CURRENT STATUS, LIMITATIONS, AND FUTURE DIRECTIONS

The TWSP continues to expand in scope and responsibility as growth and interest within the ICG/ITSU occurs, now to include 25 Member States. With an unprecedented number of locally destructive tsunamis occurring within the last few years, there has been a heightened interest in tsunamis and the TWSP throughout the Pacific Basin and elsewhere.

The following section gives a brief description of the tsunami mitigation system in the Pacific as it currently exists, the limitations of that system, and directions and areas for work to address those limitations. The current system represents dedicated individual as well as joint efforts of the Member States of ITSU, and the efforts of ITSU as a whole. Although many shortcomings remain to be addressed, significant progress has been made to improve tsunami mitigation in the Pacific from what it was when ITSU was founded in 1965.

A document entitled "The Compilation of Data and Information for the Preparation of a Master Plan," presented and approved at the 9th Session of ITSU in 1984, delineated five general areas for work that should be addressed by ITSU programs. Simply stated they are: (1) preparation of tsunami-related educational material; (2) collection and compilation of historical tsunami data, and development of better techniques for using historical data, seismic data, and modeling to provide warnings and predict runups; (3) establishment of better communications channels for transmission of real time data and dissemination of warnings; (4) development of improved seismic and water level data collection and processing equipment and techniques, establishment of new data collection stations where needed, and provision of training in the installation and maintenance of equipment and stations; and (5) improvement of existing tsunami warning centers and establishment of new centers where needed along with appropriate technology transfer, training, and documentation. These areas for work remain applicable and are discussed below within the context of a conceptual model for a tsunami mitigation plan.

To mitigate the tsunami hazard, or for that matter any rapid onset natural hazard, it is critical to accurately assess the nature of the threat posed by the hazard, to design and implement a warning technique, and to prepare at-risk areas for appropriate actions to reduce the impact of the hazard. These three essential steps: 1) ***hazard assessment***, 2) ***warning***, and 3) ***preparedness***, are the main elements of the mitigation model. They can be used to identify, develop, and categorize most of the activities necessary to effectively reduce the inevitable impact of tsunamis. Another key element, not directly a part of mitigation but that supports its activities, is tsunami-related ***research***.

Hazard Assessment

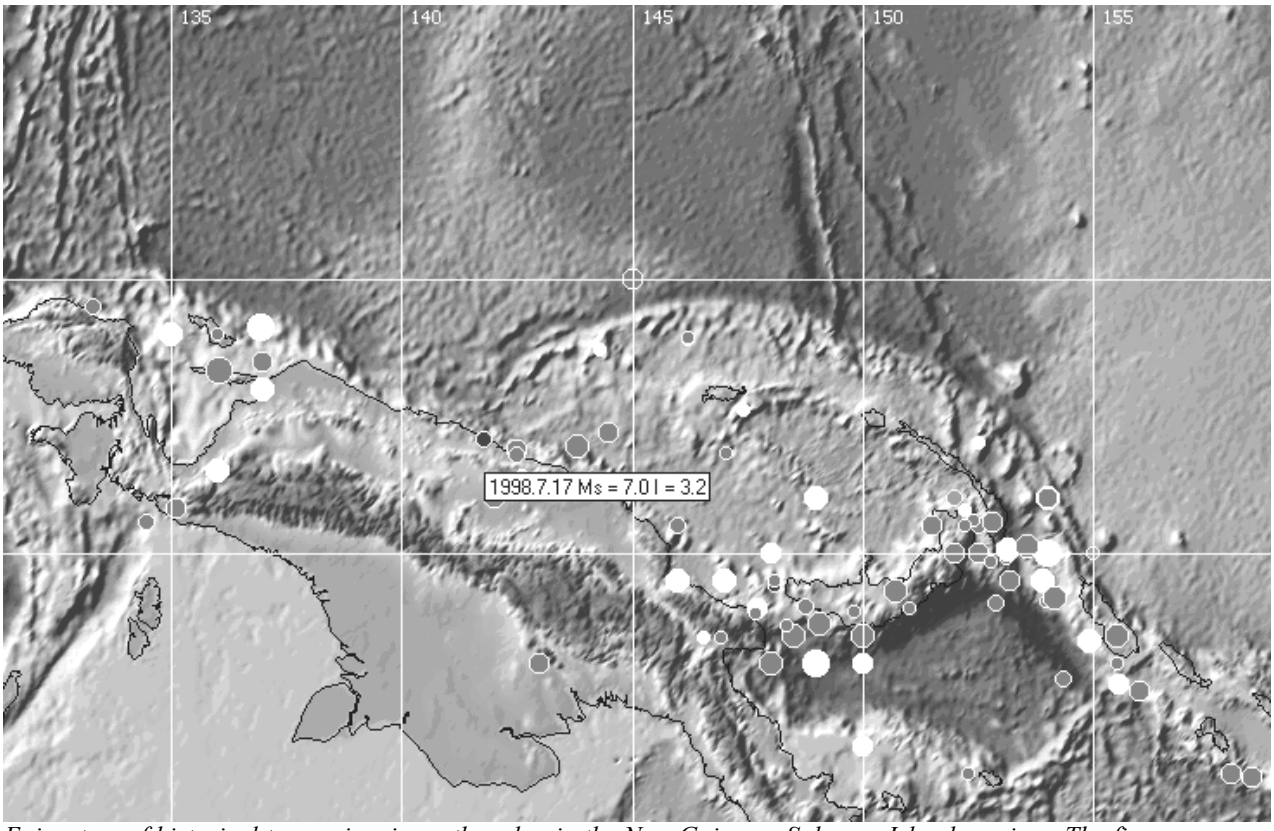
The first element for effective mitigation is hazard assessment. For each coastal community, an assessment of the tsunami hazard is needed to identify populations and assets at risk, and the level of that risk. This assessment requires knowledge of probable tsunami sources, their likelihood of occurrence, and the characteristics of tsunamis from those sources at different places along the coast. For some communities, data from earlier tsunamis may help quantify these factors. For most communities, however, only very limited or no past data exist. For these coasts, numerical models of tsunami inundation can provide estimates of areas that will be flooded in the event of a local or distant tsunamigenic earthquake. Results of the hazard assessment are also essential for motivating and designing the other two mitigation elements, warning and preparedness.

Historical Tsunami Data

Historical data are available in many forms and at many locations. The forms include published and manuscript catalogs of tsunami occurrences, field investigative reports, personal accounts of experiences, newspaper accounts, and film or video records. One of the larger collections of this type is maintained by the International Tsunami Information Center in Honolulu, Hawaii. Another major collection is maintained by the World Data Center – A (WDC-A), co-located with the US National Geophysical Data Center in Boulder, Colorado. They have available for ordering catalogs of historical

tsunamis affecting the USA, Mexico, Peru, Chile, and other Pacific locales, a worldwide historical tsunami database, a colored historical tsunami wall map, selected historical tide gauge records, and three tsunami slide sets. Still other historical tsunami data are maintained at universities and various government organizations. Tsunami catalogs have also been compiled by various Member States including Australia, Chile, Mexico, Ecuador, Japan, and the Russian Federation for their own and/or nearby shores. With encouragement and partial support from ITSU, the Russian Federation has developed a program for personal computers called the Expert Tsunami Database (ETDB) to rapidly access and view historical tsunami data in a wide variety of useful graphical formats. The IUGG Tsunami Commission has also been working to develop a generalized tsunami database format so that Member States can submit their historical data in this form to ITIC or WDC-A. The Tsunami Commission is also considering the possibility that historical and other tsunami-related data may be more effectively organized and made available through a Virtual Data Center accessible through the world wide web with links to other organizations worldwide that collect and maintain those data.

Incomplete historical data exist for many areas in the Pacific, and what does exist is not widely available nor in a form that is easily useable for hazard assessment. Continued collection and compilation of historical data are needed, particularly for areas not well covered in existing catalogs. All historical data and related parameters need to be compiled together in a common database. Better methods for accessing and viewing these data in useful ways are also needed. This includes the creation of electronic databases and related graphical user interfaces that can be distributed on electronic media or accessed through the World Wide Web.



Epicenters of historical tsunamigenic earthquakes in the New Guinea – Solomon Islands region. The figure was created using the "Historical Tsunami Database for the Pacific Region, 47B.C. – 1999A.D." graphical program developed by the Tsunami Laboratory of the Russian Academy of Sciences.

Paleotsunami Data

Research on paleotsunamis, events occurring prior to the historical record, has recently been taking place in a few regions around the Pacific. This work is based primarily on the collection and analysis of tsunami deposits found in coastal areas, and other evidence related to the uplift or subsidence associated with nearby earthquakes. In one instance, the research has led to a new concern for the possible future occurrence of great earthquakes and tsunamis along the northwest coast of North America. In another instance, the record of tsunamis in the Kuril-Kamchatka region is being extended much further back in time. As work in this field continues it may provide a significant amount of new information about past tsunamis to aid in the assessment of the tsunami hazard.

For most coastlines in the Pacific, there exist historical records of only a few tsunamis, if that. Paleotsunami research offers the possibility of gaining new knowledge about significant tsunamis stretching far back in time. Such knowledge could be extremely valuable for helping assess the tsunami hazard. ITSU Member States are encouraged to support research projects in this field.

Post-Tsunami Surveys

In recent years, following each major destructive tsunami, a post-tsunami reconnaissance survey has been organized to make measurements of runups and inundation limits and to collect associated data from eyewitnesses such as the number of waves, arrival time of waves, and which wave was the largest. The surveys have been organized primarily on an ad-hoc basis by academic tsunami researchers, with participants often gathered from several of the ITSU Member States. ITSU has encouraged the creation of international teams of experts from a variety of tsunami-related disciplines to carry out surveys under the auspices of the IOC, but none has yet taken place. A *Post-Tsunami Survey Field Guide* has been prepared by ITSU to help with preparations for surveys, to identify measurements and observations that should be taken, and to standardize data collection methods for increased consistency and accuracy.

Tsunamis are relatively rare events and most of their evidence is perishable. Therefore, it is very important that reconnaissance surveys be organized and carried out quickly and thoroughly after each tsunami occurs, to collect detailed data valuable for hazard assessment, model validation, and other aspects of tsunami mitigation. ITSU should continue to support the creation of international teams of experts, under the auspices of the IOC or other organizations, with the technical and financial resources to carry out post-tsunami surveys. Member States are encouraged to contribute to the IOC Tsunami Trust Fund to provide needed advance support for such surveys, and to also assist with procedures and logistics necessary to get teams into the field quickly. The Post-Tsunami Survey Field Guide should be updated as needed, published, and widely distributed to assist with surveys conducted by the IOC and/or other groups.

Numerical Modeling

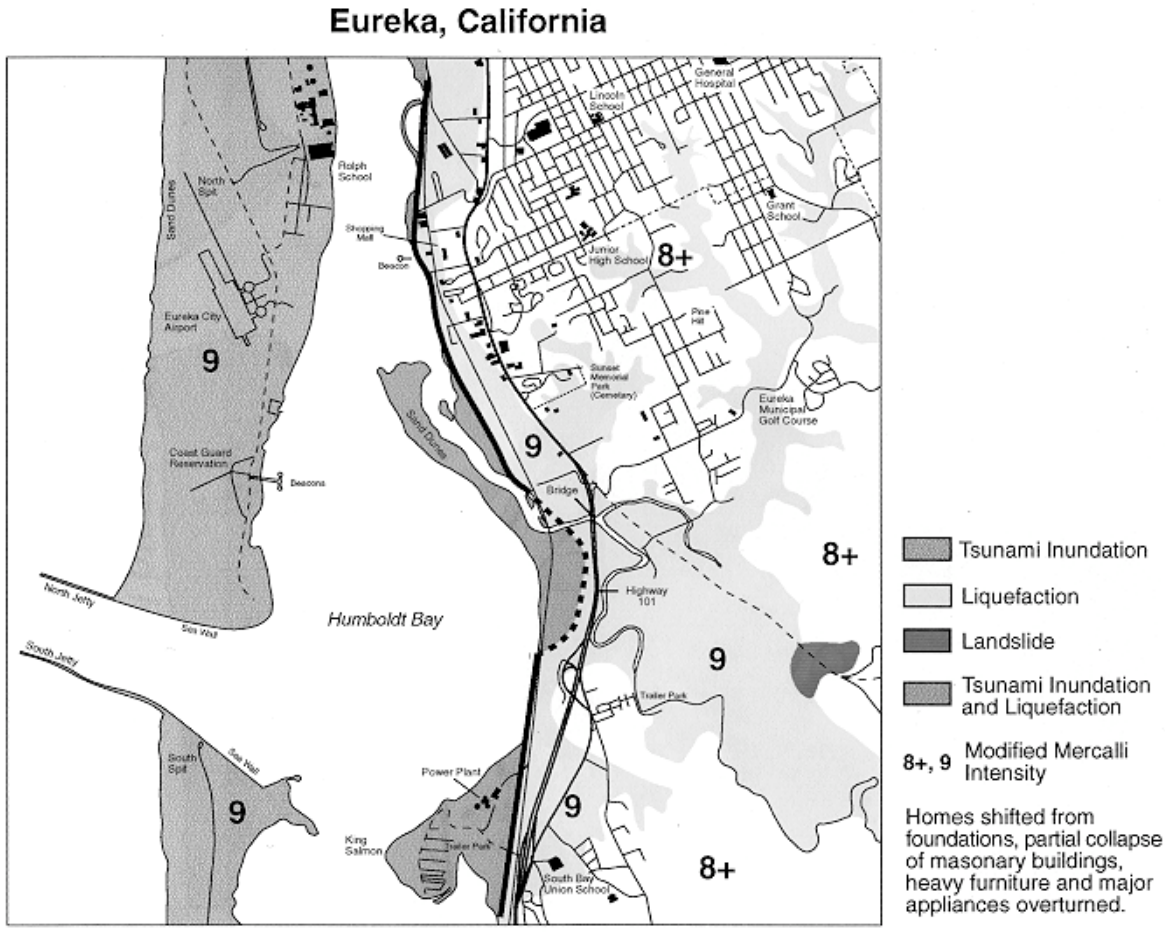
Often the only way to determine the potential runups and inundation from a local or distant tsunami is to use numerical modeling, since data from past tsunamis is usually insufficient. Models can be initialized with potential worst case scenarios for the tsunami sources or for the waves just offshore to determine corresponding worst case scenarios for runup and inundation. Models can also be initialized with smaller sources to understand the severity of the hazard for the less extreme but more frequent events. This information is then the basis for creating tsunami evacuation maps and procedures. At present, such modeling has only been carried out for a small fraction of the coastal areas at risk. Sufficiently accurate modeling techniques have only been available in recent years, and these models require training to understand and use correctly, as well as input of detailed bathymetric and topographic data in the area being modeled.

To address this problem, ITSU has supported a program called the Tsunami Inundation Modeling Exchange (TIME) that has provided the transfer of a numerical inundation model developed by Professor Shuto of Japan to Mexico, the USA, Korea, Turkey, Canada, Mexico, Greece, Colombia, Australia, Italy, Indonesia, Ecuador, Costa Rica, and Chile. Most importantly, the program also provides training in the use of the model. Many ITSU countries, including Chile, Mexico, France, Japan, and the United States have now established programs to

systematically model the potential tsunami inundation for their coastal areas at risk.

Computer programs and training necessary to perform this modeling need to be transferred to all Pacific countries at risk through programs such as the Tsunami Inundation Modeling Exchange. Member States are encouraged to develop their own national programs for carrying out estimation of tsunami runups and inundations on their own coasts using these techniques.

Historical data are very limited for most Pacific coastlines. Consequently, numerical modeling may be the only way to estimate the potential risk to those areas from the tsunami hazard. Techniques now exist to carry out this assessment.



Coastal area of Eureka, California, showing potential inundation determined from numerical modeling for a locally generated tsunami. The map also includes potential earthquake effects including liquefaction and landslides that should be considered in designing evacuation routes.