Tsunami Alert Efficiency

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“Tsunami Alert Efficiency” is the rapid, accurate and reliable conduct of tsunami warning messaging, from the detection of potential tsunamigenic earthquakes to dissemination to all people under threat, and the successful survival of every person at risk on the basis of prior awareness and preparedness.

decision matrix tsunami alert tsunami awareness tsunami efficiency tsunami hazard tsunami messages tsunami preparedness tsunami ready tsunami risk tsunami warning

Lessons learnt from recent disastrous tsunamis point towards significant gaps between the science behind tsunami warning and the practice of saving lives and minimizing risk [1][2][3]. Most notable was the identification of the 26 December 2004 Sumatra Mw 9.1 tsunamigenic earthquake in near real time, and due to the lack of communication means and unpreparedness there was no way to alert the circum-Indian Ocean inhabitants. Consequently, a quarter of million people lost their lives [4]. This catastrophe was considered an “eye-opener” [5], showing that, clearly, although tsunamis cannot be prevented, the massive loss of lives was avoidable and the scope of damages was mitigable.

About 7 years later, on 11 March 2011 the world faced another deadly tsunami event caused by the Mw 9.0 tsunamigenic Tohoku-Oki earthquake east of Honshu Island in Japan. This calamity cost the lives of about 18,500 people [6].

“Recognizing the increasing impact of disasters and their complexity in many parts of the world” [7], the third UN World Conference on Disaster Risk Reduction met on 18 March 2015 in Sendai, Japan, and decided to adopt the “Sendai Framework for Disaster Risk Reduction 2015–2030” [8]. The Sendai Framework presented four priorities for action: (1) understanding disaster risk; (2) strengthening disaster risk governance to manage disaster risk; (3) investing in disaster risk reduction for resilience; and (4) enhancing disaster preparedness for effective responses and to “Build Back Better” in recovery, rehabilitation and reconstruction. In addition, the Sendai declaration urged stakeholders to take actions in order to “…enhance our efforts to strengthen disaster risk reduction to reduce disaster losses of lives and assets worldwide” [7].

The disasters motivated the Intergovernmental Oceanographic Commission (IOC) of United Nations Educational, Scientific and Cultural Organization (UNESCO) to establish Intergovernmental Coordination Groups (ICGs) for tsunami early warning and mitigation systems (TWS) in the Indian Ocean [9]; the north-eastern Atlantic, Mediterranean and Connected Seas (NEAMTWS) [10]; and the Caribbean (ICG/CARIBE EWS) [11]; in addition to the already existing Pacific Tsunami Warning Center (PTWC) [12] in Hawaii and the Japanese Meteorological Agency (JMA) [13].

In fact, ICG/PTWC is a new name for the existing International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU), that was established in 1965 after several decades of deadly tsunami catastrophes in the Pacific Ocean by a joint international effort under the umbrella of the IOC/UNESCO, which was thus the pioneer of the ICG/TWC groups [14]. Nowadays, "… the (PTWC) provides warnings of tsunamis to the public and to organizations responsible for public safety in coastal areas of Hawai'i (since 1949), the Pacific Ocean (since 1965), the Indian Ocean (since 2005), and the Caribbean Sea (since 2006)." [15].

Thus, the space between tsunami generation at the one end, and the civil and public response at the other end, is nowadays covered by a systematic architecture of organizations that transfer tsunami alerts from end to end rapidly, accurately and reliably, on the basis of systematic Standard Operational Procedures (SOP) [16]. Yet the array of various bodies may complicate and delay the timely arrival of warning messages up to the very last threatened citizen, and therefore the alerting process should be conducted efficiently [17]. Orderly SOPs are of course required, and usually they are taken care of within the organizations [18], yet there is a need for efficient communication, because the chain is no stronger than its weakest link. Moreover, receiving the warning messages on time does not assure successful lifesaving conduct. Appropriate awareness [19] and preparedness [20] are necessary requirements for effective lifesaving behavior and must be integrated in the alerting process.

Here we describe the leading concepts behind the tsunami alerting process, emphasizing the importance of the corresponding awareness and preparedness, and discuss the difficulties and uncertainties that may downgrade its efficiency, because the effective conduct of the alerting process is the ultimate key to saving lives under threat. We aim not to rephrase existing SOPs or user guides, but bring to mind some thoughts on making tsunami alerts more efficient and effective.

References

1. Behrens, J.; Løvholt, F.; Jalayer, F.; Lorito, S.; Salgado-Gálvez, M.A.; Sørensen, M.; Abadie, S.; Aguirre-Ayerbe, I.; Aniel-Quiroga, I.; Babeyko, A.; et al. Probabilistic Tsunami Hazard and Risk Analysis: A Review of Research Gaps. Front. Earth Sci. 2021, 9, 628772. https://doi.org/10.3389/feart.2021.628772.
2. Lorito, S.; Behrens, J.; Løvholt, F.; Rossetto, T.; Selva, J. Editorial: From Tsunami Science to Hazard and Risk Assessment: Methods and Models. Front. Earth Sci. 2021, 9, 764922. https://doi.org/10.3389/feart.2021.764922.
3. Okal, E.A. Twenty-Five Years of Progress in the Science of ‘‘Geological’’ Tsunamis Following the 1992 Nicaragua and Flores Events. Pure Appl. Geophys. 2019, 176, 2771–2793. https://doi.org/10.1007/s00024-019-02244-x.
4. Marris, E. Inadequate warning system left Asia at the mercy of tsunami. Nature 2005, 433, 3–5.

5. Okal, E.A. The Quest for Wisdom: Lessons from 17 Tsunamis, 2004–2014. Phil. Trans. R. Soc. A 2015, 373, 20140370. https://doi.org/10.1098/rsta.2014.0370.
6. Uchida, N.; Bürgmann, R. A decade of lessons learned from the 2011 Tohoku-Oki earthquake. Rev. Geophys. 2021, 59, e2020RG000713. https:// doi.org/10.1029/2020RG000713.
7. WCDRR (World Conference on Disaster Risk Reduction). The Sendai Framework for Disaster Risk Reduction 2015–2030. In Proceedings of the Third United Nations World Conference on Disaster Risk Reduction, Sendai, Miyagi, Japan, 14–18 March 2015. Available online: https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf (accessed on 25 January 2022).
8. WCDRR (World Conference on Disaster Risk Reduction). The Sendai Declaration. In Proceedings of the Third United Nations World Conference on Disaster Risk Reduction, Sendai, Miyagi, Japan, 14–18 March 2015. Available online: https://www.preventionweb.net/files/43300_sendaideclaration.pdf (accessed on 25 January 2022).
9. UNESCO/IOC (Intergovernmental Oceanographic Commission of UNESCO). Tsunami Risk Assessment and Mitigation for the Indian Ocean; Knowing Your Tsunami Risk–and What to Do About It. IOC Manuals and Guides No. 52, 2nd ed.; UNESCO: Paris, France, 2015. (In English)
10. North-Eastern Atlantic, Mediterranean and connected seas Tsunami Information Centre. NEAMTIC-Home. Available online: http://neamtic.ioc-unesco.org/ (accessed on 25 October, 2021).
11. ICG/CARIBE-EWS (Intergovernmental Oceanographic Commission, Intergovernmental Coordination Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions), 2016. Eleventh Session, Cartagena de Indias, Colombia, 5–7 April 2016. Available online: http://www.ioc-tsunami.org/index.php?option=com_oe&task=viewEventRecord&eventID=1784 (accessed on 25 January 2022).
12. Tsunami.gov. U.S. Tsunami Warning Centers. Available online: https://tsunami.gov/ (accessed on 24 October 2021).
13. Jma.go.jp. Japan Meteorological Agency. Available online: https://www.jma.go.jp/jma/indexe.html (accessed on 24 October 2021).
14. Kong, L.S.L.; Paula K.; Dunbar, A.N.; (Eds.) Pacific Tsunami Warning System: A Half Century of Protecting the Pacific, 1965–2015; International Tsunami Information Center: Honolulu, HI, USA, 2015.
15. PTM (Pacific Tsunami Museum). Available online: http://tsunami.org/the-warning-system/ (accessed on 24 December 2021).
16. ICG/NEAMTWS-VIII. Interim Operational Users Guide for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and Connected Seas

(NEAMTWS); Version 2.00; ICG/NEAMTWS-VIII: Rome, Italy, 2011.

17. Papadopoulos, G.; Lekkas, E.; Katsetsiadou, K.-N.; Rovithakis, E.; Yahav, A. Tsunami Alert Efficiency in the Eastern Mediterranean Sea: The 2 May 2020 Earthquake (Mw6.6) and Near-Field Tsunami South of Crete (Greece). GeoHazards 2020, 1, 44–60. https://doi.org/10.3390/geohazards1010005.
18. UNESCO/IOC (Intergovernmental Oceanographic Commission of UNESCO), 2011. Reducing and Managing the Risk of Tsunamis. IOC Manuals and Guides; , 57, 74p.
19. Fukuji, T. ITIC Tsunami Awareness and Education Materials-International Tsunami Information Center. [online] Itic.ioc-unesco.org. 2021. Available online: http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=1349&Itemid=+1075&lang=en (accessed on 25 October 2021).
20. Weather.gov. NWS JetStream-Tsunami Preparedness and Mitigation: Individuals (You!). Available online: https://www.weather.gov/jetstream/prep_you (accessed on 25 October 2021).