TsuInfo Alert

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2011 Tohoku-Oki Earthquake and Tsunami – Remembering the Victims and Learning from the Past

By Rick Wilson, California Geological Survey (CGS)

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Many of my tsunami and non-tsunami colleagues can remember what they were doing on March 11, 2011, the day of the Magnitude 9 Tohoku-Oki earthquake and the devastating tsunami which it generated. They typically can relate what this event meant to them at a personal, professional, and emotional level. This is what this event has meant to me.

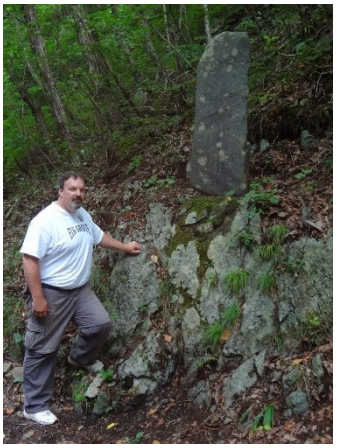

Figure 1. Monument to past tsunamis near Aneyoshi Bay (photo by Bruce Jaffe, USGS).

The 2011 tsunami was the first tsunami which most people who were not personally impacted could observe in real time on television. As the tsunami scientist for the California Geological Survey (CGS), I took part in the federal, state, and local tsunami warning coordination calls, helping to answer questions from local emergency officials who were planning their tsunami response activities. Five field observers were sent by CGS to select harbors during the event to note the impacts in California in real time, and eight field teams were formed after the event to collect perishable data and evaluate tsunami impacts.

Five months after the tsunami, I was invited by colleagues at the United States Geological Survey (USGS) to join a field reconnaissance team evaluating tsunami deposits and impacts throughout the Tohoku region. The damage to the landscape and the loss of life were heartbreaking. As a scientist, the most memorable location our team visited was Aneyoshi Bay in

Figure 2 Panorama view of entrance to Aneyoshi Bay five months after March 2011 tsunami. Note the trim line where trees were denuded (photo by Rick Wilson, CGS).

Miyako, Iwate Prefecture, where the highest tsunami run-up elevation (130 feet) was observed. I remember sitting on the beach removing pebbles from my boots, looking up 80 feet above my head at the tree trim line where the tsunami had denuded the vegetation. The V-shaped entrance to the bay and valley topography funneled the tsunami inland and upward simultaneously in an aggressive fashion. I felt overwhelmed by how powerful the tsunami must have been.

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NATIONAL TSUNAMI HAZARD MITIGATION PROGRAM LIBRARY CATALOG:
http://d92019.eos-intl.net/D92019/OPAC/Index.aspx

TsunamiReady® Recognition Milestones

By Ian Sears, NWS Tsunami Program Coordinator

As of Feb 2021, there are 170 sites recognized as TsunamiReady®.

During the time period since June 26, 2021:

- The following sites renewed their TsunamiReady® recognition:

- San Diego, CA
- Seal Beach, CA
- Dorado, PR
- Hatillo, PR
- Quebradillas, PR
- Liberty County, GA
- Canovanas, PR
- Catano, PR
- Isabela, PR
- Vega Baja, PR
- Laguna Beach, CA
- Naval Station Mayport, FL
- Naval Base Coronado, CA
- Makah Tribe, WA
- Georgetown County, SC
- Santa Barbara County, CA
- New Hanover County, NC
- San Juan, PR
- Guam, GU

Summary

Given the uncertainty surrounding COVID-19, and the non-expiration posture, there are a total of 170 tsunami ready communities. Any community that was due to expire after February 29, 2020 and has not renewed is still considered active at this time. Additionally, there are 8 new TsunamiReady supporters and 20 total TsunamiReady supporters.

NWS TsunamiReady® Program: https://www.weather.gov/TsunamiReady/

2011 Tohoku-Oki Earthquake and Tsunami – Remembering the Victims and Learning from the Past

By Rick Wilson, California Geological Survey (CGS)

(Continued from page 1)

The emotional impact from the Tohoku-Oki tsunami will always linger. My second trip to Japan was in March 2013 with a multinational group supported by the Earthquake Engineering Research Institute interested in learning about the ongoing tsunami recovery efforts. On March 11, 2013, two years to the day of the tsunami, I visited the site of the Okawa Elementary School near Ichinomaki, Miyagi Prefecture. Memorial services were taking place to honor the 74 children and 10 teachers who perished two years earlier. A hill close to the school could have provided safety but indecision and delays about what action to take led to this catastrophic loss of life.

Figure 3. March 11, 2013 visit to the Okawa Elementary School, Oshinomaki (photo by Rob Olshansky, University of Illinois).

Never forgetting the losses, the lessons we learned from the Tohoku-Oki event led to many new ideas and products to help local officials with their tsunami preparedness, mitigation, and recovery planning efforts. In California, CGS worked with the USGS and Humboldt State University to perform a statewide field reconnaissance to investigate potential tsunami deposits. This project and an analysis of the 2011 earthquake source informed our work with AECOM to develop a statewide probabilistic tsunami hazard analysis to update tsunami hazard maps. We identified a glaring need to help our ports and harbors with their tsunami response planning and mitigation efforts, so we worked with the University of Southern California to develop decision support tools called "playbooks" to plan for tsunamis of different sizes from different regions of the Pacific. Our analysis of the Tohoku-Oki event and our partnerships with the California Governor's Office of Emergency Services and the California Tsunami Technical Advisory Panel helped us create products and guidance for mitigation and recovery planning that will hopefully reduce future tsunami impacts in communities. Some of this work has also fed into guidance from the National Tsunami Hazard Mitigation Program to help communities and other U.S. States and Territories with their tsunami preparedness work.

Over the past decade, I think daily about the victims and damage caused by the Tohoku-Oki tsunami. We cannot go back in time and change history, but we can and must learn from the past and work to limit tsunami impacts in the future.

Preserving the Memory of the Great Tohoku Earthquake and Tsunami in Literature

By Elyssa Tappero, Washington Emergency Management Division

As tsunami scientists, emergency managers, and subject matter experts, we often have our attention buried in the hard data of this complex hazard. However, the true human impact of tsunamis is not captured in number of casualties or the cost of response and recovery - it is captured in the personal experiences and journeys of those who survived. While these stories can be found to some extent in our scientific resources, they are often expanded upon in works of literature. In honor of the 10th anniversary of the Great Tohoku Earthquake and Tsunami, I would like to share some of my favorite non-scientific written works on the subject.*

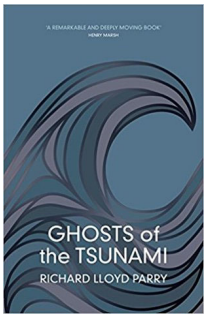
(Continues on page 4)

Preserving the Memory of the Great Tohoku Earthquake and Tsunami in Literature

By Elyssa Tappero, Washington Emergency Management Division

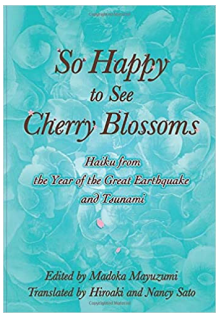
(Continued from page 3)

Ghosts of the Tsunami: Death and Life in Japan's Disaster Zone by Richard Lloyd Parry



Ghosts of the Tsunami is not a light read, yet it is absolutely worth the emotional journey. While *Ghosts of the Tsunami* touches on other aspects of the Great Tohoku Earthquake and Tsunami, its focus is the tragedy of Okawa Elementary and the 74 students lost while under their teachers' care. Parry's masterful narrative follows their grieving families through the immediate aftermath of the disaster and continues over the span of many years as some parents seek closure while others push for answers and accountability. The story of these families is a haunting reminder that disasters of this magnitude have the power to reshape the future of a community for generations – not only through quantifiable impacts like infrastructure and economic damage, but through the responsibility and emotional burden survivors carry with them.

So Happy to See Cherry Blossoms: Haiku from the Year of the Great Earthquake and Tsunami edited by Mayuzumi Madoka



Given the importance of poetry in Japanese culture, it is no surprise that there are several poetry collections about the Great Tohoku Earthquake and Tsunami. *So Happy to See Cherry Blossoms* is distinctive for both the poignancy of its 17-syllable poems, all of which were written by Japanese citizens who personally experienced the disaster, and the amount of detail provided within. Along with both the Japanese and English translations of each poem, the reader is provided with the authors name, age, the number of tsunami-related fatalities in their hometown, and either backstory or direct quotes from the author explaining the inspiration for the piece. Interspersed between chapters is also commentary from the editor, distinguished haiku poet Mayuzumi Madoka, who travelled through the disaster zone in the months after to help survivors heal through poetry writing.

In addition to these two pieces, below is a short list of additional recommendations. This is hardly an exhaustive list of the English-language literature available on the Great Tohoku Earthquake and Tsunami, but I believe there is value available for everyone (and all ages!).

- *Facing the Wave: A Journey in the Wake of the Tsunami* - Gretel Ehrlich
- *March Was Made of Yarn: Writers Respond to Japan's Earthquake, Tsunami, and Nuclear Meltdown* - Ed. David Karashima, Elmer Luke
- *Up from the Sea* - Leza Lowitz
- *Drowning in the Floating World: Poems* - Meg Eden
- *Tsunami vs the Fukushima 50: Poems* - Lee Ann Roripaugh
- *The Phone Booth in Mr. Hirota's Garden* - Heather Smith and Rachel Wada

**These are my personal views and do not represent those of my agency, nor should this list be considered any sort of official endorsement.*

Tohoku 10 Year Commemorative Activities

The NTHMP and others in the tsunami community are organizing various activities to commemorate the 2011 Tohoku, Japan earthquake and tsunami.

Redwoods Coast Tsunami Work Group – Lori Dengler

- The Redwood Coast Tsunami Work Group, including NWS WFO Eureka and NTWC, will be creating a ten-year remembrance web page to commemorate the upcoming milestone. We plan to have links to other sites and efforts that relate to the earthquake, the tsunami and ongoing recovery and resilience efforts.

Washington Sea Grant – Carrie Garrison-Laney

- To commemorate the 10th Anniversary of the Tohoku earthquake and tsunami, I will be writing an article for the March issue of Washington Sea Grant's *Sea Star* newsletter. I haven't written it yet, but it will likely focus on the research, mitigation, and outreach work in Washington that has been "inspired" by the Tohoku earthquake and tsunami.

National Centers for Environmental Information (NCEI) – Nicolás Arcos

- Short summary of 2011 Japan event (Note: will go live *10 March*): https://www.ncei.noaa.gov/news/day-2011-japan-earthquake-and-tsunami
- NCEI social media will push the above story via NCEI's Facebook, Instagram, and Twitter on *March 11*.

Washington State – Elyssa Tappero

- February TsuInfo article (page 3) featuring a review of non-scientific literature on the topic (fiction, nonfiction, poetry, etc)
- A longer version of this article on our Military Department blog (https://mil.wa.gov/news)

California Geological Survey – Rick Wilson

- February TsuInfo article (page 1) titled *2011 Tohoku-Oki Earthquake and Tsunami – Remembering the Victims and Learning from the Past*

HySEA Codes Complete NTHMP Benchmarking

By Jorge Macías, Grupo EDANYA, Universidad de Málaga, Málaga, Spain

In February 2015, we were invited by the NOAA Pacific Marine Environmental Laboratory (PMEL) with the support of the Puerto Rico Seismic Network (PRSN), to participate in the *"NTHMP Mapping & Modeling Benchmarking Workshop: Tsunami Currents"* held in Portland, Oregon. As a result we decided to apply the tsunami model benchmark process proposed by the National Tsunami Hazard and Mitigation Program (NTHMP) to our suite of *HySEA* (Hyperbolic Systems and Efficient Algorithms) codes and began with the benchmark problems proposed by the NTHMP in 2011 for propagation and inundation. The results were published in 2017 [1] for the *Tsunami-HySEA* model, hydrostatic and dispersive versions, and were presented to the Mapping and Modeling Subcommittee (MMS) of the NTHMP on January 30th, 2017 [2]. In addition, we were also invited to the *"NTHMP Mapping & Modeling Benchmarking Workshop: Landslide Tsunamis"* held in Galveston, Texas on January 9th-11th, 2017 ([3], [4]). During this workshop we worked closely with PMEL since they had expressed interest in using our model for tsunami generation when a landslide is the triggering mechanism.

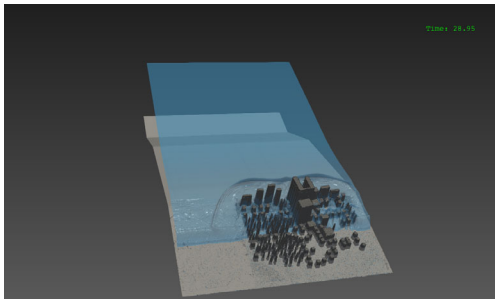
(Continues on page 6)

HySEA Codes Complete NTHMP Benchmarking

By Jorge Macías, Grupo EDANYA, Universidad de Málaga, Málaga, Spain

(Continued from page 5)

In 2017, an inter-model comparison including the *Tsunami-HySEA* model was published [5]. In 2020, two works containing the numerical results for the benchmarks proposed in the Galveston workshop were published for laboratory and field cases ([6], [7]). The NTHMP benchmarking process for the suite of HySEA codes is now complete with two other works for landslide generated tsunamis, one for rigid [8] and another for granular slides [9], which were recently published in the journal *Natural Hazards and Earth System Science*. Currently the *Tsunami-HySEA* code is used in research centers worldwide and early warning systems in Europe. In particular it is used by PMEL and PRSN in the USA, at the National Institute of Geophysics and Volcanology (Italy), the National Geographic Institute (Spain), Joint Research Center of the European Commission (Italy), the National Tsunami Monitoring System (Costa Rica), the Hydrographic and Oceanographic Service of the Chilean Navy (Chile), and the Malta Seismic Network. *Tsunami-HySEA* is being implemented in Puerto Rico and Spain to produce the next generation of tsunami inundation maps.



Simulation of BP4 for tsunami currents. Small-scale model of the town of Seaside, Oregon.

Link to HySea Codes: https://edanya.uma.es/hysea/

Grupo EDANYA Tsunami Simulation Videos: https://www.youtube.com/user/grupoedanya

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[1] Macías, J., Castro, M.J., Ortega, S., Escalante, C., González-Vida, J.M. (2017). Performance benchmarking of Tsunami-HySEA model for NTHMP's inundation mapping activities. *Pure Appl Geophys*, 1-37. [doi: 10.1007/s00024-017-1583-1].

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[7] Macías, J., Ortega, S., Castro, M.J., González-Vida, J.M. (2020). Performance assessment of Tsunami-HySEA model for NTHMP tsunami currents benchmarking. Field cases. *Ocean* Modelling, 152, 101645, ISSN 1463-5003, [doi: 10.1016/j.ocemod.2020.101645].

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Tsunami Hazard Assessment for New Caledonia

By Maxime Duphil, Jérôme Aucan, Jérôme Lefèvre (ENTROPIE, French Institute for Development, Nouméa, New Caledonia), Bernard Pelletier (GEOAZUR, French Institute for Development, Nouméa, New Caledonia), Jean Roger (ENTROPIE, now at: GNS Sciences, New Zealand), Bruce Thomas (LISAH INRAE Montpellier SupAgro, France)

Project Context

The TSUCAL (Tsunami in New Caledonia) project was funded over two years by an agreement between the Government of New Caledonia and the French Institute for Development to provide effective tools for assessing tsunami hazard to Civil Security actors. The goal was to produce a scenario database including 2944 modelled tsunami events located all around the Pacific Ocean and which may have impact on New Caledonia.

Fields of Study

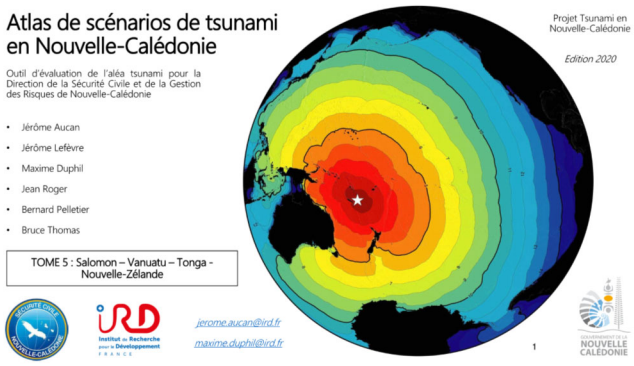

Figure 1 : Cover page of the tsunami scenarios atlas for South-West Pacific zone (Source: IRD)

Due to its location in the South-West Pacific, New Caledonia is exposed to tsunamis from several sources: at the scale of the ocean basin with transoceanic tsunamis, through regional events from the Tonga-Kermadec and Solomon-Northern Vanuatu, up to the local scale with sources located at the southern part of Vanuatu subduction zone. Since the transfer of risk management skills to Civil Security in 2014, the French Government and then the New Caledonian authorities have proposed a precautionary strategy consisting of evacuating key sectors in case of an event. The evacuation zone is currently set at less than 12m altitude and less than 100m from the coastline. In order to more objectively and thoroughly consider the hazard and improve the population alert system, multi-scenario hazard mapping was developed.

Finals Products

The delivery of the scenario database and the atlas (five volumes) should enable tsunami warning to be improved. By crossing the tsunami warnings bulletins issued from the Pacific Tsunami Warning Center (PTWC) with the database of pre-calculated scenarios, a numerical tool identifies automatically the hazard maps that come closest to a recorded event and delivers key information such as tsunami travel times and wave heights on the coast for the territory. The main goal was to optimize material and immaterial efforts deployed by the Civil Security and Risk Management Direction (DSCGR). Historically, New Caledonia has experienced few destructive tsunamis in the past 150 years (Sahal et al., 2010; Ioualalen et al., 2017). The majority of tsunamis that reached the coast were rather small or moderated events (Roger et al., 2019), like the one of December 5, 2018 for example (e.g. Roger et al., subm.). In the context of local events, the detection of an earthquake and the following issuance of a warning must be done in the shortest time in order to secure coastal populations and users as quickly as possible (time < 15 min between the earthquake and the first arrival of the tsunami at the coast). Tsunami hazard mapping is only a single part of the tsunami risk analysis, which needs to be completed with palaeotsunami studies (Pelletier et al., 2020) and coastal vulnerability studies (e.g. Thomas et al., subm.).

Empowering Communities for Tsunami Hazard

By Wildaomaris Gonzalez Ruiz, Puerto Rico Emergency Management Bureau

Geography, socioeconomics, and demographics influence how vulnerable Puerto Rico is to earthquakes and tsunamis. Using data from the 2010 census, it was determined that around 250,000 people reside within the tsunami evacuation zone. For example, in the municipality Toa Baja, 47% of the population resides inside that area. Tourists are also a factor. According to tourism data from the Puerto Rico Statistics Institute, during 2018 more than 1.2 million passengers arrived on the island from cruise ships. When communities prepare, they need to take all these factors into consideration.

Figure 1.

In Puerto Rico, there are 46 Tsunami Ready municipalities and 16 Tsunami Ready Supporter entities. Despite this, it has been a challenge for coastal communities to fully participate in the Tsunami Ready Program. This is mainly due to the low frequency of tsunamis that impact the Caribbean. The last earthquake that generated a significant tsunami that affected Puerto Rico was in 1918.

However, in 2020 the island was impacted by more than 15,000 seismic events that aroused more interest in preparing for a tsunami. For this reason, the Toa Baja Emergency Management Office, in an effort to improve tsunami evacuations in their communities, which includes about 42,000 residents and a fluctuating tourist population within the tsunami evacuation zone, decided to delineate the routes directly onto the road (Figure 1). In addition, the community of Villa del Carmen in Ponce, Puerto Rico designed its first mural which displays the tsunami evacuation route, and educates the public about the tsunami warning levels (Figure 2). Ponce has about 12,500 residents within the tsunami evacuation zone.

Figure 2.

Finally, other communities such as the municipality of Loiza, Puerto Rico are improving their tsunami preparedness and having discussions about the need for vertical evacuation structures. Other areas are even doing night drills as is the case in the San Jose Community in Mayaguez.

Experts Across the Country Take Part in Girl Scouts Science of Disaster Event

By Elyssa Tappero, Washington Emergency Management Division

In November 2020, the Girl Scouts of Western Washington, in collaboration with the Girl Scouts Heart of Central California, Girl Scouts Dakota Horizons, and Girl Scouts of Tropical Florida, expanded its emergency preparedness offerings with their "Science of Disaster: Building Community Resilience" event. This program focused on the sciences of natural hazards, including geology, meteorology, and seismology. Hundreds of Girl Scouts from 6th to 12th grades selected one of four disaster paths: Earthquakes and Tsunami, Wildfire and Landslides, Severe Storms and Tornados, or Hurricanes. During the day-long virtual program, participants learned about the environmental sciences behind their

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Experts Across the Country Take Part in Girl Scouts Science of Disaster Event

By Elyssa Tappero, Washington Emergency Management Division

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chosen disaster, how to prepare in advance of the disaster, what to expect during and after the disaster, and how to build resiliency within their families, neighborhoods, and communities. Speakers included subject matter experts, scientists, emergency managers, fire service, and law enforcement officials. Following the Girl Scout motto "If she can't see it, she can't be it", speakers also highlighted their career paths and discussed the importance of women and other minorities in STEM fields.

The 2020 event focused on the global theme of climate change and how it effects the disasters in each pathway. For the Earthquakes and Tsunami disaster path, this included discussing the impact of sea level rise on tsunamis and how coastal communities are including this long-term hazard into their planning. In the "What to Expect During and After a Disaster" section, the discussion included methods for staying calm during a disaster, how disasters can affect your mental health, why self-care in the aftermath is so important, and ways to harness your personal skills to help those around you. Action items included steps participants could take that same day to become better prepared as an individual, with their families, or as larger projects in their troops and communities.

The following speakers took part in the Earthquakes and Tsunami disaster path:

- **The Science of Disaster—**Carrie Garrison-Laney (Tsunami Hazards Specialist with University of Washington SeaGrant); Ardi Kveven (Executive Director of the Ocean Research College Academy at Everett Community College, WA)
- **Preventing and Preparing for Disaster—**Hannah Cleverly (Deputy Director of Emergency Management for Grays Harbor County, WA); Jenn Brown (Emergency Preparedness Coordinator for City of Marysville, WA)
- **What To Expect During and After a Disaster—**Elyssa Tappero (Tsunami Program Coordinator with Washington Emergency Management Division); Jessica Saunders (Mendenhall Postdoctoral Research Fellow at the Earthquake Science Center, U.S. Geological Survey); Kaitlin Owens (Associate Faculty at Everett Community College, WA)
- **Building Community Resilience—**Anne LeSage (Emergency Management Coordinator for the City of Bainbridge Island, WA); Samantha Robinson (Community Preparedness Specialist with FEMA Region 10, National Preparedness Division)

This was a truly rewarding and enjoyable event to take part in, and it's a wonderful opportunity to inspire the next generation of earth sciences and emergency management enthusiasts. Preparations for the 2021 event will begin this summer, with the event itself most likely to take place in November. This year's focus will be on the Science of Disaster: Architecture and Engineering.

If you or someone you know would be interested in taking part in the 2021 event, please contact Kari Seybolt-Murphy of the Western Washington Girl Scouts at KSeybolt-Murphy@girlscoutsww.org or 1-800-541-9852.

Social Science & Natural Hazards Research

TITLE: Dynamic Risk Perception and Behavior in Response to the Coronavirus Disease 2019 (COVID 19)
AUTHORS: Hua Qin; Christine Sanders; Yanu Prasetyo
LINK: https://hazards.colorado.edu/quick-response-report/dynamic-risk-perception-and-behavior-in-response-to-the-coronavirus-disease-2019-covid-19

SUMMARY: The frequencies and magnitudes of hazards and associated risks in modern society can be exacerbated by globalization and environmental change at local, regional, and global levels. Risk perception and related behavior constitute a fundamental theme in risk analysis. Despite the inherent dynamic nature of risk events, the temporal dimension of risk perception and behavior has been understudied in the current risk science literature. Longitudinal research design is largely lacking in this field as previous studies mostly used cross-sectional data. Infectious disease outbreaks provide a key setting for analyzing changing perception of and response to natural or human-induced hazards. In this study, we examine dynamic risk perception and behavior in response to the coronavirus disease 2019 (COVID-19) in four major U.S. cities (Seattle, Los Angeles, Chicago, and New York City). The main objectives of this research are: (1) to assess temporal changes in major dimensions of perceived COVID-19 risk and behavioral response; (2) to explore the dynamic relationship between risk perception and behavior in response to COVID-19; and (3) to analyze key factors influencing temporal changes in COVID-19 risk perception. We collected timely data on residents' perceptions and actions related to the COVID-19 outbreak through a series of three online surveys. The analysis of panel survey data revealed significant temporal changes in different dimensions of COVID-19 risk perceptions (perceived likelihood of infection, perceived harmfulness if infected, and level of anxiety) and preventive actions. Cross-lagged path models exhibited positive correlations between risk perceptions and preventive actions in each study phase, and varied across-time relationships between individual dimensions of risk perception and actions. Further regression analysis also showed that level of preventive actions had a negative effect on subsequent changes in all three risk perception indicators. These findings can inform further development of conceptual approaches to the interactions between risk perception and behavioral responses, and have important implications for both health risk management and future research directions.

TITLE: Disaster Justice for All: The Need for a More Equitable and Just Recovery Lens
AUTHOR: Alessandra Jerolleman

SUMMARY: As disasters become more frequent and severe, it is more important than ever to determine what can be done to promote more just and equitable disaster recovery. The outcomes of major disasters are nearly always inequitable, which increases the vulnerability of those who struggled before the disaster and often displaces large portions of communities. The tremendous burdens that disaster recovery imposes result in some individuals—such as renters, those working in low-paying jobs, and undocumented people—finding it nearly impossible to recover after disaster.

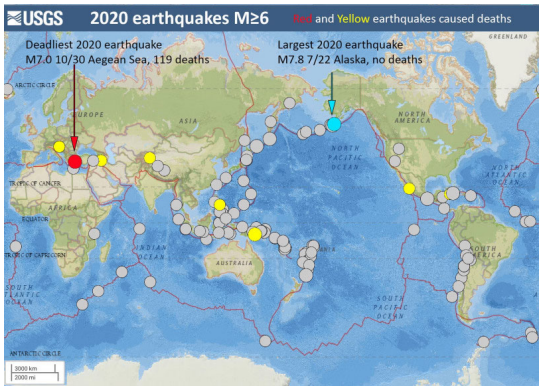
Recovery efforts will continue to replicate these patterns unless we take into consideration the systemic injustices that have shaped the landscape of risk, such as concentrating the poor and minorities into high-risk areas or refusing insurance to those considered a poor financial risk. Families who are unable to afford flood insurance or adequately maintain their homes will find it more difficult to access disaster aid, which is based on the value and condition of their home. Alternatively, the added burdens of meeting higher standards—even those for that reduce risk—can drive the gentrification of neighborhoods and displace those who cannot afford to pay such "safety premiums."

See full article:
https://hazards.colorado.edu/news/research-counts/disaster-justice-for-all-the-need-for-a-more-equitable-and-just-recovery-lens

Not My Fault: Earthquakes and Tsunamis - How Did 2020 Stack Up?

By Lori Dengler/For the Times-Standard January 3, 2020

No matter how you look at it, 2020 will stand out as a difficult year. The year when the pandemic took top billing and wildfires, the economy and political strife battled it out for the next slots. And it was a year when earthquakes and tsunamis rarely made the front page. There were fewer large or deadly earthquakes in 2020 than any year in the last two decades. At least 205 people lost their lives from earthquake related shaking in 2020, the lowest number since 1984 and about the same as the number of L.A. County residents who died from COVID on Friday.



"No catastrophic earthquakes" is good news, and even without great loss, it is worth a look back on the year to see what was learned and what surprised me.

The July 22 M7.8 south of the Alaska Peninsula was the largest earthquake of the year. It was fortuitously located about 60 miles away from the nearest town where distance muted the shaking strength to a moderate level. The 7.8 and its nearly as strong 7.6 aftershock on Oct. 19 are interesting from a tectonic perspective. They were centered in the Shumagin Gap, an area of the Aleutians that had not experienced a great earthquake in the past century and had been identified by some seismologists as a likely source of the next great Alaska quake. The 2020 earthquakes didn't quite fill the gap and they were complex.

The July earthquake was a thrust event probably on or near the subduction zone interface but it produced a very small tsunami. The October earthquake was a strike slip earthquake oriented nearly perpendicular to the main shock. It produced a modest tsunami that was larger than the bigger quake. I am still scratching my head about that one. Some seismologists now speculate that the Shumagin Gap is a transitional zone in the Aleutians and might not produce M9s. Only time will decide if they are correct.

In terms of energy release, the 2020 total was even less than last year, taking over the bottom slot for the last two decades from 2019. In my 2019 summary column, I used Tsar Bomba, the Soviet Union's largest nuclear test ever conducted, to describe seismic energy release. Tsar Bomba, an atmospheric test in 1961, released 50 megatons. The total seismic energy output in 2020 was about six tenths of a Tsar Bomba, down about 11% from last year. Earthquakes are quite capable of exceeding the Tsar's output. The seismic release in 2011 equaled about 14 Tsar Bombas.

Most tsunamis are caused by great earthquakes so it is not much of a surprise that the planet experienced fewer and smaller tsunamis this year. Only one tsunami caused damage and killed a person. It was produced by the Oct. 30 M7 earthquake in the Aegean Sea and reached a height of just over six feet. There is a cautionary tale in this tsunami. Magnitude 7 is not a very large earthquake from a tsunami perspective and yet this earthquake produced higher water levels than the two much larger Alaska earthquakes. The Oct. 30 tsunami appears to have been amplified by the shape of the seafloor and Turkish coastline. The communities affected were less than 20 miles from the epicenter and everyone felt the earthquake. It took only 10 to 15 minutes for the tsunami to arrive. It is another cautionary tale that when you feel an earthquake, you should always think tsunami and head to higher ground as soon as you can.

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The Oct. 30 Aegean Sea earthquake was also the deadliest of 2020. In addition to the tsunami death, it killed 118 people from shaking-related damage. I wrote about the complex tectonic setting and the seismic vulnerabilities of the region before ("Complications in a plate boundary," Times-Standard, Nov. 8, 2020, Page A2). It is no surprise that a number of the damaged structures were unreinforced stone a brick buildings built decades to centuries ago. But post earthquake reconnaissance studies revealed that some of the collapsed structures were built in the 1990s long after earthquake-resilient design was required in Turkey. A report by an Izmir Earthquake Research Center points to sloppy construction and poor code enforcement as the culprits. Another reminder that earthquake engineering design is only as good as what gets put into practice.

While the global activity level was lower than the recent average in 2020, U.S. activity was up both in the contiguous 48 states and Alaska. Nearly 3,000 earthquakes of magnitude 3 or larger were recorded in Alaska and the Aleutian Islands, about 1,000 more than the average over the past two decades. The reason is no surprise – the July 22 M7.8 and its vigorous aftershock sequence. Fortunately the earthquake activity was concentrated in sparsely populated areas.

Nearly 1,500 earthquakes of magnitude 3 or larger were tallied in the lower 48 states, slightly below last year and about 50% above the average over the past two decades. 2019 was high because of the Ridgecrest M7.1 and aftershocks. 2020 saw increased activity in the western U.S.: M6.5s in Central Idaho and Western Nevada, 5s in Utah, Central California and Texas. Aftershocks are still being recorded from many of these earthquakes and also from the Ridgecrest earthquake. So far the activity has been centered away from populated areas and the impacts relatively modest.

There were U.S. earthquake deaths in 2020, but not in Alaska or the lower 48. Fourteen earthquakes of magnitude 5 or larger were located along the coast and just offshore of southwest Puerto Rico. The sequence began on Dec. 28, 2019 with a 4.7 and over the next 10 months produced 118 earthquakes of magnitude 4 or larger, including a 6.4 on Jan. 7, 2020 and 14 earthquakes in the M5 range. Four deaths and nine injuries were attributed to the 6.4 and aftershocks last January.

I am guilty of ignoring Puerto Rico in my annual summaries, but it is the second most seismically active region of the United States (following Alaska), reporting about five times as many earthquakes every year on average as California. Like California, it sits in a complex tectonic environment with a transform plate boundary and major subduction zone nearby. I resolve to pay more attention in 2021.

What does all this mean for earthquake activity in 2021? We will have earthquakes in the coming months. Just because 2020 was relatively quiet doesn't mean there will be more (or fewer) quakes this year. There will be surprises and I hope impacts will continue to be low. But the only way to minimize impacts is to build resilient communities, invest in sciences and engineering, enforce building codes, Drop Cover and Hold On when the ground shakes, and be sure to head to high ground if you are on the coast. I am fond of saying we are one day closer to the next great temblor today than we were yesterday.

Note: Primary source of earthquake information (https://earthquake.usgs.gov/);
tsunami information (https://www.ngdc.noaa.gov/hazard/tsu_db.shtml);
impact information https://en.wikipedia.org/wiki/List_of_earthquakes_in_2020.

Link to original article: https://www.times-standard.com/2021/01/03/lori-dengler-earthquakes-and-tsunamis-how-did-2020-stack-up/

TSUNAMI RESEARCH & EVENTS

RESEARCH

Angove, M.; Kozlosky, L.; Chu, P.; Dusek, G.; Mann, G.; Andserson, E.; Gridley, J.; Arcas, D.; Titov, V.; Eble, M.; McMahon, K.; Hirsch, B.; Zaleski, W., 2021, Addressing the meteotsunami risk in the united states: Natural Hazards, https://doi.org/10.1007/s11069-020-04499-3.

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Nelson, A. R.; Hawkes, A. D.; Sawai, Y.; Horton, B. P.; Witter, R. C.; Bradley, L.-A.; Cahill, N., 2021, Minimal stratigraphic evidence for coseismic coastal subsidence during 2000 yr of megathrust earthquakes at the central Cascadia subduction zone: Geosphere, v. 17, no. 1, p. 171–200, https://doi.org/10.1130/GES02254.1.

Shtienberg, G.; Yasur-Landau, A.; Norris, R. D.; Lazar, M.; Rittenour, T. M.; Tamberino, A.; Gadol, O.; Cantu, K.; Arkin-Shalev; E.; Ward, S. N.; Levy, T. E., 2020, A Neolithic mega-tsunami event in the eastern Mediterranean: Prehistoric settlement vulnerability along the Carmel coast, Israel. PLoS ONE, v. 15, no. 12, e0243619, https://doi.org/10.1371/journal.pone.0243619.

Tufekci-Enginar, D.; Suzen, M. L.; Yalciner, A. C., 2021, The evaluation of public awareness and community preparedness parameter in GIS-based spatial tsunami human vulnerability assessment (MeTHuVA): Natural Hazards, v. 105, p. 2639–2658, https://doi.org/10.1007/s11069-020-04416-8.

Watt, J. T.; Brothers, D. S., 2021, Systematic characterization of morphotectonic variability along the Cascadia convergent margin: Implications for shallow megathrust behavior and tsunami hazards: Geosphere, v. 17, no. 1, p. 95–117, https://doi.org/10.1130/GES02178.1.

UPCOMING NTHMP & RELATED EVENTS

- March 11, 2021—CARIBE WAVE 21 Tsunami Exercise https://www.weather.gov/ctwp/caribewave21
- March 22-26,2021—California's Tsunami Preparedness Week https://www.tsunamizone.org/california/
- March 26,2021—NTHMP WCS Winter Meeting (Virtual) https://nws.weather.gov/nthmp/index.html
- March 30,2021—NTHMP MMS Winter Meeting (Virtual) https://nws.weather.gov/nthmp/index.html
- March 30,2021—NTHMP MES Winter Meeting (Virtual) https://nws.weather.gov/nthmp/index.html
- March 30,2021—NTHMP CC Winter Meeting (Virtual) https://nws.weather.gov/nthmp/index.html
- April 19-23, 2021—SSA Annual Meeting (Virtual) https://www.seismosoc.org/annual-meeting/ssa-2021/