The National Tsunami Warning System of Chile (Sistema Nacional de Alarma de Maremotos - SNAM)

The Chilean Tsunami Warning System operated by the Hydrographic and Oceanographic Service of the Chilean Navy (SHOA) has been in operation since 1964, as a consequence of the May 1960 Chilean tsunami. The system, headquartered in Valparaiso, makes use of seismic information from 31 short period seismic stations provided by the National Seismic Network run by the Department of Geophysics of the University of Chile, one TREMORS system, and 3 six-component (3 strong motion, 3 seismic) broadband stations. The system also utilizes 19 tide stations, 7 sending their data in real time by satellite to the SNAM, and the others are bubblers that send data upon request. The SNAM disseminates tsunami warnings to all coastal communities through the Navy Communications Facilities and through the National Emergency Office Radio Network.

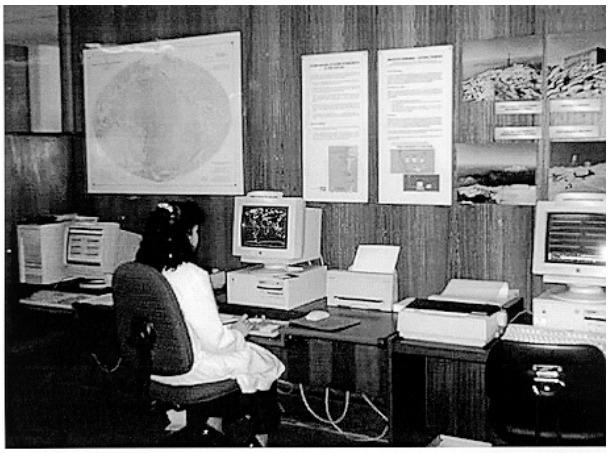
Headquarters of the Chilean Tsunami Warning System (SNAM) operated by the Hydrographic and Oceanographic Service of the Chilean Navy is located in Valparaiso.

Other National Warning Systems

Australia. Australia is in the process of developing a tsunami warning system for its Indian Ocean coast as well as its Pacific coast. The system will be operated by the Bureau of Meteorology. Seismic data will be provided by the Australian Geological Survey Organization (AGSO) and an AGSO Tsunami Warning and Earthquake Alert System is being prototyped. The National Tidal Facility (NTF) will provide sea level response monitoring and interpretation capabilities.

Colombia. Colombia's Observatorio Sismológico del Suroccidente (OSSO) is developing a warning system based on digital broadband seismometer data input to a TREMORS analysis system. Dissemination of results to appropriate organizations will be through INMARSAT. Potential runups will be determined using numerical modeling techniques acquired through the TIME program.

Nicaragua. As the base for a national tsunami warning system, Nicaragua has 20 short-period vertical seismometers with data telemetered in real time to the Instituto Nicaraguense de Estudios Territoriales (INETER). Data from a broadband seismic station at Boaco, and an array of strong-motion accelerometers may also be accessible in near real time via telephone links. A network of 7 digital mareographic stations is also being deployed on both the Pacific and Atlantic coasts and in Lake Managua, with access to the data by telephone. Communication links



Operations room of the National Tsunami Warning System of Chile (SNAM).

and procedures for tsunami warnings are being developed between INETER and Civil Defense. A siren system to alert the public is also planned.

Peru. The National System Warning System of Peru, with its center located in Callao, is operated by the Dirección de Hidrografía y Navegación del Perú (DHN). They administer a network of 10 mareograph stations, with data from the Callao station sent in real time to the Center. Peru has also recently acquired two TREMORS systems to strengthen its warning capabilities. Notification to Civil Defense is made by a dedicated magnetic telephone.

Republic of Korea. The Korea Meteorological Administration (KMA) of the Republic of Korea now utilizes a real-time network of 12 short-period and 8 broadband seismometers, and a TREMORS, in combination with information

from some of the other warning centers to monitor its tsunami threat. The plan is for a network of 31 short-period and broadband stations with an automated analysis system. In addition, a real-time sea level monitoring system will be installed on an island off the eastern coast. Dissemination of warnings is made through the public weather service system.

The present system of warning centers has gaps in its coverage. Southeast Asia, the southwest Pacific, and Central and South America have no regional tsunami warning centers. Yet these areas are extremely vulnerable. They are adjacent to some of the most active and tsunamigenic seismic zones, and have been struck by fourteen of the eighteen most recent destructive local tsunamis (see table on page 4). In addition, although PTWC provides warnings for distant tsunamis crossing the Pacific Ocean basin, there are no corresponding centers to warn against tsunamis crossing most of the Pacific's marginal seas.

Regional warning centers should be established in Southeast Asia, the southwest Pacific, and Central and South America. In many parts of these regions, rudimentary systems already exist. New centers can be developed utilizing existing resources, as well as technologies and methodologies transferred from other warning centers. Training for operational personnel can be provided by ITSU through ITIC, or arranged through existing warning centers. All national warning centers are encouraged to share critical seismic, water-level, and warning information in a timely way with neighboring countries that do not have warning systems and share the tsunami threat on a common body of water.

Outside the Pacific region no tsunami warning centers exist, although the tsunami hazard exists on both sides of the Atlantic Ocean, in the eastern Indian Ocean, and in the Mediterranean, Caribbean, and Black Seas. Efforts to establish warning centers in those areas should be encouraged and ITSU should provide information and guidance based on its accomplishments and many years of experience in the Pacific.

Warning centers need to continue their efforts to reduce the time it takes to get out initial warnings, to provide evaluations that are as accurate as possible, and to operate reliably in all aspects.