Strengthening Decision Making for Tsunami Early Warning in the Pacific Islands

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OBSERVATIONS:

For the past eight years, the Pacific Disaster Center has been engaged in disaster risk reduction activities in the Pacific Islands—a central pillar of which is strengthening decision making abilities for Pacific Island nations and states around the issue of tsunami early warning. In October 2004—just eight weeks before the Great Sumatra Earthquake and Indian Ocean tsunami—the Pacific Disaster Center conducted a tsunami tabletop exercise for disaster managers from throughout the Pacific Island nations and states as part of the East-West Center's *Leadership Seminar for Pacific Island Disaster Managers*. The purpose of the tsunami exercise was to identify and discuss gaps in tsunami warning capabilities and to discuss Standard Operating Procedures for disseminating warning information to at-risk populations.

Six key observations and findings emerged from this activity that have identified current preparedness gaps in the region: 1) Information and Communication Technology capabilities vary across the Pacific Islands and are often inadequate for early warning purposes; 2) the need to elucidate an overarching "Concept of Operations" at national/state levels for tsunami early warning under which Standard Operating Procedures are framed; 3) most islands currently lack adequate response plans; 4) islands lack assessments of potential tsunami impacts prior to occurrence (e.g. via vulnerability assessments) or after impact; and 5) national/state-level Information and Communications Technology gaps exist that impact warning receipt; and 6) failures often result when warnings are disseminated to remote areas. Converging on solutions that address these gaps and shortfalls will greatly strengthen the Pacific Islands within the greater framework of tsunami warning in the Pacific Basin, and could significantly reduce the loss of human life and property from future tsunami events.

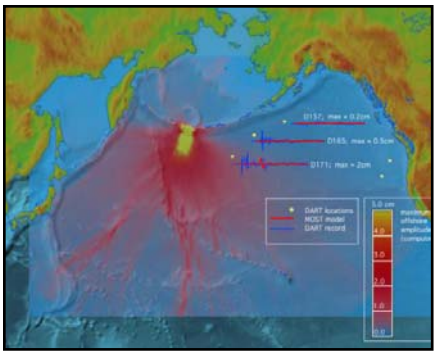


Figure 1: Modeled depiction of tsunami wave heights (generated by an earthquake near Alaska) travelling across the Pacific Ocean, as detected by the DART tsunami bouy system. (Image: NOAA)

PERSPECTIVE:

To address the findings and gaps identified above, the Pacific Disaster Center has identified four proposed solutions to strengthen decision making for tsunami early warning in the Pacific Islands: 1) Develop national/state-level "Concepts of Operations" for tsunami early warning; 2) Assess risk and vulnerability; 3) Augment Information and Communication Technology capabilities for remote areas; and 4) Promote tsunami awareness throughout the region. *Building on these activities has the potential to ultimately save lives and property if a destructive tsunami were to strike in the Pacific Islands in the future.*

BACKGROUND:

Pacific Islands Tsunami Tabletop Exercise

During the *Leadership Seminar for Pacific Island Disaster Managers: Disaster Risk Reduction for Sustainable Island Development* conducted at the East-West Center in Honolulu, Hawaii, USA in October 2004, the Pacific Disaster Center facilitated a tsunami "tabletop" exercise for national disaster managers from 17 Pacific Island nations and states (Figure 2 and Figure 3, below).

The exercise was developed and conducted to identify and discuss: a) the means by which Pacific Island nations and states receive early warning messages from international data providers; b) the organization(s) within national structures that receive early warning messages; and c) actions that are taken on a national/state level to provide early warning notification to appropriate authorities and the general public.

Figure 2 (Left): Pacific Islands Disaster Managers in the East-West Center's Leadership Seminar for Pacific Island Disaster Managers: Disaster Risk Reduction for Sustainable Island Development. Figure 3 (Right): As part of the seminar, the participants visit the Hawaii State Civil Defense (HSCD) Emergency Operating Center to discuss technologies used to coordinate tsunami warning and disaster response in the State of Hawaii. (Images: East-West Center)

In terms of exercise processes, the participants were grouped to discuss similarities between Standard Operating Procedures (SOPs) (i.e. nations and states with more developed SOPs were grouped together). During the exercise, all participants were led through a scenario in which a large earthquake generated a tsunami in the Pacific Basin, and warning bulletins were transmitted by the Pacific Tsunami Warning Center (PTWC) to each island nation. The differing sets of actions by each nation/state were subsequently documented and classified in terms of: a) where actions were taken in the individual national/state organizational structure, and; b) what specific actions were taken.

Figure 4: Devastation of a coastal village in Papua New Guinea following the 1998 Aitape tsunami that claimed approximately 3,000 lives. (Image: Commonwealth of Australia)

Figure 5: Housing in coastal community of Madang, Papua New Guinea, which is similar in structure to communities throughout the Pacific Islands region. (Image: PDC)

Exercise participants included Disaster Managers from the following countries (Please note that Niue was a seminar participant, but absent from the exercise):

- American Samoa
- Commonwealth of the N. Marianas Islands
- Cook Islands
- Federated States of Micronesia
  - Chuuk State
  - Kosrae State
  - Pohnpei State
  - Yap State
- Fiji
- Guam
- Kiribati
- Marshall Islands
- Palau
- Samoa
- Solomon Islands
- Tokelau
- Tonga
- Tuvalu
- Vanuatu

"...Regional organizations are committed to mitigating against a tragedy on the scale of the 2004 Indian Ocean tsunami from happening in the Pacific Basin..."

- Dr. Allen Clark, Executive Director, Pacific Disaster Center

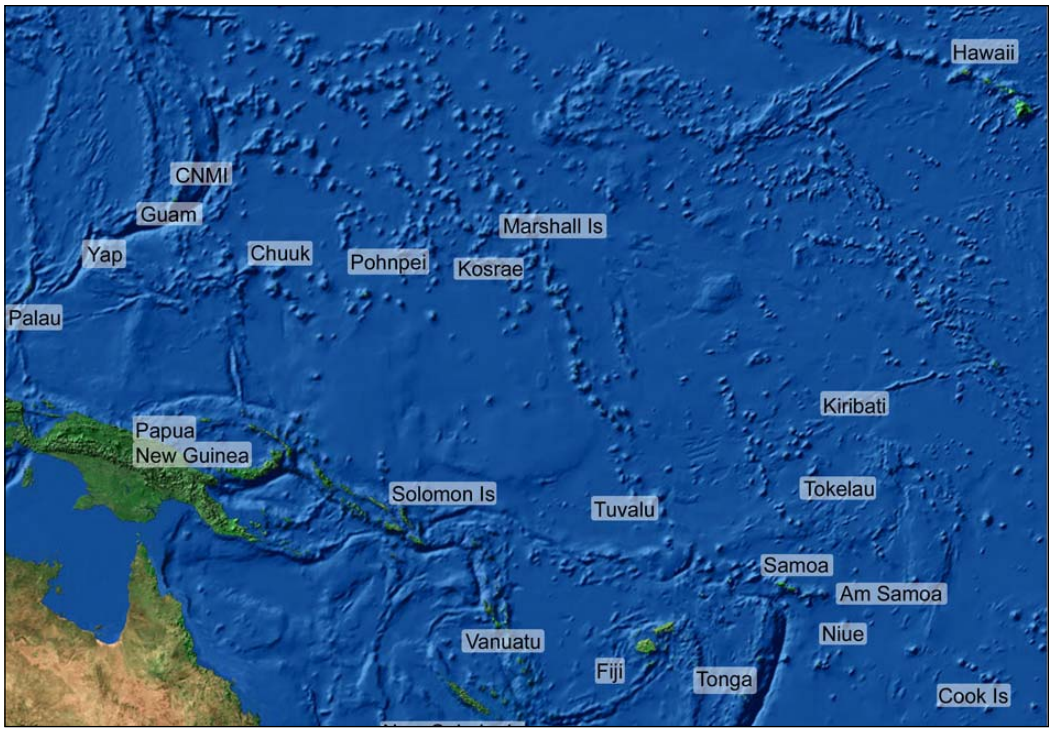


Figure 6: Map of Pacific Island Nations and States in the Western Pacific Basin. (Image: PDC)

Most Deadly Pacific Basin Tsunamis since 1700

Deaths	Location
40,000	*South China Sea, 1782*
30,000	*Japan, 1707*
27,000	*Japan, 1826*
25,674	*Chile, 1868*
22,070	*Sanriku, Japan, 1896*
15,030	*Japan, 1792*
13,486	*Ryukyu Trench, 1771*
5,233	*Japan, 1703*
5,000	*Nankaido, Japan, 1605*
5,000	*Philippines, 1976*
4,000	*Borneo, Indonesia, 1952*
3,000	*Papua New Guinea, 1998*
3,008	*Sanriku, Japan, 1933*
2,000	*Chile, Hawaii, Philippines, Japan, 1960*
165	*Hawaii, Alaska, 1946*
122	*Alaska, Hawaii, 1964*

Source: Wikipedia

OBSERVATIONS:

Findings and Gaps from the Pacific Islands Tsunami Exercise

During the exercise, the following six key findings and gaps were identified by Pacific Island decision makers:

1) Warning Receipt - Information and Communication Technology capabilities vary across the Pacific Islands, and are often inadequate for early warning purposes. Warning delivery from the Pacific Tsunami Warning Center is not robust or redundant. Warnings are often delivered via facsimile, and are frequently not read until too late for early warning notification and evacuation.

2) Concept of Operations - Very few Pacific Islands have documented "Concepts of Operations" to understand organizational and institutional relationships, arrangements, and protocols for early warning.

3) Standard Operating Procedures - SOPs are not standardized, and in some cases do not exist. Moreover, existing SOPs are not understood by all key agencies and organizations.

4) Planning - Most islands currently lack response plans. If they are in place, these plans are often inadequate.

5) Risk Assessment - Most islands lack risk and vulnerability assessments to assist in the early warning process.

...six key findings and gaps were identified by Pacific Island decision makers...

6) Warning Dissemination - Most islands have inadequate warning dissemination to remote and isolated villages or islands.

(It should be noted that exercises such as this are extremely effective mechanisms for identifying inadequacies such as those described above. It should also be stressed, however, that National Disaster Management Organizations in Pacific Island nations and states work diligently towards the goal of protecting populations and property.)

In some cases, it was found that Pacific Island nations and states—for example, American Samoa, Guam, Fiji, and Tonga—received warning information through their respective meteorological offices, often via facsimile. Warning information was also received through the Emergency Managers Weather Information Network (EMWIN) system.

From the tabletop exercise, it became evident that there is a continual need to further explore-beyond the SOP level—the overarching "Concept of Operations" for national/state-level tsunami early warning throughout the Pacific Islands. Such a "CONOPS" would encompass overarching issues such as inter- and intra-organizational relationships, commonalities (or differences) between warning formats, as well as *key interdependencies required for the effective institutionalization of a unified national/state level tsunami early warning framework*. Coupled with the CONOPS concept is the need to establish procedures in Pacific Island nations/states that identify and institutionalize the historical "lessons learned" from previous earthquake and/or tsunami events.

In addition, the exercise pointed out that there were generally no response plans in place to assess the consequences of a tsunami following its impact—nor had assessments of potential vulnerability been undertaken beforehand. An additional and extremely important gap that was identified that pointed out that, in many cases, *national/state level warning systems do not extend to remote areas such as isolated villages or outlying islands*.

Tsunami warning, dissemination, and evacuation processes in the Pacific Islands

Figure 7 (below) depicts a high-level representative example of a tsunami warning, dissemination, and evacuation process that is currently applicable to some Pacific Island nations/states. This is also a process that many Pacific Island nations/states strive to implement:

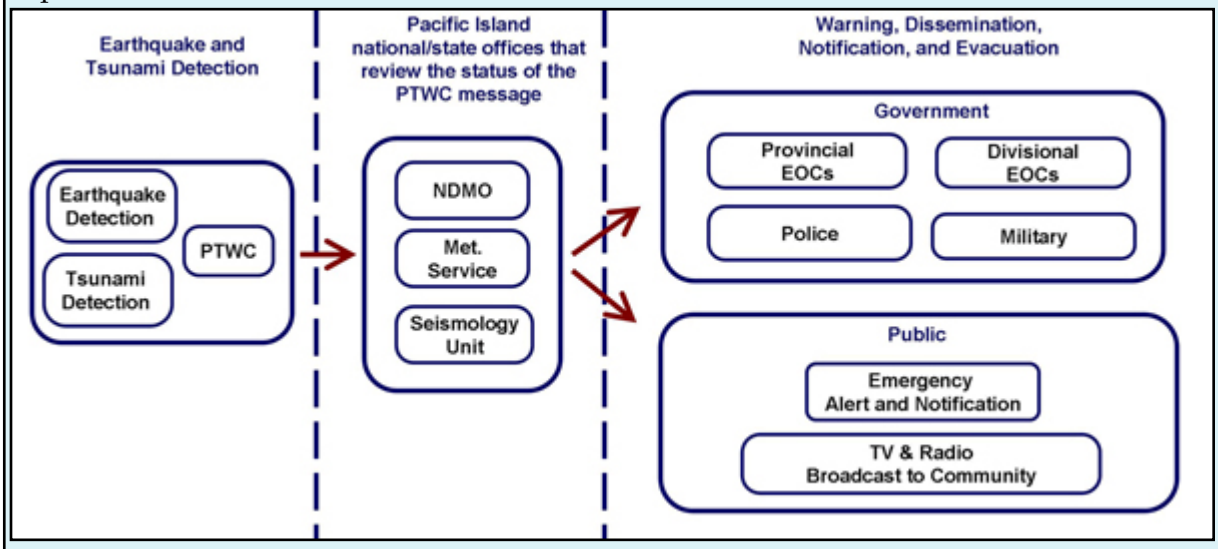


Figure 7: High-level flow diagram of tsunami warning, dissemination, and evacuation processes in the Pacific Islands. (Source: PDC).

This tsunami warning, dissemination, and evacuation processes currently applicable to some Pacific Island nations/states for distant or tele-tsunamis. Tsunamis generated by local or regional sources pose a greater warning challenge for Pacific Island nations and states. As shown above, a tsunami warning is forwarded to the national/state Meteorological (Met) Service, Seismology Unit, and National Disaster Management Organization by the Pacific Tsunami Warning Center (PTWC) following the detection of an earthquake tsunami event. These agencies initiate official Emergency Alerts and Notifications, which are in turn disseminated to the public via television and radio. These agencies also take appropriate steps by coordinating with Emergency Operation Centers (EOCs), the police, and the military to facilitate evacuations, as appropriate. Please note that such a process assumes that there is adequate warning time prior to tsunami impact (e.g. a distant tele-tsunami), and accordingly differs in the case of local and regional tsunami events.

...there were generally no response plans in place to assess the consequences of a tsunami following its impact...

DISCUSSION:

Proposed Solutions

To address the findings and gaps identified above, the Pacific Disaster Center has identified four proposed solutions to strengthen decision making for tsunami early warning in the Pacific Islands:

1) Developing national/state-level "Concepts of Operations" for tsunami early warning;
2) Assessing risk and vulnerability;
3) Augmenting Information and Communication Technology capabilities for remote areas; and
4) Promoting tsunami awareness throughout the region.

Proposed Solution 1:

Developing National/State-level "Concepts of Operations" for Tsunami Early Warning

...Thai government officials found the [CONOPS] document, and the ensuing stakeholder workshops...to be an extremely important vehicle...

The following example from the Pacific Disaster Center's work with the Government of Thailand is applicable to nations and states throughout the Pacific Islands.

As part of its project to provide technical assistance to the National Disaster Warning Center, Thailand, the Pacific Disaster Center has completed a "Concept of Operations" report in relation to a proposed Decision Support Platform for earthquake and tsunami early warning. This report, authored in conjunction with Thai officials:

a) Describes the existing national Early Warning System CONOPS in relation to relevant information providers and intergovernmental organizations;
b) Summarizes the existing analysis and decision-making processes that are related to the early warning system; and
c) Outlines organizational "focal points" for all key domestic and international organizations that work with the National Disaster Warning Center to help provide early warning data and information.

Thai government officials found the document, and the ensuing stakeholder workshops intended to scrutinize and validate the report, to be an extremely important vehicle to outline processes to drive and augment inter-organizational cooperation for early warning.

The conduct of similar studies at the national/state level in the Pacific Islands would be extremely useful to:

a) Define both intra- and inter-organizational relationships at the domestic level;
b) Spotlight how early warning messages are processed and disseminated upon receipt from international warning provider agencies;
c) Examine the definitions and interrelationships of tsunami early warning SOPs; and
d) Articulate these relationships within an overarching framework for the purpose of "institutionalizing" them at the national/state level.

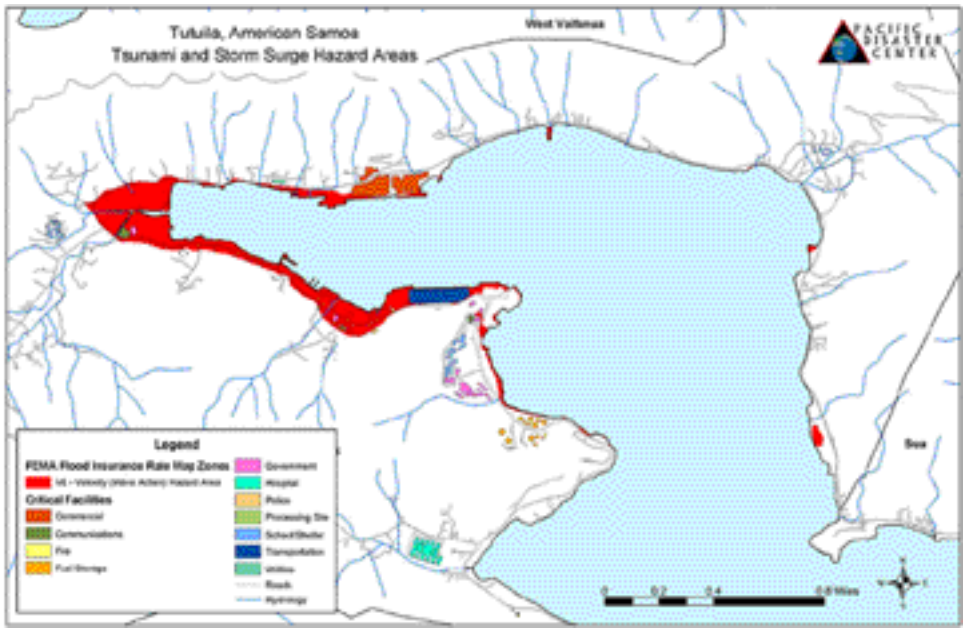
Proposed Solution 2:
Assessing Risk and Vulnerability

For the past eight years, the Pacific Disaster Center has been engaged in Risk and Vulnerability Assessment activities. For the Pacific Islands, these activities include three studies which were all conducted in 2003:

a) Developing a comprehensive Multihazard Risk and Vulnerability Assessment and Hazard Mitigation Plan for American Samoa (Figure 8);
b) Conducting a Risk and Vulnerability Assessment for tsunami hazard for Suva Harbor, Fiji (Figure 9); and
c) Assessing flood losses to selected buildings in Port Vila and Mele Bay, Vanuatu from an earthquake-generated tsunami, (Figure 10).

Undertaking such activities is instrumental to increasing knowledge about vulnerable areas. Accordingly, these assessments are required for implementing warning strategies *before* a tsunami occurs, as well as *supporting post-impact assessment processes*—which are critical to recovery activities yet are widely lacking throughout the Pacific Islands.

..undertaking such activities is instrumental to increasing knowledge about vulnerable areas...



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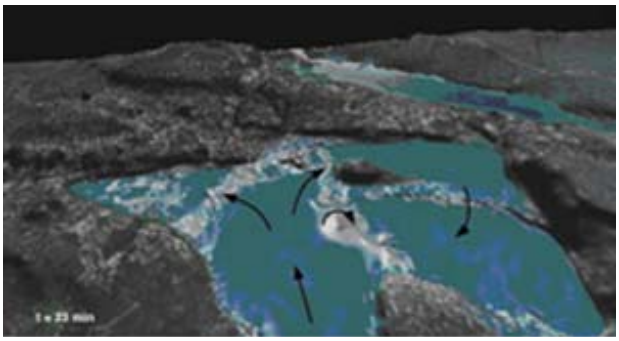

Figure 8 (Top): Geographic Information Systems-based "Tsunami Risk and Storm Surge Risk Map" for critical facilities that was created by PDC as part of the Multihazard Risk and Vulnerability Assessment and Hazard Mitigation Plan for American Samoa. Figure 9 (Bottom Left): PDC Modeling graphic depicting the dynamic wave propagation and Suva Harbor inundation based on a 1953 earthquake and tsunami event from Pacific Disaster Center's 2003 tsunami visualization project for Fiji. Figure 10 (Bottom Right): Computed flow patterns during tsunami inundation of Port Vila Harbor for a worst-case scenario from the PDC's 2003 tsunami visualization project for Vanuatu.(Images:PDC)

Proposed Solution 3:

Augmenting Information and Communication Technology Capabilities for Remote Areas

In 2005, the Pacific Disaster Center conducted an Information and Communication Technology Gap Analysis for the Kingdom of Tonga to assess the nation's ability to: a) access weather information products from regional and international organizations; and b) disseminate these products to Tonga's disaster managers. It was deemed that dissemination of early warning messages to the Kingdom's outer islands was a critical gap. This is a theme that is relevant throughout Pacific Island nations and states, as noted above.

To address the ICT shortfalls in Tonga, the Pacific Disaster Center has recommended installing computer systems equipped with dial-up modems and High Frequency transceivers (as a back-up communications system for remote weather station locations) at each outer island meteorological office. Such a "baseline solution" would enable remote areas in the Kingdom to access and distribute weather and other hazard information to disaster managers over the Internet via dial-up Internet Service Provider. Another recommended solution, depicted in Figure 11, included adding the Emergency Managers Weather Information Network system to this baseline—which would provide the remote areas with an alternative way of accessing critical information.

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The implementation of a similar ICT solution throughout the Pacific Islands could greatly augment the ability for tsunami early warning messages to consistently reach a more expansive area, including remote regions. The development of ICT capabilities will also strengthen capacities throughout individual nations—e.g. building ICT "redundancies" can directly address the issues encountered during the May 2006 earthquake event which disrupted power to Tonga, and, conversely, the Kingdom's ability to receive early warning messages.

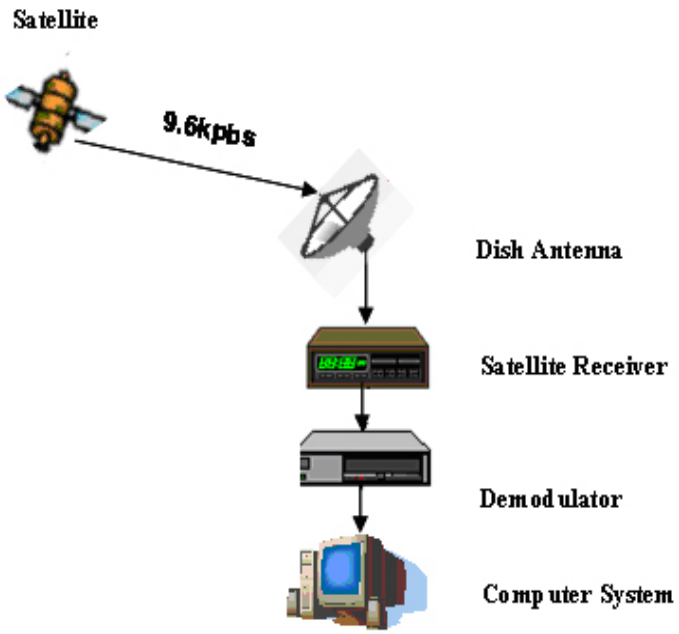

Figure 11: Schematic of the proposed Emergency Managers Weather Information Network System for the Tonga's outer island meteorological offices.

Proposed Solution 4:
Promoting Tsunami Awareness Throughout the Region

Critical to the three solutions described above—and to the strengthening of tsunami early warning decision-making through the Pacific Islands—is *increasing the knowledge about tsunami hazards at all levels of Pacific Island society*, spanning from the community level to the decision makers themselves.

In an effort to foster greater awareness of the dangers posed by tsunamis in the Pacific Islands, the Pacific Disaster Center developed and delivered "Tsunami Awareness Kits" to the South Pacific Applied Geoscience Commission (SOPAC) in Fiji in 2005. Tailored to the unique culture and geography of the region (specifically Fiji in this first project phase), the Kits were developed in collaboration with Pacific Island nations as well as regional organizations including SOPAC, the United Nations Educational, Scientific, and Cultural Organization, and the International Tsunami Information Centre. The content of the Kit is a collection of existing international best practices from the United States and the international community augmented by material collected from and specific to the Pacific Islands (Figure 12). Target audiences include disaster managers, government and community leaders, business owners, and educators.

...the Tsunami Awareness Kit provides information and guidelines that communities and other stakeholders can use to both respond to and reduce their vulnerabilities to tsunamis..

The Tsunami Awareness Kit provides information and guidelines that communities and other stakeholders can use to both respond to and reduce their vulnerabilities to tsunamis, as well as to develop "country specific" educational and policy-oriented materials.

Figure 12: Tsunami Awareness Kits (pictured above) were delivered in 2005 to the South Pacific Applied Geoscience Commission in Fiji. PDC and its partner organizations will facilitate application of the Kit in other Pacific Islands.

Continuing to pursue tsunami awareness and educational activities will provide a foundation for strengthening all aspects of tsunami early warning decision making, and will empower nations and communities in the Pacific Islands to take appropriate action when a tsunami event occurs. For example, follow-up from the October 2004 tabletop exercise was formally briefed to leaders from throughout the region during the *Standing Committee of the Pacific Islands Conference of Leaders* in May, 2005 (Figure 12).

Figure 12: A high-level delegation from throughout the Pacific Islands visited the Pacific Disaster Center and East-West Center in May 2005 for a briefing on variety of disaster-related issues, including tsunami early warning. Many of these leaders represent the highest level of decision making in Pacific Island nations and states.

...building on these activities has the potential to ultimately save lives and property if a destructive tsunami were to strike the Pacific Islands in the future...

CONCLUSIONS

In conclusion, the Pacific Disaster Center's 2004 tsunami tabletop exercise for Pacific Island national disaster managers brought to the forefront the need for: a) developing "Concepts of Operations" for tsunami early warning; b) conducting risk and vulnerability assessment activities to help gain knowledge of vulnerable areas and therefore augment early warning operations; and c) enhancing Information and Communication Technologies to allow for national/state early warnings to be extended to remote areas and to achieve redundancy.

To address these important gaps, it is critical for Pacific Island nations and states to undertake Concept of Operation studies, conduct risk and vulnerability assessments, augment ICT capabilities for disaster early warning, and foster greater tsunami awareness throughout the region in general.

Building on the activities documented in this paper has the potential to ultimately save lives and property if a destructive tsunami were to strike the Pacific Islands in the future. Most of the findings, gaps, and recommended solutions to strengthen decision making for tsunami early warning in the Pacific Islands are transferable to other regions, including the countries affected by the 2004 Indian Ocean tsunami disaster.

ACKNOWLEDGEMENTS

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