
Sarff, Danna	Makah Indian Tribe
Schwartz, Eben	California Coastal Commission
Starnes, Andrew	U.S. Coast Guard Pacific Area
Stein, John	NOAA National Marine Fisheries Service
Stewart, Janna	Alaska Department of Environmental Conservation
Symons, Lisa	NOAA National Marine Sanctuaries
Tada, Sawako	Japan Ministry of the Environment
Wallace, Nancy	NOAA Marine Debris Program
Watabayashi, Glen	NOAA OR&R Emergency Response Division
Whaley, Aneesah	NOAA OR&R Business Services Group
Whelan, Paul	NOAA OR&R Assessment and Restoration Division
Yender, Ruth	NOAA OR&R Emergency Response Division

Break-out Groups

Communications

Bldg. 1, 1st floor, WRC Conference Room

Alison Hammer	Facilitator
Dianna Parker	Team Lead
Paul Whelan	Note Taker
Aaron Parker	
Aneesah Whaley	
Eben Schwartz	
Keeley Belva	
Linda Kent	
Louise Johnson	
Nancy Wallace	
Sarah Marquis	
Travis Doty	

Response

Building 9, Rooms A and B

Liz Kretovic	Facilitator
Nir Barnea	Team Lead
Keith Cialino	Note Taker
Andrew Starnes	
Bob Butchart	
Chuck Matthews	
Danna Sarff	
Elaine Busse Floyd	
Janna Stewart	
John Kennedy	
Lisa Symons	
Ruth Yender	
Ryan Parker	
Scott Godwin	
Vernee Holley	

Science

Building 1, 2nd floor WFM, Conference Room

Doug Helton	Facilitator
Peter Murphy	Team Lead
Sherry Lippiatt	Team Lead
Kim Albins	Note Taker
Allen Pleus	
Amy MacFadyen	
Glen Watabayashi	
Jan Hafner	
Jessica Miller	
John Stein	
Karla Robison	
Liam Antrim	
Masafumi Kamachi	
Nikolai Maximenko	
Samuel Chan	
Sawako Tada	
Sonia Gorgula	
Steve Rumrill	
Tahzay Jones	
Tomoko Dodo	

Appendix 4: Interagency Communications Plan Framework

Incident: Severe Marine Debris Event

Goal/Outcomes

1)
2)

Key strategies for communicating

1)
2)
3)

Audiences

- General public
- Special populations
- Media
- Congress

Key messages

1)
2)
3)

Communications team/contacts

(Example) NOAA:
Marine Debris Program (Office of Response and Restoration)
NOS Public Affairs

Roles and responsibilities

Subject matter experts/spokespersons

- Name, Affiliation, Phone, Email—EXPERTISE
- Name, Affiliation, Phone, Email—EXPERTISE

Available resources for information creation and dissemination

(Example) NOAA Marine Debris Program:
Tools

- Social media: Facebook, Twitter, Flickr, Instagram
- Marine Debris Program website, blog, and e-newsletter

Available skill-sets

- Writer-editor
- Press officer
- Graphic designer
- Video production

Talking Points

1)
2)
3)

Checklist: Initial actions

Notification

__ Engage leadership and provide initial assessment and plan outline.

__ Contact local, state, and federal communications team as identified in this plan.

Coordination

__ Identify lead for communications team and agree on check-in time and frequency.

__ Designate roles and responsibilities among communication team, as necessary.

__ Identify and secure spokespersons within each agency, including media spokesperson and community meeting speaker.

Questions for team to answer:

- *Who is responsible for coordinating information with the science and emergency operations teams?*
- *Who will release which information, when, and how?*
- *What are the respective information verification and clearance procedures within each agency?*
- *Have designated spokespersons received media training and do they understand their roles?*
- *How will we ensure leadership is receiving the same information?*

Actions for public and media

__ Develop list of pre-cleared facts.

__ Draft messages and talking points, including those for special populations.

__ Develop media contact list.

__ Develop list of public and internal stakeholders who must receive direct, regular information.

__ Prepare initial media statement for reporters and websites.

Messages and Audience

__ Identify all methods of information dissemination to public, stakeholders:

- Fact sheets
- Social media: Twitter, Facebook, Instagram
- FAQs
- B-roll and photos
- Web content
- Listserves
- Press releases
- Newsletters
- Hotlines

Appendix 5: Abstracts of the Background Presentations

Short abstracts of the background presentations are provided below.

NOAA
The March 11, 2011 earthquake and tsunami in Japan was a natural disaster and a human tragedy. This tragedy resulted in an estimated 5 million tons of debris being swept into the ocean, of which it is estimated that 70% sank quickly. Initially, after the event debris patches could be seen by satellite. These patches broke up and dispersed and were no longer visible a few weeks after. In order to mitigate the impacts of this debris on the shores of the United States, the NOAA Marine Debris Program (MDP) provided scientific support, assisted in coordination and provided communications and outreach support for the effort. NOAA assisted with data collection, shoreline monitoring, modeling, and leading coordination calls for those involved in the response. The NOAA MDP also helped to coordinate the drafting of contingency plans for Hawaii, Alaska, Washington, Oregon, and California. NOAA has worked closely with other federal partners, the states, and the Governments of Canada and Japan to minimize the impacts of this debris.

Japan
Senior Consul Tomoko Dodo of the Consulate-General of Japan in Seattle provided background on the impact of the March 11, 2011 disaster, and how Japan has supported NOAA, the states, and other partners in the response to tsunami debris (JTMD). The arrival of and subsequent response to JTMD in the United States and Canada has resulted in new opportunities for significant collaboration between many different agencies, and between Japan, the United States, and Canada. Japan has been extending professional, scientific, and material support to its partners, and is grateful for the new relations established through this collaboration. These efforts have mitigated the impact of JTMD and promoted public understanding. A valuable network is now in place for continuing to address the JTMD situation and broader issues such as general marine debris on an international scale.

Alaska
The Alaska Department of Conservation (DEC) PowerPoint presentation began with several maps demonstrating the size and complexity of the Alaska coastline. It described the administrative structure of marine debris responsibilities in Alaska, and the efforts of DEC, including the 2012 aerial survey and the selection of contractors for the 2014 aerial survey and debris cleanup contracts. Several slides illustrated the process of evaluating and prioritizing cleanup locations, which was accomplished with the assistance of numerous state and federal partners. Photographs and data from the 2012 aerial survey and numerous cleanup projects illustrated the huge volume of debris facing Alaska. A photo of a typical high-energy beach illustrated the difficulty and the danger of working on many of Alaska's coastlines. Another slide illustrated the complexity of land ownership on Kodiak Island (replicated throughout Alaska's coastline). Several slides addressed the plan for using the NOAA/Government of Japan funding, including a map of the priority cleanup areas and the allocations for the 2014 aerial survey and cleanup projects. Several slides presented data documenting the 10-fold surge in post-tsunami marine debris. The final slides described Alaska's public awareness and education efforts, and the lessons learned thus far in the process of using Alaska's allocation of the Government of Japan funds.

Ucluelet, British Columbia
The presentation on tsunami debris driftage from the Great Eastern Japan Earthquake of March 2011 outlined the District of Ucluelet's contributions toward science, response, and communications/outreach relating to JTMD. To help address the possible influx of tsunami debris driftage, Environmental and Emergency Service Manager Karla Robison established a scientific monitoring site through the NOAA Marine Debris Monitoring and Assessment Project, directed large scale cleanup projects which at times

required specialized cleanup teams, acquired a response and recovery plan, initiated a regional emergency committee, established Japanese relations, and assisted the Provincial and Federal Tsunami Debris Coordinating Committee. The Department and a small team of volunteers discovered and analyzed the first pieces of recognized JTMD material with probable Japanese species to be recognized in British Columbia and the first JTMD wood with living Japanese biofouling to land in North America. A communications plan evolved to administer media relations for local to international audiences, and to advise and engage with the public. The Department received $81,538 in debris cleanup funds from the $1 million grant that was graciously provided by the Government of Japan. The successful proposal is supported by significant in-kind contributions in terms of volunteer efforts and resources from 26 collaborative partner agencies and organizations. The Department continues to collaborate with local and international partners to collect data, assess the debris, and reduce possible impacts to our natural resources and coastal communities.

Washington

Possible JTMD began arriving on the Washington coast in December 2011, and to address the critical need for information, Washington State agencies and partners conducted a series of public meetings to present what they knew. Ever since then, Washington Department of Ecology has provided a public website on JTMD and updates it regularly. The Washington State JTMD Task Force launched in January 2012, taking a "whole-of-government" approach, whereby the entire coastline of Washington State is treated the same. Planning efforts started in February 2012, and the Washington State Marine Debris Response Plan was subsequently signed by the governor. JTMD was removed in various ways. Small debris was removed mostly by volunteers with help from Washington Conservation Corps when needed. Department of Ecology and U.S. Coast Guard responded to hazardous debris. Skiffs and other medium-size JTMD were removed by state agencies, mostly by Washington State Parks. The Misawa dock, a large JTMD item, was removed by federal agencies, with the state providing critical assistance to remove invasive species and provide outreach. Washington Department of Fish and Wildlife has been working on the aquatic invasive species aspect of JTMD since it became a high-priority issue with the arrival of the Misawa dock in Oregon, has collected samples from many JTMD items, and collaborates closely with experts in the field. JTMD, an unprecedented event, benefited greatly from close collaboration with NOAA and other federal agencies, and with the Government of Japan.

Oregon

Oregon Parks and Recreation Department's (OPRD) JTMD response was straightforward, as the agency already has established jurisdiction over the public beach along the whole Oregon coast. It did not differ greatly from already established debris response policy. OPRD's greatest challenge was funding. OPRD spent a significant amount of money, which far exceeded its biannual budget for solid waste disposal, on 26 large dumpsters up and down the coastal park system, as well as on printed debris bags and awareness signs. OPRD established a 2-1-1 call-in number for the public to report large marine debris items of concern. Many reports of aquatic invasive species turned out to be transient pelagic gooseneck barnacles. There were many calls regarding the concentrated "debris rafts" from county commissioners concerned about economic damages to the fishing industry as well as calls about radiation, which were addressed by the Oregon Health Authority. OPRD worked with Oregon State University, Oregon Department of Fish and Wildlife, NOAA, U.S. Bureau of Land Management, U.S. Forest Service, and other agencies to remove debris from sensitive sites and areas normally not under OPRD jurisdiction. The four OPRD beach rangers continue to find and remove items likely from the March 11, 2011 Great Tohoku Earthquake and tsunami. Any item that could be tied to the disaster is passed along to the Consulate-General of Japan in Portland.

California

California is a large state with 20 coastal counties and many stakeholders, and coordinating efforts to address JTMD has been a complex endeavor. Outreach and communication was critical to provide fact-based information on the scope and possible impact of JTMD, and as the need shifted to response planning, California collaborated with federal agencies and other states, and developed its own Concept of Operations (ConOps) that provides the guidelines for the state's response to JTMD. California established a JTMD Workgroup, comprised of representatives from state and local agencies, federal agencies, and the private sector to coordinate JTMD efforts and facilitate the formulation of the ConOps. Monitoring of marine debris, mostly by NOAA-managed sites and some by public volunteers, provided an idea of quantities of marine debris washing up on California beaches. California benefited from good coordination with NOAA, the Government of Japan, and all the members of the JTMD Workgroup. The funding received from NOAA and the Government of Japan greatly helped to alleviate concerns about the cost of cleanup. California was not impacted greatly by JTMD, but overall, the coordination, outreach, planning, and funding placed California in a good place to address future JTMD if it arrives.

Hawaii

Hawaii's presentation outlined the activities for holistic and cooperative action-planning to respond to the potential threats posed to the Hawaiian Archipelago by marine debris generated by the Japan tsunami. Early efforts centered on planning for the many potential impacts and to integrate knowledge and expertise across agencies and specialties, ranging from emergency response to marine invasive species. The Hawaiian Archipelago experienced challenges due to stakeholder jurisdictions, mandates, and resource allocation. The participants from NOAA, representing the Marine Debris Program, Office of Response and Restoration, and the Office of National Marine Sanctuaries, provided coordination between all entities and resources in order to attempt a unified response. In the end, JTMD response challenges stemmed from the shortcomings of existing stakeholder mandates to garner necessary resources and the lack of focused national legislation providing guidance for actions and monetary resources for a structured response. The response in the Hawaiian Archipelago eventually was based on local codes of practice, negotiated formal agreements, and efforts of individuals in various agencies to create a response framework.

Modeling

The challenges of modeling the spread of Japan tsunami debris across the Pacific Ocean were categorized into four areas: understanding how accurate the model outputs needed to be, working with the limited data available, calibrating model parameters, and figuring out how to present the model results. The modeling effort begins with understanding who the audience is, what questions the model results need to answer, and what resources are available. This in turn will determine which tools to use and how to approach the corresponding challenge. The next step is to obtain data to initialize the model. In the case of modeling tsunami debris across the Pacific, modelers needed to estimate the information about where the debris came from, how much there was, and what type of debris it was. Winds and currents for the entire North Pacific over a span of several years were used in the modeling effort and these data came with their own degrees of scientific uncertainty. In addition, the fate of the debris as it crosses the Pacific over several years needed to be dealt with in the modeling. The final piece of the tsunami debris modeling challenge was figuring out how to present the results and convey to the audience the uncertainty involved with the modeling effort. This comes back to understanding who the audience is and what questions need to be answered.

Aquatic Invasive Species

As of April 2014, the Aquatic Invasive Species Workgroup had acquired biological samples from more than 160 items classified as JTMD based on the presence of characteristic Japanese biota. The most common items include docks, buoys, skiffs, post and beam timber, and pallets. The majority of the items were collected from Oregon (76), followed by Hawaii and the Northwestern Hawaiian Islands (48), Washington (19), British Columbia (10), California (4), and Alaska (2). In collaboration with taxonomic experts, more than 200 taxa have been identified, including more than 160 animal and more than 40 algal taxa. At least 15 invertebrate species are known to have been successfully introduced outside of Japan, including the barnacle *Megabalanus rosa*, the crab *Hemigrapsus sanguineus,* the mussel *Mytilus galloprovincialis*, the amphipod *Jassa marmorata,* the seastar *Asterias amurensis,* and the sea squirt *Didemnum vexillum.* Several species were reproductive upon arrival, including *M. galloprovincialis* and *J. marmorata*. There was geographic variation in the occurrence of reproductive mussels: 100% of the individuals collected in Oregon contained gametes, whereas an average of 80% and 28% of the individuals on debris items collected in Washington and Hawaii, respectively, contained gametes. The Workgroup continues to collect data on species identity, population structure, reproductive condition, growth histories, genetics, and parasite/pathogen presence from JTMD biota, while also quantifying spatial and temporal variation and biodiversity attrition over time. The continued delivery of debris with living, adult coastal species to the northwest Pacific coast provides an opportunity to advance understanding of invasion biology.

Penny Pritzker
United States Secretary of Commerce

Dr. Kathryn D. Sullivan
Under Secretary of Commerce for Oceans and Atmosphere

Dr. Holly A. Bamford
Assistant Administrator, National Ocean Service