

2022 Annual Report to the NOAA Science Advisory Board from the Tsunami Science and Technology Advisory Panel

Approved by the TSTAP January 18, 2023. Reviewed by EISWG March 13, 2023.

1. Executive Summary

The purpose of this report is to provide an annual update to NOAA's Science Advisory Board on the Tsunami Science and Technology Advisory Panel's (TSTAP) activities and subject matter expert briefings for the 2022 calendar year.

Following the quadrennial report submitted to the NOAA Administrator in 2021, the TSTAP developed a work plan for 2022 and a long-term strategic plan focusing on specific topics to address gaps in knowledge and improve response outcomes. During 2022, subject matter experts briefed the TSTAP on topics summarized as follows (with the inclusion of findings):

- **Tsunami Vulnerability and Risk:** Determining tsunami mitigation strategies requires an understanding of the people and infrastructure most at risk. This could be accomplished by conducting a systematic national effort to determine the number of people in tsunami inundation zones and their evacuation potential. A national dataset developed in conjunction with state/local partners would ensure the use of proper, standard, and well-vetted data.
- **Social Science on Alerts and Warnings:** Pre-written templates informed by social scientists for forecasts improve accuracy, timeliness of release, and message clarity, which will lead to better understanding by the public and media. The U.S. Geological Survey's earthquake forecasts developed by social scientists could be a model for tsunami forecasts.
- **National Weather Service (NWS) TsunamiReady® Recognition Program:** TsunamiReady is a NWS-managed recognition program with a goal of improving community tsunami hazard preparedness. The program has different category designations based on guidelines that when fulfilled can earn a community TsunamiReady recognition and provide signage for public awareness.

TsunamiReady recognition may promote a false sense of security in communities that do not have evacuation options.

- **NWS Advanced Weather Interactive Processing System (AWIPS) Transition for Tsunami:** Rapid dissemination of consistent forecast and decision support products is a critical need of community emergency managers seeking life-saving guidance, especially in the first few hours following tsunami generation. Each recent tsunamigenic event has reinforced the need to improve these products.
- **Tsunami Alerts:** A formal social science study *specific to tsunami alerts* would inform selection of the headline term that would be used if the Tsunami Advisory term is replaced. A poorly chosen replacement term presents great risk to NOAA, the NWS, and the public. The TSTAP supports the recommendations of a letter dated November 3, 2022, sent by the Emergency Management Directors of five Pacific states to the NWS Director to retain the use of the Tsunami Advisory alert term and level.
- **Introduction and Briefing by the New Director of NWS:** The TSTAP was briefed by Mr. Ken Graham who cited the Tsunami Program as one of his top ten NWS priorities.

All of the briefings to the TSTAP in 2022 focused on topics that require some amount of follow up. The TSTAP will continue to receive briefings from subject matter experts and will use the observations and findings written in this report (and future annual reports) in their next quadrennial update report. Some of the key findings discussed here may result in future recommendations to NOAA.

2. Background

The Tsunami Science and Technology Advisory Panel (TSTAP) was established by legislation (P.L. 115-25, Section 503, *et seq*). The TSTAP was formed in August, 2020, and is one of five standing NOAA Science Advisory Board (SAB) working groups.

The Charge to the TSTAP as described in its *Terms of Reference* is two-fold:

- 1) Every four years, beginning in 2021, the TSTAP will deliver a report to the SAB through the Environmental Information Services Working Group (EISWG.) Per the *Tsunami Warning, Education, and Research Act* (TWEREA) component of The Weather Act (P.L. 115-25), the NOAA Administrator shall submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science, Space, and Technology of the House of Representatives a copy of the most recent Panel review report.

The first Report was submitted in December, 2021. ([Copy here](#))

- 2) In the years in which a report is not submitted to Congress by the NOAA Administrator, the TSTAP shall provide a report on its activities to the SAB at one of the SAB's in-person meetings.

Following is the 2022 TSTAP Activities Report on the Panel's work during 2022. This report is intended as an update for the NOAA SAB and, unless the SAB directs, is not transmitted to Congress.

3. 2022 TSTAP Activities

3.1. Work Plan

The TSTAP Annual Work Plan for calendar year 2022 is an internal document meant to provide focus and direction on TSTAP reviews, observations, and findings on issues or concerns not previously discussed or investigated in-depth. Early in 2022, the TSTAP reviewed a list of topics to consider, and prioritized them through an informal ranking process.

The following items and discussion topics are included in the 2022 TSTAP Work Plan and in this Report:

- Development and approval of a TSTAP Strategic Plan
- Review and report on a timely event – the Tonga volcanic eruption/tsunami on January 15, 2022
- Recommendations to fill TSTAP membership vacancies
- Tsunami Vulnerability and Risk
- Social Science on Alerts and Warnings
- NWS TsunamiReady[®] Recognition Program
- NWS AWIPS Transition for Tsunami
- Tsunami Alerts
- Potential future work of the TSTAP

For "Expert Briefings, Section 5," we summarize the observations and findings from the presenters. The TSTAP has initiated a review of these findings to determine their urgency and importance for suggested, more immediate action by NOAA. The "Initial TSTAP findings" in each Expert Briefing section summarizes the discussions and status of the TSTAP review.

3.2 Media Interviews and Requested Presentations

During February, March, and April 2022, TSTAP Co-Chairs and members participated in media interviews regarding the 2021 TSTAP Report. This was a natural and anticipated outcome following the release of the Report to Congress by NOAA. The Co-Chairs and panel members were also requested to make presentations about the 2021 TSTAP Report to the National Tsunami Hazard Mitigation Program and the Cascadia Coastline and Peoples Hazards Research Hub.

3.3 Planning for TSTAP In-Person Meeting

The TSTAP discussed having its first in-person meeting as authorized by the TSTAP Terms of Reference. A number of locations for this meeting were discussed and justified. Ultimately, the NOAA Pacific Tsunami Warning Center and the International Tsunami Information Center co-located at the NOAA Inouye Regional Center in Honolulu were chosen since several items in the December 2021 TSTAP Report address the overall tsunami warning system and there was a lack of first-hand familiarity with the operations of these centers by most TSTAP members. The meeting was authorized and scheduled for September, 2022. In June 2022, however, the TSTAP was notified that travel funding for this meeting and for all of FY 2022 had not been budgeted by the NWS.

The TSTAP Co-Chairs officially requested this issue be elevated to the highest levels within NOAA to have this matter resolved. As of passage of the Omnibus Federal Budget in December 2022, the National Weather Service reached out to ask about dates when we want to meet. The TSTAP conducted a poll and determined members will be available May 2-4, 2023.

3.4 Filling TSTAP Vacancies

An original member of the TSTAP resigned in December 2021 due to workload. The TSTAP was advised that it had eight positions; six were filled. The TSTAP discussed potential candidates who would help inform us on our work. Two highly qualified professionals, both of whom are retired, were identified for these vacancies.

A justification memo was prepared by TSTAP Co-Chairs and submitted to Dr. Decker who submitted it through channels. NOAA Administrator Spinrad appointed Dr. Lori Dengler and Ms. Marie Eblé in April, 2022. All positions on the TSTAP were then completely filled.

4. 2022 TSTAP Documents and Reports

4.1 TSTAP Strategic Plan

Since the TSTAP is an ongoing, rather than project-oriented, working group, and on advice from SAB Executive Director Dr. Cynthia Decker, the TSTAP developed a 5-point long-term Strategic Plan. The Plan covered how the TSTAP will conduct business in line with its *Terms of Reference* and manage its ongoing operations.

The TSTAP Strategic Plan was written and approved with minor revisions as requested by the EISWG. The SAB approved it by unanimous consent at its meeting on August 30, 2022. [The TSTAP Strategic Plan is available on the SAB website here.](#)

4.2 Review of the Tonga volcanic eruption of January 15, 2022

The TSTAP Strategic Plan states that when a significant tsunami event affects U.S. coastlines, the TSTAP will conduct a review of the event, and if warranted, will inform the SAB and NOAA of findings and observations relevant to recommendations in the 2021 TSTAP Report.

On January 15, 2022, the uninhabited volcanic island of Hunga Tonga-Hunga Ha'apai northwest of Tonga erupted explosively producing a Pacific-wide tsunami. The Pacific and National Tsunami Warning Centers (TWCs) indicated they struggled to develop reliable tsunami forecasts because their forecast systems are not designed for non-seismic (e.g., volcanic) source events. Many hours after the event, and only a few hours prior to arrival in Hawaii, Alaska, and the West Coast of the U.S. mainland, the TWCs forecasted "Advisory" level alerts for these U.S. states. Although this forecast was relatively accurate in predicting the resulting coastal tsunami wave heights, uncertainty in the forecasts and delayed alerting remained significant issues leading up to the arrival of the tsunami. In some areas where the tsunami coincided with a high tide, moderate flooding and damage occurred along beaches and within harbors. Approximately \$10M in damage occurred to harbors and coastal structures along the West Coast of the U.S.

Based on a post-tsunami assessment, the TSTAP found that 15 of the 22 recommendations it made in its December 2021 report, addressing forecasts, messaging, and response, were exemplified by this event. For this reason, the TSTAP developed a supplemental case study [report](#) to reinforce the recommendations of the 2021 report, the most relevant of which include:

- Expand TWC forecast capabilities to include all seismic and non-seismic tsunami events.
- Provide more timely decision support and response oriented information to emergency managers, especially within the first hour.
- Upgrade the notification and messaging system.
- Incorporate tidal conditions and other factors influencing flooding into decision support tools.
- Improve forecast and alert capabilities within unique and complicated waterways such as Puget Sound and the San Francisco Bay area.

This assessment demonstrated the urgency for NOAA to address the recommendations made in the original December 2021 report to help protect U.S. coastal residents, visitors, and property during future tsunamis.

The *NOAA Tsunami and Technology Advisory Panel's Post-Tsunami Review Report* on that event was presented to the EISWG and SAB by the TSTAP Co-Chairs and on approval by both groups, was provided to NOAA on April 27, 2022. ([Link here](#)).

5. 2022 TSTAP Expert Briefings

5.1 Tsunami Vulnerability and Risk

5.1.1 Presentation Summary: Dr. Nate Wood of the U.S. Geological Survey (USGS) briefed the TSTAP on Tsunami vulnerability and risk during its April 13, 2022, meeting. The U.S. does not currently have an adequate understanding of populations vulnerable to tsunamis. Looking at how to reduce loss of life from tsunamis involves (at a minimum) an exposure analysis:

- Discover who is at risk through a Sensitivity Analysis - Determine who may need more assistance to prepare for, respond to, and recover from future tsunamis. Vulnerability attributes include age, employment, gender, housing, race and ethnicity, and socioeconomic status. For example, older adults may not be able to run to higher ground and renters or vacationers may not be aware of the hazards and actions to take.
- An Exposure Analysis would determine the number of people (and infrastructure) in the hazard zones. This also includes looking at the future population changes for evacuation planning. Exposure analysis results can also be used to guide evacuation policies under different scenarios.
- Study the Adaptive Capacity- Will people be able to evacuate in time before waves arrive? Is the system (town, state, nation) designed for this hazard/event?

- Risk Reduction - What efforts can be undertaken to address specific issues of community vulnerability to tsunamis? Determine which areas have more time to evacuate than others, then divide into groups to determine risk reduction strategies (education vs. vertical evacuation structures).

Risk from local and distant source tsunami events: The U.S. faces tsunami threats from distant and local-sourced tsunamis. A distant tsunami is one that originates away from the impacted population: the earthquake is not felt, the wave arrives in over three hours, and alerts must be distributed. A local tsunami is one that originates proximal to the impacted area: the earthquake is felt, and the wave arrives within three hours. The potential for loss of life from these events differs depending on the tsunami source and the amount of time available to evacuate.

A national understanding of the people impacted and their ability to evacuate during a tsunami is needed. Dr. Wood reviewed the December TSTAP report and identified two recommendations that would directly help at-risk individuals evacuate a distant tsunami: “improve message composition and dissemination” and “ensure consistency in evacuation maps.” During a distant source tsunami it is critical that the alert messages from the Tsunami Warning Centers are conveyed in a way that inspires appropriate actions and that the local communities have exercised evacuation from a distant source event. In the case of a local tsunami, the two TSTAP report recommendations that would help at-risk individuals are “ensure consistency in evacuation maps” and “conduct evacuation modeling and feasibility studies for vertical evacuation structures.” In order for people to be able to survive a local tsunami they need to have a place to go (nearby high ground or a vertical evacuation structure) and be able to reach safety in time.

Exposure and sensitivity analysis: There is an incomplete understanding of the numbers and demographics of people in hazard zones, their social vulnerability, and their level of understanding of the risk. This information is critical for helping people manage their risk (including consistent education, guidelines on effective community exercises, active tsunami working groups, and strengthening the NWS TsunamiReady Program).

Reducing loss of life from tsunamis involves analysis in exposure (how many people impacted), sensitivity (characteristics of the people), adaptive capacity (are people able to reduce or manage vulnerabilities), and risk reduction (efforts to reduce/manage risk). An investment of time and money is needed to help communities understand their vulnerabilities and implement actions to address those vulnerabilities.

- Community based assessments- asking communities how they are vulnerable and how they might want to solve it.

- Evacuation and loss mortality studies- such as using the USGS Pedestrian Evacuation Analyst Tool and FEMA's HAZUS software. People need metrics that will impact them personally in order to see behavior change. They need to know how many daycares won't be able to evacuate in time, or how their community may fare in a disaster.
- Economic loss- The FEMA National Risk Index does not take into account large threats (only averaging historical data), so Dr. Wood does not recommend using the tsunami data here to understand risk.
- Perception and preparedness studies- Used to understand if at-risk individuals would/could evacuate and if they have done anything to prepare. This is not a well-studied area (for tsunami, though there are deep and thorough studies related to hurricanes), so increasing these studies specifically for tsunami events is recommended, as is evaluating the effectiveness of tsunami education content and approaches.

5.1.2 Initial TSTAP findings: There is a need for a national effort to determine the number of people in local tsunami inundation zones and those who would not have time to evacuate. Understanding the people and infrastructure that are at the most significant risk during a local tsunami is critical for determining mitigation strategies. A national dataset developed in conjunction with state/local partners would ensure the use of proper and well-vetted data.

5.2 Social Science on Alerts and Warnings

5.2.1 Presentation Summary: Dr. Sara McBride of the U.S. Geological Survey (USGS) briefed the TSTAP on this topic during its May 18, 2022, meeting. She focused on lessons learned from the USGS aftershock forecast program and the importance and use of social science in effectively communicating scientific information to the public during geologic hazard events.

Learning from earthquake aftershock forecasting: Earthquake aftershock forecasts are derived from a statistical model to predict expected aftershocks following an earthquake sequence. New Zealand began making public aftershock forecasts in the past 10 years, and a social science evaluation of these earthquake forecasts improved both their context and how they are provided.

Social science studies of New Zealand aftershock forecasts revealed what information should be provided, how it should be formatted, the message frequency that is most helpful, and that information needs changing at the beginning, middle, and later in the forecast sequence.

Recipients, especially decision makers, the public, and the media, need more than tables with numbers. They need context (information, text, narratives, stories, scenarios, and maps) to understand a forecast. Including all of these features in a forecast leads to understanding and comprehension by different groups.

It is noted that many people found aftershock forecasts valuable and comforting, even if they did not understand them well.

Social Science informs the usefulness of earthquake products: Since 2017, the USGS developed and released aftershock forecasts for earthquakes exceeding magnitude 5.0. Social scientists found that a template with pre-approved language enabled more rapid release of information. Tailoring a forecast is sometimes necessary for complex and prolonged earthquake sequences. To this point, the USGS created a wide-ranging social science working group as the relatively new earthquake alerting system called "ShakeAlert" was being developed. This working group continues to provide significant and ongoing support to the USGS to improve the ShakeAlert system.

Social science studies of public and media reaction to earthquake forecasts led to significant improvements in pre-designed templates, recognizing that ongoing social science review of this work leads to improved and more accurate interpretation and response. There are analogies from this work that can be applied to tsunami forecasts. Incorporating and embedding qualified social scientists to review and inform its warning practices is a standard procedure within the USGS and would be helpful for NOAA to do the same for its Tsunami Program.

5.2.2 Initial TSTAP findings: Pre-written templates informed by social scientists for forecasts improve accuracy, timeliness of release, and message clarity leading to better understanding by the public and media. The USGS efforts for earthquake forecasts can be applied to tsunami forecasts by qualified social scientists.

5.3 NWS TsunamiReady® Recognition Program

5.3.1 Presentation Summary: Mr. Ian Sears of the NWS Tsunami Program briefed the TSTAP on the TsunamiReady Program during its June 15, 2022, meeting. Additionally, Dr. Nate Wood, of USGS also touched on TsunamiReady during his briefing on tsunami vulnerability and risk, some of his comments are captured here as well.

The TsunamiReady Program is an NWS-managed collaboration between local, state, and Federal partners to promote tsunami hazard preparedness. The program operates under established guidelines for preparedness, mitigation, and response. The Program encourages communities and States to develop consistent educational materials,

increase public awareness and understanding of tsunami hazards, and improve community planning to prepare for, mitigate, and respond to tsunami events. Communities that satisfy program Guidelines apply for recognition and if they are determined eligible by the local NWS Warning Coordination Meteorologist in coordination with a TsunamiReady Board (where one exists) they are formally recognized by NWS as a TsunamiReady Community for a period of four years.

The TsunamiReady Program is an integral part of NTHMP's strategic theme of *Tsunami Education and Preparedness*, a specific goal of which is to establish and maintain TsunamiReady communities. This includes recognizing and increasing the number of TsunamiReady communities, and increasing the number of TsunamiReady supporters.

TsunamiReady builds relationships and supports Impact Based Decision Support Services: The NWS has adopted "impact-based decision support services (IDSS)" into its [official Mission Statement](#) and Strategic Plan. TsunamiReady is a key component of the relationship-building and preparedness phase of the IDSS cycle. Because of this, the NWS will continue to rely on the TsunamiReady Program to promote tsunami preparedness at the community level.

TsunamiReady tiers: The TsunamiReady Program uses a tier structure based on tsunami risk to designate communities as TsunamiReady. A Tier Two rating means a community has a greater tsunami risk as well as more significant challenges to mitigate those risks, and therefore must take additional resilience steps to earn their TsunamiReady Tier Two recognition. Higher risk communities are not required to apply for Tier Two recognition. A program category called TsunamiReady Supporters recognizes organizations, schools, businesses, etc. that may or may not be in TsunamiReady communities but support the goals of the TsunamiReady Program.

A map and list of TsunamiReady communities and supporters available to the public can be found at <https://www.weather.gov/tsunamiready/communities>. As of the last time the NWS updated the TsunamiReady website (September 1, 2022), there are:

1. 199 TsunamiReady communities and 26 TsunamiReady supporters.
2. Two TsunamiReady Tier Two recognized communities: Manila, California, and King Salmon, California
3. No additional communities pursuing Tier Two recognition as of Mr. Sears' briefing. The Tier Two communities are not shown on the TsunamiReady communities online map, but will appear in a future update.

Adding Flexibility to TsunamiReady: There are potential benefits to adding greater flexibility to the TsunamiReady Program to customize recognitions so that they better

accommodate individual community circumstances and improve community equity. Mr. Sears suggested that future changes to the TsunamiReady Program could be vetted with the tsunami community and the NTHMP. Another idea of Mr. Sears was that the Warning Coordination Meteorologists at NWS Weather Forecast Offices (those in charge of officially recognizing TsunamiReady communities) in each state could work more consistently and collaboratively with the states and how they approach TsunamiReady. Puerto Rico's TsunamiReady committee could be a model for other states to adopt as it includes local, state, and Federal officials and has been functioning effectively for >12 years.

Strengthen TsunamiReady: There is an apparent conflict between the intended meaning of TsunamiReady recognition, and a false sense of security that such recognition may give to vulnerable communities.

The name TsunamiReady itself could be misleading to the public, particularly tourists who may be confused about what TsunamiReady means in an unfamiliar location. In addition, there are differences in vulnerabilities, with some communities being so vulnerable that they can't be 'ready' for a tsunami because they have no high ground or vertical evacuation structures, and therefore no way for the people to evacuate in a local tsunami event.

Dr. Nate Wood in his briefing on tsunami vulnerability and risk described the need to strengthen the TsunamiReady Program so that when community members and tourists see the "TsunamiReady" sign when they enter a community they can be sure that the community is in fact ready for a tsunami. Dr. Wood cited the findings of the 2011 National Academy Report on the Tsunami Program which summarized that the TsunamiReady program is lacking:

- Metrics to assess preparedness and needs
- Criteria to assess performance during a tsunami
- Accountability measures
- Criteria/guidance on what constitutes effective public outreach/preparedness

Discussions among the TSTAP, Dr. Nate Wood, and Mr. Ian Sears during their briefings explored potential advantages of modifying the TsunamiReady Program. The TSTAP could engage in a deeper discussion of potential program revisions, including the creation of more recognition categories, the creation of non-optional criteria for exclusion from recognition, and the addition of metrics by which to assess the Program. One potential new category highlighted by the Tonga tsunami could be a TsunamiReady category specifically for harbors and ports. It should be noted that according to NWS Directive 10-704, the NTHMP has a stated role to provide recommendations directly to

the NWS for any modifications to the TsunamiReady Guidelines. The TSTAP does not have an identified role in this directive, however may provide feedback to the SAB to be transmitted to NOAA through their annual and quadrennial reports.

The [International] Tsunami Ready Programme: Modeled on NWS' TsunamiReady program, the Ocean Decade Tsunami Programme, established by the UN General Assembly for 2021-2030, the *Tsunami Ready Programme* has a goal of having 100% of at-risk communities around the globe recognized as *Tsunami Ready*. The U.S. will be a leader in this effort. This goal may be unrealistic because of the vast amount of different coastlines, and inequities in resources in coastal communities. A definition of "at-risk" has yet to be determined, and there is yet no systematic way to help communities develop a strategy and identify resources needed. The UNESCO Ocean Decade Program recognizes the United States and other developed countries as having a Tsunami Ready Programme in place.

5.3.2 Initial TSTAP findings: TsunamiReady is an NWS-managed recognition program with a goal of improving community tsunami hazard preparedness. The program has different category designations based on criteria that when fulfilled can earn a community TsunamiReady recognition and physical signage for public awareness. TsunamiReady recognition may promote a false sense of security in communities that do not have evacuation options. While the NTHMP is empowered to suggest modifications, changes, and improvements to the TsunamiReady Program, the TSTAP may choose to continue to discuss the issues raised in Dr. Wood's and Mr. Sears' briefings, and during conversations among TSTAP members. The TSTAP has not formally discussed the impact the Tsunami Ready Programme may have on the US TsunamiReady Program.

5.4 NWS AWIPS Transition for Tsunami

5.4.1 Presentation Summary: Mr. Ian Sears of the NWS Tsunami Program and Mr. Jim Buchman of the NWS Central Processing Office briefed the TSTAP during its July 13, 2022 meeting, on plans for the two tsunami warning centers to disseminate products through the Automated Weather Information Processing System (AWIPS).

AWIPS to unify messaging of the two tsunami warning centers: NOAA intends to transition the product generation and dissemination procedures used autonomously by the two tsunami warning centers to AWIPS to unify messaging of the two centers. The AWIPS framework is now widely used for NOAA forecasting of weather events impacting terrestrial and ocean environments, including hurricanes, tornados, thunderstorms, and storm surge. Broadcast to NOAA Weather Radio and automated requests for FEMA to activate Wireless Emergency Alerts are controlled by AWIPS

interaction with the Emergency Alert System (EAS) which is activated by NWS Weather Forecast Offices (including for tsunamis).

A project entitled AWIPS Tsunami Operations Messaging Service (ATOMS) is underway to standardize tsunami warning center messaging with one another and with those of the NWS. The AWIPS ingests a wide array of processed data (radar, satellite, models, meteorological, and surface observations) but does not ingest seismic data, data from global navigation satellite systems, Deep-Ocean Assessment of Tsunami (DART), or other ocean data needed for tsunami forecasting. These 'raw' data will be pre-processed by tsunami duty scientists and then transferred to the ATOMS.

Improving timeliness and consistency of tsunami messaging: The ATOMS project holds the promise of significantly improving the timeliness and consistency of tsunami messaging. Transition of the two Tsunami Warning Centers to the AWIPS standard platform now in use across NWS offers consistent product dissemination and the ability to evaluate the threat posed by a tsunami from any AWIPS station after processed data are available through the ATOMS. The ATOMS, as planned, will expedite messaging by providing recommendations and automating distribution after rapid assimilation of all available information. The fact that the automated distribution stream does not include the Twitter feed supported by NTWC is a concern of the TSTAP.

Update of the Tsunami Forecast System: A coincident effort to update the Tsunami Forecast System (TFS) is underway. Centralization of data processing and analysis, forecast methods, access to past or 'historical' tsunami event data held by NESDIS National Center for Environmental Information (NCEI), and computational platforms are considered in this effort. An Interface Control Document defines the boundary between the ATOMS messaging component and the TFS.

5.4.2 Initial TSTAP findings: Rapid dissemination of consistent forecast and decision support products is a critical need of community emergency managers seeking life-saving guidance, especially in the first few hours following tsunami generation. The need to address the shortcomings of current product dissemination is reinforced with each tsunamigenic event. The use of AWIPS to disseminate tsunami forecasts aims to:

1. Quickly provide emergency managers with products that meet their needs.
2. Clarify warning center specific area of responsibility protocols.
3. Provide the two tsunami warning centers with resources and training so staff can become familiar and comfortable with new technology and methods.
4. Plan for centralized processing of raw data and transfer of these data to the AWIPS.

5.5 Tsunami Alerts

5.5.1 Presentation Summary: Mr. Mike Angove of the NWS Tsunami Program, Ms. Yvette LaDuke of California Emergency Services and Co-Chair of the National Tsunami Hazard Mitigation Program's (NTHMP) Warning Coordination Subcommittee, and Mr. Rick Wilson and Ms. Corina Allen in their roles as members of the NTHMP, briefed the TSTAP during its August 10, 2022, meeting.

Several of the recommendations in the 2021 TSTAP Report addressed issues with Tsunami Alert levels (Watch, Advisory, and Warning.)

The NWS HazSimp initiative will cause a significant change for all NWS warning products. The NWS intends to eliminate all Advisory level alerts for all of its products by 2024. For tsunamis, the current Tsunami Advisory alert (forecast tsunami amplitude between 0.3 to 1.0 meters) is issued when a tsunami with the potential to generate strong currents or waves dangerous to those in or very near the water or in harbors is imminent, expected, or occurring.

The NWS will change Tsunami Advisory to something else in order to eliminate the Advisory term. This is a requirement due to a decision made by the NWS to eliminate all Advisory alerts for all hazards. At the time of this briefing, the TSTAP was informed by the NWS that there was not an option to retain the Tsunami Advisory term.

The NWS is working closely with state and territory representatives who participate in the NTHMP's Warning Coordination Subcommittee to scope out the effects of this change, advise and select headline language as a replacement for the Tsunami Advisory term, and how to best implement this change come 2024 when it is to take effect.

Removal of the Advisory alert level: The NWS has stated that social science on the general term of "Advisory" has been done and has shown the term "Advisory" is confusing to the public. The TSTAP agrees that the term is confusing and there may be a need to replace it.

However, the social science done for the NWS in its HazSimp process was about weather advisories (winter, hurricanes, and severe weather), not ocean-related terminology. Extrapolating social science about weather terminology to tsunami alerts, where specific life-saving actions are warranted, is not recommended because extrapolation is inconsistent with current social science practices.

Social science study for tsunami alert levels: Implementing such a major change in alert & warning terminology for tsunamis without engaging “outside” credentialed social scientist(s) to study the matter and share observations with the NWS and the NTHMP before final decision-making on the term to replace the Tsunami Advisory term is completed or adopted could have many unintended consequences and poses a risk to NOAA and the public.

The TSTAP was provided with a letter cosigned by State Emergency Managers voicing support for retaining use of “Advisory” term and level: On November 3, 2022, the Directors of emergency management agencies for the states of Alaska, California, Hawaii, Oregon, and Washington sent a letter to the NWS Director Ken Graham to support maintaining the existing “Tsunami Advisory” term and level. The TSTAP concurs with this letter until such time as a tsunami-specific social science study on said alert level, or alternatives to replace it, can be conducted and results are socialized with stakeholders.

5.5.2 Initial TSTAP findings: Not having a formal social science study *specific to tsunami* of the selection of the headline term that will replace the Tsunami Advisory presents great risk to NOAA, the NWS, and the public. The TSTAP has not advised the SAB on this decision-making process on changing the Tsunami Advisory term. However, we have observed that an essential step of conducting a formal tsunami-specific social science study is not planned (the NWS confirmed this during the August 10 TSTAP meeting). Until an extensive tsunami-specific social science study is completed and fully socialized with stakeholders to obtain agreement on any term change, the TSTAP supports the request in the letter from the five states to retain the “Tsunami Advisory” term and alert level.

5.6 Discussion with the New Director of the National Weather Service

5.6.1 Presentation Summary: Mr. Ken Graham, Director of NOAA's National Weather Service (NWS) and Assistant Administrator for Weather Services at NOAA, as well as Allison Allen, NWS Analyze, Forecast, and Support Office Director, and John Murphy, NWS Chief Operating Officer, briefed the TSTAP on how the Tsunami Program and TSTAP efforts align with NWS priorities.

National Weather Service Tsunami Priorities: Tsunamis are one of the top ten priorities for the NWS. Mr. Graham discussed some areas where the NWS is looking to strengthen the Tsunami Program, they include:

- Unification efforts: Maintaining two Tsunami Warning Centers and unifying them to have similar tools and dissemination technology (ATOMS), and similar systems, so that for any single event there would be one forecast common to both centers and the centers would have better backup capability. Looking for funding within AWIPS to be able to do this.
- Tsunami.gov: Redesigning tsunami.gov website (similar to the Hurricane Center) for better functionality and a similar design to other NWS websites. They have a FY23 contract to do this redesign and are in the process of gathering requirements and functionality as well as a social science component for user interface and decision making.
- Federal Funding Request: Mr. Graham mentioned budget requests to provide support for common analytic systems, dissemination systems, a common place to work, and cloud-based solutions for data.
- Support NWS staff: Provide flexibility for the workforce and support staff needs. Move NWS Chat to Slack, which will be tested in the Pacific in 2023 and implemented later in the year.
- Climate Change and tsunami: Tsunami is included in the NWS discussion of what makes a climate ready nation and NWS recognizes that the tools (such as observation data) and risks for climate change and tsunami are related.

5.6.2 Initial TSTAP findings: The TSTAP recommendations in the 2021 quadrennial report are helping to drive the requirements and plans for TWC harmonization and the NWS Tsunami Program. With tsunamis as one of the top ten priorities of the NWS, TSTAP efforts and recommendations can support this NWS priority.

6. CLOSING REMARKS

The purpose of this report is to provide an update to NOAA's Science Advisory Board on the Tsunami Science and Technology Panel's (TSTAP) activities and subject matter expert (SME) briefings for the 2022 calendar year. 2022 TSTAP activities included developing a TSTAP Strategic Plan and evaluating and developing a report for tsunami response activities related to the January 15, 2022, tsunami originating from the Tonga islands. SMEs briefed the TSTAP on the following new topics not addressed directly in the Dec. 2021 TSTAP quadrennial report to the NOAA Administrator and Congress:

- Improving understanding of the national tsunami vulnerability and risk to people and infrastructure
- Improving inclusion of social science review for tsunami alerts and warnings
- Issues and gaps of the NWS TsunamiReady recognition program in the U.S.
- Improvements from the NWS AWIPS transition for tsunami messaging

- Challenges to the public understanding of tsunami alerts and messaging
- Discussion of future tsunami-related goals of the NWS from the perspective of the NWS Director.

In 2023, the TSTAP may continue to further evaluate 2022 SME briefing topics and develop a list of future SME briefings to discuss additional important tsunami-related topics. Ongoing TSTAP discussions will likely address concerns with messaging related to TsunamiReady recognition, expected changes to the NWS Tsunami “Advisory” alert level, and the need for social science review and assistance. As time permits and if included in TSTAP Work Plan priorities, future briefings may explore tsunami warning, preparedness, and mitigation activities of the international community and continue to work with NOAA and other Federal, State, and private partners to improve the end-to-end tsunami warning system. The TSTAP will also review the responses by NOAA to recommendations outlined in the 2021 TSTAP report.

7. Appendix

List of TSTAP members for 2022

Co-Chairs:

Dr. Rocky Lopes, Certified Emergency Manager, Applied Social Scientist, formerly supporting the NOAA/NWS Tsunami Program. Retired.

Mr. Rick Wilson, Senior Engineering Geologist, California Geological Survey

Members:

Ms. Corina Allen, Chief Hazards Geologist for the Washington State Geological Survey

Dr. Lori Denger, Emeritus Professor of Geology, CalPoly Humboldt University

Ms. Marie Eblé, Oceanographer (retired), formerly with the NOAA Pacific Marine Environmental Laboratory

Dr. Carrie Garrison-Laney, Tsunami Hazards Specialist and NOAA Center for Tsunami Research/Pacific Marine Environmental Lab Liaison, Washington Sea Grant

Dr. Diego Melgar, Assistant Professor of Geophysics, University of Oregon

Dr. Aurelio Mercado, Retired Professor of Oceanography, University of Puerto Rico

NOAA/NWS Representative:

Mr. Michael Angove, NWS Tsunami Program Lead

USGS Representative:

Dr. Paul Earle, Director of Operations, USGS National Earthquake Information Center

Environmental Information Services Working Group Liaison:

Dr. Thomas W. Altshuler, Senior Vice President Defense Strategy and Business
Development, Teledyne Marine