Protecting Communities from the World’s Most Dangerous Waves

Tsunamis threaten the safety, resiliency and sustainability of nearly every coastal community on earth. Approximately 680 million people who live in low-lying coastal zones (<10m above sea-level) are to varying degrees exposed to tsunami risks. This number is expected to increase to more than one billion by 2050 (IPCC Special Report on Ocean and Cryosphere, September 2019; https://report.ipcc.ch/srocc/pdf/SROCC_SPM_Approved.pdf)

Between 1992 and 2019, 295 confirmed tsunamis were observed worldwide. Thirty-five of these resulted in loss of life. We do not know when and where the next tsunami will hit, but we know the impacts can be devastating. The Indian Ocean Tsunami (IOT) of December 2004 took nearly 230,000 lives in 14 countries and resulted in damages of almost US$10B. Small Island Developing States (SIDS) and Least Developed Countries (LDC) are especially vulnerable. The 2009 Samoa tsunami, for example, resulted in losses equal to 30% of the Samoan GNP. Major economies also suffer. Japan saw US$220B in economic damage and over 18,000 deaths from the 2011 Tohoku tsunami.

Timely and reliable tsunami warnings have saved, and will continue to save, countless lives around the world. When combined with dedicated public preparedness efforts, accurate tsunami amplitude and inundation forecasts enable communities to know what to do and precisely where to go when a tsunami is headed for the coast. Since most known tsunami source regions are close to populated coastlines these forecasts must be produced within minutes, if not seconds, of tsunami generation. In extreme cases (e.g. Palu Bay Indonesia 2018), there may be insufficient time to produce any public alerts. In these instances, vulnerable communities must be educated and prepared to act decisively based only on natural warning signs.

There have been major advances in the Global Tsunami Warning and Mitigation System since the IOT in 2004. Under the auspices of the UNESCO IOC, entirely new warning and mitigation systems have been established in the Indian Ocean, Caribbean, South China Sea and Northeast Atlantic/Mediterranean. Still, critical capability gaps remain. Even for well-understood earthquake sources, the current global system requires a minimum of 20-30 minutes after origin to produce useful tsunami wave height forecasts. This works well for tsunamis that reach coastlines hours after generation, but provides insufficient time for national authorities faced with protecting populations near a tsunami’s source to execute anything more than generic, pre-planned responses. In such near-field locations, a tsunami can strike in as little as 5-10 minutes after origin, and any ordered actions are based on broad assumptions containing high degrees of uncertainty. Presently, accurate flooding or inundation forecasts cannot be produced for many locations around the globe due to lack of detailed coastal bathymetry data. Further, for tsunamis generated by poorly understood and/or non-seismic sources (e.g., landslides, volcanic flank collapse, or weather-induced), or that occur within inland waterways or large lakes, virtually no capability to produce forecasts in real-time exists. Perhaps most importantly in terms of life safety, according to recent surveys more than 50% of tsunami-threatened countries do not have the dedicated tsunami evacuation maps and plans necessary to effectively and quickly respond to tsunami warnings.
To address these deficiencies, we, as representatives of the Global Tsunami Warning and Mitigation System, propose a project under the UN Decade of Ocean Science for Sustainable Development to couple fundamental **advances in rapid tsunami source characterization and forecasting capability** with **dedicated capacity development efforts**, specifically targeted at **SIDS and LDCs**. To do this, we must:

1. Improve our **understanding of the hazard** by expanding our knowledge of past or potential tsunami sources,

2. Ensure critical tsunami generation parameters are identified through the optimal use and **real-time sharing** of **new and existing** sensors and data,

3. Develop new, rapid tsunami **source characterization techniques** in order to leverage new data sources, such as the GNSS ground station network,

4. More quickly **detect and measure tsunamis directly**, through ocean observations to include **instrumentation of undersea cables**,

5. Ensure **100% of tsunami-vulnerable communities** around the world meet the guidelines outlined in the **UNESCO/IOC Tsunami Ready program**.

The **accelerated deployment of SMART repeaters** on fiber optic submarine cables in partnership with the telecommunication industry could prove particularly effective as a means of detecting and measuring tsunamis. When combined with existing land-based seismic and geodetic sensors, coastal sea level gauges and deep-ocean tsunameters, these instruments have the potential to both rapidly characterize tsunamigenic earthquake sources, and provide nearly instantaneous measurements of the tsunami itself as it propagates. The SMART cables can also provide critical temperature data to support climate monitoring and many other uses. By partnering with the **Seabed 2030 hydrographic survey initiative** to ensure nearshore coastal zones have complete bathymetric/topographic data coverage, we could, **within 10 years**, realize the capabilities needed for Tsunami Warning Centers around the world to generate **accurate tsunami impact forecasts within 10 minutes of origin** for the vast majority of potential sources, whether seismic or non-seismic.

Equally important is the need to address community preparedness. **Tsunami evacuation maps** must be developed through inundation modeling of worst-case scenarios. Coordinated **community response plans**, to include timely dissemination of warnings, need to be established to enable the public to quickly evacuate inland or vertically to safe zones or buildings. Plans to minimize impacts to **critical infrastructure and marine assets** must be in place to enable quicker post-tsunami restoration of services. These preparedness needs apply to **all** coastal communities with tsunami risk, but SIDS and LCDs stand to benefit most from an initiative of this scale.

This Project directly supports United Nations Sustainable Development Goal Number 11 by applying advancements to Ocean Science to saving lives and reducing the number of affected people and economic losses in Coastal Cities and Communities.