

FY18 NOAA/NWS Tsunami Activities Grants Awarded

By Rocky Lopes, NOAA/National Weather Service Tsunami Program

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NOAA's National Weather Service is pleased to announce \$5,892,670 in grant funds have been awarded or transferred within NOAA to support projects to make coastal communities throughout the United States and its territories safer from tsunamis. Grants are provided to coastal states, territories, and entities who subscribe to the goals and high-priority public safety strategies of the National Tsunami Hazard Mitigation Program (NTHMP).

FY18 NOAA/NWS grants for the performance period from September 1, 2018, through August 31, 2019, have been awarded to 12 state and territory government entities to support these tasks.

After thorough review and judging of grant task requests with priorities of the NTHMP and NOAA/NWS, the NTHMP Grant Review Panel recommended, and the NTHMP Chair approved, a commitment of \$5,999,690 in total grant awards. However upon rigorous and thorough Federal Government review by the NOAA Grants Specialist between May and August, some grants were reduced when more information and details indicated lower costs due to more precise cost estimates, changes in some applicant's indirect cost rates and to which object classes the indirect costs applied, and recalculation of some grant requests after resolving mathematical errors.



The variety and number of tasks are an example of the difficult and challenging work undertaken by NTHMP partners to fulfill the NTHMP Mission "to mitigate the impact of tsunamis through public education, community response planning, hazard assessment, and warning coordination."

A full description of the tasks that FY18 NOAA/NWS grants are supporting is on the NTHMP website, here: <http://nws.weather.gov/nthmp/grants/2018grants/index.html>

TsuInfo Alert

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This publication is free upon request and is available in print by mail and online at:

<http://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/tsunamis/tsuinfo-alert>

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NATIONAL TSUNAMI HAZARD MITIGATION PROGRAM LIBRARY CATALOG:

<http://d92019.eos-intl.net/D92019/OPAC/Index.aspx>

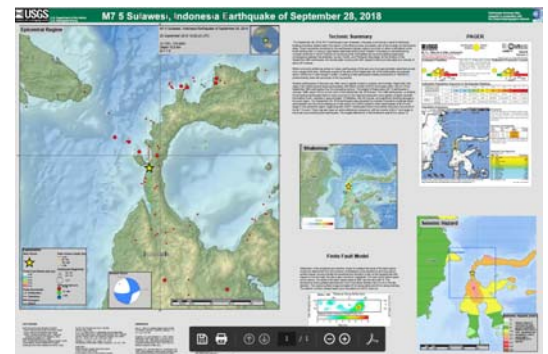
The views expressed herein are those of the authors and not necessarily those of NOAA, the Washington Department of Natural Resources, or other sponsors of TsuInfo Alert.

Significant Tsunami Event: Sulawesi, Indonesia September 28th, 2018

On September 28, 2018, a M 7.5 earthquake occurred at 10:02 UTC near Sulawesi, Indonesia (<https://earthquake.usgs.gov/earthquakes/eventpage/us1000h3p4/executive#executive>). As a result of this earthquake a destructive tsunami was generated. At the time of publication of this edition of TsuInfo Alert, this event and its impacts are still being studied. In future editions we expect to be able share more official information. As with all tsunamis, state, territory, and Federal partners in the National Tsunami Hazard Mitigation Program hope to learn from this event and make improvements to their own tsunami preparedness and planning.

See the following articles for more details:

- <https://foreignpolicy.com/2018/10/04/is-the-world-ready-for-the-next-big-tsunami/>
- <https://graphics.reuters.com/INDONESIA-QUAKE/010080MZ19R/index.html>
- <http://temblor.net/earthquake-insights/finding-of-the-unexpected-tsunami-due-to-the-strike-slip-fault-at-central-sulawesi-indonesia-on-28-september-2018-from-the-preliminary-field-survey-at-palu-7855/>



Puerto Rico's Tsunami Summer Workshop for Tsunami Warning Focal Points Operators

By Roy Ruiz-Vélez and Gisela Báez, Puerto Rico Seismic Network

On August 21st and 23rd, 2018, a tsunami response workshop for local and state tsunami warning focal points (TWFP) was held in the municipality of Bayamón and Coamo as part of the Puerto Rico-National Tsunami Hazard Mitigation Program (PR-NTHMP) initiatives. Puerto Rico has 46 TsunamiReady communities with more than 250,000 residents and much of its critical infrastructure inside tsunami prone zones. Due to the tectonics and geology of the Caribbean Region, a local tsunamigenic earthquake will give Puerto Ricans minutes to respond and execute a massive evacuation of residents, visitors and floating population from the tsunami evacuation areas. This prospective impact drives the mission of educating and preparing the population and emergency managers for such a scenario. With that in mind, the PR-NTHMP TsunamiReady program developed these two workshops for emergency



TWFP workshop in Bayamón Municipality

managers, first responders, dispatchers and radio operators from the 46 local emergency management offices (OMMEs), nine State Emergency Management regional offices (PREMA Zones) and the PR-TWFPs. The workshop focused on the Puerto Rico tsunami evacuation and communication protocols, Pacific Tsunami Warning Center (PTWC) and NWS tsunami products and PRSN regional products. Additionally, the workshop included vital information on how to interpret the products and make decisions based on the tsunami scenario (local, regional or distant). Approximately 150 TWFP personnel were impacted through these workshops that included a practical desktop exercise.



Emergency managers participating during the practical session

After the theoretical training, the participants were divided into small groups to apply that training in a hands-on exercise. Different scenarios and communities were assigned to each group where they were required to discuss and develop a small presentation, explaining the response and evacuation approached for that community and scenario combination. As a final review, a question and answer session was conducted to address the participant questions regarding the main theme of the workshop.

Acknowledgements: The PR-NTHMP program acknowledges PREMA, CTWP, PRSN personnel and Bayamon OMMEAD for their commitment and support in coordinating these workshops. Funding for the workshop was supported by NOAA Grant #NA17NWS4670014.

United Nations Calls for Reducing Economic Impacts of Tsunamis

By Christa Rabenold, NOAA/National Weather Service Tsunami Service Program

Large tsunamis do not happen often, but they pose a significant threat to coastal communities around the world. Globally, since the beginning of the twenty-first century, 48 tsunamis have caused roughly \$300 billion (2018 dollars) in damage.¹

Recognizing that the tsunami hazard poses a global threat that requires international attention and cooperation, the United Nations (UN) General Assembly designated November 5 as World Tsunami Awareness Day. Each year, the UN Office for Disaster Risk Reduction calls on governmental and nongovernmental organizations, as well as individuals, to observe the day by engaging in efforts to raise tsunami awareness and share innovative approaches to risk reduction.

For the third year in a row, World Tsunami Awareness Day will align with the International Day for Disaster Reduction and the “Sendai Seven Campaign.” This year, the two campaigns are focusing on the third target of the Sendai Framework for Disaster Risk Reduction, which aims to reduce economic losses associated with disasters.

The often-reported damage estimates from a disaster do not tell the full story of economic loss. These estimates typically only report direct market costs (i.e., losses to physical assets with market value, things that can be purchased, like buildings and infrastructure). However, direct non-market costs and indirect costs (e.g., business interruption, loss of livelihood), which are much more difficult to estimate, are also significant components of an event’s total losses, the effects of which can last for years. Estimating economic loss is complicated and inexact, but to ease recovery, it is important to understand and address all types of potential losses before disaster strikes.

To support World Tsunami Awareness Day and help promote the global culture of tsunami awareness, the National Weather Service includes tsunamis in its annual fall safety campaign. Tsunami-related social media messages that can be adapted to incorporate World Tsunami Awareness Day are available at: <https://www.weather.gov/wrn/fall2018-tsunami-sm>

Help spread the word about World Tsunami Awareness Day! On the Web, visit the World Tsunami Awareness Day website to learn more: <https://www.unisdr.org/tsunamiday>.

On social media, use hashtags #TsunamiDay and #TsunamiPrep.

¹National Centers for Environmental Information/World Data Service. n.d. Global Historical Tsunami Database. NOAA National Centers for Environmental Information. https://www.ngdc.noaa.gov/hazard/tsu_db.shtml



NTHMP NEWS

Tsunamis and FEMA's Community Rating System—New Fact Sheets

Adapted from the NFIP/CRS Update (August/September 2018)

The National Tsunami Hazard Mitigation Program (NTHMP), in cooperation with FEMA's Community Rating System (CRS), has produced two new fact sheets that explain the relationship between the CRS and tsunami programs.

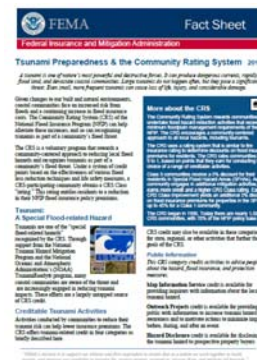
The CRS is a voluntary program that provides flood insurance premium discounts to policyholders in communities that undertake certain actions to reduce all types of flood hazards. Tsunamis are one of the "special flood-related hazards" recognized by the CRS.

"Tsunami Preparedness & the Community Rating System" combines a brief overview of the risks posed by tsunamis with a capsulized explanation of the ways in which communities can address those risks by employing techniques credited under the CRS. It notes that tsunami-related credit points are available under 11 activities of the CRS, including one or more under each series: public information, mapping and regulations, flood damage reduction, and warning and response. It ends with a call for emergency managers—who currently handle the tsunami hazard in most communities—to engage with their local floodplain management program to address tsunami risk in a comprehensive fashion while also improving the community's CRS rating.

"Tsunami Outreach & the Community Rating System" emphasizes the importance of public information programs in changing people's behavior and thus saving lives and minimizing property damage in the face of tsunami hazards. The fact sheet describes the CRS credit available for outreach projects about tsunami risk, a map information service that supplies tsunami hazard information, disclosure of the tsunami hazard, and making tsunami protection information publicly available. It also describes the public information benefits of the CRS-creditable TsunamiReady program administered by NOAA.

The fact sheets are available for download from the FEMA website at:

<https://www.fema.gov/national-flood-insurance-program-community-rating-system>



NTHMP to Update Compendium of Tsunami Education Resources

By Christa Rabenold, NOAA/National Weather Service Tsunami Service Program

In 2012, the National Tsunami Hazard Mitigation Program (NTHMP) released a list of resources that had been developed for use in schools to educate students about tsunamis and related natural hazards. The NTHMP is planning to update this list, the Compendium of Tsunami Education Resources, and is interested in hearing about new and updated resources. Resources of interest include, but are not limited to, standards-aligned lesson plans and curricula, general tsunami and related hazards lessons and activities, information and resources for educators that are not curricula or lesson plans, and videos appropriate for a classroom setting.

If you have information about an educational resource that you would like to share, please send it to christa.rabenold@noaa.gov for consideration by the end of November 2018. If the resource is not available online, please provide details about how it can be acquired. The current compendium is available at: <https://nws.weather.gov/nthmp/documents/CompendiumTsunamiEd.pdf>.

Live Exercise Training at the National Tsunami Warning Center

By Kara Gately, National Tsunami Warning Center and
Rocky Lopes, Tsunami Program Deputy at NWS Headquarters

On August 9th, the U.S. National Tsunami Warning Center (NTWC) practiced event response as part of a real-time coordinated exercise. The exercise was created and facilitated by Rocky Lopes, Certified Emergency Manager and Tsunami Program Deputy at NWS Headquarters, Kara Gately, Senior Watchstander at NTWC, and Mike Angove, Acting NTWC Director.

The scenario incorporated the January 23, 2018 earthquake parameters and observations, plus lessons learned from the resulting tsunami warning, to practice event response and flow of communication. The exercise provided NTWC personnel training in: event response roles and responsibilities, team situational awareness, event coordination, and Communications Center procedures. The exercise also addressed several recommendations from the NWS Service Assessment: Gulf of Alaska Tsunami, January 23, 2018.

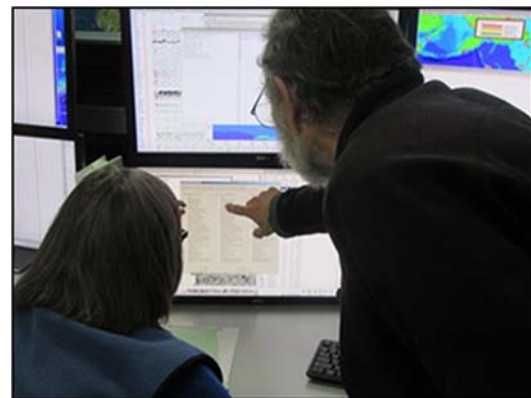
Event response in the immediate aftermath of issuing a tsunami warning has many aspects which are unique to NTWC. While continuing with expert analysis of the latest seismic information and water level observations, two duty scientists must also recall all staff, perform the NAWAS call and complete call down list notifications, check the message dissemination, and a multitude of other tasks – all while the phones are ringing off the hook.

During weekdays, daytime NTWC duty scientists are supported by the rest of the office staff, which includes electronic technicians, information technology specialists, and an administrative support assistant. When tsunami alerts occur, support staff¹ setup a “Communications Center” in the conference room, where incoming phone calls are then able to be properly responded to, logged, and addressed.

While Watchstanders at NTWC practice simulated hypothetical tsunami events monthly, the exercises are often done individually, or as pairs, and they require no coordination with the rest of the office or interaction with the outside world. This scenario was different in two major ways. First, it brought a majority of the NTWC response team together with the goals of simulating the environment for both the operations floor and Communications Center and exercising the flow of information between the two. Second, it was coordinated in real-time as a fully simulated event, complete with Jan 23rd historical data on NTWC operational software, and with outside participants calling in on the phone and “acting” as core partners or concerned citizens.

Historical seismic data from the M7.9 on Jan 23rd was used in the Earlybird software to simulate the operational environment. This consisted of rapid earthquake characterization, including determination of location and magnitude, and message generation. Historical DART data was also utilized within SIFT forecasting software, and the forecast product was output displayed alongside the historical water level observations from coastal tide gauges on Jan 23rd.

¹who are not actively addressing higher priority ET/IT issues on the operations floor



David Hale and Peggy Johnson sending out the next message with updated watch/warning/advisory segments, based on the latest forecast.

(Continues on Page 7)

NTHMP NEWS

Live Exercise Training at the National Tsunami Warning Center

By Kara Gately, National Tsunami Warning Center and
Rocky Lopes, Tsunami Program Deputy at NWS Headquarters

(Continued from page 6)

The exercise commenced with two Watchstanders on normal duty operations responding to a seismic alarm. Immediately after Bulletin #1 was issued, the phone lines began ringing. This gave the duty scientists on the operational floor a wonderful chance to practice two seldom used features at NTWC, one old, one new. The “All Call” switch was enabled for real, allowing NTWC to test the telephone recall function for all staff, a tool which is used during tsunami events. Then the new “Event Mode” button was pushed on the updated phone system – silencing all ringing on the operations floor and directing calls to the Communications Center.

Watchstanders then continued on working the simulated tsunami event, performing expert analysis while working together as a coordinated team. As additional Watchstanders arrived they were assigned roles with known responsibilities, following the Incident Command System protocols. Seismic analysis, water level observations, tsunami forecasting, messaging, call down lists, conference calls, and the warning decision process were all enacted, with the role of Event Coordinator being exercised.

Meanwhile, the warning support team dealt with a barrage of ringing phone lines and questions coming into the Communications Center. As an additional component to make the exercise feel authentic, partners from states & territories and colleagues from NWS offices were provided roles to play as “callers” and given questions to ask. Archived phone calls from the January 23rd event log were used to create realistic commentary for external dialers, who then called NTWC during the live exercise with their questions. The many calls were addressed while testing updates to Communications Center response procedures. Calls were rerouted as necessary to NWS Public Affairs, local emergency management, and to the operations floor. This allowed staff to evaluate the effectiveness of the updated Communications Center procedures, and discuss ideas for improving the flow of information and team situational awareness. Dan Belanger (Alaska DHS/EM) also participated in the live scenario as an observer for the Communications Center and its operations, providing helpful insights from a partner’s point of view.

The exercise was performed twice, once in the morning and once in the afternoon, to accommodate the different shifts for NTWC duty scientists who perform rotating shift work. Each exercise lasted about an hour, with an hour facilitated debrief. The feedback from the discussions was very positive. The staff enjoyed getting to work together in real-time on a simulated event, where all aspects of operational response had to be coordinated. The exercise provided a much more realistic simulation of the physical environment at NTWC in the immediate aftermath following a tsunami alert, and that exposure was appreciated by those responding. Watchstanders received valuable training in roles and responsibilities on the operations floor, and the teamwork that must be utilized to exchange information and coordinate the event with efficacy. Overall, a much better understanding of operational needs was gained. Areas for improvement were identified, and many new ideas for addressing them were discussed.

NTWC is continuing with training exercises in simulated real-time which emphasize roles and responsibilities, and practice team event response. Project teams are working on implementing new ideas which address the areas that were identified for improvement. For example, the “All Call” function was identified as older hardware which could be improved upon. As a result, a new “All Call” system with increased capabilities was tested, and implemented into operations at NTWC on Oct. 2nd, 2018.

NTWC plans to repeat this type of live coordinated exercise in 2019. Thank you to all the partners who participated as “callers”. We really appreciate your help with this and could not have done it without you.

Grenada's St. Patrick Parish and Haiti's Fort Liberté recognized "Tsunami Ready"

Originally published by UNESCO's Intergovernmental Oceanographic Commission (IOC): <https://on.unesco.org/2NLYJta>

As many other coastal cities of Northern Haiti, Fort Liberté (over 20,000 habitants) was hit by a tsunami on 7 May 1842. Based on tsunami modelling, the city has an estimate of 2,000 people potentially exposed to tsunami inundation by a local source generated tsunami, leaving very short time to respond. Conscious of the danger, Mr Louis Jacques Etienne, Mayor of Fort Liberté, submitted a request for Tsunami Ready recognition, which was awarded on 28 September 2018. Funded by USAID, the program was implemented with the support of Haiti's National Civil Protection and Navigation and Maritime Service, and international partners including IOC/UNESCO and its Caribbean Tsunami Information Centre (CTIC), as well as the U.S. National Oceanic and Atmospheric Administration (NOAA)/National Weather Service and its Caribbean Tsunami Warning Program (CTWP).

A week earlier, on 20 September 2018, the parish of St. Patrick, Grenada, also received the recognition, empowering one of the country's most vulnerable coastal communities to take effective action in the event of a potential tsunami. The CTWP and the CTIC implemented the project in collaboration with the Government of Grenada, NGOs and other regional organizations, with funding also provided by USAID.



"Tsunami Ready" ceremony at Fort Liberté, Haiti, on 28 September 2018. Credit: IOC

Achieving Tsunami Ready recognition encompasses a variety of preparedness requirements, including tsunami inundation and evacuation mapping, installation of tsunami signage, distribution of preparedness and outreach materials, public awareness activities and tsunami exercises, preparation of local Standard Operating Procedures for tsunamis, and the identification and training of Local and National Tsunami Focal Points for receiving and disseminating alerts.



"Tsunami Ready" ceremony at St. Patrick Parish, Grenada on 20 September 2018.

Over the past 500 years 75 tsunamis have killed 4,484 people in the Caribbean and adjacent regions, according to the Global Tsunami Database maintained by the U.S. NOAA. The tragic tsunami in Indonesia on 28 September 2018 highlights the need for at-risk communities to develop response plans should a tsunami arrive in order to save lives and minimize economic loss.

The Tsunami Ready recognition is granted only upon the satisfactory completion of a verification process confirming fulfilment of the guidelines – the conduct of the pilot projects in both Haiti and Grenada extended over one and half years. The programme is implemented by IOC's Intergovernmental Coordinating Group for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG/CARIBE EWS).

St. Patrick Parish and Fort Liberté join over 50 other coastal communities in the Caribbean that have been recognized as Tsunami Ready. The CARIBE EWS Tsunami Ready pilot project is modelled after the successful US TsunamiReady® program executed in Puerto Rico and the US Virgin Islands and an earlier Tsunami Ready project piloted jointly by the IOC/UNESCO and NOAA, which recognized the nominations of Anguilla and the Virgin Islands (UK). Just before Hurricane Irma, the Virgin Islands (UK) had renewed its Tsunami Ready status under the CARIBE EWS Programme.

Several other Caribbean Member States have indicated their interest in piloting the Tsunami Ready recognition programme, which is also being piloted across the other three regional tsunami early warning systems led by IOC/UNESCO – the Indian Ocean, Pacific Ocean and the North Eastern Atlantic, Mediterranean and Connected Seas.

NTHMP NEWS & CURRENT RESEARCH

CURRENT TSUNAMI RESEARCH

Chen, Yunguang; Park, Hyongsu; Chen, Yong; Corcoran, Patrick; Cox, Daniel; Reimer, J. J.; Weber, Bruce, 2018, Integrated Engineering-Economic Model for the Assessment of Regional Economic Vulnerability to Tsunamis: *Natural Hazards Review*, v. 19, no. 4, 14 p.

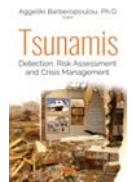


Goff, J.; Goto, K.; Chagué, C.; Watanabe, M.; Gadd, P. S.; King, D. N., 2018, New Zealand's Most Easterly Palaeotsunami Deposit Confirms Evidence for Major Trans-Pacific Event: *Marine Geology*, v. 404, p. 158-173, doi.org/10.1016/j.margeo.2018.08.001.



Huan, V. N. P.; Harahap, I. S. H.; Alaloul, W. S., 2018, Modelling of Tsunami Due to Submarine Landslide by Smoothed Particle Hydrodynamics Method: *MATEC Web of Conference*, v. 203, no. 01001, https://www.matec-conferences.org/articles/mateconf/pdf/2018/62/mateconf_iccoee2018_01001.pdf.

Johnston, J. B.; Dudley, W. C.; Goff, J., 2018, Chapter 8: The untold side of the tsunami hazard - Interviews with Survivors. IN Barberopoulou, A., editor, *Tsunamis: Detection, Risk Assessment and Crisis Management*. Natural Disaster Research, Prediction and Mitigation Series: Nova Science Publishers Inc., p. 213-243.



Maqtan, Raidan; Yusuf, Badronnisa; Hamzah, S. B., 2018, Physical Modeling of Landward Scour Due to Tsunami Bore Overtopping Seawall: *MATEC Web of Conference*, v. 203, no. 01003, https://www.matec-conferences.org/articles/mateconf/pdf/2018/62/mateconf_iccoee2018_01003.pdf.

New Digitized Marigram Data Available from NCEI

By Aaron D. Sweeney, NOAA National Centers for Environmental Information

Scanned images of paper tide gauge records (marigrams) have been digitized for eight large Pacific tsunami events and one tsunami generated by a volcanic eruption in Indonesia (1854, 1883, 1896, 1933, 1946, 1952, 1960, 1964, and 1968).

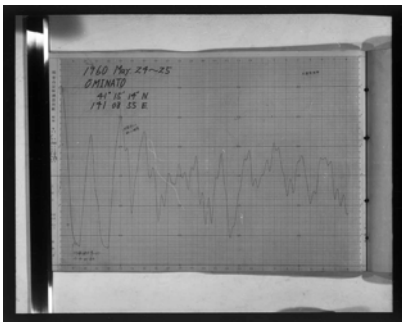


Figure 1: A scanned image of part of a marigram from Ominato, Japan, depicting water levels observed during the May 22, 1960 tsunami event.

A total of 47 digitized marigrams have been added to the tsunami data archived and stewarded by NOAA's National Centers for Environmental Information (NCEI) as part of the Tsunami Data Management Plan. These water level data in netCDF and CSV formats are available from NCEI at

<https://www.ngdc.noaa.gov/nndc/struts/form?t=102890&s=3&d=3> by limiting your search to "only records with digital data." If you have questions, please email haz.info@noaa.gov

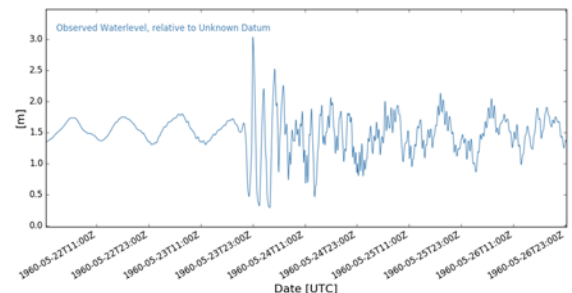


Figure 2: A plot of the digitized data obtained from the Ominato marigram.

TSUNAMI MAPS & NTHMP EVENTS

Tsunami Hazard Maps of Port Angeles and Port Townsend, Washington—Model Results from a ~2,500-year Cascadia Subduction Zone Earthquake Scenario

By Daniel W. Eungard, Corina Forson, Timothy J. Walsh, Edison Gica, and Diego Arcas

ABSTRACT: New tsunami modeling along the Strait of Juan de Fuca within an area surrounding the communities of Port Angeles and Port Townsend uses a simulated magnitude 9 earthquake event along the Cascadia subduction zone (L1 scenario) with a maximum slip of ~89 ft (27 m), inferred to be a ~2,500 year event. This new Cascadia subduction zone earthquake scenario aims to approximate the seismic design requirements in the building code standard for critical facilities, and the tsunami modeling is more conservative (greater inundation) than previous models. Modeling results indicate that sea level immediately following the earthquake gradually recedes to a maximum drawdown of ~6.5 ft (2 m) before the first tsunami wave arrival. This first wave is projected to inundate as high as 21 ft (6.4 m) locally in Port Angeles and Port Townsend approximately 60 minutes and 100 minutes respectively following the earthquake. Current velocities from the tsunami waves locally approach 26 knots, presenting a significant navigational hazard to the maritime community. Tsunami wave inundation is expected to continue over 8 hours and remain hazardous to maritime operations for more than 24 hours. This study is limited in that modeling does not account for tide stage, tidal currents, liquefaction, or minor topographic changes that would locally modify the effects of tsunami waves. Due to these limitations, this modeling should not be used for site-specific tsunami inundation assessment or for determining effects on the built environment. However, this model is an appropriate tool for evacuation and recovery planning.



CITATION: Eungard, D. W.; Forson, Corina; Walsh, T. J.; González, F. I.; LeVeque, R. J.; Adams, L. M., 2018, Tsunami hazard maps of Port Angeles and Port Townsend, Washington—Model results from a ~2,500-year Cascadia subduction zone earthquake scenario: Washington Geological Survey Map Series 2018-03, 6 sheets, scale 1:11,000 and 1:16,000, 11 p. text. [http://www.dnr.wa.gov/publications/ger_ms2018-03_tsunami_hazard_pt_angeles_pt_townsend.zip]

UPCOMING NTHMP & RELATED EVENTS

- ◆ November 4–7, 2018—Geological Society of America (GSA) Annual Meeting (Indianapolis, Indiana) <https://community.geosociety.org/gsa2018/home>
- ◆ November 5, 2018—World Tsunami Awareness Day <https://www.unisdr.org/tsunamiday>
- ◆ December 10–14, 2018—American Geophysical Union Fall Meeting (Washington, D.C.) <https://fallmeeting.agu.org/2017/future-meetings/>
- ◆ January 7–10, 2019—Association of Environmental and Engineering Geologists (AEG) Coastal Hazards Symposium: Engulfing the Coast (Dauphin Island, Alabama) <https://www.aegweb.org/event/coastalhazards>
- ◆ January 28–February 1, 2019—NTHMP Annual Meetings (San Diego, California) <https://nws.weather.gov/nthmp/2019annualmeeting/index.html>
- ◆ April 23–26, 2019—Seismological Society of America (SSA) Annual Meeting (Seattle, Washington) <https://www.seismosoc.org/>

