Tsunami Science and Technology Advisory Panel (TSTAP)

2023 Annual Report and White Paper on Complicated Inland Waterways

Corina Allen, TSTAP co-chair

March 20, 2024

2023 TSTAP Annual Report

Executive Summary:

- TSTAP in-person meeting May 2023
- NOAA response to 2021 Quadrennial Report
- White Paper for Alerting for Complicated Inland Waterways
- National Risk Index (FEMA) Statement (briefed SAB in July 2023)
- Subject Matter Expert Briefings
- TSTAP Terms of Reference Update (pending NOAA approval)

TSTAP In-Person Meeting at NOAA's Pacific Marine Environmental Lab in Seattle, WA

Briefing by NOAA on Response to 2021 TSTAP Quadrennial Report

- Valuable walk through and Q & A on the NOAA response by Mike Angove, former NOAA Liaison to TSTAP.
- NOAA concurred with or supported many of the recommendations the TSTAP made; however, for many of the recommendations NOAA did not commit resources or provide actionable responses.
- The TSTAP has requested NOAA develop work plans and schedules to address each recommendation.

NOAA's response and progress on TSTAP 2021 recommendations

Color coded recommendations based on briefings from NOAA, the NTHMP, NWS leadership, and SME briefers accordingly:

- GREEN: Progress is being made by NOAA and funding and/or staff resources have been allocated and TSTAP is aware of progress.
- YELLOW: NOAA generally concurs with this recommendation and may be looking for resources or opportunities to address this recommendation.
- RED: NOAA partially concurs or is open to this recommendation but no indication of how this recommendation will be addressed or completed has been provided to TSTAP. For many of these recommendations NOAA suggested that other partners, such as the NTHMP, work on this.

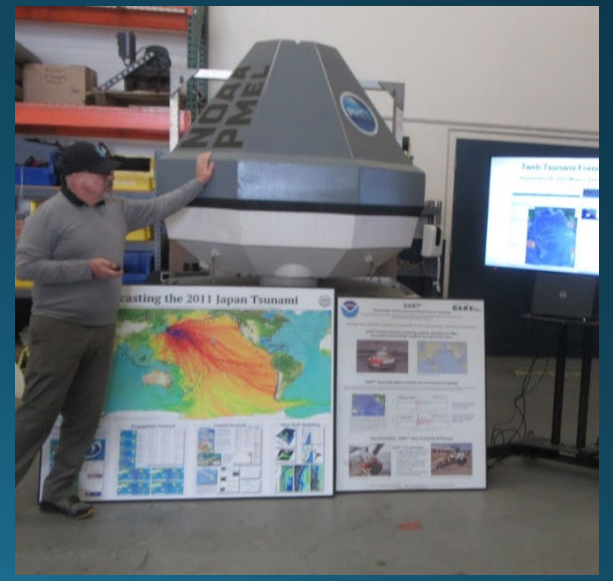
TSTAP Table Summarizing NOAA's Progress on TSTAP Recommendations

- NOAA committed to working on several recommendations, including TWC unification, TWC backup, and an enterprise-wide technology upgrade for the warning system.
- It appears to the TSTAP that NOAA's priorities are focused on regional tsunami detection, forecasts, and warnings and not TSTAP recommendations related to research, mitigation, resilience, and preparation as well as state/local forecasts, warning, and response needs.
- For several of the recommendations NOAA referred the recommendation to another entity, primarily the National Tsunami Hazard Mitigation Program (NTHMP) which does not have the authority to direct NOAA activities.

Major Recommendations	Sub-Recommendations: It is recommended that the NOAA Administrator... [TSTAP 2023 Annual Report color code]	NOAA Responses and TSTAP Follow-Up
1. Improve unification and capabilities of the Tsunami Forecast System.	1.1. Align and consolidate TWCs and overhaul the forecast system to unify detecting earthquake parameters and produce the same products (e.g., forecast wave heights). [GREEN]	NOAA mostly concurred. Some alignment issues will be implemented through installation of Tsunami AWIPS communication system (Q2FY24) and common analytical system (CAS; unknown completion date). However, NOAA indicated that the priority for expanding forecast location products may not be addressed until "second phase" of Tsunami AWIPS which has no timetable to be completed. TSTAP requests updates from NOAA on this work and will reference their "white paper" which identifies several remaining issues with needed forecast products.
	1.2. Undertake a comprehensive, enterprise-wide technology upgrade for the warning system/program. [GREEN]	NOAA concurred. The transition of legacy TWC product and message generation software to AWIPS and the development and fielding of the TWC common analytic system will address this recommendation. TSTAP requests updates from NOAA on this work.
	1.3. Strengthen the collaborative relationship and expand MOU with the USGS for identifying earthquake parameters and source mechanism. [YELLOW]	NOAA generally concurred with this recommendation, defending its ongoing relationship with the USGS. NOAA is confident this collaborative effort can be adequately supported through the existing NOAA/USGS MOU. TSTAP requests updates from NOAA, especially on meetings with the USGS and actions/outcomes from those meetings and exercises regarding improvements to the TWS. TSTAP also requests that NOAA ensure that the needs of state/local officials are being met and the results are being communicated to those locals/states.
	1.4. Ensure sufficient backup capabilities for tsunami forecasting and alerting. [YELLOW]	NOAA indicated it is fully committed to complying with this recommendation. NOAA believes by pursuing the TWC alignment activities (i.e., AWIPS and CAS), full service back-up between TWCs will be achieved. TSTAP requests updates from NOAA on this work and will reference their "white paper" which identifies several remaining issues with common and consistent forecast products.
2. Improve tsunami detection and observation systems.	2.1. Increase development and improve dissemination of observation networks like tide gauges, web-cameras, and real-time observer programs. [RED]	NOAA partially concurs. The NOAA position is that only deep ocean pressure measurements (DART) provide the information needed for tsunami forecasts. Tide gauges, web-cameras, and other real-time observer programs cannot substitute for deep-ocean measurements. TSTAP will follow up with NOAA. TSTAP believes that with the high number of DART outages and high cost of maintenance, alternatives to supplement DARTs should be sought for at least forecast validation during events. TSTAP requested that other NOAA programs responsible for ocean observing (e.g., tide gauges) be consulted.
	2.2. Expand detection capabilities to all seismic and non-seismic sources. [RED]	NOAA concurs with this recommendation. However, this is a research and development (R&D) effort as there are no reliable indicators of tsunami generation by non-seismic sources before impact to a coastline. TSTAP will follow-up with NOAA on progress of R&D work. TSTAP requested an annual status report/briefing of new technologies evaluations (e.g., Ionospheric tomography and GPS occultation) and examples of non-seismic source capabilities (e.g., Barry Arm landslide in Alaska).
	2.3. Work with NSF and international partners to share and expand the use of GNSS to determine fault rupture extent and movement. [GREEN]	NOAA concurs with this recommendation to expand the use of GNSS. NOAA is engaged with USGS and NASA to add improved earthquake and tsunami characterization capability into tsunami warning center operations. TSTAP requested NOAA provide status report or briefing on outcome of operational testing of GNSS scheduled in Calendar Year 2023.
	2.4. Further consider the use of airborne and satellite observing platforms. [RED]	NOAA concurs with this recommendation. NOAA is actively pursuing airborne and remote-sensing observation platforms for the purpose of tsunami detection and measurement as R&D resources permit. TSTAP is uncertain about the NOAA commitment to pursuing airborne and remote-sensing observation platforms. TSTAP has requested NOAA provide a status report or briefing on achievements, outcomes, and next year funding status.
3. Provide more extensive, consistent, and accurate tsunami messages and products.	3.1. Improve the integration of TWC warning functions with USGS, state, and local warning needs and functions. [RED]	NOAA concurred with this recommendation. Ongoing dialogue with the USGS regarding capabilities such as ShakeAlert has led to enhanced interagency coordination. Integration of Earthquake Early Warning (EEW) into NOAA tsunami forecasts and warnings, while ensuring messaging consistency. This is an area of ongoing discussion between NOAA, USGS, and state partners. There appears to be no commitment from NOAA other than to continue to talk about it. TSTAP requested a progress report/update from NOAA on discussions with USGS regarding tsunami alert integration into EEW platforms.
	3.2. Improve tsunami message composition and dissemination methods including updating the tsunami.gov website, creating a single domestic bulletin, and early messaging before a tsunami forecast is developed. [YELLOW]	NOAA concurs with this recommendation. NOAA is actively pursuing a complete tsunami.gov re-design starting in fiscal year (FY) 2023. AWIPS is expected to greatly improve the quality of tsunami product generation and messaging. TWC are reviewing if and how core partners can be provided with additional, early real-time information as TWC duty scientists conduct five tsunami analysis. NOAA is evaluating the best way to convey the entirety of the tsunami threat in actionable, consistent terms. Consolidating domestic bulletins is one option being considered. TSTAP requests briefings on progress into improvements to Tsunami.gov, bulletins, and messaging/communication during the first several hours during an event where a forecast is still being evaluated, which may include evaluation of state early messaging templates and sharing of ATFM data within the first 30-60 minutes.
	3.3. Make available foundational forecast data from propagation models and inundation model results to constituents. [RED]	NOAA is open to this suggestion. TWC standard operational procedures are cautious not to issue speculative information in the typically high-uncertainty, high pressure environment that follows tsunami generation in order to limit confusion. NOAA is open to sharing pre-decisional foundational data and analysis with core partners. NOAA will address this in CY23 through the WCS of the NTHMP. TSTAP requests briefings on evaluations and progress by NOAA and recommendations by the NTHMP WCS. TSTAP will reference their "white paper" which addresses some issues related to this recommendation.
4. Develop enhancements to Tsunami Warning Center forecasts and alert systems.	4.1. Expand granularity in tsunami alert regions where complicated waterways exist (e.g., Puget Sound, San Francisco Bay, etc.). [RED]	NOAA partially agreed with this recommendation. NOAA thinks it is better to more broadly describe the threat because of technical difficulties providing more detailed forecasts in complex waterways. NOAA believes it will also be able to better address this during the AWIPs and CAS upgrades and will work with the NTHMP WCS to help rectify. TSTAP requests continued updates on this topic and has addressed the more specific and clarifying requests through their "white paper" to assist with follow up questions, especially if NOAA will follow recommendation from the NTHMP WCS which it does not have to do. TSTAP is also concerned if and when AWIPs can address this recommendation and that the CAS is unsupported and uncertain if and when it will be completed.
	4.2. Update special procedure areas threat database thresholds, breakpoints, and forecast point locations. [RED]	NOAA partially agreed with this recommendation. NOAA agrees that replacing "procedural" areas with dynamic forecasts and alerts based on real-time data is important as long as this is done carefully and in full consultation with core partners. NOAA indicated that this will be addressed through the NTHMP WCS in CY23 and changes in product or message generation will be enabled through the transition to AWIPS as part of the TWCU effort. As with Recommendation 4.1, these topics are the primary focus of the TSTAP "white paper." TSTAP is concerned about NOAA commitment to complete this work and if NOAA will follow the NTHMP WCS recommendations. TSTAP requested briefings from the NTHMP and NOAA at the end of CY 23 to learn about what has been done on this recommendation.
5. Improve consistency in tsunami preparedness and mitigation products for communities.	5.1. Develop a standardized framework for characterizing, selecting, and using consistent tsunami sources between states. [RED]	NOAA is open to this suggestion, though states have the sole authority to implement it. NOAA will refer this to the NTHMP Modeling and Mapping Subcommittee (MMS) to evaluate the value of establishing common source parameters to be used by all states and territories, understanding that risk assessments may vary. Referred to NTHMP MMS. TSTAP has requested updates from NOAA and the NTHMP MMS regarding this recommendation. Uncertainties exist in the responsibilities and capabilities of the MMS, and NOAA's support for funding development of logic trees and a probabilistic (PTHA) framework for consistent regional tsunami sources and modeling these PTHA sources for consistent mapping products, such are the FEMA National Risk Index (NRI). Work being completed by the states and federal partners through the USGS Powell Center Tsunami Source Workgroup is a good initial step. Follow up with FEMA regarding support for this work is a possibility.
	5.2. As the sponsor of the NTHMP, ask the NTHMP to update guidelines for evacuation maps that ensures consistency between states/communities further, the NWS should update the tsunami map page on the NTHMP website. [RED]	NOAA is open to this suggestion, though states and local entities have sole authority for evacuation maps. This will be addressed in CY23 within the NTHMP MMS and through website contractors hired by NOAA. TSTAP will request briefings from NOAA and the NTHMP MMS about updating evacuation maps and the associated NTHMP website. Developing a plan and schedule will be helpful. Like other recommendations, support/funding to do this work remains an issue so recommendations for NOAA to engage other funding agencies, such as FEMA, might provide the support needed for producing consistent evacuation maps and NRI products.
	5.3. Prioritize probabilistic tsunami hazard mapping at a national scale, especially for updating ASCE/Building Code "Tsunami Design Zone" maps. [RED]	NOAA is open to this suggestion, though considered outside of scope of NOAA. NOAA understands the value in a national probabilistic database to support common design and construction concerns. NOAA will raise this issue within the appropriate NTHMP subcommittees, as well as through consultation with the Department of Homeland Security (or FEMA) and National Institute of Standards and Technology (NIST) and consider further actions as resources permit. TSTAP will request briefings from NOAA and the NTHMP about support for consistent PTHA maps. Developing a plan and schedule will be helpful. Like other recommendations, support/funding to do this work remains an issue so TSTAP agrees with NOAA that raising this issue with FEMA and NIST could share support for PTHA products. NOAA's continued work with the USGS Powell Center Tsunami Source Workgroup should continue.
6. Produce guidance for improving long-term community resilience to tsunami hazards.	6.1. Develop guidance and products for tsunami mitigation/recovery consistent with and leveraging climate change adaptation strategies. [RED]	NOAA is open to this suggestion however it is considered outside of scope of Tsunami Program. While climate change certainly contributes to tsunami impacts, it does not directly impact NOAA's detection, forecast, and alerting capability. NOAA will discuss potential next steps with the Office of Oceanic and Atmospheric Research (OAR) and National Ocean Service (NOS) leadership. TSTAP requests updates from the NOAA and would like to participate in discussions with the OAR and NOS to help clarify the recommendation. A plan and timeline for this work would help it progress.
	6.2. Conduct evacuation modeling, feasibility studies, and risk analyses for vertical evacuation structures. [RED]	NOAA is open to this suggestion however it is considered outside of NOAA's purview. Vertical evacuation is an important consideration of a comprehensive tsunami impact mitigation strategy. NOAA will work with NTHMP Partners and other government and industry experts, as resources allow, to explore establishing common standards. NOAA will also encourage states to consider incorporating vertical evacuation studies in their NTHMP grant proposals. TSTAP requests updates from the NOAA and NOAA facilitation of meetings between the NTHMP and FEMA. A plan identifying resources and examples of successful VES work would help this process.
7. Improve tsunami hydrodynamic modeling.	7.1. Improve tsunami modeling capabilities in the following conditions/areas: variable landscapes (i.e., surface roughness), heavy vegetation, built environment, and dynamic river systems. [RED]	NOAA partially concurred with this recommendation, however the type of fine-scale modeling suggested here would normally be outside NOAA's operational alerting scale. However, NOAA admits this is a high priority recommendation for states like Washington and California with high populations in complex coastal environments like the Puget Sound area and San Francisco Bay, as well as populated areas along rivers. NOAA will look for opportunities to partner with NTHMP member states and territories to advance this scale of modeling capability as resources permit. TSTAP requests reports or progress updates from NOAA as well as a plan to support resources needed to improve modeling capabilities. Although a relatively low priority for NOAA's operational forecast system, NOAA should assist states and communities where this is an admitted high priority.
	7.2. Conduct a greater number of high-resolution bathymetric surveys. [RED]	NOAA concurred with this recommendation and will address as resources permit. NOAA has a well-defined procedure, led by the NOS and the National Weather Service Office of Water Prediction, for establishing priorities for bathymetric surveys. With increasing emphasis on terrestrial and coastal flooding, this will include areas important for tsunami warning and mitigation. NOAA ensured that the concerns of the TSTAP are emphasized in future year budget and program planning processes. TSTAP will ask NOAA for progress updates and to identify any support needed to fulfill this recommendation. A plan and schedule for engaging other programs within NOAA will be requested.
	7.3. Develop a data portal for detailed information for advancing research and model development. [RED]	NOAA concurred with this recommendation and will look to provide this sort of portal in FY23 through the NOAA OAR. TSTAP will ask NOAA for progress updates and to identify any support needed to fulfill this recommendation. A plan and schedule for engaging other programs within NOAA would be helpful. TSTAP can assist NOAA in identifying datasets to include or link to.
8. Develop tsunami research priorities and leverage research opportunities	8.1. Coordinate with Federal, state and territory agencies that have funded research that includes tsunami to leverage and prioritize research opportunities and provide consistent and useful products. [RED]	NOAA concurred with this suggestion. NOAA indicated it will be raised as an agenda item with the Interagency Council for Advancing Meteorological (ICAM) Services as a potential interagency working group. TSTAP will ask NOAA for progress updates and to identify any support needed to fulfill this recommendation. A plan and schedule for engaging other programs within and outside NOAA will be requested.

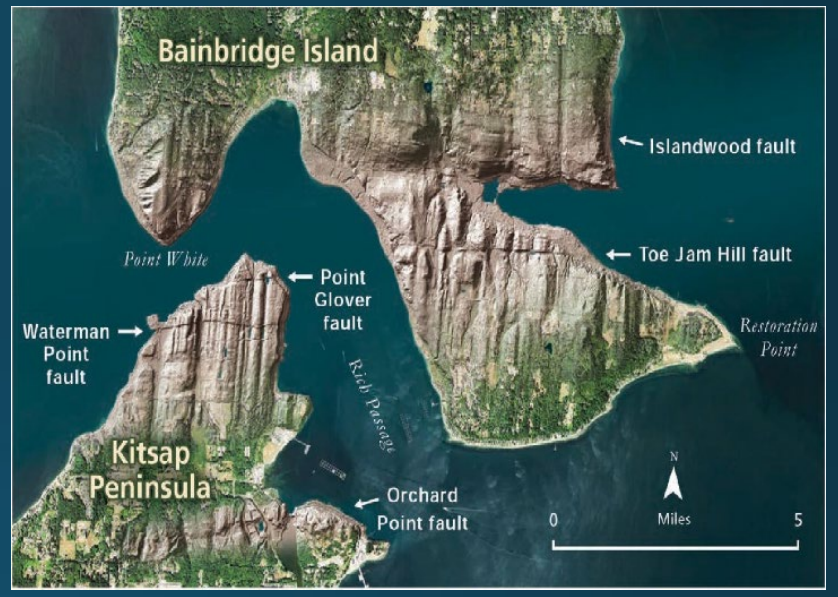
Tours of NWS Forecast Office and DART facility

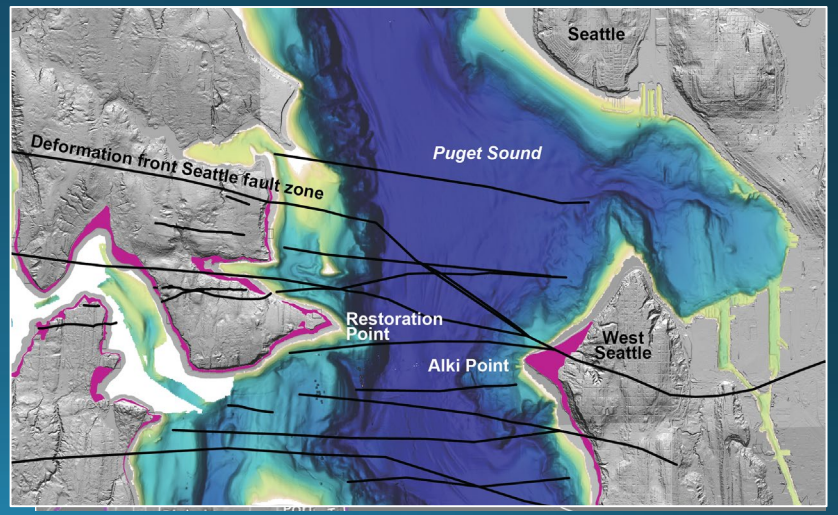
- NWS Seattle Weather Forecast Office (WFO)
  - Tour of AWIPS System and discussion for how that will be updated for tsunami alerts.
  - TsunamiReady® recognition and WCM involvement
  - Training and steps for WFO staff to learn about tsunami alerting
- DART facility and Discussion with the National Center for Tsunami Research (NCTR)
  - NCTR is part of the OAR Line Office of NOAA and is not part of the NWS Line Office like the other tsunami programs and warning centers are.
  - Main objective of NCTR is to do research and development in support of TWC operations: DART systems development and upgrades, tsunami detection, observation, and forecasting technology, and working with and for other partners and entities on tsunami science and research.



Field Trip to Bainbridge Island

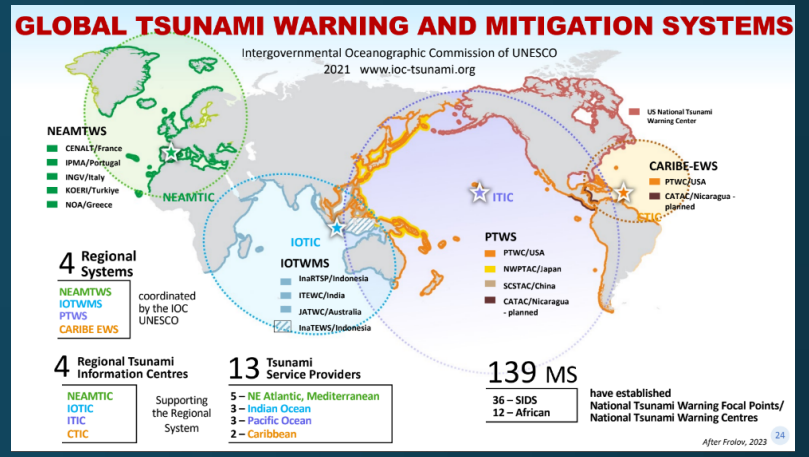
- Looked at geologic evidence of an earthquake along the Seattle fault zone in the year 923–924 CE. This earthquake uplifted a block of land between what is now West Seattle and Bainbridge Island and generated a large tsunami. This source is a significant threat for Seattle and Puget Sound.
- Met with locals on the island who were able to learn from TSTAP experts and local emergency managers and shared some of the challenges in receiving information about tsunami hazards, alerting, and potential mitigation options.
- We gained an indelible impression of the hazards of a future tsunami event in a complicated waterway that is criss-crossed by faults, far outside the typical subduction zone tsunami setting that the TWCs routinely alert on (Note: this issue is further explained in the TSTAP White Paper).





SME Briefings

- **International Tsunami Ready and International Tsunami Program Efforts**
  - Supported by UNESCO / IOC, the International Tsunami Ready Programme is an adaptation of U.S. TsunamiReady®.
  - Learned about global tsunami detection and forecasting and how the TWCs fit in.
- **National Tsunami Hazard Mitigation Program (NTHMP)**
  - Goal of understanding whether the NTHMP was aware of the TSTAP recommendations, and whether the committees have been working towards addressing them.
  - TSTAP was informed by the WCS that the items from recommendations that can be done easily have been already completed. Moving forward is complicated due to lack of resources and the fact that WCS doesn't have the authority to direct changes to TWC products or workflows.
  - The TSTAP will continue to request briefings from the NTHMP and NOAA on how progress is going on TSTAP recommendations that were referred to the NTHMP.



SME Briefing: Allison Allen, Director of the NWS Analyze, Forecast, and Support Office

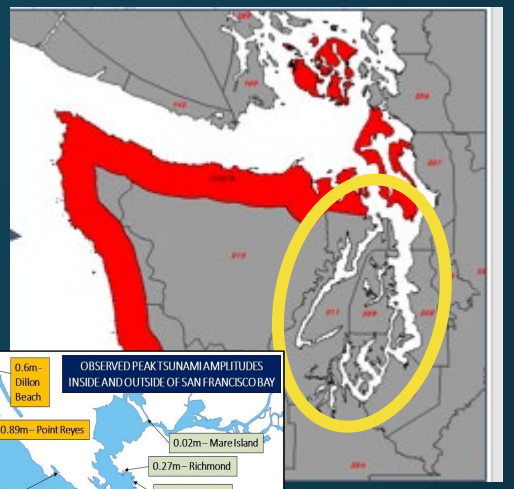
- NWS Director Ken Graham included the Tsunami Program among his top 10 initiatives requiring priority attention. Ms. Allen described the work of the Tsunami "Ken's 10" group that she is leading.
- Working to achieve a single common organizational chain of command for the TWCs and tsunami program and to provide a common layer of analytic guidance.
- Several contracts for Tsunami Program improvements have been awarded.
    1) Redesign of tsunami.gov
    2) Social science to look at the language used in tsunami watches, warnings, and advisories
    3) Addressing information technology vulnerabilities at both tsunami warning centers
- Developing and implementing the AWIPS Tsunami Operations Messaging Service (ATOMS) which will harmonize tsunami alerting between both TWCs is planned for launch and completion in FY25 (Note: NOAA Response indicated delivery in FY24.)
- Scoping for what would constitute the Common Analytical System (CAS) has been done, with the hope the CAS will be ready by FY26 if resources permit.

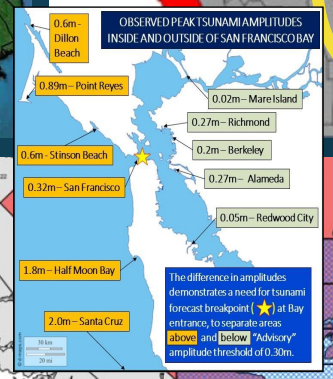
White paper on Prioritizing Upgrades to Tsunami Forecast Capabilities to Protect Public Safety in Large Coastal Population Centers and Complicated Waterways

- Existing tsunami alerting and forecasting procedures support the protection of lives and property along most coastlines vulnerable to tsunami impact.
- However, the system currently in place does not allow proper forecast capability and flexibility for many miles of coastline in bays and sounds with large coastal populations and dense infrastructure; these large population centers include Seattle, San Francisco Bay, and Honolulu.
- Additional forecast capabilities need to be prioritized for safety and proper alerting and forecasting for these complicated waterways.
- Although the TWCs had the staff capable to implement many of improvements proposed in the white paper a decade ago, they have now indicate they will not be able to implement improvements until they have executed a "second phase" of the Tsunami Advanced Weather Interactive Processing System (AWIPS) and have completed the implementation of a common analytic system (CAS). Depending on available resources the CAS implementation could take more than a decade to implement and thus is not a viable short-term solution for an event that may happen any day.

White Paper Continued

- The tsunami warning system needs to be updated to add breakpoints, special procedure areas, and forecast points to meet the needs to state and local partners.
- This white paper describes these needs in more detail and serves as a reference for TSTAP reports and recommendations.





Examples of:

1. Breakpoints
2. Special Procedure areas
3. Forecast points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 * Washington
Neah Bay          1245  PDT May 23   40 hrs     3.6- 6.6 ft
Long Beach        1250  PDT May 23   48 hrs     8.7-16.1 ft
Moclips           1255  PDT May 23   48 hrs     8.6-15.9 ft
Westport          1300  PDT May 23   48 hrs     8.4-15.7 ft
Port Angeles      1325  PDT May 23   48 hrs     4.6- 8.5 ft
Port Townsend     1350  PDT May 23   36 hrs     3.0- 5.6 ft
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