TWO DECADES OF GLOBAL TSUNAMIS 1982-2002

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Several Russian researchers established the precedent for this catalog. S. L. Soloviev and Ch. N. Go were authors of earlier tsunami catalogs: *A Catalog of Tsunamis on the Western Shore of the Pacific* (1974) and *A Catalog of Tsunamis on the Eastern Shore of the Pacific* (1975), covering the earliest reports of tsunamis in the Pacific up to 1968. S. L. Soloviev, Ch. N. Go and KH. S. Kim authored the updated *Catalog of Tsunamis in the Pacific 1969-1982* with an English version published in 1992. These catalogs helped establish the importance of the historical record in evaluating tsunami risk and source mechanisms. This catalog follows the format of these earlier catalogs but extends the coverage worldwide.

Recently there has been an increase of interest in the field of tsunamis. This has resulted in numerous workshops with important papers being presented on the occurrence and effects of tsunamis and the publication of these papers in proceedings. In the period from 1992 to 1994 there was an increase in the number of destructive tsunamis following a relatively quiet period. International survey teams investigated most of these. Events in this period were the subject of *Tsunamis: 1992-1994, Their Generation, Dynamics and Hazard* edited by Kenji Satake and Fumihiko Imamura (1995). This is a particularly useful reference.

The International Tsunami Information Center (ITIC) operated by the NOAA National Weather Service (NWS) in Honolulu, Hawaii, publishes the *Tsunami Newsletter* usually twice per year and reports on current events and information from the Pacific Tsunami Warning System. The center is a major source for information on recent tsunamis, meetings, and papers. The United States Geological Survey's National Earthquake Information Center (NEIC) includes information on recent earthquakes it locates and on those events which have tsunamis associated with them. These were formerly published as the Preliminary Determination of Epicenters (PDE) and now are available at http://neic.usgs.gov/neis/data_services/ftp_files.html.

There are increasing numbers of Web sites operated by the warning centers, universities and government agencies that also carry information on current tsunamis and field surveys. This includes the Tsunami Bulletin Board operated by the ITIC. All of these sources (as well as the many research papers published in the scientific literature) are acknowledged as important contributors to this catalog.

INTRODUCTION

Purpose

The principal purpose of this catalog is to extend the cataloging of tsunami occurrences and effects begun in 1988 by Soloviev, Go, and Kim (*Catalog of Tsunamis in the Pacific 1969 to 1982*) to the period extending from 1982 through 2001, and to provide a convenient source of tsunami data and a reference list for tsunamis in this period. While the earlier catalogs by Soloviev were restricted to the Pacific region including Indonesia, this catalog reports on known tsunamis worldwide. The year 1982 was included in this catalog because the data in the Soloviev and Go catalog for that year was incomplete.

The Pacific is by far the most active zone for tsunami generation but tsunamis have been generated in many other bodies of water including the Caribbean and Mediterranean Seas, and Indian and Atlantic Oceans and other bodies of water. There were no known tsunamis generated in the Atlantic Ocean in the period from 1982 to 2001 but they have occurred there historically. North Atlantic tsunamis include the tsunami associated with the 1755 Lisbon earthquake that caused up to 60,000 fatalities in Portugal, Spain, and North Africa. This tsunami generated waves of up to seven meters in height into the Caribbean. Since 1498 the Caribbean has had 37 verified tsunamis (local and remote sourced) plus an additional 52 events that may have resulted in tsunamis. The death toll from these events is about 9,500 fatalities. In 1929, the Grand Banks tsunami off the coast of Labrador generated waves of up to 15 meters in Newfoundland, Canada, killing 26 people, and the waves were recorded along the New Jersey coast. Smaller Atlantic coast tsunamis have been generated in the Norwegian fjords, Iceland, and off the coast of the New England states of the United States. Major tsunamis have also occurred in the Marmara Sea in Turkey associated with the Izmit earthquake of August 17, 1999.

Discussion

Major sources of data on the occurrence of tsunamis include the *Preliminary Determination of Epicenter (PDE)* reports by the United States Geological Survey (USGS), and the International Tsunami Information Center (ITIC). These sources, however, were often incomplete and their lists of tsunami events differed. This suggests that additional tsunamis may have occurred that escaped the attention of the compilers of this current catalog. These events would most likely be small local tsunamis not reported by international agencies. Most tsunamis, like most earthquakes, are small and are only observed instrumentally. Until the meeting of the UNESCO, IOC/ITCG (Lima, Peru, September 1997) the Pacific Tsunami Warning Center (PTWC) did not routinely attempt to determine if small local tsunamis had been generated by local earthquakes. Their primary concern was for Pacific-wide hazardous tsunamis. Attendees at the conference suggested that each earthquake over magnitude 6.0 be checked for any evidence of a local tsunami.

Tsunamis can be generated by seafloor displacement occurring during earthquakes and/or collapse

of sub-aerial landmasses into lakes and reservoirs. Tsunamis may also result from landslides and volcanic activity independent of earthquakes. Any catalog that limits the listing of tsunami events to those produced by earthquakes will miss important tsunami events produced by other means.

Many areas where destructive tsunamis occur such as the Caribbean have not yet developed a warning system although a warning system is in the planning stages at this writing (2002). Checking for recordings of small tsunamis has not been routinely done in the Caribbean. This lack of tsunami monitoring in the Caribbean is due to an ignorance of the tsunami history there. The Caribbean has had 90 local tsunamis since 1498, and these have resulted in 9,200 fatalities.

There is a wide spread misunderstanding of what constitutes a tsunami. Although the popular notion of a tsunami is that of a large, breaking wave such as depicted as in the classical Hokosai picture, a tsunami is any sudden, non-meteorologically-induced impulse in water regardless of size. Concerning the Cape Mendocino earthquake and tsunami event *The Triplicate* (April 25, 1992) reports the coordinator of the County Office of Emergency Services as having stated that tides in Crescent City harbor fluctuated from two to four feet (0.6 to 1.2 m) between 11:20 A.M. and 4:30 P.M., "but no tsunamis were generated." This statement is an indication of the general lack of understanding of what constitutes a tsunami since a measure of water fluctuation in the harbor at Crescent City is proof that a tsunami occurred.

It is often difficult to get firm data on tsunami effects. Since tsunamis are often associated with large destructive earthquakes locally, it is often difficult to separate the losses due to each phenomenon. Also, fatality figures often omit people listed as "missing" indefinitely. We have attempted to use official numbers for fatalities, injuries, and damage rather than news reports although these official sources frequently underestimate losses for political reasons.

The tsunami height is defined as the peak-to-trough excursion of the wave, generally as measured on marigrams. The amplitude is essentially half the height. There is some confusion in measuring runup heights which are more closely related to amplitudes as they are based on the height reached by the wave above the sea level at the arrival time, not on the full excursion from withdrawal to rise which may be referred to a the height of the tsunami. In the reports available there is considerable variation on reported scaled heights from marigrams but these differences are small in comparison to the uncertainty of instrumentally measured wave heights and the actual height. Depending on the instrument and its condition, the measured heights may be less that the actual wave height by a factor of two or more. Marigraphs were designed to measure long period tides, and some instruments have sampling rates as low as one value every 15 minutes, much longer than local tsunami wave periods. Most tsunamis are not registered on such instruments. Others may be over-damped due to clogging of the intake hole or other limitations. The wave heights on the shore may also vary due to the configuration of the offshore bathymetry and coastal features such as coves, which may focus the tsunami energy.

The earthquake epicenter is not necessarily the location of the origin of the tsunami. The epicenter is the point on the surface of the earth directly above the hypocenter where the earthquake rupture begins. However, the rupture may move to the surface along a diagonal path. When a tsunami is

generated by an earthquake, the source of the tsunami is generally where the rupture breaks the ocean floor. The earthquake may also cause a landslide that can generate a tsunami.

Since this catalog contains information on 154 tsunamis, it necessarily has to be a summary of the reports of the events. More details can be found in the cited original reports, particularly with regard to the conclusions of research conducted on the events. Almost all of the tsunamis reported during this period are due to seismic effects. An exception, the 1994 Skagway tsunami, was due to a landslide without a causative earthquake. Other events such as the 1996 Irian Jaya tsunami are probably multiple cause events with the earthquake displacements causing a tectonic tsunami and the vibrations causing additional submarine landslide tsunamis. This is also probably true for the 1992 Flores Island, Indonesia, event where there were reports of initial receding of the ocean a few minutes after the earthquake, and large scarps on the coastline. Although tsunamis generated by volcanic eruptions can be deadly, this catalog includes only one, the tsunami at Rabaul in 1994.

The increase in the availability of data due to the investigations by international survey teams, the sharing of data on international Web sites, and the increase in tsunami meetings and their published proceedings has made the compilation of this catalog easier than was compilation of earlier catalogs.

EVENT DESCRIPTIONS

#1. 1982, January 11. An earthquake (Ms 6.9) in the Philippines at 14:10 UT caused a tsunami that was recorded at Legaspi, Philippines, with a runup of 0.1 m. Oscillations continued for one hour.
Soloviev, et al. 1992.
Validity 2.

#2. 1982, February 24. An earthquake (Ms 5.4) at 4:22 UT occurred in the Java Trench. The earthquake was felt at Medan, Indonesia, and also on Pinang, Peninsular Malaysia. A minor tsunami was generated.
Tsunami Newsletter, Vo. XV, No. 2, August 1982; Soloviev et al. 1992.
Validity 2.

#3. 1982, March 11. An earthquake (Ms 5.8) at 10:32 near Ambon, Indonesia, triggered an unconfirmed tsunami.
Alaska Earthquake Information Center.
Validity 1.

#4. 1982, March 21. An earthquake (Ms 7.1) at 2:32 UT off the coast of Hokkaido Island, Japan generated a tsunami. Bridges, roads, and dams were damaged in Urakawa. At 11:45 the regional administration of JMA in Sapporo issued a warning of the tsunami danger along the Pacific coast of Hokkaido. The weak tsunami was recorded along the coast of Hokkaido and on the northeast coast of Honshu. A strong low tide was observed at Urakawa. The high tide at Urakawa penetrated 3 m inland reaching a height of 108-114 cm above the calm sea level. Eyewitnesses at Mitsuishi said the tsunami did not reach the surface of the piers. Some ships in the harbor touched bottom. A whirlpool was observed in the port. The maximum rise of water was estimated at 45 cm above calm sea level. The following runups were recorded: 0.2 m at Ayukawa, 0.1 m at Enoshima, 0.6 m at Erimo, 0.6 m at Hachinohe, 0.1 m at Hanasaki, 0.3 m at Hiroo, 0.2 m at Kamaishi, 0.3 m at Kuji, 0.2 m at Kushiro, 0.1 m at Miyako, 0.2 m at Muroran, 0.2 m at Ofunato, 0.2 m at Shimanokoshi, 0.3 m at Shoya, 0.2 m at Tomakomai, and 1.3 m at Urakawa.
Tsunami Newsletter, Vol. XV, No. 2, August 1982; Soloviev et al. 1992.
Validity 4.

#5. 1982, July 23. A tsunami was generated by an earthquake (Ms 6.8) near Ibaraki, Japan, at 14:23 UT. It was recorded with the following runups: 0.4 m at Ayukawa, 0.2 m at Choshi, 0.2 m at Hatachi, 0.1 m at Kamaishi, 0.1 m at Mera; and 0.3 m at Onahama.
Iida, 1984.
Validity 4.

#6. 1982, December 19. An earthquake (Ms 7.7) at 17:44 UT in the Tonga Islands generated a tsunami that was recorded at Pago Pago, American Samoa, with a runup of 9 cm, at Honolulu, Hawaii, with a runup of 4-5 cm., at Kailua-Kona, Hawaii, with a runup of 6 cm, and at Papeete, Tahiti, with a runup of 15 cm.
Tsunami Newsletter, Vol. XVI, No. 1, May 1983.

Validity 4.

#7. 1982, December 25. An earthquake (Ms 5.9) occurred at 12:28 UT in the Flora Island region causing landslides and damage and injuring 390. An unconfirmed tsunami was reported by PDE.
PDE.
Validity 2.

#8. 1982, December 28. An earthquake (Ms 6.4) at 6:37 UT occurred south of Honshu, Japan, and generated a tsunami that was recorded on Hachijo Island with a runup of 0.4 m.
Murty and Rafiq, 1991; Pacific Tsunami Warning Center, 1983; Coast and Geodetic Survey; *Tsunami Newsletter*, Vol. XVI, No. 1, May 1983.
Validity 4.

#9. 1983, March 12. A magnitude 6.9 Mw (USGS) earthquake at 01:36 UT caused a 3 m local tsunami observed at Ceram, Indonesia. As this was a fairly large wave that was not reported elsewhere, it may have been due to a landslide generated by the earthquake**.**
PDE.
Validity 4.

#10. 1983, March 18. A magnitude 7.9 Mw (USGS) earthquake at 09:05 UT caused damage (MMI VII) along the SE coast of New Ireland. A concrete pier at Muliana on the East coast of New Ireland collapsed completely. Landslides and cracks occurred, trees were uprooted and steam was ejected from fumaroles in the Feni Islands. Slight damage (MMI VI) and minor landslides were reported in the Rabaul area. Felt at Bougainville and MMI III at Port Morseby, New Guinea. A tsunami with heights of 18, 23, 24, and 26 cm was recorded at Rabaul during the first half hour. A minor tsunami was observed in the Feni Islands and along the southeastern coast of New Ireland. A two-cm tsunami was reported at Guam.
PDE; *Tsunami Newsletter*, Vol. XVI, No. 1, p. 5, May, 1983.
Validity 4.

#11. 1983, May 26. A magnitude 7.8 Mw (USGS) earthquake at 03:00 UT in the central region of the Sea of Japan, Nihonkai-Chubu, about 80 km off the west coast of Akita Perfecture, Honshu, Japan, caused 103 fatalities and 324 injuries. One hundred of the fatalities were due to the tsunami, and four fatalities resulted from the earthquake in Japan.

Seismic Information: Aftershocks indicate two main faults with the southern one striking N20E and the northern one striking N15W and both having dip angles of 20 to 30 degrees (Koyama, 1988). The fault length was 120-130 km running north to south with a breadth about 40 km east to west (Iwasaki, 1986).

Narrative Information: Although a warning was issued 14 minutes after the earthquake, the first tsunami wave arrived at Oga Peninsula in eight minutes. Since destructive tsunamis are less common along the coast of the Sea of Japan than along Japan's Pacific coast, the people probably were less sensitive to the tsunami threat indicated by the earthquake. However, at the Oga aquarium there was

a man who had experienced tsunamis before. After feeling the earthquake, he watched the sea. He saw the wave approaching and was able to warn the people with a loud speaker in time for them to evacuate safely.

Fatalities and injuries: Many of the fatalities and much of the damage occurred on the Oga Peninsula, Honshu, where 13 pupils on an excursion were killed. The earthquake was weakly felt by the pupils on a bus that was on its way to Kamoaosa Beach. The 45 students accompanied by their two teachers and two fathers had disembarked and were beginning to eat lunch when the sea retreated. The returning wave washed them out to sea where several were rescued in a stretch of calm water 300 meters off shore. Workers at Noshiro Harbor were caught by the tsunami and 34 were killed. Nine of these were on boats and 25 were on caissons. Of the total of 100 fatalities in Japan, 40 were workers in the construction works, 29 were fishing on a beach, 13 were the students on excursion, four were tourists, eight were in fishing boats which capsized, five were farmers working paddy fields inundated by the tsunami, and one was a patrolman watching the tsunami. Along the eastern coast of the Sea of Japan, South Korea, there were three deaths and two injuries.

Damage: Houses (3,513) were destroyed, including 52 that were washed into the sea. The tsunami sunk 225 vessels, and 451 were washed out to sea. The tsunami also damaged 1,187 other vessels. Among the 67 ships under construction in Noshiro Harbor, 40 were destroyed (Iwasaki, 1986). At the beach of Minehama, 233 of 1,000 four-ton tetrapods were scattered, and 36 were broken. In Noshiro Harbor, 4,000-ton caissons were translated and dislocated. There was extensive damage to roads, dwellings and vessels due to the earthquake and tsunami. Severe tsunami damage occurred as far away as Yamaguchi Prefecture in the southwestern part of Honshu. In South Korea 70 boats were damaged. Several small fishing boats were washed ashore, some ships had their mooring lines broken, and stacks of boxes and barrels on the beach were washed ashore. Damage also occurred in the Japan Sea along the Primore coast of Russia. The total damage was about $800 million (U.S. dollars).

Tsunami Runup Information: The tsunami hit the Oga Peninsula about eight minutes after the earthquake origin. The maximum runup was 14.9 meters on a dune in the village of Minehama and 10.6 meters at Hachimori. At a construction site of Noshiro Harbor near the center of the North Akita Coast that has a smooth sandy beach 55 km long, waves as much as 12.7 meters occurred. Fortunately, this beach is sparsely inhabited, and, although waves of 5 to 6 meters were measured, only a few houses on low land were inundated. However, some of these houses were destroyed. The second wave had two or three small waves of short period in front of it. The height of these waves was reported to be 6 to 8 meters, and the wavelength was on the order of 100 meters. The tide gage in the harbor recorded only waves of 2.09 meters and half wave periods of 5 minutes (Shuto, 1983). Shuto showed that the breakwaters were effective in reducing the size of the waves in the harbors by up to 5 meters.

There were four breaking waves and 2 or 3 non-breaking waves near the north side of Oga Peninsula with periods of about 10 minutes. At Fukaura the observed wave height was 1.5 m but the recorded height was 65 cm. (Okada, 1990) (It is not unusual for tide gages to under-record the actual tsunami height.) Estimated heights of the tsunami were 14.93 meters at Minehama, Honshu, and 2 to 6

meters along the southern Hokkaido and northern Honshu coasts. The tsunami was recorded at 63 stations in Japan including some on the Pacific Coast. The wave was recorded as a rise in most marigrams but began as a fall in eight stations east of the source region. This suggests a subsidence of the sea bottom in the eastern half of the source region.

Outside of Japan runups were also significant. Along the Japan Sea Primore Coast of Russia two to four meter waves inundated 200 to 400 meters of the coast. The maximum height at the Primorsky Territory, Russia, was 4.5 meters in Valentine Bay and about 40 cm at the southwestern part of Sakhalin (Pelinovsky et al. 1985). Waves of 2.7 meters were reported at Kunasi Island, and of 4.2 meters at Shikotan Island, the southern most of the Kuril Islands.

The tsunami arrived on the shores of South Korea about 1 hour and 30 minutes after the origin time of the earthquake. It was observed along 100 kilometers of the South Korean coast from Kang to Ulchin with heights of over one meter. The main effects on the South Korean coast were between Imwon and Sokch'o where a rise of the water of 3.2 meters was followed by a drop of 5.6 meters. The maximum height was five meters at Ullung-Do Island (South Korea). A two- meter runup was measured at Imw-njni in Samch'ŏk, South Korea.

The tsunami continued for 48 hours with reflections and free earth oscillations within the nearly enclosed Sea of Japan (Sataki and Shimazaki, 1988). Tsuji (1988) found evidence of the tsunami on the marigrams for up to four days. Shuto and Imamura (1995) examined the anomalous late arrivals of the tsunami from the computed expected arrival times, (two minutes late in the north and ten minutes late in the south) and concluded from aftershock patterns that the differences could be explained by a second fault in the north and a zone of aseismic creeping in the south.

Shuto, 1983; Shuto et al. 1993; Li-San Hwang and Hammack, 1984; Tsuji, 1986, 1988, and 1995; Kijura, 1986; Pelinovsky et. al 1985; Iwasaki, 1986; Iida, 1984; Koyama, 1988; Okada, 1990; Sataki and Shimazaki, 1988; Shuto and Imamura 1995; Pacific Tsunami Warning Center's Tsunami Warning Log, 26 May 1983; *PDE.*
Validity 4.

#12. 1983, June 9. A magnitude 6.3 Mb (USGS) earthquake at 12:49 UT was felt with intensity IV (JMA) in Akita, Japan area. Water level along the coast reportedly rose 60 cm (amplitude).
Preliminary Determination of Epicenters citing a Foreign Service report.
Validity 4.

#13. 1983, June 21. A magnitude 6.9 Mw (USGS) aftershock of the May 26 earthquake at 06:25 UT caused some damage on northern Honshu, Japan, and a tsunami with heights of one meter at Akita where ten fishing boats were evacuated by the warning, at Noshiro where workers were evacuated and at Wakami. At Aomori, a fishing boat was overturned but no injuries occurred, and at Fukaura the wave was 40 cm high. The *Tsunami Newsletter* reported 9 to 14 cm at Fukaura, and 28 cm at Esashi, south west of Hokkaido. Many sites on west coast of northern Honshu had 50 cm waves. Iida reports heights of 31 cm at Fukuara, 54 cm at Esashi, 98 cm at Yoshioka, 30 cm at Senposhi, 37 cm at Noshiro, 16 cm at Akita (see information above), 13 cm at Sakata, 25 cm at Iwafune, 28 cm at

Ryotsu, 17 cm at Awashima, 7 cm at Oga, 4 cm at Maizuru, and 14 cm at Sakai. Note that more than one runup value is given for Akita, Fukuara and Esashi. This was a back-arc tsunami since the main subduction zone is on the Pacific side of Honshu.
Foreign Service report; *PDE*; *Tsunami Newsletter*, Vol. XVI, No. 2, p. 11; *Manichi Daily News*, Tokyo.
Validity 4.

#14. 1983, August 6. A magnitude 7.0 Mw (USGS) earthquake at 15:44 UT in the Aegean Sea caused slight damage on Lemnos and damage to four monasteries in the Mount Athos area. Papaioannou reported a weak sea wave observed at Myrina, Lemnos Island and gives the tsunami intensity as a 2+. The *PDE* gives the focal mechanism as a strike slip fault.
Papazachos and Papazachou, 1989.
Validity 4.

#15. 1983, August 17. A magnitude 6.5 Ms (USGS) earthquake at 10:55 UT in Kamchatka Bay, Russia generated a faint tsunami of 2 cm recorded by the tide station in the town of Ust-Kamchatsk 29 minutes after the earthquake.
Zayakin, 1990.
Validity 4.

#16. 1983, August 17. A magnitude 6.5 Ms (USGS) earthquake at 12:17 UT in the Philippines caused 16 fatalities 47 injuries and extensive damage in the Pasuquin-Laoag-Batac and Serrat areas. There were unconfirmed reports of a small tsunami along the coast of Ilocos Norte Province.
PDE.
Validity 2.

#17. 1**983, October 4.** A magnitude 7.3 Ms (USGS) earthquake at 18:52 UT caused 5 fatalities and 24 injuries in the Copiapo-Chanaral, Chile region and a 1.5 m drop in the sea level possibly due to an uplift of the coast near Chanaral. A minor tsunami of 10 to 20 cm was recorded at Valparaiso but not reported elsewhere.
PDE; *Tsunami Newsletter* 16, No. 2, p.10.
Validity 4.

#18. 1983, November 30. A magnitude 7.6 Ms (USGS) earthquake at 17:46 UT caused some damage (MMI VI) to buildings and piers on Diego Garcia in the Indian Ocean. There was a 1.5-meter rise in water height in the lagoon and significant wave damage near the southeastern tip of the island. Four-centimeter waves with 20-minute periods were recorded at Victoria, Seychelles, and a large zone of discolored seawater was seen 35 to 40 nautical miles NNW of Diego Garcia. *The Tsunami Newsletter* reported 10-40 cm in Seychelles Islands.
PDE, citing Chief of Naval Operations.
Validity 4.

#19. 1984, January 8. A magnitude 6.6 Ms (USGS) earthquake at 15:24 UT at Sulawesi, Indonesia, killed two, injured 23 and may have generated a tsunami in the Mamuju area. There was no mention

of waves in *PDE* or the *ISC* in connection with the Sulawesi earthquake.
Validity 1.

#20. 1984, February 11. A magnitude 5.4 Ms (USGS) earthquake at 08:02 UT occurred in the West Corinthos Gulf, Greece, which caused damage in the Managouli-Aiyion area and created an intensity 3 tsunami at Sergoula.
Papadopoulos, 1993.
Validity 4.

#21. 1984, March 24. A magnitude 7.0 Ms (USGS) earthquake at 09:44 UT in the Kuril Islands, Russia, caused a 14 cm tsunami at Nemuro, Hokkaido (unconfirmed). Warning issued by JMA.
PDE.
Validity 2.

#22. 1984, June 13. A magnitude 5.5 Ms (USGS) earthquake at 02:29 UT south of Honshu, Japan, caused a 6 cm tsunami at Hachijo-jima with intensity I at Yokohama.
PDE.
Validity 4.

#23. 1984, August 6. A magnitude 6.7 Ms (USGS) earthquake at 19:07 UT at Kyushu, Japan, injured nine people and caused damage IV (JMA). The earthquake was also measured with intensity IV on SW Shikoku. An 18-cm wave was recorded at Nobeoko.
PDE.
Validity 4.

#24. 1984, September 18. A magnitude 6.9 Ms (USGS) earthquake at 17:03 UT off of the east coast of Honshu, Japan, was felt with intensity IV (JMA) at Tateyama and III at Tokyo. It was felt on the south coast of Hokkaido and on the north Honshu coast. There was a 11-cm tsunami at Hachijo-jima; 10 cm was measured at Ishinomaki; 5 cm at Onahama; and 3 cm at Tateyama.
PDE.
Validity 4.

#25. 1984, December 28. A magnitude 7.0 Ms (USGS) earthquake at 10:38 UT occurred near the coast of Kamchatka in the Bering Sea and created a tsunami which reached Ust-Kamchatsk 18 minutes after the earthquake with a recorded height of 2 cm. It was recorded about 33 minutes after the earthquake with a height of 17 cm at the Village of Nikolskoe on Bering Island in the Komandorsky Islands.
Zayakin, 1990.
Validity 4.

#26. 1985, March 3. A magnitude 7.8 Ms (USGS) earthquake at 22:47 UT caused at least 177 fatalities and 2,575 injuries in Chile. There were reports of subsidence of the coast areas at Valparaiso and Vina del Mar and numerous landslides. The earthquake was felt from Copiapo to Valdivia.

Chile Tsunami Wave Heights: Observers estimated that the tsunami reached three meters at Talcahuano. The maximum recorded height was 1.82 m at Talcahuano. It was also recorded at Coquimbo, 55 cm, Arica, 50 cm, Antofagasta, 18 cm, Inquique, 23 cm, Caldera, 20 cm, Talcahuano, 1.82 m, and Valpraiso, 1.15 m with an initial rise of 0.2 m at 22:50 UT.

In the source region, the tsunami was reported at Quintay as four rises and falls observed during the first two to three hours with the first rise being gentle. The third and fourth waves rose to a height of 2.0 m above the normal tide inundating 15 m of the coast over the high tide line and 10 to 15 m below the low tide line. At Algarrobo there were also four rises and falls reported with the first occurring immediately after the earthquake followed by a fall exposing 150 m of the beach bottom. The last and strongest occurred at 02:00 UT with the rise reaching 1.5 m above the high tide and inundating 70 m inland from the high tide line.

At El Quisco four rises and falls were also reported with the last being the highest. At La Castilla and El Tabo Camp sites the sea receded 50 to 60 m. At Las Cruces the sea receded 10 to 12 m on the beach south of town. At Costa Azul a rise and fall immediately after the earthquake was 2-3 m high and inundated 40-50 m inland. At Cartagena the rise reached 2-3 m high and inundated 24 m inland. At San Antonio a rise and fall of 3-4 m was observed. The Department of Commerce reported a loss of about $3 million at San Antonio due to destruction of 4 of 7 berths resulting in a drop in production of copper. Whether this was due totally to the earthquake or partially to the tsunami was not clear.

Wave Heights Outside Chile as given by the Tsunami Warning Log:
In Hawaii: 77 cm at Hilo; 15 cm at Honuapo; 5-7 cm at Kailua-Kona; 5 cm at Mahukona; 36 cm at Kahului; 3 cm at Honolulu, Pearl Harbor and Pu'uloa, Honuapo, Hawaii, 7-11 cm at 13:33 UT with a period of 15 minutes; Kailua-Kona, Hawaii, 5-7 cm at 13:48 UT with a period of 15 minutes; Hilo, Hawaii, 48 cm at 13:55 UT with a period of 17 minutes; Mahukona, Hawaii, 5 cm at 15:04 UT, with a period of 17 minutes; Kahului, Hawaii, 36 cm; Honolulu, Hawaii, 3 cm at 14:16 UT with a period of 17 minutes; Pu'uloa, Hawaii, 3 cm at 14:33 UT.

In Japan: Kushiro, Japan, 10 cm; Nemuro, Japan, 15 cm; Chichijima, Japan 17 cm; Onahama, Japan, 15 cm; Owase, Japan, 13 cm; Hachinoche, Japan, 12 cm;

In Alaska: Adak, Alaska, 15 cm at 19:38 UT with a period of 8 minutes; Sand Point, Popov Island, Alaska, 15 cm at 18:30 UT with a period of 24 minutes; Kodiak, Alaska, 4 cm at 18:25 UT with a period of 15 minutes; 4 cm at Womens Bay, Kodiak; Seward, Alaska, 5 cm at 17:27 UT with a period of 7 minutes; and Yakutat, Alaska, tiny ripples.

In other areas: Coast of Ecuador, 15 cm at 00:45 UT with period of 54 minutes; Rititea, French Polynesia, 11 cm; Papeete, Tahiti, 10 cm; 11 cm at Rikitae, Gambier Islands; and 10 cm at Kushiro, Nemuro; and Miyako Japan. (Nakamura (1993) lists recordings at Muroto-misaki, Komatsujima, Sumoto, Kobe, Osaki, Tannowa, Wakayama Shirahama, Kushimoto as faint traces.) Hong Kong, China, recorded 10 cm. Petropavlovsk-Kamchatky recorded a 2 cm height 22 hours and 23 minutes

after the earthquake. A rise of 3 cm was recorded at Ust-Kamchatsk, Russia. No recordings were reported from Raratonga, Cook Islands, or Majuro.
Trivelli, 1983; Nakamura, 1992; Nakamura, 1993; *Tsunami Hazards*.
Validity 4.

#27. 1985, March 16. An earthquake (Ms 6.3) at 14:54 UT in the Leeward Islands caused six injuries and damage on Guadeloupe Island, and minor damage at Montserrat. It was also felt on Antigua, St. Kitts, and Puerto Rico. A several centimeter tsunami was recorded at Basse Terre, Guadeloupe. (BRK Ms 6.8.)
Lynch and Shepherd, 1995; *PDE*.
Validity 4.

#28. 1985, April 13. A magnitude 6.2 Mb (USGS) earthquake (01:06 UT) caused damage to buildings at Denpasar on the southwest coast of Bali, Indonesia. There were unconfirmed reports of waves several meters high on south beaches of Bali.
Tsunami Newsletter, Vol. XVII, No. 1, p.4; *PDE.*
Validity 2.

#29. 1985, July 3. A magnitude 7.2 Ms (USGS) earthquake at 04:37 UT caused landslides in New Britain and a 1.3-m tsunami at Rabaul and seiches which lasted 15 hours. In Simpson Harbor the runup was 1.2 meters with seiches recorded for 15 hours.
Tsunami Newsletter, Vol. XVII, No. 2, p. 6; *PDE.*
Validity 4.

#30. 1985, September 19. A magnitude 8.1 Ms (USGS) earthquake at 13:18 UT caused $3 to $4 billion dollars of damage in Mexico and at least 9,500 fatalities, 38,000 injuries and left 100,000 people homeless. An area of about 825,000 sq km was affected. In Mexico City, 412 buildings collapsed and another 3,124 were seriously damaged. About sixty percent of the buildings in Ciudad Guzman, Jalisco, were destroyed. It was felt as far away as Guatemala City and Texas.

Tsunami Damage and Effects:
A tsunami was generated which caused some damage to Lazaro Cardenos in the state of Michoacan where half a minute after the first pulse of the earthquake the sea level dropped and receded 60 meters from the coast. The short time and recession indicates a probable landslide source. The returning water inundated 500 m inland to heights of 2.5 m. It eroded the beaches destroying 1,500 meters of the railway lines between the steel mill of Las Truchas and the fertilizer factory FERTIMEX. It eroded the filling material in the bridge giving access to FERTIMEX and washed it out. Beach configurations showed up to two meters of vertical change in deposits of sand. It traveled up the Balsas River as a bore as far as 9.5 km upstream (Farreras and Sanchez, 1991).

At Playa Azul, Michoacan (located about 25 km north of Lazaro Cardenos) the tsunami strongly eroded the beach, depositing sand two meters higher. It inundated 150 m inland, washing away frail palapa restaurants and flooding some other restaurants and hotels near the shore. The first tsunami arrived at the end of the earthquake shaking, about 1 minute later than at Lazaro Cardenas. Four

waves with periods of about half an hour were seen.

At Ixtapa, Guerrero, tsunamis had similar effects flooding a few swimming pools and hotels near the beach. The water first receded and on return overtopped a 1.5-meter wall around the Sheraton hotel swimming pool. Returning tourists reported that waves were hitting their hotel that is usually 25 m away from the shore. (*Denver Post*, September 20, 1985).

At Ixtapa-Zihuatenjo the water also receded returning to destroy many beachfront restaurants. The estimated heights were three meters at Ixtapa-Zihuatanejo, 2.5 m at Lazaro Cardenos, and Playa Azul, 1.15 m recorded at Acapulco, and 1.0 m at Manzanillo (Farreras and Sanchez, 1991).

A letter from Richard Behn dated October 7, 1985, reports that a Captain Alt Elias Cordoba Araico was in Zihuatanejo at the time of the quake and that the water first receded to the end of the 200 meter pier, a depth of 2.5-3.0 meters, then returned flooding the land 2.5-3.0 meters above normal levels.

Tide Station Reports:
Tide stations recorded heights of 1.15 m with a travel time of 23 minutes at Acapulco, 1 meter at Manzanillo, 60 cm at La Liberdad, Ecuador, 58 cm at Acajutla, El Salvador, 24 cm at Kahuli, Hawaii, and Pago Pago, Samoa, 22 cm at Hilo, 21 cm at Baltra Island, Galapagos, 14 cm at Apia, Samoa, 7 cm at Rikitea, Gambier Islands, 5 cm at Papeete, Tahiti. There are unconfirmed reports that ships off the coast of Mexico saw waves up to 30 meters high and some fishing boats are missing.
Farreras and Sanchez, 1991; *Denver Post*, September 20, 1985; *PDE.*
Validity 4.

#31. 1985, September 21. A magnitude 7.6 Ms (USGS) aftershock at 01:37 UT caused additional casualties and damage in the Mexico City area and 1.2-m waves peak to trough were recorded at Acapulco (Sanchez and Farreras, 1993). A wave height of 2.5 m was reported at Zihuatanejo, and overtopped the pier. It inundated 200 m inland. The waves were observed for nine hours due to resonance in the bay. Captain Alt Elias Cordoba Araico reported that the same effects were observed for this event as for the September 19 event.
Farreras and Sanchez,1991; Sanchez and Farreras, 1993.
Validity 4.

#32. 1986, May 7. A magnitude 7.9 Ms earthquake at 22:47 UT in the western Aleutian Islands caused minor damage (MM intensity VI) at Adak and Atka. At Adak, which has a population of 4,000 to 5,000 at its naval base, damage consisted of cracked masonry, windows, differential settling, some rock falls, sand boils and slumping under and beneath the wharf which left the wharf warped in one area. There were no reports of earth slumping having caused a tsunami or of tsunami damage.

Tsunami Wave Heights:
The tsunami was recorded throughout the Pacific. In Alaska the following wave heights were

recorded: Adak, 175 cm (Tsunami Warning Log); Sand Point, 10 cm; Dutch Harbor, and Unalaska, 25 cm. Midway Island recorded 67 cm; Wake Island recorded 10 cm; Kapaa, Kauai recorded 91 to 122 cm; Hanalei, Kauai recorded 61 to 91 cm. The waves at Kapaa and Hanalei were observed as well as recorded. The wave was recorded at Kahului, Hawaii, with a height of 36 cm; at Honolulu, Hawaii, with a height of 40 cm; at Hilo, Hawaii, with a height of 55 cm, at Nawiliwili, Hawaii, with a height of 78 cm, at Honuapo, Hawaii, with a height of 18 cm, at Kailua-Kona with a height of 8 cm, and at Makukona, Hawaii, with a height of 17 cm.

In Vancouver, Canada, it was recorded at Cape Scott Lighthouse as five waves with the maximum height of 140 cm. The wave registered 45 cm at Coquimbo, Chile; 25 cm at Valparaiso, Chile; and 9 cm at Easter Island. In Japan, the tsunami was recorded as 10 cm at Miyako; 16 cm at Tateyama; 9 cm at Ofunato; 12 cm at Shimizu; and 46 cm at Kushiro, Hokkaido. (Hatori (1987) gives data for 25 Japanese stations that recorded this tsunami.) On Bering Island, at the village of Nikolskoe, the tsunami was recorded 3 hours and 13 minutes after the earthquake with an amplitude of 17 cm, and with an amplitude of 8 cm at Ust-Kamchatsk. At Chichi-jima, Bonin Islands, the wave had a height of 24 cm. At Port Littleton, New Zealand, the tsunami had a height of 40 cm.

On the West Coast of the United States the tsunami had a height of 12 cm at Crescent City, California, 18 cm at Neah Bay, Washington, and 9 cm at Toke Point, Washington. In Samoa the wave height was 2 cm at Pago Pago, Samoa, and 5 cm at Apia, Samoa. At Truk Atoll it had a height of 6 cm, and at Johnston Island it had a height of 3 cm. In New Zealand it had an amplitude of 40 cm at Port Littleton and a height of 3 cm at Raratonga, Cook Is. On the west coast of South America the following were measured: La Libertad, Ecuador, 14 cm: Isla Lobos de Afuera, Peru, 7 cm; and La Punta, Peru, 15 cm. At Papeete it was recorded with a height of 7 cm. On May 17, 1986 16:20 UT magnitude 6.6 Ms (USGS) aftershock occurred in the Andreanof Islands but no tsunami was recorded at Adak or Atka.

Zayakin, 1990; Talandier and Ocal, 1989; Tsunami Warning Log; Pararas-Carayannis, 1986; *PDE*; Lander et al. 1993.
Validity 4.

#33. 1986, October 20. A magnitude 8.1 Ms (USGS) earthquake at 06:46 UT in the Kermadec Islands near New Zealand, knocked objects from shelves at Raoul Island. It was also felt at Napier and Wellington, New Zealand. In Hawaii, it created a 22 cm tsunami at Hilo, 15 cm at Kahului, 13 cm at Honolulu, 7 cm at Kona, and 14 cm at Honuapo. In the Pacific, 14 cm was recorded at Papeete, Tahiti, and 10 cm was recorded at Pago Pago, Samoa *(PDE). The Tsunami Newsletter*, Vol. 21, no. 1, p. 6 reports a 10-12 cm wave recorded in Bay of Haurli, Rapa Island, New Caledonia. Arrival times at the following stations were: Pago Pago 09:00, Papeete, 11:15, Honolulu, 15:18, Hilo, 15:32, Kahului, 15:20, Kona, 15:32, and Honuapu, 15:35 all UT.
PDE
Validity 4.

#34. 1987, February 6. A magnitude 6.3 Ms (USGS) earthquake at 13:16 UT near the east coast of Honshu, Japan, was felt with intensity V (JMA) at Onahama, intensity IV (JMA) at Mito, Sendai,

Tokyo, Utsunomiya and Yokohama and Hikone, and Wajima, Honshu to Kushiro, Hokkaido. It was also felt at Oshima and Hachijo-jima. It caused a tsunami with heights of 12 cm at Onahama, 8 cm at Ishinomaki, and 7 cm at Ofunato.
Manichi Daily News, Tokyo; *PDE*.
Validity 4.

#35. 1987, February 8. A magnitude 7.4 Ms (USGS) earthquake at 18:33 UT at East Papua, New Guinea, killed at least three people by a landslide, and did some damage. Three hundred people were left homeless. Landslides and ground cracks occurred at Umboi Island and sand liquefaction on Malai Island. It was felt in the Cape Gloucester area, New Britain, and as far away as Wewak, Port Moresby, New Guinea, 250 km to the south and Rabaul, New Britain. A 1.5 m tsunami struck Umboi but the people had already been evacuated.
Tsunami Newsletter, April 1987.
Validity 4.

#36. 1**987, March 5.** A magnitude 7.3 Ms (USGS) earthquake at 09:17 UT in northern Chile killed one and caused damage to the Antofagasta area. It generated a local tsunami of 22 cm at Caldera, 20 cm at Coquimbo, 14 cm at Valparaiso, and 18 cm at Arica.
PTWC; *PDE*.
Validity 4.

#37. 1987, March 18. A magnitude 6.7 Ms (BRK) 6.4 Mb (USGS) earthquake at 03:36 UT in Kyushu, Japan, caused one fatality and a fatal heart attack. Five people were injured and damage and landslides occurred in the Miyazaki region. It generated a 7-cm local tsunami recorded along the coast of Kyushu at ebb tide (FBIS Bangkok). All boats were evacuated at Kagoshima Bay, and people were evacuated at Shikoku.
PDE.
Validity 4.

#38. 1987, March 24. A magnitude 5.1 Ms (5.7 Mb) (USGS) earthquake at 12:50 UT near the west coast of Honshu, Japan, produced a wave (Abe, 1988). A wave height of 11 cm was recorded at Kushiro, 10 cm at Miyako, 16 cm at Tateyama.
Tsunami Newsletter, Vol. 20, No. 2, p. 25; Abe, 1988.
Validity 4.

#39. 1987, June 18. A magnitude 6.0 Mb (USGS) earthquake at 14:03 UT in the Solomon Islands reportedly generated a tsunami but the tsunami was not listed in the *PDE.*
Validity 1.

#40. 1987, July 6. A magnitude 6.6 Ms (USGS) earthquake at 02:49 UT near the Vanuatu Islands was felt strongly on the Banks Island and caused a small local tsunami. No details are available. Vila, Vanuatu was evacuated.
PDE.

Validity 3.

#41. 1987, October 6. A magnitude 7.6 Ms (USGS) earthquake at 04:19 UT was felt at Nuku'alofa and American Samoa and produced a 25 cm tsunami at Pago Pago, American Samoa. It was reported in the *Tsunami Newsletter* and the PDE but not reported at Rarotonga, Cook Islands, or elsewhere.
Validity 4.

#42. 1987, October 12. A magnitude 6.8 Ms (USGS) earthquake at 13:57 UT was felt (V) at Arawa and Panguna, Bouganville and at Rabaul. An 8-cm tsunami was recorded at Rabaul.
Ripper and Letz, Port Moresby Geophysical Observatory, 1987; NEIC/ISC; *PDE*.
Validity 4.

#43. 1987, October 16. A magnitude 7.4 Ms (USGS) earthquake (20:48 UT) caused damage at Kandrian, New Britain. The sea inundated and receded 30 m at Kandrian, and a small wharf was destroyed and two jetties damaged. It was recorded as 13 cm at Rabaul. Multiple event.
PDE; Ripper and Letz, 1987.
Validity 4.

#44. 1987, November 17. A magnitude 6.9 Ms (USGS) earthquake at 08:46 UT in the Gulf of Alaska was felt widely in southern and southeastern Alaska and generated a 12-cm wave was recorded at Yakutat. It was not recorded by the deep ocean gages.
Lahr et al. 1988; Pararas-Carayannis, 1987; Gonzalez et al. 1990; *PDE*.
Validity 4.

#45. 1987, November 26. A magnitude 6.5 Ms (USGS) earthquake at 01:43 UT at Timor, Indonesia caused landslides, killed 37 people and injured 108. Two hundred thirty-seven buildings were damaged on Pantar Island. Mt. Sirung Volcano erupted but *PDE* doesn't mention any tsunami.
Validity 0.

#46. 1987, November 30. A magnitude 7.6 Ms (USGS) earthquake at 19:23 UT in the Gulf of Alaska was felt throughout southern and southeastern Alaska. It generated a small tsunami of 85 cm at Yakutat where boats rose and fell slowly without damage. Twenty-five cm was recorded at Sitka, Alaska. Deep ocean bottom gages in Alaska off the Shumagin Gap area recorded the wave as 1 cm at AK8, 2 cm at Ak7 and 3.5 cm at WC9 off the State of Washington's coast. It was recorded at Seward, Alaska, but while intermittent power failures made it impossible to determine the height accurately, it was approximately 10 cm (Gonzalez et al. 1990). It was recorded at Hilo, Hawaii, with a height of 15 cm, at Nawiliwili, Kauai, with a height of 12 cm, and at Honolulu, Hawaii, with a height of 5 cm. It was recorded at San Francisco with a height of 5 cm.
Lander, 1996; *PDE.*
Validity 4.

#47. 1988, February 5. A magnitude 6.7 Ms (USGS) earthquake at 14:01 UT near the coast of northern Chile caused minor damage in the Taltal region and Antofagasta (MMI VI) and was felt elsewhere in northern Chile. It caused a 12-cm peak-to-trough tsunami that was recorded at Caldera

at 15:00 (GOES Thrust transmission).
PDE.
Validity 4.

#48. 1988, March 6. A magnitude 7.6 Ms (USGS) earthquake at 22:38 UT in the Gulf of Alaska caused $5,000 damage to the ships Exxon *Boston* and Exxon *New Orleans* at 57.63 N and 142.75 W and a tsunami with amplitudes of 38 cm at Yakutat, 12 cm at Sitka, 8 cm at Kodiak, and was recorded on deep ocean gages AK7 and AK8 and WC9 with heights of 4.6, 3, and 5.6 cm respectively. The earthquake occurred on transform faults oriented north to south at the boundary between the Aleutian subduction zone and Fairweather fault zone on the west coast of southern Alaska and Canada.
Lander, 1996; *PDE;* Gonzalez et al. 1990; Lahr et al. 1988.
Validity 4.

#49. 1988, April 20. A mass of about 200,000 cubic meters of material from the northeast flank of the volcano La Fossa on the Island of Volcano in the southern Tyrrhenian Sea became detached. It fell down into the sea in about 10 seconds, generating a small tsunami in the bay between Point Nere and Point Luccia. This part of the island is completely uninhabited. A fisherman in a nearby boat observed the event. The positive leading wave came from Point Rioa and propagated throughout the bay. A second fisherman, who was near Point Luccia, also noticed the wave.

A wave of about 5.5 meters height was seen in the Porto di Levante and presumably even at Monterosa, Lipari Island. The seismometer network of the Aeolian Islands recorded the landslide vibrations. The landslide mass was estimated through models of the terrain inferred from photogrammetric campaigns carried out in 1981 and 1991.
Tinti 1998; Barberi, 1990.
Validity 4.

#50. 1988, June 24. A magnitude 5.4 Mb (USGS) earthquake occurred at 02:06 UT in Luzon, Philippines. A tsunami with a height of 65 cm was reported at Quarry Bay Station at 06:25 UT in Hong Kong, China. It was also recorded at Tai Po Kau with a height of 1.03 meters probably due to the shallower water and the channeling effect of the Tolo Harbour. No other tsunamis were reported in ISC or PDE.
Pararas-Carayannis, 1991; *National Report of Hong Kong* at IOC/ITSU, Vol. 26, No. 7, p. 17.
Validity 2.

#51. 1988, July 5. A magnitude 6.8 Ms (USGS) earthquake at 20:32 UT in the New Britain region destroyed seven water tanks and four brush houses in the Kandrian area. It generated a tsunami in the Arawe Islands area. A small tsunami swept through Maklo village in Papua, New Guinea, but did not cause damage. Between Pailili Island and Kunbun Village swollen seas and bubbles were observed. At Kunbun Village sounds like a jet engine were heard.
Ripper, July 25, 1988; *PDE.*
Validity 4.

#52. 1988, August 10. A magnitude 7.4 Ms (USGS) earthquake at 04:38 UT in the Solomon Islands generated a tsunami which killed one person and washed away 100 homes in 13 villages along the southwest coast of San Cristobal Island where the tsunami flooded 50 to 100 meters inland on the southwest coast of Makira (HNR). A 17 cm peak-to-trough tsunami recorded at Honari, Guadalcanal. (*Port Moresby Port Courier*, Friday 12 Aug 1988) Two thousand people were evacuated. Thirteen villages were affected, and 1 person drowned.
Smithsonian Institution, 1997, Vol. 13, No. 8; *PDE*
Validity 4.

#53. 1989, May 23. A magnitude 8.2 Ms (USGS) earthquake at 10:55 UT near Macquarie Island generated a small tsunami along the SE coast of Tasmania recorded at Hobart, Tasmania, and Eden, Jervis Bay and with a height of 0.2 meters at Sydney harbor, New South Wales, Australia. *PDE*.
Validity 4.

#54. 1989, June 26. A magnitude 6.1 Ms (USGS) earthquake at 03:27 UT in Hawaii injured five people, destroyed five homes, and damaged 100 others in the Puna District. It generated several landslides. It also generated a small tsunami with maximum wave heights of 57 cm at Honuapo, 21 cm at Kapoho, and 14 cm at Hilo.
Tsunami Newsletter, Oct 1989; *PDE*.
Validity 4.

#55. 1989, September 4. An magnitude 6.9 Ms (USGS) earthquake occurred at 13:14 UT south of Alaska. It generated a small tsunami that was recorded at Sand Point, Alaska with less than 0.1 meter runup. It was also reportedly observed at Unalaska, Alaska.
ATWC.
Validity 4.

#56. 1989, October 18. A magnitude 7.1 Ms (USGS) earthquake at 00:04 UT near Loma Prieta caused extensive damage in the San Francisco, California, area. There were 62 fatalities, 3,757 injuries, and an estimated $5.6 billion in damage. It generated two small tsunamis in Monterey Bay, one due to an uplift of the bay observed in the north end and the other due to a landslide in the submarine Monterey Canyon near the middle of the bay. It was recorded at Monterey with a maximum recorded height of about 40 cm and period of nine minutes, and arrived about 20 minutes after the earthquake. This is consistent with an origin in the northern part of the bay. Seiches continued for about 24 hours. Due to the insensitivity of the gages to the short periods, the real height may have been twice as high.

Stephen Scheilblauer, the harbor master at the Santa Cruz Yacht Harbor on the north end of the bay, reported that several docks had become stuck to the piers and had to be manually lifted or broken implying a rise of the harbor bottom. Several boats were also left lying on the bottom. A small tsunami was observed to be rushing out of the harbor. There was a vertical uplift of the land of 0.1 to 0.2 m. At Moss Landing near the head of the canyon, the water suddenly drained from the Old Salinas River about 10 minutes after the earthquake exposing a large portion of its bed. The harbor level dropped by one or more meters before rising again.

Side-scan sonar showed palm-shaped slides about 1.65 m thick and 1.4 to 2.9 km long down the canyon. A video camera in operation recorded the earthquake's arrival and the beginning motion of the water 138 seconds after the shock indicating a source about 432 meters away, or at the head of the canyon.

Lander et al. 1993; McNally et al. 1989; Schwing et al. 1990, Gardner-Taggart and Barminski, 1991; Ma et al. 1990; *PDE; Tsunami Newsletter.*
Validity 4.

#57. 1989, October 29. A magnitude 6.6 Ms (USGS) earthquake at 05:25 UT felt from central Honshu to Hokkaido, Japan, generated a small tsunami at Honshu, Japan, with a maximum height of 11 cm at Ofunato, 10 cm at Ayukawa, 6 cm at Miyako and 3 cm at Hachinohe.
(FBIS Okinawa) *PDE.*
Validity 4.

#58. 1989, November 1. [10:25 UT] A 4.4 Ms (5.2 Mb) (USGS) earthquake at 10:25 UT in the Mona Passage by the north coast of Puerto Rico generated a small tsunami reported in *El Nuevo Dia* and a notable augmentation of the sea level in the area of Cabo Rojo.
Puerto Rico Civil Defense report; Aurilio, Kevin Acevedo, and Jose Martinez Cruzado, University of Puerto Rico*; El Nueva Dia*, Nov. 2, 1989, p. 11; *PDE*, 1989.
Validity 3.

#59. 1989, November 1. A 7.4 Ms (USGS) earthquake at 18:25 UT far east of Sanriku, Japan, generated a tsunami of 91 cm at Miyako, 69 cm at Hachinohe, 62 cm at Ayukawa, 54 cm at Urakawa. (All readings may be the range rather than wave height.) (JMA)
National Report of Japan, IOC/ITSU XIII, 1991.
Validity 3.

#60. 1990, February 20. A 6.4 Ms (USGS) earthquake at 6:54 UT near the coast of Honshu, Japan, was felt with MMI IV (JMA) at Tokyo and elsewhere on Honshu. It produced a 32-cm tsunami at Oshima.
National Report of Japan, IOC/ITSU, Vol. 17, 1991.
Validity 4.

#61. 1990, March 25. A 6.4 Ms (USGS) earthquake at 13:16 UT was followed by a second earthquake of Ms 7.0 (USGS) at 13:23 UT that was felt throughout Costa Rica, injured ten people slightly, and damaged about sixty buildings. Several landslides blocked roads for some time. A small seismic sea wave was reported from Quepos to Tambor. It was recorded with an amplitude of 30 cm at Quepos and was also recorded at Tampor. A rise of one meter was observed at Puntarenas. The earthquake and wave occurred at low tide.
Molina, 1997.
Validity 4.

#62. 1990, April 5. A magnitude 7.5 Ms (USGS) earthquake at 21:13 UT in the Mariana Islands was felt on Saipan and on Guam with MMI IV. It generated an observed tsunami at the dock at Tinian but no damage. The height was reported as 3-4 meters but that was considered exaggerated.

It was recorded with maximum wave heights of 47 cm at Muroto-misaki, Japan; 32 cm at Mera, Japan; 28 cm at Kushimoto, Japan; 39 cm at Chichi-shima, and Ayukawa, Japan; 43 cm at Tosashimizu, Japan; 18 cm at Aburatsu, Japan; 19 cm at Yaene, Japan; 16 cm at Okada, Japan; 11 cm at Owase, Japan; 11 cm at Choshi, Japan; 4 cm at Uchichura, Hyugashirahama, and Naha, Japan; 24 cm at Kailua-Kona, Hawaii; 6 cm at Midway, 4 cm at Wake Island and 3 cm at Truk.

Andy, Ted and Lauren Fairfield, crew members of the *Jungle Boat* on the Talafofo River, also observed it on Guam. At about 8 A.M. they were at the loading area next to the bridge to the floating raft they used for boarding passengers when a rush of foamy seawater came under the bridge and headed up river. The raft rose nearly two meters above normal levels. The water receded after 15 minutes or longer as a strong rip current. Debris was carried two miles up the river. The shape of the bay focuses the incoming wave into the river mouth at the head of the bay. It was also recorded by deep ocean bottom marigraphs in Japan (Okada, 1991).
NEIC; *PDE*; Okada, 1991; *National Report of Japan,* 1991.
Validity 4.

#63. 1990, May. George Pararas-Carayannis, then Director of the International Tsunami Information Center, reported being told of a tsunami sometime in May near an island called Bohol that was visually observed with 4-5 meters height on Caniguin Island north of Mindanao, Philippines. There were only about six earthquakes reported in the Philippines in May, and all were below magnitude 5. If this is a valid report, it may have been a local landslide event as no tsunami records can be found.
Pararas-Carayannis, 1990.
Validity 1.

#64. 1990, September 23. A 6.5 Ms (USGS) earthquake at 21:13 UT occurred south of Honshu, Japan, and was felt with intensity III JMA on Hachijo-jima, and Miyake-jima and in the Osaka-Owase-Yokkoichi area. It generated a slight tsunami at Hachijo-jima and Oshima.
PDE.
Validity 4.

#65. 1990, December 13. A 5.3 Ms (5.5 Mb) (USGS) earthquake at 00:24 UT near Sicily, Italy, caused at least 18 fatalities and 300 injuries. The most damaged cities were Augusta, Carlentini, Lentini, Melilli, Militello, and Priolo Gargallo. At Augusta, sailors observed an anomalous wave offshore. In the Augusta district called Contrada Granatello the road along the coast was flooded by a wave. At Catania small submarine landslides were reported, and, at Agnone Bagni, close to Augusta, bathymetric changes as large as 50 meters were reported.
Lo Guidice and Rasa, 1990; De Rubeis et al. 1991; *PDE*.
Validity 4.

#66. 1991, January 4. An aseismic tsunami occurred at Evdilos on the north coast of Ikaria Island,

Greece in the Aegean Sea. The wave had a period of about ten minutes. The sea disturbance lasted about three days January 2 through 4. There is no information of a disturbance in other coastal areas. The wave intensity was 2 (light wave, only very slight damage, if any). The long duration of the wave would suggest a storm wave, but the lack of any other reports may suggest a slump-generated wave.
Papadopoulos, 1993.
Validity 1.

#67. 1991, February 9. A 6.9 Ms (USGS) earthquake at 16:19 UT in the Solomon Islands caused minor damage at Honiara, and was felt strongly at Guadalcanal. It generated a 4-cm tsunami at Honiara.
PDE.
Validity 4.

#68. 1991, February 16. A 5.7 Ms (USGS) earthquake at 01:23 UT occurred southeast of Shikotan in the Kuril Islands and was felt at Severo-Kurilsk. One and a half hours later intensification of the seiches were observed in Little Kuril (Malokuril'skaya) Bay with periods of about 18 minutes. Synchronized measurements of the bottom hydrostatic pressure performed at this time both inside and outside of the bay made it possible to analyze the response of the bay to the tsunami signal arriving from the open ocean. It had a maximum height of 8 to 10 cm.
Dzhumagaliyev, 1994; *PDE*.
Validity 4.

#69. 1991, February 21. A 6.5 Ms (USGS) earthquake at 02:36 UT in the Bering Sea was felt on St. Paul Island, Pribilof Islands and at Adak, Andreanof Islands. It caused a small tsunami. This is the first earthquake of record from this region to have caused a tsunami. It was recorded with heights of 30 cm at Dutch Harbor, Unalaska, and 22 cm at Sweeper Cove. Adak.
Lander et al. 1993; *PDE*.
Validity 4.

#70. 1991, April 22. A 7.6 Ms (USGS) earthquake at 21:57 UT occurred near the eastern coast of Costa Rica and caused 47 fatalities and 109 injuries. This was a back-arc tsunami that occurred on the opposite side of Costa Rica from the main subduction zone in the Pacific eastern edge. It left 7,439 people homeless and caused severe damage in the Limon-Pandora area. A tsunami affected the coasts from north of Limon, Costa Rica, to Panama. A two-meter wave inundated 300 meters in the Cahuito-Puerto Viejo area of Costa Rica causing some additional damage in some places. In Costa Rica, the sea receded 20 to 500 meters from the shoreline immediately after the earthquake.

Tsunamis were also reported from the Bastimentos, San Cristobal (10 cm) and Colon Islands and at Puertobelo, Panama (60 cm). At Carenero Island violent waves destroyed dwellings. The tsunami was recorded at Coco Solo, Province of Colon, with a height of 76 cm approximately one hour after the earthquake. In Panama the sea receded for about 15 minutes after the earthquake for a distance of 100 to 400 meters. At San Cristobal Island the sea reportedly receded several meters for about 45 minutes (this seems unlikely for a local tsunami period). At Bocas del Toro, Panama, people

reported that Las Delicias sand bank normally covered by 60 to 90 cm of water emerged as the sea receded less than 10 minutes after the earthquake and remained above the water for five to seven minutes. Afterward the wave entered the bay with great force, flooding 50 to 100 meters inland in the flat northern part of the town.

Approximately three and a half hours (an excessively long time) after the earthquake, the wave was recorded on tide gages at Mayaguez Islands, Puerto Rico, and at Limetree, St. Croix, Virgin Islands, with amplitudes of about 7 cm. The water disturbance lasted four to five hours.

Two principal types of runup behavior were observed. In some locations a wave of two to three meters advanced rapidly to the beach and flooded 10 to 100 meters. This type of behavior was reportedly observed at the mouths of major rivers in the area including Baca Matina, Bocas del Pantano, Boca Moin, and the Estrella River. Widespread liquefaction and compaction of unconsolidated sediments were the probable cause of the amplified waves. The second type of inundation was a gradual increase in the water level with the formation of large waves. This was observed at de Moin, Limon, Cahuita, Punta Uva, Bocas del Toro, and Carenero. Some areas were protected by off shore reefs and coastal uplift. During the wave recession people went on the beach to catch trapped fish.
PDE; Camacho, 1993; Molina, 1997; *Tsunami Newsletter*, July 1993, p. 6-7.
Validity 4.

#71. 1991, October 14. A magnitude 7.1 Ms (USGS) earthquake at 15:58 UT in the Solomon Islands was felt strongly in the area. It produced a 15 cm tsunami at Honiara and 10 cm at Rabaul.
Tsunami Newsletter, Vol. 24, No. 2, p. 1.
Validity 4.

#72. 1992, January 5. A series of small earthquakes with the maximum being estimated at 3.7 and with a focal depth of 8 to 12 km occurred off the southwest coast of Hainan Island, China. The tide rose abnormally beginning at 14:30 and continued until 17:00 Beijing time. It was recorded by four gages around the island including at Beibu Bay with the maximum at Yulin Station near Sanya Port with a period of about 20 minutes and a maximum amplitude of 80 cm. Fishing boats in various harbors were damaged by ramming, and many had broken anchor chains.
Lin Ye et al. 1993.
Validity 4.

#73. 1992, April 25. A magnitude 7.1 Ms (USGS) earthquake at 18:06 UT occurred near the coast of northern California at Petrolia at the southern edge of the Cascadia zone where there is concern for a possible large tsunami in the future. It injured 95 people, caused $61 million in damage and generated a small but interesting tsunami. A fisherman was launching a boat at Trinidad, California, 94 kilometers north of the epicenter, when a 1.8-meter wave ran up under the boat trailer and car. Another fisherman at the same location was removing his boat from the water when the wave flooded the back of the boat. Both vehicles had to be pulled out of the sand by a tow truck. Crab fishermen off Clam Beach observed changes of several feet in water levels while tending their pots. It was observed at Crescent City harbor as waves 0.9 to 1.2 meters in height with periods of ten to

fifteen minutes. One man was backing down a boat ramp when waves came up under the cab of his truck. Waves were not observed near the epicenter but a maximum uplift of 1.4 meters was measured.

The tsunami was recorded along the California and Washington coasts with heights of 66 cm at Crescent City, 24 cm at Arena Cove, and 21 cm at Point Reyes, California, 9 cm at Port Orford, Oregon, 10 cm at Hilo, Hawaii, and 15 cm at Kahului, Hawaii. It was also recorded at Arcadia, 22 cm; North Spit, 39 cm; Fort Point, 7 cm; Alameda, 7 cm; Monterey, 5 cm; and Port San Luis, California, 9 cm. It had an observed height of 1.8 meters at Trinidad, California.
Lander et al. 1993; *Tsunami Newsletter*, July 1993, p. 4-5; Gonzalez et al. 1995; *PDE*.
Validity 4.

#74. 1992, May 17. A magnitude 7.5 Ms (USGS) earthquake at 10:15 UT near Mindanao, Philippines, caused minor damage at Tandag, and Bislig. A small tsunami was generated.
PDE.
Validity 4.

#75. 1992, May 27. A magnitude 7.0 Ms (USGS) earthquake at 05:14 UT near Santa Cruz Island was felt strongly at Lata Station, and a small tsunami was observed.
PDE.
Validity 4.

#76. 1992, July 18. A magnitude 6.9 Ms (USGS) earthquake at 08:37 UT off the east coast of Honshu, Japan, caused a tsunami that arrived at Hachinohe at 9:35 UT with a 24 cm wave amplitude; at Miyako at 9:07 UT with an amplitude of 42 cm; and at Aikawa at 9:25 UT with an amplitude of 28 cm. It was also measured with amplitudes of 46 cm at Ofunato.
Cable to the USGS on July 18, 1992; *PDE.*
Validity 4.

#77. 1992, September 2. A magnitude 7.2 Ms (USGS) earthquake at 00:16 UT off the Nicaragua coast killed at least 168 people, injured 489, and left more than 13,500 homeless. More than 40,000 people were affected with loses. The combined effects of the earthquake and tsunami destroyed at least 1,500 homes, and 185 fishing boats were lost in the tsunami. The total damage was estimated at $20 to $30 million.

Tsunami Effects:
The tsunami affected 26 towns along 250 kilometers of the Nicaragua coast. The tsunami arrived about one hour after high tide, maximizing its effect. Most people reported only one significant wave (Sataki et al. 1993). Some noticed an initial withdrawal and up to three waves. Walls of water were reported at Masachapa, Pochomil, and San Juan del Sur all of which have shallow ocean depth near the coast. This led the non-linear waves to form into breaking waves. Many people reported hearing the roar of the waves before their arrival (Abe et al. 1993).

Source Mechanism:

The waves arrived at the coastal villages at nearly identical times indicating a linear generation source parallel to the coast. Considering the extent of coastal area affected, the tsunami source is probably the same area as defined by the aftershocks which filled an area about 200 km parallel to the trench and 100 kilometers down slope of the trench with many of the aftershocks on the shelf. The generating earthquake filled a seismic gap.

The source mechanism was a shallow- dipping thrust earthquake of 16 degrees to the northeast. Only about half of the people felt the earthquake even though the source was only about 100 kilometers away. They described it as weak and soft. The initial drop suggests a subsidence of the sea bottom initially perhaps due to the release of compression in the upper layer followed by a rise due to a thrusting of the upper layer (Sataki et al. 1993). The relatively large tsunami for such a moderate earthquake indicates that this is a tsunami earthquake.

Damage and Fatalities:
Some damage was also reported from Costa Rica. The damage and fatalities were due to the tsunami that reached a height of 9.9 meters at El Transito decreasing to the north and remaining at 6 to 8 meters south to Marsella. At El Transito eighty percent of the buildings were swept away. There were fourteen children and two adults killed there. At Popoyo, where the height reached almost six meters, fatalities and damage occurred. Since the land is one or two meters above sea level the water would have been about two or three meters deep (Abe, 1994). There was considerable variation in runup heights in the area probably due to offshore structures or topographic features causing focusing. Since the rise in the water level was not too rapid, the adults had an opportunity to run away while children and physically impaired adults often could not escape the waves.

Tsunami inundation of 1,000 m was reported at Masachapa where 15 fatalities occurred. The largest runups were observed along the coast of central Nicaragua. These became smaller to the north and south. The tsunami was recorded on the marigram at Corinto, Nicaragua, with a height of about 40 cm as a small initial drop followed by larger rise. The observed runup was 2.9 meters. The tsunami was also recorded on the marigram at Puerto Sandino, Nicaragua, but the record was off scale. These waves arrived 52 to 64 minutes after the earthquake.

The following runup heights were measured: Mechapa, 4 m; Jiquilillo 2 m; Corinto, 3-4 m; Poneloya, 5 m; Salinas Grandes, 3-5 m; Miramaar, 4 m; El Velero, 6 m; El Transito, 10 m; Masachapa 3-6 m; Pochomil, 5 m; La Boquita, 2-6 m; Casares, 4-6 m Huehuete, 5 m; Las Salinas, 6.5 m; Popoyo, 3-6 m; Marsell, 5-8 m; San Juan del Sur, 2-5 m; Playa El Coco, 3 m; El Ostional, 2.5 m; Puerto Solev, 1 m; Cuajiniquil, 1 m. Wave heights were 111 cm at Baltra Island, 83 cm at Easter Island, 29 cm at Socoro Island, Mexico, 28 cm at Cabo San Lucas, Mexico, 18 cm at La Libertad, Ecuador, 10 cm at Valpraiso, Chile, 6 cm at Kawaihae, Hawaii, 10 cm at Hilo, Hawaii, and 13 cm at Kesennuma, Japan.
PDE; Abe et al. 1993; Abe, 1994; Baptista et al. 1993; Ide et al. 1993 ; Kanamori e. al 1993; Molina, 1997; Sataki et al. 1993; *Tsunami Newsletter*, July 1996, p. 1.
Validity 4.

#78. 1992, December 12. A magnitude 7.5 Ms (USGS) earthquake at 05:29 UT occurred in the

Flores, Indonesia, region producing a tsunami that reached shore in five minutes. The source was a thrust fault dipping 32 degrees to the south and extending about 110 km from Cape Batumanuk to Cape Bunga.

Source Information:
Most observers reported that they saw the sea recede or saw the exposed ocean bottom before the first wave arrived. They heard a roar like an airplane or thunder signaling the waves' approach. Most reported three waves with the second being the highest, and the wave looking like a bore. This was a back arc tsunami as it was on the opposite side of the island of Flores from the main subduction zone. The coast was uplifted by 0.5 meters to 1.1 meters west of Cape Batumanuk and subsided as much as 1.6 meters on the eastern side of the cape.

Damage and Fatalities:
The earthquake and tsunami caused at least 2,080 fatalities or missing people, including 1,490 in Maumere, Flores, and 700 on Babi Island. More than 500 were seriously injured and 90,000 were left homeless. The number of destroyed or damaged structures included 30,789 homes, 808 schools, 188 churches and mosques. Nineteen people were killed and 130 houses were destroyed on Kalootoa Island 120 km north of Flores Island. On Flores fifty to eighty percent of the buildings were damaged or destroyed including ninety percent of the buildings at Maumere.

Wuring, a residential area two kilometers west of Maumere, is built on a sand spit with only a two-meter elevation. Here eighty percent of the wooden houses built on stilts collapsed and 87 of the 1,400 inhabitants were killed although the tsunami only reached 3.2 meters. Many fishing vessels drifted into the residential area causing more damage.

At Wailiti village, 5 km northwest of Maumere, the wave reached heights of 2.1 meters, and six fishing boats were washed ashore. One person was killed. On Pomana Besar Island waves up to 3.2 meters flooded Ngolo and Buton villages killing 25 people.

On Babi Island, about 40 kilometers northeast of Maumere, the tsunami arrived about three minutes after the earthquake killing 263 of the 1,093 inhabitants in Pagaraman and Kampungbaru on the south coast. All of the houses were washed away. A gap in the coral reef let the wave in at a height of 3.4 meters.

At Cape Bunga on the northeastern tip of Flores Island a huge wave of 26.2 meters came on shore at Riangkroko village and completely wiped out all signs of the village killing 137 people. Inundation up the Nipah River at Riangkroko was 600 meters. Coral debris was carried 200 meters up the beach. Large trees and other vegetation were swept away.

At Leworahang on Hading Bay multiple massive submarine slides occurred and the tsunami was larger than expected probably because a submarine landslide augmented its height. A section of the coastline 150 meters wide and two kilometers long disappeared with the earthquake leaving behind vertical cliffs. The tsunami arrived shortly thereafter washing over the 14-meter cliffs. There were 24 fatalities there and twelve houses were completely submerged.

At Lewobele, six kilometers to the west, at least two more landslides occurred each about one kilometer long producing tsunamis of 10.8 meters. About half of the fatalities and damage were attributed to the tsunami. Massive submarine slumps of 20 meters along with the landslides may have caused some of the high runups. Some villages were totally destroyed including Kampungbaru on Babi Island.

Measured Wave Heights:
The tsunami was recorded at Palopo, Celebes Island, with a positive first motion 104 minutes after the earthquake and with a maximum height of 27 cm and a period of 69 minutes. The tsunami at Flores inundated 300 m with a wave height of 25 m. Most of the areas reported an initial withdrawal and several waves. Damage also occurred on Sumba Island south of Flores and Alor Island to the east of Flores. Wave heights of one to two meters were reported at Ambon Island south of Ceram and heights of ten meters were reported at Butung and Muna islands south of Celebes.
Yeh et al. 1995; Tsuji et al. 1995A, and 1995B; Akagiri, 1994; Kawata, 1993, Kawata et al. 1995; *PDE*, *Tsunami Newsletter*, July 1993, p. 2-4.
Validity 4.

#79. 1993, February 7. A magnitude 6.2 Ms (Mw 6.6) (USGS) earthquake at 13:27 UT near Noto Peninsula on the west coast of Honshu, Japan, injured 16 people and caused some damage at Ishikawa. The earthquake caused a small tsunami with a maximum of 0.5 m recorded as a sharp rise at Wazima and was also recorded at Naoetsu as a gentle rise. At other stations the first motion was masked by noise and was barely detectable. The tsunami had periods of 12 to 18 minutes. The source region was computed to have been 15 km long with a dip angle of 42-degrees with a one-meter displacement.
Abe and Okada, 1995.
Validity 4.

#80. 1993, May 7. An aseismic tsunami occurred at Leros Island, Greece, in the east Aegean Sea. It had a period of 12 minutes, a height of 0.5 meters and a MMI of III. As the period is that of the free oscillation of Laki Bay, this event was probably a storm surge.
Papadopoulos, 1993.
Validity 1.

#81. 1993, June 8. A magnitude 7.3 Ms (Mw 7.3) (USGS) earthquake occurred at 13:04 UT near the east coast of Kamchatka, Russia, causing damage at Severo-Kurilsk. A tsunami with an amplitude of 10 cm was recorded at Petropavlosk-Kamchatshiy. The following amplitudes were also recorded: 12 cm at Hilo, Hawaii; 10 cm at Shemya; 8 cm at Midway; 5 cm at Wake Island; and 5 cm at Haleiwa, Hawaii.
PDE; Johnson et al. 1995.
Validity 4.

#82. 1993, July 12. A magnitude 7.6 Ms (7.3 Mw) (USGS) earthquake at 13:17 UT in the Sea of Japan near Hokkaido caused a back-arc tsunami that caused damage in all of the countries bordering

the Sea of Japan. The earthquake a rupture length of 150 km, a movement of 2.5 m and a dip to the east of 24 degrees. The tsunami was 32 meters high on Okishuri, Island, where the most destruction occurred. The whole island subsided by 5-80 cm. This tsunami was extensively studied. Research teams conducted field surveys, and researched effects on breakwaters, structures, and source mechanisms.

Measured Wave Heights:
The wave measured ten meters along the west coast of Hokkaido, nearly one meter at Aomori, Honshu, Japan, three meters at Nakhodka, Russia, 2.72 meters along the northeast coast of South Korea, and 2.1 meters at Chongjin, Democratic Republic of Korea. The highest wave on Korean shores was at Mukho station on the northeast coast (2.72 meters.) The tsunami was recorded at five other stations in Korea: Ulleungdo at 93 cm, Sokcho at 179 cm, Pohang at 59.7 cm, Ulsan at 31 cm, and Pusan at 23.8 cm. The range of amplitudes in Korea illustrates the effects of local topography.

Damage and Fatalities in Japan:
The tsunami caused about 330 fatalities, destroyed several hundred homes and caused about $1.2 billion dollars in damage. (Fatalities in Japan were not differentiated as to earthquake or tsunami.) Property damage included 71 ports on Hokkaido and property loses due to the earthquake and tsunami were $179 million. One person in a fishing boat was killed off Aomori, Honshu, Japan. Three were missing off the southeastern coast of Russia; 165 were killed on Okushiri; about 74 were killed on Hokkaido.

Damage in Russia:
Damage was caused to a factory at Kamenka, Sakhalin Island, and to Vladivostok, Russia, which reported two-meter waves. Waves with heights up to four meters were observed on the Primorye coasts of Russia. Damage in Russia exceeded $6.5 million.

Damage in Korea:
Damage of nearly half a million dollars occurred, mostly to fishing boats and equipmentSigrist, 1994b; Hokkaido Survey Group, 1993; *PDE*; Sataki and Tanioka, 1995; *Russian National Report,* IOC/ITSU, 1993.
Validity 4.

#83. 1993, August 8. A magnitude 8.0 Ms (7.5 Mw) (USGS) earthquake at 08:34 UT south of the Mariana Islands caused extensive damage on Guam injuring 48 people, destroying one hotel and damaging others in the Tumon Bay region. Damage was estimated at $120 million. A tsunami was generated, which was recorded in Agana, but the gage with a 15-minute sampling rate produced a poor recording. The tsunami was most strongly observed on the west coast. A truck was washed into Pago Bay but the driver escaped injury due to the shallowness of the Bay. Other vehicles were washed into the bay at Ylig. The wave was observed from the north coast at Inapsan beach where vehicles had to drive through water to leave the area to the south coast at Inarajan where the roads were covered with debris. The highest wave seems to have occurred in the Talofoto River where the water rose 2.13 meters at the bridge and inundated the river for a quarter of a mile. The principal source of data came from a paper prepared for University of Guam coursework by Judy Flores

(1993) that contained extensive interview data on effects.

Wave Height Recordings:
The tsunami was recorded with an amplitude of 15 cm at Kwajalein Atoll; in Nawiliwili, Hawaii, with an height of 6 cm; at Port Allen, Hawaii, with a height of 15 cm; and at Haleiwa with a height of 10 cm; by deep water gages in Japan with heights of 3 cm; and on shore stations with heights of 60 cm. A high wave was reported seen in Turon Bay and would probably have been from a local landslide tsunami. The tsunami was recorded at Agana and Apra harbors on Guam but the sampling rate of 15 and 6 minutes respectively made the record nearly useless for determining the arrival times, amplitudes, or periods of the waves.
Judy Flores, 1993.
Validity 4.

#84. 1993, November 13. A magnitude 7.0 Ms (Mw 7.0) (USGS) earthquake occurred at 01:18 UT near the east coast of Kamchatka, Russia. It was felt at Petropavlovsk-Kamchatskiy and produced a local 10-cm tsunami at Azachi Bay.
Satake and Imamura, 1995; *Tsunami Newsletter*, Vol. 25, No. 2. p. 1.
Validity 4.

#85. 1994, January 17. A magnitude 6.8 Ms (Mw 6.7) (USGS) earthquake occurred at 12:3 UT in Southern California. It caused 60 fatalities and injured 7,000 more. It left 20,000 people homeless and damaged 40,000 buildings in the Northridge area in Los Angeles. Earthquake damage was estimated at $13 to $20 billion dollars. The earthquake may have generated a 10 cm tsunami.
Gusiakov, 1995.
Validity 2.

#86. 1994, January 21. A magnitude 7.2 Ms (Mw 7.0) (USGS) earthquake at 02:24 UT occurred near Halmahera, Indonesian. The earthquake killed seven people and injured 40. In the Kau area 550 homes were destroyed. The earthquake produced a two-meter damaging tsunami.
Satake and Imamura, 1995.
Validity 4.

#87. 1994, February 15. A magnitude 7.0 Ms (Mw 6.6) (USGS) earthquake at 17:07 UT off the Southern coast of Sumatera, Indonesia, killed at least 207 people and injured 2,000 more. The homeless numbered 75,000. Much of the damage was due to landslides and mudslides in the Liwa area including at least 6,000 homes, shops, and government buildings. The damage was estimated at $169 million US. Satake and Imamura (1995) list this as a damaging tsunami with seven fatalities.
Satake and Imamura, 1995.
Validity 4.

#88. 1994, April 8. A magnitude 6.3 Ms (Mw 6.4) (USGS) earthquake at 01:11 UT off the east coast of Honshu, Japan, generated a tsunami with heights of 22 cm at Ofunato at 02:13 UT, 10 cm at Hachinohe (02:13 UT), and 10 cm at Ayukawahama (02:22 UT). The wave began as a drop of 9 cm at Hachinohe (02:08 UT) and at Ofunato (02:14 UT).

PDE; Telegram from the NWS, Washington, D.C.
Validity 4.

#89. 1994, June 2. A magnitude 7.2 Ms (Mw 7.8) (USGS) earthquake at 18:18 UT occurred south of Java, Indonesia. The earthquake was about 200 km off the southeastern coast of Java. The earthquake occurred at night, and awoke only about 10 to 20% of the people. About 30 to 40 minutes after the earthquake, the waves (three distinct waves) began to arrive. Most of the people were still sleeping when the wave arrived, and the mostly-straw houses were washed away.

About 223 people were killed, 15 were listed as missing, and 423 injured. The tsunami destroyed 1,500 homes, and 278 boats. The most affected districts were Lumajang, Jember, and Banyuwangi. Most of the fatalities and damage was caused by a tsunami at the villages of Pancer, Lampon, and Rajekwesi in the Banyuwangi district, the most eastern of the districts.

At Pancer, an important village situated on sand dunes of a river mouth into the bay, more than 70% of the 1,000 buildings were destroyed but only 4% (122 people) of the 3,000 inhabitants were killed, and 15 were missing. All of the straw houses were destroyed, and most of the brick buildings were severely damaged. The second wave was the largest and penetrated 300 meters inland. Palm trees between the village and the sea helped to mitigate the wave damage although most were uprooted. The maximum runup height was 9.5 meters. The wave advanced up the river causing lateral flooding. One boat was carried 60 meters inland.

Lampon, the most eastern of the villages surveyed, had a population of 700 inhabitants before the tsunami. There were 35 fatalities and 40 straw houses destroyed some of which were 500 meters inland. The wave destroyed houses 500 meters inland. Most of the damage occurred near the river where there was significant erosion. The wave penetrated one kilometer along the river. A maximum wave height of eleven meters was measured over a steep bank.

At Rajekwesi there were 1,200 inhabitants and 300 homes. Seventy percent of the homes were built with straw. There were 33 fatalities, 14 missing, and 70 homes destroyed. Eyewitnesses reported the first wave was about one meter high, and the second wave was six to seven meters high and had an inundation of 100 meters. There was large erosion of the beach and riverbank. Palm trees near the shore were uprooted. The straw houses were leveled, and all brick buildings were damaged.

At Watuula Village of about 600 inhabitants, 16 straw houses were destroyed, three fishermen were killed, and 30 boats were severely damaged. The wave reached a height of 7.58 meters.

At Pulo Merah there were eight fatalities and 20 houses were destroyed. Many others were severely damaged. The water penetrated about 700 meters inland, carrying fish, shellfish, and stones. At the village of Puger there was no tsunami damage although the third wave penetrated 300 meters inland, about the same extent as that of large storm waves. Six fishermen who were working on the open sea were missing.

At the village of Cape Pelindu, a small fishing village of about 300 inhabitants, the maximum wave

was 3.2 meters. It destroyed three homes and the wall protecting the fishery. It penetrated 350 meters inland.

A witness on the island of Bambangan reported that a tsunami from this event measured 4.6 m and that two days later a second tsunami arrived (see below).

Only slight tsunami effects were observed on the Island of Bali at the village of Soka where some fishing boats were damaged and beaches eroded. The runup height was nearly five meters and the inundation was about 100 meters in a small inlet near the village.

On the northwestern coast of Australia the tsunami was recorded at Broome, Dampier, Barrow Island, King Bay, Onslow and Carnavon although the gages were operating at 15-minute sampling rates, making the amplitudes uncertain. The recorded amplitude at Dampier was about 45 cm, and 20 cm or less at the other stations. Several ships near King Bay were moved and the wave ruptured a line transferring petroleum between two tankers, and spilling some oil. A surge of three to four meters at Baudin carried fish, rocks and coral two to three hundred meters inland, and destroyed part of the car park railing. The area was deserted at the time but residents in a nearby trailer park heard a roar like a train. There were similar reports of inundations elsewhere along the coast. Areas that had gaps in the offshore coral reef were most exposed.
Satake and Imamura, 1995; *PDE.*
Validity 4.

#90. 1994, June 3. The first of two large aftershocks of the June 2 earthquake in Indonesia (see above) occurred on this date. The magnitude Ms 6.5 earthquake at 21:07 UT produced a tsunami. Eyewitness accounts at Soka state that an aftershock was felt the next afternoon and another tsunami was observed. Both the original and the aftershock had recorded wave heights of 3.7 meters there.
Synolakis et al. 1995a; Tsuji et al. 1995b; Maramal and Tinti, 1997; Gary Foley, 1994; Satake and Imamura*,* 1995*, PDE,* Jose Borrero, 1995.
Validity 4.

#91. 1994, June 4. (00:58 UT) A magnitude Ms 6.3 aftershock produced a tsunami. Eyewitnesses on the island of Bambangan reported another tsunami arrived two days later than the main shock. This aftershock produced a wave of 3.0 meters. On June 4, six Australian pro surfers experienced the ride of their lives when a tsunami struck their surf camp at G-Land, on the edge of the Plengkung Jungle in eastern Java. The six were sleeping at the camp when the 6.0-meter tsunami waves hit washing surfers, huts, and everything else at the camp into the jungle. Two of the surfers were swept hundreds of feet into the jungle. All survived. There was a third aftershock on June 5 (01:45 UT) of Ms 6.2 that may have produced a tsunami.
Synolakis et al. 1995a; Tsuji et al. 1995b; Maramal and Tinti, 1997; Gary Foley, 1994; Satake and Imamura, 1995; *PDE;* Jose Borrero, email.
Validity 4.

#92. 1994, September 1. A magnitude 7.0 Ms (Mw 7.1) (USGS) earthquake at 15:15 UT occurred about 90 miles off the northern coast of California at the Mendocino escarpment on the Gorda and

Pacific plate boundary. The motion is strike slip with the Gorda plate moving east with respect to the Pacific plate. The earthquake was felt as far away as San Francisco Bay area and in Roseburg, Oregon. It caused slight damage at Honeydew and uplift of about one meter near the coast. It generated a tsunami with maximum wave heights of 14 cm recorded at Crescent City.
PDE.
Validity 4.

#93. 1994, September 19. Eruptions of Tavurvur and Vulcan Volcanoes near Rabaul, New Britain, caused massive ashfall and pyroclastic flows that resulted in $280 million in damage. The pyroclastic flows from Vulcan generated a tsunami in Simpson Harbor. The tide gage on the Main Wharf recorded a wave at 1.2 meters beginning at 7:43 A.M., but other waves were much higher. At 9:30 A.M. local time the tsunami washed small boats across Cleland Drive in the area near the Pacific Brewery. The tide was at its lowest point at 7:30 A.M. indicating that the waves were at least several meters high. The press reported five vents in activity including some in the harbor, but those were actually the result of hot pyroclastic flows reaching the water. The ash reached depths of 35 mm at the Main Wharf, 50 mm at South Pacific Brewery, and 75 mm at Island Communications. Floating pumice covered most of Simpson Harbor. The tide gauge was interrupted at 6 P.M. but another peak phase of eruption at Vulcan at 7 P.M. may have produced a strong tsunami along the eastern shore of Simpson Harbor reaching 200 meters inland. More damage was caused by mudflows from the volcano that seeped under closed doors.
Blong and McKee, 1995.
Validity 4.

#94. 1994, October 4. A magnitude 8.1 Ms (Mw 8.2) (USGS) earthquake at 13:23 UT in the southern Kuril Islands, Russia, caused at least eleven fatalities, none due to the tsunami, and 242 injuries mostly due to collapsing of a military hospital on Iturup Island. There were 140 people injured in Japan, including one woman whose car plunged off a collapsed bridge and one man who died of a heart attack. The earthquake generated a tsunami with a height of 4.5-6.0 m at the southern part of Dimitrova Bay, Shikotan Island and 3.0-7.1 meters at Tserkovnaya Bay indicating multiple waves in the tsunami. Evidence of four separate runup heights also indicates a multiple wave attack.

On the west side of the island the height at Malo-kurilskaya was one to two meters. The tide gage indicated a subsidence of 53 cm. Eyewitnesses reported the initial wave to be a rise as was confirmed by the marigrams that also showed periods of about 20 minutes. Elsewhere on the island the heights were measured from 8.5 meters at Tserkovnaya Bay to 2.6 meters. On Kunashiri Island the maximum height was surveyed at 5.3 meters at Petrova Point. On Iturup Island the maximum height was 3.4 meters and on Polonsky Island the maximum height was 4 meters.

At Yuzhno-Kurilsk the heights ranged from 2.5-3.0 meters. In the older part of the town, waves penetrated 200 to 300 meters on the gentle, sloping beach damaging all houses. The wave penetrated 500 meters along the river destroying two bridges and washing away two homes dragging another 300 meters. All moorings were destroyed and two 300-ton fishing boats, five pontoons, and several motorboats were thrown on dry land. None of the fatalities were due to the tsunami as the maximum heights were 1.5-2.0 meters in populated areas. This was fortunate since a warning could not be sent

to the area due to the disrupted communications caused by the earthquake.

Recorded wave heights outside of the Kuril Islands:
The highest waves in Japan were 346 cm at Hanasaki; 180 at Nemuro; 164 at Kushiro; 162 at Chichi-shima; 144 cm at Miyako; 130 cm at Hachinohe; 92 cm at Ofunato; 62 cm at Onahama; 46 cm at Omae-zaki; 42 cm at Choshi, Honshu; and 26 at Abashiri, Hokkaido. Alaska wave heights included: 15 cm at Shemya, and Adak, Alaska; and 7 cm at Unalaska. Elsewhere the following heights were reported: 30 cm at Papeete, Tahiti, French Polynesia; 16 cm at Pago Pago, American Samoa; 17 cm at Wake Island; 50 cm at Midway Island; 48 cm at Hilo; and 0.8 m at Kahalui, Hawaii; and one meter at Crescent City, California.
Yeh et al. 1995 (with copies of marigrams); Gusiakov, 1995; Lander, 1996.
Validity 4.

#95. 1994, October 8. A magnitude 6.8 Ms (Mw 6.8) (USGS) earthquake at 21:44 UT at Halmahera, Indonesia, caused one fatality and injured 52 people. It damaged 500 buildings and some bridges and piers. A tsunami less than three meters high was generated. Satake and Imamura, 1995 lists "damaging tsunami" and one fatality but gives no more information.
Satake and Imamura, 1995.
Validity 4.

#96. 1994, October 9. A magnitude 7.1 Ms (Mw 2.0) (USGS) aftershock at 07:55 UT of the October 4 earthquake in the Kuril Islands was felt in the Kushiro area of Hoddaido, Japan, and produced a tsunami of 18 cm at Hanasaki and 6 cm at Kishiro, Japan.
PDE; Satake and Imamura, 1995.
Validity 4.

#97. 1994, November 4. A negative tide of 1.2 m at 7:10 pm local time was the probable cause of a submarine landslide-generated tsunami that caused about $25 million damage and one fatality in Skagway Harbor, Alaska. It produced a tsunami of nine to eleven meters. Because the event was not associated with an earthquake, there was about a year delay before the tsunami community became aware of the event. At the time there was a major reconstruction in progress on the PARN dock (Pacific and Arctic Railway and Navigation Company) involving extraction of the old wooden piers and replacement with concrete piers in new caissons. The tide was 1.2 meters below lower low water.

Just before the tsunami occurred there was a 25 mph wind blowing. It suddenly stopped, indicating something was blocking it. (A landslide into the ocean may push water with it, and where the slide comes to a rest, the water may pile up into a mound before forming a return wave.) Paul Wallen was working in one of the caissons with his brother when the wave arrived bringing with it debris which poured into the caisson. His brother escaped, but Paul was washed away by a second larger wave. His body was not found until January 24 under the remaining pier where it had been washed by the waves.

There were 9,000 cubic yards of new granitic riprap material placed on the pier foundation. Lander

(1996) concluded that the tsunami probably originated from collapse of supporting delta material at the dock site based on the limited information available at the time. The extensive studies now available indicate a probable source from a submarine landslide of material from the mouth of Skagway River located on the opposite side of the harbor and which had increased in volume by recent floods. The decrease in tidal level would have influenced the flow of the river at its mouth, perhaps triggering the landslide that went down the entrance of the harbor to Taiya Inlet.

The tsunami was recorded on the tide gage in the harbor with a period of three minutes that continued for about 30 minutes with a maximum height of two meters. The harbor has a natural period of about three minutes. The record shows an initial one-minute period drop which could have been due to a drop in atmospheric pressure with the additional drop in the water level as the water was forced out of the harbor by the landslide or by the drop in the wind just before the tsunami came into the harbor.

Workmen on the PARN dock observed the tsunami. The low tide may have exposed more of the water-saturated sediments, and this was probably the cause of a collapse of glacial sediments deposited by floodwaters in the Skagway River. The depth of a considerable part of the inlet was deeper after the event and shallower at a distance of 1,525 meters down the inlet.

Modeling results helped identify the location of the slide. A 22 million cubic yard slide used in a model reproduced the 3-minute tide gauge period, the recorded amplitudes, the duration of the wave, and the wave direction. There was a 4 million cubic yard slide from the PARN Dock area but models show that it would produce a wave with only one-third of the period observed, half the observed amplitude and would be 90 degrees wrong in direction of the observed wave.

Two D7 caterpillars were lost. The wave caused $2 million in damage to the floating ferry terminal in the middle of the harbor. It entered the small boat harbor and caused another $100,000 in damage. Total damage was about $25 million.
Kulikov et al. 1996; Lander, 1996; Cornforth and Lowell, 1996.
Validity 4.

#98. 1994, November 14. A magnitude 7.1 Ms (Mw 7.0) (USGS) earthquake at 19:15 UT in the Verde Island Passage between Luzon and Mindoro Islands, Philippine Islands caused at least 87 dead and missing due to the earthquake and tsunami on Mindoro Island. Most of the casualties were children. Two hundred thirty-five people were injured. On Mindoro 797 houses were destroyed and 3,288 damaged and seven more houses were destroyed at Batangas, Luzon.

An international survey team with members from Korea, Thailand, the United States, and Philippines surveyed the tsunami effects on Mindoro from Calapan Bay to Subaang Bay, the southeastern coast of Luzon near Lobo, and the islands in the passage of Verde, Baco Island, Silonay Island and Anaganahao Island. A local tsunami occurred with a maximum runup of 7.3 meters on the southwest coast of Baco Island at Sitio Pino and 6.1 meters on the northern coast. Eyewitnesses reported the water first receded 45 meters. There were no deaths on Baco Island and only one home destroyed. Three waves were reported with the second being the highest.

The tsunami produced a sound on its return like that of a landing jet airplane. It had heights of 1.5 to 4.0 meters along the northern Mindoro coast. One effect was the breaking loose of a moored, 4,000-ton barge in the Baruyan River sweeping it 1.6 km upstream. The wave penetrated upstream about two kilometers. This happened before the first tectonic tsunami wave reached the Mindoro coast and must have been due to a local landslide generated tsunami.

The heights ranged from 2.3 to 4.2 meters along the Luzon coast near Lobo. On Verde Island the maximum wave was 2.8 meters, and there was no damage or fatalities. On Mindoro Island the tsunami contributed to the damage in the Calapan and Puerto Galera areas. At Calapan the wave receded 100 meters and returned as a white line with a drumming noise. The tsunami was recorded on the marigram from Batangas, Luzon, with a height of about 20 cm. The marigraph was used to correct the runup measurements for tidal levels. The Lubang fault, the source fault, was a strike-slip fault.
PDE; Imamura et al. 1995c.
Validity 4.

#99. 1994, December 28. A magnitude 7.5 Ms (Mw 7.7) (USGS) earthquake at 12:19 UT off the east coast of Honshu, Japan, caused three fatalities, more than 200 injuries, and damage in the Hachinohe area. A local tsunami produced the following wave heights: 110 cm at Miyako, 88 cm at Hachinohe, 54 cm at Ofunato, 10 cm at Choshi, Honshu, and 48 cm at Urakawa, 36 cm at Hakodate and Kushiro, Hokkaido.
PDE.
Validity 4.

#100. 1995, January 16. A magnitude 6.8 Ms (Mw 6.8) (USGS) earthquake at 20:47 UT in Honshu, Japan, caused a disaster in Kobe, Japan, with 5,502 people killed and 36,896 people injured. Over 200,000 buildings were damaged or destroyed. There were landslides that caused 28 fatalities near Nishinomiya. A 20 cm tsunami was recorded. Not mentioned in *PDE*.
Validity 4.

#101. 1995, April 7. A magnitude 8.0 Ms (Mw 7.4) (USGS) earthquake at 22:07 UT occurred in the Tonga Islands and generated a tsunami recorded with a height of 30 cm at Pago Pago, American Samoa, and 5 cm at Niue Island, New Zealand, east of Tonga.
PDE.
Validity 4.

#102. 1995, April 21. A magnitude 7.3 Ms (Mw 7.1) (USGS) earthquake at 00:34 UT near Samar, Philippines, caused some damage at Borongan and Sulat. It triggered a tsunami with a height of 20 cm at Legaspi, Luzon.
PDE.
Validity 4.

#103. 1995, April 21. A magnitude 6.9 Ms (Mw 6.6) (USGS) aftershock at 05:17 UT of the Samar,

Philippine Island earthquake caused a 20 cm tsunami.
Validity 4.

#104. 1995, May 13. A magnitude 6.6 Ms (Mw 6.4) (USGS) earthquake at 08:47 UT near Greece caused injury to 25 people and did substantial damage in the Gevena-Kozani area. Five thousand homes were destroyed, and 7,000 others were damaged. Damage was estimated at $450 million. The captain of *Rio Amazonas*, a 6,000-ton freighter that at the time of the earthquake was anchored close to the epicenter, said that the ship moved wildly and that the depth increased from 60 to 84 feet in the matter of a few hours (depth was measured by an on-board fathometer). This depth increase was a step function, not a gradual increase. There was no physical evidence of a tsunami.
Synolakis, 1995; Gonzalez, 1995.
Validity 1.

#105. 1995, May 14. A magnitude 6.9 Ms (Mw 6.5) (USGS) earthquake occurred at 11:33 UT in the Flores Sea, Indonesia. Eleven people were missing from Timor, 19 injured, and a 1.5-meter tsunami destroyed several homes in the Dili area and damaged 40 fishing boats. Considerable damage also occurred in the Maliana region. The ITIC reported that they received a report from Indonesia that this was a subsidence and no one saw a wave return. In an email on May 30, Prasetya said, "We conclude that no tsunamis have been generated directly by the earthquake which was reported by the newspaper to have occurred on 14 May 1995. The wave run-up occurred at some places due to land subsidence in coastal areas." There is probably a problem with the understanding of the definition of a tsunami. The subsided areas were discontinuous, and the inundation was 120 meters.
PDE; Tsunami Newsletter, Vol. 27, No 2, p. 4-5; Prasetya, 1995.
Validity 4.

#106. 1995, May 16. A magnitude 7.7 Ms (USGS) earthquake occurred at 20:13 UT in the Loyalty Islands, and generated a tsunami with heights of 40 cm at Port-Vila, Vanuatu, 10 cm at Pago-Pago, American Samoa; 6 cm at Lautoka, Viti Levu, Fiji; and 5 cm at Suva, Fiji; 3 cm at Apia, Western Samoa; 3 cm at Nuku'alofa, Tonga; 5 cm at Rarotonga, Cook Islands; and along the coast of New South Wales.
PDE.
Validity 4.

#107. 1995, May 27. A magnitude 7.5 Ms (Mw 7.1) (USGS) earthquake occurred at 13:03 UT near Sakhalin, Russia, killing about 1,989 people and injuring about 750 people. It caused severe damage in the Neftegorsk region and some damage in the Okha region. Russian investigators mentioned a small, indistinct, tsunami near the settlements of Sabo and Val where night fishermen reported that ice from the Sea of Okhotsk started going to the coast after the earthquake. At Val water waves came to the river mouth after the earthquake. A tsunami was not recorded at the marigraph at Nogliki, about 150 km south.
Kaistrenko, 1995; *PDE;* Gusiakov, 1995.
Validity 3.

#108. 1995, June 15. A magnitude 6.3 Ms (USGS) earthquake occurred at 00:15 UT in Greece near

the Gulf of Corinth. It killed 26 people and injured 60 in the Aiyion area and caused extensive damage estimated at $600 million (US). It generated a tsunami that arrived at Eratini immediately after the earthquake. It had a runup height of 0.4-0.5 meters after a withdrawal of one meter a few minutes after the earthquake for a wave height (range) of 1.5 meters. As there were no other reports of a tsunami, and with the immediate arrival after the earthquake, the tsunami was probably due to a landslide of unconsolidated sediments in the mouth of the local river (Papadopoulos, 1996). The water disturbance lasted about twelve hours but no damage was reported.

Synolakis (1995) reported that the marigraph at Patras 780 km away did not show clear evidence of a tsunami except for high frequency noise immediately after the earthquake. A 600- ton freighter was anchored in 18-meter-deep water when the crew was awakened by sounds of the anchor being pulled. The sea was calm but the ship was moving wildly and ended up in 25 meters depth. This movement of the ship could have been due to a submarine landslide moving the anchor or the effects of a seaquake. Landslide tsunamis are usually very local and would not have been recorded at a remote site.
PDE; Papadopoulos, 1996; *Tsunami Newsletter*, January 1996; Synolakis, 1995.
Validity 4.

#109. 1995, July 30. A magnitude 7.3 Ms (Mw 8.0) (USGS) earthquake at 05:11 UT near the coast of northern Chile caused three fatalities, left 630 homeless, and damaged 110 homes and buildings in the Taltal, Antofagasta, and Mejillones regions. The aftershock area outlines a region about 180 km north-south by 70-80 km east-west with a shallow dipping thrust fault part of which is on shore. It filled a previously identified seismic gap. The land was uplifted by about 40 cm as measured by GPS near Mejillones Peninsula (Nishenko, 1985).

In Antofagasta six small fishing boats were sunk and 12 others damaged at the fishermen's wharf. The oceanographic ship *Purihalar* anchored in the center of Blanco Encalada Bay observed a drop sea level from 11 m to 1.5 m (a drop of 9.5-m) on their sonar as the ship was pushed toward the shore and then away by the strong currents. It generated a tsunami two hours and 45 minutes after high tide that was lower by about 30 cm than the high tide maximum. It penetrated inland 250 to 300 meters at La Riconada destroying part of a coastal road. At one point it cut across 245 meter-wide Punta Cangrejos temporarily creating an island off the point and trapping several fishermen.

This event was widely recorded. The following wave heights were observed in Chile: a maximum runup of 245 cm at Calenta Blanco, a recorded height of 280 cm at Antofagasta, 120 cm at Calenta Punta Grande, 170 cm at Caldera, 149 cm at Arica, 64 cm at Iquique, 40 cm at Juan Fernandez Island, 106 cm at Talcahuano, 70 cm at Tocopilla, 65 cm at Valparaiso, 31 cm at Easter Island, and 40 cm at Isla Juan Fernandez.

In Mexico's coasts the following runups were observed: 23 cm at Isla Socorro, and 10 cm at Cabo San Lucas.

In Hawaii the runups were: 75 cm at Hilo, 70 cm at Kahului, 15 cm at Honolulu and Port Allen, 12 cm at Nawiliwili, Kauai, and 12 cm at Wake Island.

Four stations observed the tsunami on the United States west coast: 35 cm at Crescent City, California, 25 cm at Santa Monica, California, 11 cm at San Diego, California, and 10 cm at Los Angeles.

Several Alaska stations also recorded the tsunami: 30 cm at Adak, 20 cm at Shemya, 21 cm at Sand Point, 15 cm at Dutch Harbor, Unalaska; 10 cm at Kodiak, 9 cm at Seward, and 11 cm at Sitka, and Yakutat.

The tsunami was recorded at stations throughout the Pacific: 33 cm at Pago Pago, American Samoa; 41 cm Apia, Western Samoa; 15 cm at Papeete, Tahiti; 30 cm at Raiatea Island; 150 cm at Nuku Hiva, Marquesas Islands; 32 cm at Port Vila, Vanuatu; 13 cm at Nuku'alofa, Tonga; 10 cm at Lautoka, Fiji; and 10 cm at Gold Coast, Queensland, Australia.

In Japan the following were observed: 16 cm at Miyako, 26 cm at Hachinohe, 30-40 cm at Kesenmuma, 30 cm at Fudai Village, 21 cm at Ayukawa, 20 cm at Hanasaki, and lesser amplitudes at other locations in Japan.

Surprisingly, it was observed 7,000 km away as a 3-meter wave at Tahauku Bay, Hiva-Oa, Marquesas Islands, where it sank two boats and inundated 250 m up Taahuku River flooding 40,000 square meters of land. The wave had a period of about 15 minutes and the second wave was the largest. The total damage from this event was $131,000.
Ramirez, et al. 1997; Ruegg et al. 1996; Ortlieb et al. 1995; Monfret et al. 1995; Klotz et al. 1996; Guibourg et al. 1997; *PDE*; *Tsunami Newsletter*, Vol. 28, p. 50.
Validity 4.

#110. 1995, August 16. A magnitude 7.8 Ms (Mw 7.6) (USGS) earthquake at 10:27 UT in the Solomon Islands caused minor damage in the epicentral region. A landslide blocked the road between Kokopo and Rabaul, New Britain, and another occurred at the Blue Lagoon, New Britain. The earthquake generated a tsunami with heights of 55 cm at Rabaul, and 11 cm at Kwajalein Island.
PDE.
Validity 4.

#111. 1995, September 14. A magnitude 7.2 Ms (Mw 7.4) (USGS) earthquake at 14:05 UT near the coast of Guerrero, Mexico, caused three fatalities, 100 injuries, and left 500 homeless. Extensive damage occurred in Guerrero and in Oaxaca where 400 were left homeless. At Manzanillo the natural harbor seiche increased to a height of 42 cm an hour after the earthquake but a tsunami was not recorded at Cabo San Lucas or Socorro Island.
Validity 3.

#112. 1995, October 9. A magnitude 7.4 Ms (Mw 7.4) (USGS) earthquake at 15:36 UT near the coast of Jalisco, Mexico, caused at least 49 fatalities, injured 100, and left nearly 1,000 people homeless. People in high-rise buildings as far away as Houston, and Dallas, Texas, and Oklahoma City felt the earthquake. The land subsided about 14 cm at Manzanillo. The fault had an angle of 16

degrees and a rupture length of 200 km.

The earthquake generated a tsunami that affected about 200 km of the coast from north of Playa de Cuyatlan to south of Tenacatita. In regions with steep onshore topography, the damage was minor, but on shallow beaches it was severe. Most of the inundation was in the Tenacatita Bay area, and Port Manzanillo suffered damage from erosion from a 12-knot current.

North of Manzanillo at Barra de Navidad, a small tourist town buffered from the Pacific by a strip of sand about 100-m wide, had damage to hotels, homes, roads and bridges. One fatality due to the tsunami occurred when a fisherman wading close to the shore could not outrun the 5.1 m wave. The runup range was 3.7 to 5.1 meters. Most people were aware of the tsunami hazard and ran to higher ground, but some returned to coastal areas too soon and were swept out to sea by the second wave.

At the north end of Manzanillo Bay, in Santiago Bay, the sea was slightly higher, and it overtopped the sea wall and flowed onto streets in a neighborhood. Further north in the bay the seawall was overtopped and sand covered the first six steps of stairs leading to the beach. Maintenance workers on the cliffs at the north end of Manzanillo Bay observed the tsunami arriving about 15 minutes after the earthquake. It receded several hundred meters and returned splashing over the top of the cliffs with a 10.9-meter runup, the highest observed. The cliffs are located at the end of a narrow, steep-sided indentation of the coast that may have augmented the runup in this area.

At Manzanillo and the surrounding area the initial wave was reported as a withdrawal 15 minutes after the earthquake. When the waves receded, they formed a whirlpool just outside of the harbor entrance.

In Manzanillo Bay there was extensive damage due to tsunami currents. Current meters measured currents of 12 knots. These currents scoured away the banks undermining portions of road, a monument, and a house, all of which collapsed into the ocean. Some hotel lobbies were flooded, soaking the furniture and depositing sand. Four or five waves were observed each with decreasing amplitude. An eyewitness reported seeing ships rise above the horizon, and one large ship was seen floating above the sea wall.

Southward from Manzanillo the sandy beach is uninterrupted for 80 km. The runup heights decreased from 4.75 to 1.75 meters. At a cooling water intake for a power plant just south of Manzanillo eyewitnesses reported the wave overtopped the structure knocking over benches on the structure's roof. This gives an estimated height of at least 4.75 meters. At the southern end of Manzanillo Bay the runup was 2.3 meters. Three waves came over the berm and into the streets of a neighborhood some 15 to 20 minutes after the earthquake, but caused no damage.

The most obvious damage occurred at La Manzanillo on Tenacatita Bay where the tsunami flooded four meters above mean sea level. The water inundated 200 meters of the land leaving high water marks inside a church and hotel. At the north end of Tenacatita Bay the force was greater, and, after the initial withdrawal, the returning wave smashed walls of houses facing the beach. A small pickup truck was flipped over. A camper was pushed about 30 meters back from the shoreline and into some

palm trees. A wave penetrated up the river and into a marsh depositing overturned boats 500 meters inland.

At Paraiso the first wave (non-damaging) was described as a withdrawal of 50 meters followed by a slowly returning wave that reached a height of 1.76 meters.

At Cuyatlan there was erosion leaving a scarp 1.5 meters high, and residents reported that the beach had been about 20 meters wider before the earthquake. The runup there was 2.7 m following an initial withdrawal. There were no reports of damage.

Further north at Playa de Oro the sea receded first and returned with a 4.08-meter runup flooding a beach house.

No one was killed in Boca de Iguanas but several houses were destroyed. The runup heights were 3 to 5.1 meters. To the north runup heights of 2.5 to 5 meters were measured with the 4.9-meter level being observed at San Mateo. The low population in the area accounts for the lack of damage in this area.

In Puerto Vallarta sailors reported feeling the earthquake and seeing "shock waves" race across the bay. The bay began to drain as if "someone had tilted the basin." Several of the yachts were damaged as the waves knocked them together. The tsunami had periods of 15 to 20 minutes and lasted 2 hours.

Researchers from the Guadalajara Physics Department had earlier installed two submerged sensors about two kilometers off shore on September 19 to measure temperature, conductivity, and pressure. The instruments were at 50 meters depth and about 240 meters apart. They were suspended at depths of about 37.6 meters and were sampling at 1-minute intervals. A measurable change in sea level occurred eight minutes after the earthquake, cresting five minutes later. It had an initial rise of about two meters and a drop of 3.3 meters below normal sea level at the time. The waves continued for six hours. The tsunami peaked with a 3.7-m amplitude (a height of about 7.4 meters). Subsidence in the area was about 32 cm. There was no change in the temperature or salinity of the water.

The following runups were recorded in Mexico: 4.5 meters at Melaque, 4.4 meters at Cuastecomate, 3.8 meters at El Tecuan, 3.5 meters at Punta Careyes, 3.2 meters at Chamela, 3.4 meters at Perula, 2.9 meters at Punta Chalacatepec, 2 meters at Manzanillo, 51 cm at Cabo San Lucas, and 20 cm at Isla Socorro (on top of a high tide).

Outside Mexico the following runups were recorded: 8 cm at Baltra, Galapagos, Ecuador; 1 meter at Hiva Oa, French Polynesia; 30 cm at Nuku Hiva, French Polynesia; 7 cm at Papeete, French Polynesia; 37 cm at Hilo, Hawaii; 34 cm at Kahalui, Hawaii; 12 cm at Nawiliwili, Hawaii; and 11 cm at Kawaihea, Hawaii; 37 cm at Pago Pago, American Samoa; and 4 cm at Southport and 5 cm at Mooloolaba, Queensland, Australia.
PDE; Filonov, 1997a and 1997b; Borerro et al. 1997; Farreras and Ortiz, 1998; *National Report of Mexico,* IOC/ITSU-XVI/7, p. 21-41.

Validity 4.

#113. 1995, October 18. A magnitude 6.9 Ms (Mw 6.9) (USGS) earthquake at 10:37 UT in the Ryukyu Islands, Japan, caused one injury on Amami O-shima, Japan. It generated a tsunami with a maximum height of 2.6 meters at Urabaru, a small fishery harbor on the southeastern side of Kikai-shima facing the epicenter, 2.4 meters at Kowase, 0.1 to 2.4 meters on Amami O-shima causing minor damage to some boats. It was recorded with a maximum height of 80 cm at Nakano-shima and 24 cm at Okada, and 18 cm at Chichijima (PDE).
PDE, Imamura et al. 1995.
Validity 4.

#114. 1995, October 19. A magnitude 6.9 Ms (Mw 6.7) (USGS) aftershock at 02:42 UT in the Ryukyu Islands caused landslides on Kikai-shima and generated a tsunami with heights of 1.5 meters along some coastal areas. It was observed near Amami O-Shima. It was recorded with heights of 11 cm at Tosashimizu, Japan, and 9 cm at Murotomisaki, Japan.
PDE.
Validity 4.

#115. 1995, November 1. A magnitude 6.4 Ms (6.6 Mw) (USGS) earthquake at 00:35 UT in central Chile was felt at La Serena and Santiago. It produced a 13 cm tsunami at Caldera. The *PDE* did not mention a tsunami.
Tsunami Newsletter, Vol. XXVIII, No. 1. p. 13.
Validity 4.

#116. 1995, November 22. A magnitude 7.3 Ms (7.1 Mw) (USGS) earthquake at 04:15 UT in Egypt caused at least eight fatalities and 30 injuries at Nuwaybi. It caused damage in northeastern Egypt. One more person was killed and two slightly injured at Al Bad, Saudi Arabia. A possible tsunami was observed at Aqaba, Jordan.
PDE.
Validity 3.

#117. 1995, December 03. A magnitude 7.9 Ms (7.6 Mw) (USGS) earthquake at 18:01 UT in the Kuril Islands southwest of Etorofu Island produced a tsunami with a height of 1.09 meters at Shikotan, Russia, and was recorded with heights of 37 cm at Nemuro, and 10 cm at Kushiro, Hokkaido, 13 cm at Hachinohe, 20 cm at Chichijima, 17 cm at Hanasaki, and 6 cm at Ayukawa Bay, Honshu, Japan; 20 cm at Shemya and 10 cm at Adak, Alaska; 13 cm at Wake Island, 41 cm at Midway, Island, 31 cm at Crescent City, California, and 7 cm at Papeete, Tahiti, and Nuku Hiva, French Polynesia, but was not recorded at Tahauku in the Marquesas Islands.
Lander, 1996; *PDE.*
Validity 4.

#118. 1995, December 31. An aseismic tsunami occurred on the night of the December 31, 1995, and into the morning of January 1, 1996, in the Western Corinthos Gulf and was observed along a ten-kilometer section of the coast east of Aeghio City with heights of 1.5 to two meters. It caused

flooding in cultivated areas and coastal houses and caused partial destruction of the coastal road. Sand deposits and erosion caused the shift of the coastline 20 meters inland. The tsunami's source probably was related to the June 15 event that may have left the sediments unstable.
Papadopoulos, 1996.
Validity 4.

#119. 1996, January 1. A magnitude 7.6 Ms (Mw 7.8) (USGS) earthquake at 08:05 UT near Sulawesi, Indonesia, produced a 2.84-meter tsunami at the Village of Tonggolobibi which killed nine people, and injured 63. Tonggolobibi is located only 14 kilometers from the epicenter that was a back arc event with deep thrusting. The tsunami destroyed 183 houses and damaged 228 units in the Bangkir-Tolitoli area. It affected about 100 kilometers of the coast but there were no reports of tsunami data being recorded outside of Sulawesi. The land subsided by about one meter. It occurred at high tide. As the wave arrival times were very short, (about five minutes after the earthquake) and several sites reported an initial withdrawal, some of the wave action may have been due to tsunami-induced landslides. Breaking waves were also reported at about half of the sites. Three waves were observed. The wave penetrated as much as 200 meters up riverbeds and carried five boats including two 500-ton motorboats 250 meters on shore. Since the tsunami occurred at a high tide of 59 cm, and there was a subsidence of the land of about 70 cm, it was difficult to estimate the wave heights.
PDE; Pelinovsky et al. 1996.
Validity 4.

#120. 1996, January 2. A volcanic eruption in the Karymskoye freshwater lake in eastern Kamchatka began in the afternoon of January 2nd and continued for about ten to twenty hours. The initial observation from an over flight at 15:40 LT showed that the ice cover of the lake had melted and a phreatomagmatic eruption was in progress from a vent off the northern shore of the lake in a water depth of 40-50 m. Explosions occurred every four to twelve minutes. Six explosions were observed with an average interval of six minutes between them. Between explosions the lake water displayed intensive bubbling and steaming. The strongest explosions produced a rapidly rising, smooth-surfaced bulb-like mass of expanding gas and pyroclastics. This bulb grew to a height of 450 m, and then it began to collapse as jets of black pyroclastics mixed with steam pierced the shell. A light gray "collar" appeared around the center of the explosion about 130 m high. This collar propagated radially about 20 to 40 m/s to form a tsunami. Meanwhile the pyroclastic jets reached their maximum height of one km and collapsed back into the lake to produce a base surge. The interaction between the base surge and the lake water contributed to the formation of complex waves.

The steep northern shore of the lake was violently eroded by the tsunamis and surges, with all plants and soil less than 1.5 m thick stripped off, and poorly consolidated bedrock exposed. Along the rest of the shoreline, more than 1.3 km from the crater, the tsunamis carved new cliffs two to three meters high, eroded the layer of frozen soil up to 50 cm thick, and removed the vegetation. The tsunamis deposited several discontinuous, finely laminated layers of sand and gravel up to 35 cm thick, with scattered pebbles, and fragments of plants. The strongest event produced the highest runup of 30 m on the shore 700 m from the center of the crater. At the most distant points (1.3 km from the crater) the runup was two to three meters.

Belousova et al. 1996.
Validity 4.

#121. 1996, February 17. A disastrous magnitude 8.1 Ms (8.1 Mw) (USGS) earthquake at 05:59 UT in Irian Jaya, Indonesia, had a focal mechanism of a shallow dipping fault to the southwest consistent with the subduction of the Caroline plate. The earthquake caused at least 108 fatalities with 51 more people missing, 100 were seriously injured, and 10,000 left homeless. One hundred seven were killed on Biak Island and there were three deaths on Yapen as given in March 4 reports. The tsunami damaged or destroyed 5,043 houses with extensive damage on Biak and Supiori Islands.

In the village of Korim on Biak Island all of the 187 houses were destroyed. There were 68 fatalities and missing people. The waves had surveyed heights of up to 5.5 meters. The village was on a small bay facing directly toward the source. The inundation along 700 meters of the coast penetrated 800 meters inland. Sand deposits were estimated to be 3,000 cubic meters in the vicinity. Survivors reported that about five minutes after the earthquake, people heard a sound like drums or airplanes that many recognized as the sound of a large approaching wave. Having been warned by the sound, many fled to higher ground. The leading wave was reported as a depression.

There was a permanent subsidence of eastern Biak Island of 0.5 to 1 meters as inferred from interviews with survivors who reported the tides now higher than before. At Wari, a small bay just northwest of Korim, the tsunami runup was 1.4 to 4.3 meters. The wave penetrated far inland as it reversed the course of a small river that normally empties into the bay.

The tsunami runup ranged from 1.6 to 7.7 meters at Farusi Wardo on the western side of Biak Island and facing away from the source. This unexpectedly high wave was probably a second tsunami generated by a local landslide, as the area affected was only 100 to 300 meters wide and flanked by undamaged area on both sides. Three or four landslides also occurred on the adjacent hillsides. The first wave arrived from the west-southwest, and the second and largest wave arrived from the south. The survey measured runup heights of 1.6 meters at Biak village on the south side of the island.

Press reports mentioned waves of four meters at Manokwari on the Doberai peninsula (formerly known as the Vogelkop due west of Biak); 7 meters at Sarmi on the mainland due east on Biak; and 7 meters at Yapen Island due south of Biak Island. Runup values of 0.6 to 1.56 meters were reported on South Supiori Island and 0.94 to 1.21 meters on North Supiori Island. Other runups were 1.02 to 2.92 meters on Pai Island; 1.6 to 2.42 meters on Owi Island; 0.61 to 1.24 meters on Auki Island, three small islands southeast of Biak. The tsunami caused 40 fatalities and 19 were missing. It also caused damage along the north coast of Irian Jaya from Manowari to Sarmi.

The tsunami was widely recorded in the Pacific and was recorded at Apra, Guam, at 6 cm; in Alaska with a height of 71 cm at Shemya and at Adak with a heights of 20 cm; Chi Chi Island, Japan, 1.06 meters; Shionomisaki, Japan, 1.92 meters; Tateyama Chiba, Japan, 1.8 meters; Makurasaki, Japan, 1 meter; Hachinohe, Japan, 38 cm; Ishigaki, Ryukyu, Japan, 32 cm; Crescent City, California, 36 cm; Santa Monica, California, 10 cm; and Port Orford, Oregon, 8 cm.

Imamura et al. 1997; Andrew Moore, Kent State University, Ohio; Lander, 1996; *Tsunami Newsletter*, July 1996; *PDE.*
Validity 4.

#122. 1996, February 21. A magnitude 6.6 Ms (Mw 7.4) (USGS) earthquake at 12:51 UT about 130 km off the north coast of Peru was not strongly felt onshore. However, the earthquake generated a tsunami that affected about 450 km of the coast from Haucho, north of Lima to Huanchaco, north of Trujillo. It caused twelve fatalities and about 100 injuries. Three hundred seventy-five people needed assistance including 85 who had crops destroyed. Fifteen houses were destroyed and 22 others were damaged. Two boats were destroyed, and twenty-three others damaged. All along the affected area grass shacks were damaged or washed away.

At Culebras an unreinforced brick wall was pushed over and at Coishco several reinforced brick and concrete factories were damaged and 400 tons of fishmeal stored behind them were damaged or destroyed. Six line fishermen at Coishco, who were fishing from rocks since the harbor was closed to boats, were drowned. (The harbors of Coishco and Enapu at Chimbote had been closed to boats for five days due to high waves from storms.)

The marigraph at the end of the 1,000 m pier at Enapu showed the arrival of the tsunami at 9:06 A.M. local time (14:06 UT) with a rise of 2.7 m with the tide level at 1.6 meters above MLLW. The pier was inundated for 800 meters of its length from the landward end and a small pickup truck was carried about 10 meters along the pier but was not washed off. A 2-meter guard shack at the land end of the pier was destroyed and the guard seriously injured. The maximum runup height was measured at 4.9 m there. One boat sank.

The tide gauge from Salaverry (the port for the city of Trujillo) showed a rise of 75 cm and a drop of at least 65 cm where it went off scale. Two adults and two children aged six and eight years old, who were collecting firewood near the mouth of the Santa River, and two others looking for gold at Campo Santa were drowned by a bore up the river. Two people were injured at Coishco. About 150 beach huts and some homes and small boats were destroyed.

About 10 km south of Chimbote at Tombolo a sandy deposit connecting rock outcrops in the sea with the land and separating Chimbote Bay from Samanco Bay was 1.5 km wide and 4.5 km long and flat on the west end. A small rock cove called Ensenada La Posa, on the island end of the Tombolo showed tsunami measurements of four meters (the highest observed). The tsunami washed some fishing boats 300 meters inland.

A survey of elevations was conducted by a team of U.S. and Peruvian scientists who found the wave heights often marked by sand deposits of 4 to 11 cm over the native grasses to distances of 200 meters from the shore. Deposits were observed along the banks of Rio Santa up to 300 meters upstream. The marigraph at Chimbote showed a rise of 1.1 meters before malfunctioning. Both gages show the initial motion as a rise although some interviewed observers reported the first wave as a withdrawal. This is because the initial rise was less noticeable than the full height withdrawal that also created a noise as it dragged pebbles and shells down the beach slope.

The tsunami was recorded with heights of 0.9 meters at Callao, Peru (incomplete record); at Easter Island with a height of 0.6 meters; at Santa Cruz, Ecuador, 0.4 meters; at Socorro, Mexico, 25 cm; at Hilo, Hawaii, 20 cm; and at Kahului, Hawaii, 30 cm. Tsunami was observed as far away as Tahauku Bay, Marquesas Islands, French Polynesia as a series of several waves with the first being three meters high causing some damage in several bays.
Bourgeois et al. 1996; Ocola, 1996.
Validity 4.

#123. 1996, February 25. A magnitude 6.9 Ms (Mw 7.1) (USGS) earthquake at 03:08 UT off the coast of Guerrero, Mexico, was felt on the coasts of Guerrero and Oaxaca. It produced a tsunami recorded with an amplitude of 12-cm at Baltra, Ecuador, and recorded by the marigraph at Acapulco arriving at about 4:12 UT with an amplitude of 164 cm. The Acapulco marigraph samples at 15-minute intervals so the heights and arrival times are approximate. Validity 4.

#124. 1996, June 10. A magnitude 7.6 Ms (Mw 7.9) (USGS) earthquake at 04:04 UT about 95 km west-southwest of Adak generated a tsunami which was widely recorded in Alaska and Hawaii. In Alaska it had a height of 102 cm at Adak, 15 cm at Shemya, 12.5 cm at Unalaska, 10.2 cm at Sand Point, and 12.5 cm at Kodiak. In Hawaii it measured 15 cm at Kawihae, Hawaii, 55 cm at Kahului, 33 cm at Nawiliwili, 38 cm at Hilo, 10 cm at Honolulu, 20 cm at Port Allen, 46 cm at Midway, and 3 cm at Johnson Island. On the United States west coast the tsunami measured 10 cm at Port Angeles, Washington, and 30 cm at Crescent City, California.
PDE.
Validity 4.

#125. 1996, June 10. A magnitude 7.1 Ms (Mw 7.3) (USGS) aftershock of the June 10, 1996, earthquake occurred at 15:25 UT about 48 km from Adak and also produced a tsunami of 25 cm at Adak but did not leave a discernable trace at other Alaskan stations.
Lander, 1996.
Validity 4.

#126. 1996, September 4. A magnitude 5.1 Ms (Mw 5.7) (USGS) earthquake at 18:16 UT near Izu Islands south of Honshu, Japan, in the vicinity of Ogasawara, produced a tsunami of 26 cm at Hachijo-jima and 20 cm at Okada, O-shima, and 16 cm at Miyake-jima.
PDE, JMA.
Validity 4.

#127. 1996, September 5. A magnitude 7.0 Ms (Mw 6.9) (USGS) earthquake occurred at 08:14 UT in the vicinity of the East Pacific Rise and produced a tsunami of 18 cm at Easter Island and 9 cm at Juan Fernandez. It was also reported from Lobos de Afuera and Valparaiso. This is one of the largest earthquakes on record to occur along the East Pacific Rise and the only known tsunamigenic earthquake to have occurred on this ridge system.
Tsunami Newsletter, January 1997; PTWC; *PDE*.
Validity 4.

#128. 1996, October 18. A magnitude 6.6 Ms (USGS) earthquake occurred at 10:50 UT near the southeast coast of Kyushu, Japan, and was felt with MMI IV JMA in eastern Kagoshima Prefecture and MMI III JMA at Miyazaki and western Kagoshima Prefectures. It was felt with MMI III on Tanegashima where a local tsunami with height of 19 cm was recorded.
PDE, *Tsunami Newsletter,* January 1997.
Validity 4.

#129. 1996, October 19. A magnitude 6.6 Ms (Mw 6.6) (USGS) earthquake occurred at 14:44 UT near the southeast coast of Kyushu, Japan, causing some damage at Miyazaki and a tsunami there of 1.1 meters. It also caused tsunamis of 40 cm at Nichinan, Kyushu; 14 cm at Murotomisaki; 12 cm at Tosashimizu, Shikoku; 14 cm on Tanega Shima; and minor tsunami waves observed on the coast of Shikoku. The earthquake was also felt with intensity IV, JMA, at Kumamoto, Kurume, and Oita.
PDE; Tsunami Newsletter, January 1997.
Validity 4.

#130. 1996, November 12. A magnitude 7.3 Ms (Mw 7.7) (USGS) earthquake at 17:00 UT near the coast of Peru caused at least 14 fatalities, 560 injuries, and left 12,000 people homeless from Chincha Alta to Acari south of Lima. Fifty people were missing in a collapsed mine at Acari. People in high-rise buildings as far away as Guayaquil, Ecuador, and La Paz, Bolivia, felt the earthquake. The earthquake generated a tsunami with recorded heights of 25 cm at Calloa, Peru; 35 cm at Arica, Chile; and 21 cm at Caldera, Chile.
PDE; *Tsunami Newsletter*, January 1997.
Validity 4.

#131. 1996, December 2. A magnitude 6.6 Ms (Mw 6.9) (USGS) earthquake occurred at 22:18 UT in the vicinity of the southeast coast of Kyushu, Japan, and produced a tsunami with a maximum height of 21 cm at Nichinanaburatsu, 15 cm at Aburatsu, 10 cm at Tosashimizu, and 4 cm at Hyugahososhima.
PDE; *Tsunami Newsletter*, January 1997; JMA.
Validity 4.

#132. 1997, April 10-11. Waves up to 15 meters high were reported inundating the town of Cedeno, Gulf of Fonseca, on the west coast of Honduras. Apparently, fishermen had earlier observed indications on the 10th that manifested the 15-meter waves at 3 P.M. (local time) and another large wave on the 11th at 4 A.M. The wave inundated 200 m inland destroying 65 buildings including those constructed of concrete block. A hotel and restaurant were totally destroyed. Domestic animals were killed and preliminary damages were estimated at $300,000. Damage may have occurred also at Boca del Viejo and the small island of Guipo. The event may have been a storm surge.
George Kaminsky, Washington Department of Ecology.
Validity 1.

#133. 1997, April 18. A magnitude 4.7 Ms (USGS) earthquake at 15:06 UT in the Fiji Islands was suggested as the source for evidence of a tsunami recorded at Norfolk Islands at 16:30 UT. It is too

small, too far away, and not reported from other locations to be a likely source.
Validity 3.

#134. 1997, April 21. A magnitude 7.9 Ms (7.7 Mw) USGS earthquake at 12:02 UT in the Santa Cruz Islands caused significant damage to the islands of Hiu, Tegua, and Lo, Torre Islands and Ureparapara in the Bank islands of Vanuatu. It was followed by a tsunami recorded on a few regional gages with heights of one meter or less. It washed away seven houses and destroyed three others. There were no injuries or fatalities reported. The tsunami inundated about 7 to 15 meters destroying some concrete buildings. The tower of the automatic weather station at Linua was bent by the waves and was left standing at an angle. Many fish were washed ashore. The tsunami was recorded on the tide gages at Lord Howe Island at Crowdy Head and Tweed Heads. It was recorded with a height of 10 cm at Chichijima, Japan. Funafuti and Suva, Fiji recorded less than 10 cm; Vanuatu Islands recorded less than 20 cm.
UNDP/UNDHA, 1997; Lyman,1997.
Validity 4.

#135. 1997, July 9. A magnitude 6.9 Ms (Mw 7.0) earthquake at 19:24 UT near Venezuela caused at least 81 fatalities, 522 injuries, and extensive damage and landslides in the Carioco-Cumana area. At least 3,000 people were left homeless. Several people were injured in the Barcelona-Puerto La Cruz area. Some damage was done on Isla Margarita and electrical, telephone, and water services were disrupted on Isla Cohce and Isla de Margarita. It was felt in much of northeastern Venezuela as far west as Maracaibo. It was also felt on Trinidad and Tobago. A large wave observed on the southwest coastal beach on Tobago receded a few minutes after the earthquake.
PDE; Mercado, 1997a.
Validity 3.

#136. 1997, October 14. A magnitude 6.7 Mb (Mw 7.8) (USGS) earthquake at 09:53 UT south of the Fiji Islands was felt in Wellington, New Zealand. A small tsunami was recorded at Suva.
PDE.
Validity 4.

#137. 1997, December 5. A magnitude Ms 7.6 (Mw 7.8) (USGS) earthquake occurred at 11:27 UT off the eastern coast of Kamchatka. It produced a small tsunami that had local runup heights of 0.5 to 1.5 meter measured at several sites where the survey team could land. They observed a strip of broken ice and sea grass cast on the shore. It was recorded at Petropavlovsk-Kamchatskiy with an amplitude of only 2 cm. A nearer marigraph at Ust-Kamchatsk was not operating. It was not recorded in Japan except as a sea oscillation of height of 10 cm at ChikeiIt (possible tsunami). In Hawaii it was recorded at the following locations: Kahului, 60 cm; Haleina, 52 cm; Hilo, 47 cm; and Honolulu, 5 cm; Snug Harbor, 10 cm; Hanalei, 30 cm. In Alaska it was recorded at Adak and Unalaska with heights of 15 cm. The wave was recorded at Midway with a height of 12 cm.
Gusiakov, 1997; ATWC, 1997; Gonzalez, 1997.
Validity 4.

#138. 1997, December 15. An 8-meter wave was observed at 15:00 to 16:00 UT (3 A.M. to 4 A.M.

local time) at the lighthouse on Kronotskiy Cape. The wave destroyed a bridge across a small river 50 meters from the river mouth. A pile of barrels lying on the beach was covered with sand, silt and grass. There was no major earthquake in the area with the largest event about magnitude 5.0 Mb. This tsunami is believed to be due to a submarine landslide as there are several submarine canyons with steep bottoms around the Cape. The magnitude 7.8 Ms earthquake ten days earlier may have made the submarine sediments unstable and a landslide may have been triggered by one of the small aftershocks.
Gusiakov, 1998.
Validity 3.

#139. 1997, December 26 [3:00 LT]: A volcanic debris slide of 60 million cubic meters occurred in the White River Valley, Montserrat, on Dec. 26th (named the Boxing Day Collapse.) On the night of the eruption there were reports of a wave inundating the Old Road Bay area, 10 km from the landslide site. A small tsunami was generated, probably by the steep flow front of the debris avalanche, possibly assisted by the pyroclastic flows as they entered the sea at the mouth of the White River Valley. The tsunami wave was refracted around the coastline of Montserrat, and achieved considerable run-up in Old Road Bay.

The wave was estimated to have been about 1 m higher than the road which lies 2-m above water level, and to have moved inland a maximum distance of 80 m. A variety of objects, including a small wooden boat, a roof to a shelter, and a stone table were displaced several meters inland and a large log was carried even further by the wave. Impact marks up to 1 m were also on the side of palm trees facing the sea. The grass was oriented in such a way as to indicate the retreat of the wave. An observer reported seeing the sea move out and then back in, which is typical of a landslide-generated tsunami. The focusing of the wave at Old Road Bay can be attributed to the peculiarities of wave behavior along a coastline and the abrupt change of coast direction at Old Road Bay. The wave moved inland here, and because the coast abruptly changes direction, the wave moving parallel to the coast would have met the shore head-on. Also, the shallow offshore bathymetry and onshore topography in the area aided extended wave runup.

Since July 18, 1995, when this stratovolcano in the Soufriere Hills began erupting (the first recorded eruption of this volcano in historic times) there have been several debris slides that reached the ocean, but the authors have not found a report of unusual waves.
Mangeney et al. 1998; Calder et al. 1998.
Validity 4.

#140. 1998, March 25. A magnitude 8.0 Ms (Mw 8.1) (USGS) earthquake occurred at 03:12 UT near the Balleny Islands near Antarctica south of New Zealand. This is an oceanic ridge area. No tsunami has yet been reported from New Zealand but Australia reported some waves of 10 cm.
PDE.
Validity 3.

#141. 1998, May 3. A magnitude 7.3 Ms (Mw 7.5) (USGS) earthquake occurred at 23:30 UT in the Philippine Sea south east of Taiwan and produced a small tsunami with amplitudes of 4 cm at

Miyako and at Ishigaki-Shima, Yonaguni Island in the Ryukyu Islands, Japan, and at Naha, Okinawa.
Tsuji, 1998; *PDE.*
Validity 4.

#142. 1998, July 17. A magnitude Ms 7.1 earthquake occurred near the northwest coast of Papua New Guinea 850 km (510 miles) northwest of Port Moresby, the capitol of Papua New Guinea (PNG). The earthquake, which occurred at 6:49 P.M. local time, was followed by a series of three catastrophic tsunami waves that devastated the villages of Sissano, Warupu, Arop (1 & 2) and Malol on the north coast of PNG killing at least 2,182, injuring 1,000, and displacing more than 10,000.

The earthquake was felt widely in PNG coastal communities. In the Aitape region, it was reportedly strong enough to make walking difficult and to knock objects over. According to the National Earthquake Information Center (NEIC), the main shock was followed 20 minutes later by two moderate aftershocks that occurred so close together that they appeared to be a single event.

The three waves affected a 40-km length of coastline from the mouth of the Bliri River on the west to the town of Aitape on the east. This length of coastline was home to around 15,000 people before the tsunami. The area is predominantly tropical swamp land—a home to tribes that rely on subsistence farming and fishing and live in beach homes made of local materials. This section of coastline was particularly vulnerable because a narrow strip of land separates the ocean from Sissano Lagoon, a lagoon formed by a tsunami in 1907.

At many locations along this stretch of coastline the first wave arrived about twenty minutes after the main shock (just after the first aftershocks). The trough of the first wave arrived soon after dark accompanied by loud sounds that drew curious tribesmen to the beach where they viewed the exposed sea floor. This was followed by an air blast that reportedly knocked people off their feet and a seven to ten-meter tsunami crest. At Warupu and the Arop villages the second crest was described as riding on the back of the first and breaking over the villages, sweeping debris over the spit and washing it into the lagoon or 500 m inland from the coast. Trees were uprooted, and mature mangroves were broken off at distances of 1,300 m from the shore. Maximum wave heights reached nearly 15 m along a twenty-km stretch of the lagoon area.

The villages of Arop and Warupu were entirely destroyed. All that remained were the posts of elevated houses, and the foundations of cement block buildings. The tsunami destroyed three schools, a health sub-center, a health aid post, a number of mission buildings and churches as well as the government administration center at Sissano. Two bridges on the road between Aitape and Malol were demolished or damaged. Over 10,000 homeless survivors were accommodated in seven care centers set up for this purpose. A major concern was the health and sanitation in the care centers. Rebuilding began in areas where land was available. Residents of Warupu Village left without a location in which to rebuild.

Survivors were reportedly lifted off their feet, tossed around, and stripped of their clothes. Some victims were found impaled on mangrove stumps, and others received deep cuts from metal debris.

The most common injuries included bone and limb fractures, lacerations, and soft tissue injuries. Lack of immediate medical attention, heat, and shock contributed to the development of gangrene that in turn forced the amputation of 34 limbs. Some also suffered pneumonia after saltwater inhalation. Many of the casualties were children.

Several lessons were immediately obvious from this tsunami. Ground shaking and loud sounds from the sea provided tsunami warnings that were largely unheeded by area inhabitants unfamiliar with tsunamis. Spits between lagoon areas and the sea are particularly prone to damage from tsunamis and should be avoided in rebuilding after the tsunamis. Trees and mangroves apparently exacerbated rather than reduced the impact of the waves with the exception of coconut palms. These palms presented limited surface area to impede the wave and hence were not contributors to dangerous wave-borne tree debris. Lagoons do not dissipate tsunami energy. In fact, the tsunamis seemed to travel farther from the coast across the lagoon areas than in areas where the journey inland was over land. Also tsunamis tend to recur in the same areas as previous tsunamis.

Stations in New Guinea that recorded the tsunami include: Yap, 2.5 cm; Malakal, Koror, Palau, 1.5 cm; Pohnpei, Micronesia, 1.5 cm.

Christchurch, South Island, New Zealand experienced a small tsunami from this event. Other tide gages in New Zealand recorded the following: Jackson Bay, 3.0 cm; Kaikoura, 2.3 cm; Summer Head, 5 cm. The most likely cause of the tsunami is a sediment slump 25 km offshore caused by the earthquake (American Geophysical Union, 1999). This event is the largest known tsunami ever to have occurred in the area although the tsunami/earthquake history dates only from 1900.

The tsunami was also recorded at the following tide gages in Japan: Ofunato, 10 cm; Ayukawa, 10 cm; Takeyama, 10 cm; Irozaki, 14 cm; Izu-Ohshima, 15 cm; Miyake-Jima, 20 cm; Hachinijo-jima, 11 cm; Chichij-jima 8 cm; Kushimoto, 10 cm; Kushimoto, 10 cm; Katsuura, 10 cm; Muroto, 13 cm; Tosa-shimizu, 15 cm; Aburatsu, less than 10 cm; Tanegashima, 10 cm; Naze, 12 cm; Naha, less than 10 cm; Miyako-jima, less than 10 cm; Ishigaki-jima, less than 10 cm; Yonaguni-jima, less than 10 cm.
Earthquake Engineering Research Institute (California) Special Earthquake Report, *Reconnaissance Report on the Papua New Guinea Tsunami of July 17, 1998*.
Validity 4.

#143. 1998, November 29. A magnitude 7.7 Ms (Mw 7.7) (USGS) earthquake occurred near Taliabu Island, Indonesia, at 14:11 UT. Gegar Sapta Prasetya in an email to Frank Gonzalez mentioned that the newspaper reported a wave of 2.75 m height that had been observed by eyewitnesses.
PDE; Gegar Sapta Prasetya.
Validity 2.

#144. 1999, August 17. On August 17, 1999, at 3:02 A.M. local time a magnitude (Mw) 7.4 earthquake occurred on the northern Anatolian fault. The earthquake epicenter was 11 km (7 miles) southeast of the City of Izmit, in a densely populated area in the industrial heartland of Turkey, and

less than 80 km southeast of Istanbul. The epicenter was located very close to the south shore of the Bay of Izmit, an eastward extension of the Marmara Sea.

The earthquake generated a tsunami along the coast of Izmit Bay in the Marmara Sea. The tsunami had a maximum runup of 2.5 m along the northern coast of the bay opposite the epicenter and 1 to 2 m on the southern coast. The tsunami wrecked havoc in water front areas. Fishing boats were broken, and sea front cafes were flooded. Boats plowed into promenades and shop fronts. A huge refrigerator used by boardwalk venders was deposited by the wave on the second floor balcony of a neighboring apartment building. Reports indicate that at least 150 people lost their lives in the waves. Tons of fish were washed ashore, dumped on waterfront properties and left to rot. An oil refinery caught on fire as a result of the earthquake and spread a layer of oil on the waters of Izmit Bay damaging wildlife. Tourism in the area came to a halt as seaside restaurants and promenades slumped into the sea.

The town of Hereke, in North Izmit Bay, had a small harbor and a municipal pier. The local police office reported that the wave came up a small inlet and flooded to a depth of 50 cm over the parking area in front of the police station. There was a significant slope failure on the east side of the harbor about 60 m long by 12 m wide. Along the entire length of the slope failure, a 1 m by 30 cm concrete sidewalk also fell into the harbor.

The city of Sirinyali, a few km west of Yalikent, had the highest measured runup of 2.5 m. The wave was more forceful here than in any other place. It came in strong enough to break the windows of the sea front basement apartments and flood them with seashells and seaweed. There was also subsidence of 10-15 cm at this location.

At Yalikent, a leading tsunami depression wave that withdrew about 25 m was followed by a tsunami wave from the southeast with a measured runup of 1.6 meters. The septic system was flooded as the wave came in causing a back flushing of toilets and sinks in the houses. Several small boats were pulled out to sea, and two were lost. Wooden benches washed up on the beach and debris was deposited in flower beds. There was a permanent sea level rise relative to the small pier, indicating local subsidence of 15-20 cm.

The town of Degimendere was very close to the epicenter of the earthquake, and felt the strongest shaking. Many buildings were destroyed, and fatalities were heavy in the surrounding area. The shoreline subsided about two meters, and the waterline advanced 50 m inland from its location prior to the earthquake. The scarp, left by subsidence, was approximately two meters tall. Prior to August 17th the area in the center of town was the location of a restaurant and park with many tall trees. After the quake, the entire area was beneath the waters of Izmit Bay.

Water from the first wave came over the road and into the first floor of the buildings along the shore. Boats were snapped in pieces along the promenade and washed over 30 m inland by the wave. Reports indicated that a huge refrigerator used by ice-cream venders on the promenade was washed up onto the second floor balcony of a block of flats. The snapped prow of a wooden rowboat was embedded in a shop front. Tons of fish were washed ashore on the waves and dropped into seafront

properties that are popular holiday homes for Turkish families living in industrial centers like Izmit and Istanbul. A passenger ferry was stranded in what used to be a popular amusement park that was also flooded by the waves. More than 150 bodies were pulled out of the Sea of Marmara at this point.

In the small seaside town of Halidere, all of the boats normally on the beaches floated 30-50 meters up the streets. The measured runup here was between one and two meters. One man's yard was flooded and a mooring buoy was deposited in his back yard. Seaweed traces were found 50 meters up a street. The residents reported that the sea level had risen two meters or more and that a beach in front of the seawall had been removed. A road ended abruptly in the bay. Everything had subsided about two meters.

Guzelyali is a small fishing harbor on the south shore of Izmit Bay. The harbor is located behind a breakwater. Reportedly a leading depression wave was followed by a tsunami overtopping the seawall in the back of the harbor, and causing small boats to lose their mooring lines. When the sea wall was measured, a height of 1.25 m was obtained for the tsunami. The entire harbor was covered with a 2.5 cm to15 cm (1-6 inch) thick layer of oil that may have come from the large refinery fire across Izmit Bay.

Tens of thousands were rendered homeless in the region of Karamursel located on the Bay of Izmit by the combined effects of this tsunami, subsidence, earthquake and liquefaction.
Jose C. Borrero, University of Southern California.
Validity 4.

#145. 1999, November 26. On the 26th of November 1999, at 13:21 UTC a magnitude 7.5 (Ms) earthquake occurred in Vanuatu. Vanuatu is a chain of volcanic islands located about 2,000 km northeast of Australia in the heart of Melanesia. Prior to its independence from Great Britain in 1980 the country was called the New Hebrides.

The Vanuatu island arc is formed by the subduction of the Australian plate under the Pacific plate and is seismically active. The earthquake occurred on a thrust fault formed in the back arc of the subduction zone. The epicenter was given as 16.45 South, 168.18 East or approximately 90 miles North of Port Vila. Most of the earthquake damage occurred on Pentecost Island. Because of Vanuatu's steep topography, landslides accompanied the earthquake. Some of these landslides may also have occurred offshore. Minor earthquake damage also occurred on the islands of Ambrym, Malekau, and Epi.

The earthquake generated a tsunami that attacked the coast of Vanuatu, with runups ranging from 1.5 to 6.6 meters. The tsunami reached nearly 6 m above sea level at Baie Martelli, a village near the southern tip of Pentecost Island. The complete destruction of Baie Martelli resulted in only five deaths among the over 300 inhabitants. The villagers were attending an evening wedding celebration and were out of their homes where they had a clear view of the sea when the earthquake occurred. They had recently watched a video of the deadly 1998 Papua New Guinea tsunami so they recognized the tsunami threat when the water receded from the bay. They ran uphill away from the

water, a good safety procedure in areas where there is a tsunami hazard.

Destruction at Baie Martelli was reportedly caused by three waves led by a receding wave. The first and smallest wave arrived about 10 minutes after the earthquake. It was followed by two larger waves arriving about 15 minutes apart. Most village buildings constructed of woven grass walls with corrugated metal roofs were totally destroyed. Even the few concrete structures were very badly damaged but most remained standing. Perhaps the strongest of these concrete structures was the church that survived the tsunami. The wave did not exceed the height of the 4.5 m church, but water impounded in front of the church, surged over the rooftop, collapsing the roof and flooding the interior. The tsunami also dug 1.5 m deep scours at the leading corners of the building. The community's piped water supply was destroyed. All public and private possessions in the community, including seven boats and four generators, were lost.

Gardens were covered with sand. The sand formed a 5-16 cm thick layer in almost all the areas the tsunami reached. Its likely sources are the shore face, which village residents say was eroded by the wave. Some visible pits were dug into the coastline by the tsunami. The tsunami was also blamed for the wreck of a 50-ton ship, the *Halimon,* on the coast of eastern Malakula Island.

Five were killed at Ena Village in the earthquake, and five in the tsunami at Baie Martelli at Southern Pentecost. The National Disaster Management Office said the tsunami also struck the villages of Ena and Vemagely. The 1998 Papua New Guinea tsunami struck similar primitive coastal villages but the death toll for the tsunami was 2,182. This area is not frequently damaged by tsunamis so the only source of information for the residents was probably the video. The tsunami of Pentecost Island clearly illustrates the benefit of education in the saving of lives.

The following wave heights were recorded: Port Vila, Vanuatu, 0.6 m; Lautoka, Fiji, 12.5 cm; Funafuti, Tuvalu, less than 5 cm; Nauru, less than 5 cm; Apia Samoa, 5 cm; Pago Pago, American Samoa, 10 cm; Niue, 7 cm; Kwajalein, Marshall Islands, less than 5 cm; Papeete, Tahiti, less than 5 cm; Chatham Islands, New Zealand, 5 cm; Wake Island, less than 5 cm; Nawiliwili, Kauai, Hawaii, 10 cm; Honolulu, Oahu, Hawaii, 5 cm; Kahului, Maui, Hawaii, 10 cm; Kawaihae, Hawaii, Hawaii, less than 5 cm; Hilo, Hawaii, Hawaii, 5 cm; Point San Luis, California, 5 cm.
Andrew Moore, Tohoku University (Sendai, Japan).
Validity 4.

#146. 2000, January 26. Tawi Tawi, Philippines. Hundreds of traditional stilt houses were destroyed. Maximum runup 20 meters.
Discovery Online.
Validity 3.

#147. 2000, March 29. A huge wave swept over the bow of an Everett-based Navy destroyer, knocking six crewmen around on the deck and leaving one of them with two broken legs and the others with minor injuries. The destroyer, based in Everett, Washington, was about seven miles west of the Golden Gate Bridge, on its way out to sea after a weekend in San Francisco, when the wave hit, officials said. This is probably a non-tectonic tsunami.

Associated Press.
Validity 2.

#148. 2000, May 4. A magnitude 7.5 earthquake (04:21 UT) killed 46 people, injured 264, and left 30,000 homeless near Sulawesi, Indonesia. It caused extensive damage, and power outages occurred in the Luwuk area, Sulawesi, and on nearby islands. Eighty percent of the buildings were damaged or destroyed on Banggai by the earthquake. Much of the damage east of Luwuk and on Peleng was caused by a local tsunami with estimated wave heights up to six meters.
PDE.
Validity 4.

#149. 2000, June 18. A 7.8 magnitude earthquake at 14:44 UT and in the South Indian Ocean knocked small items from the shelves in stores. A small local tsunami was generated with an estimated wave height of 30 cm in the Cocos Islands.
PDE.
Validity 4.

#150. 2000, July 1. A 6.1 magnitude earthquake on Honshu, Japan, (07:01 UT), generated a local tsunami with a recorded wave height of 7 cm at Minamiizu. A landslide killed one person, several were injured; minor damage and power outages occurred on Kozu-shima.
PDE.
Validity 4.

#151. 2000, November 4. Point Arguello, California. The Ballena research vessel was sunk. There are four well-defined, mature canyons of the Arguello Canyon system. Each of these canyons exhibits unique and similar head morphologies that suggest collapse structures. These heads all notch the distal edge of the continental shelf in about 100 meters depth of water. They are located near or over the southwestern margin of the Santa Maria Basin, a major hydrocarbon basin. The EM300 bathymetric images show that all four canyons have detritus lobes that flow down canyon from the heads; these appear to represent evacuated material from beneath the collapsed heads. Along the downslope margins of the canyons, down-dropped walls and slump material indicate sediment failures occur regularly downslope. These canyons are quite sinuous, and it appears that these bends result from mid-slope canyon wall failure. Authigenic carbonate deposits have been collected at the heads of some of these canyons. It is speculated that the collapse heads, rilles, depressions and mounds are fluid-induced, possibly by escaping gas and fluids associated with the offshore hydrocarbon-rich Santa Maria Basin. This is possibly a landslide-generated tsunami.
Bernard, 2000.
Validity 3.

#152. 2000, November 16. A magnitude 8.2 earthquake (04:54 UT) New Ireland, Papua New Guinea generated a damaging local tsunami at Kokopo and Rabaul, New Britain. The inundation of a hardware store in Rabaul that occurred 20-30 minutes following the first earthquake was most likely caused by a seiche. A runup of 0.9 m was reported in Rabaul. Tsunami damage was also observed along the southwestern coast of New Ireland, the west coast of Bougainville and on Buka.

It was not certain whether the tsunami was the result of this earthquake or othe aftershock that occurred a few hours later.
PDE; Tsunami Newsletter.
Validity 4.

#153. 2000, November 16. A magnitude 7.8 earthquake occurred (7:42 UT) in the New Ireland Region, Papua New Guinea (5.0S, 153.3E) at a depth of 45 km. A tsunami was generated but it was difficult to determine if the tsunami was generated by this earthquake or by the previous one that occurred about three hours earlier. Because it was dark by the time the aftershock occurred, it was difficult to verify when some coastlines were inundated.
PDE; Tsunami Newsletter.
Validity 4.

#154. 2001, June 23. At approximately 15:33 local time **(**20:33 UT) near the coast of southern Peru (16.1S 73.4W) a major Mw = 8.4 earthquake occurred which was among the largest earthquakes worldwide in the last 35 years. The quake, centered near the Peruvian coastal city of Ocoña, generated strong shaking across all of southern Peru and northern Chile. Many cities and towns in the region sustained heavy damage, especially the Peruvian towns of Moquegua, Punta de Bombon, and the mountain city of Arequipa. In addition, the earthquake and resulting rockslides badly damaged several stretches of the Pan-American Highway, a route vital to the economy of southern Peru.

The earthquake also generated a tsunami that struck the Peruvian coast and was observed on tide gages across the Pacific Ocean. In Peru, damage from the tsunami was, fortunately, limited to the south-central portion of coastline stretching from the town of Atico in the north to Matarani in the south.

The area surrounding the city of Camana was hit hardest by the waves. Camana is a popular and picturesque summer resort of around 20,000, some 560 miles (900 km) south of Lima. Here, maximum runup measurements exceeded seven meters in some locations, with greater than one-kilometer inundation in some places. The powerful surges destroyed hundreds of homes, hotels and restaurants in La Punta, a popular resort area located along a narrow strip of beach immediately south of Camana. According to reports, 2,500 hectares of agricultural land were inundated in Camana. The tsunami swept over the town, and its surrounding rice and sugarcane fields. This was one of the hardest-hit areas by both the earthquake and tsunami.

About 26 people are known to have perished as a result of the tsunami, with roughly 70 missing. The death toll would have been even higher had the event not occurred during the Southern Hemisphere winter when the beaches are nearly empty. If the tsunami had struck during the peak of the summer tourist season, the loss of life would have been far greater. According to eyewitnesses, the tsunami consisted of between three and five separate surges, with either the second or third as the largest.

Small tsunami waves measuring a few centimeters were recorded or observed in southern and central Pacific and as far away as Hawaii and Japan.

The following tsunami wave measurements were reported from tide stations throughout the Pacific:

Peru: Callao, 0.8 m; Camana, 4 m.

Chile: Antofagasta, 0.9 m; Arica, 2.5 m; Baltra Island, Galapagos, 0.3 m Caldera, 1.0 m; Coquimbo, 1.3 m; Corral, 0.9 m; Easter Island, 0.35m; Iquique, 1.65 m; Juan Fernandez, 0.8 m; Punta Carona, 0.35m; San Antonio, 0.5 m; Santa Cruz, Galapagos, 0.9 m; Talcahuano, 2.5 m; Valparaiso, 0.6 m.

SW Pacific: Kiribati, Christmas Island, 0.05 m; Cook Island, Rarotonga, 0.08 m; Western Samoa, Apia, 0.25 m; American Samoa, Pago Pago, 0.32 m; Fiji, King`s Wharf, 0.1 m; Fiji, Lautoka, 0.1 m; Tonga, Nukualofa, 0.2; New Zealand, Chatham Island, 0.55 m; Vanuatu, Port Vila, 0.25 m. An oscillation of 30 cm peak to trough was recorded at Port Vila, Vanuatu, in the Southern Pacific. Additional tide gages in the Central and South Pacific (Fanfuti, Kembla, Lombrum, and Suva) recorded a small tsunami.

NW Pacific: Marshal Islands, Kwajalein, 0.1 m; Kuril-Kamchatka, Russia, Ust-Kamchatsk, 0.12 m; Wake Island, 0.1 m.

Mexico: Cabo San Lucas, 0.25 m.

USA, California: Arena Cove, 0.15 m; Crescent City, 0.4 m; La Jolla, 0.1 m; Los Angeles, 0.1 m; Monterrey, 0.15 m; Port San Luis, 0.27 m; Pt. Reyes, 0.2 m; San Diego, 0.1 m; San Francisco, 0.07 m; Santa Monica, 0.2 m.

USA, Alaska: Adak, 0.2 m; Dutch Harbor, 0.12 m; Kodiak, 0.08 m; Sand Point, 0.24 m; Seward, 0.03 m; Sitka, 0.05 m; Yakutat, 0.05 m, Johnston Island: 0.1 m.

Japan: Cape Todo, 0.2 m; Hanasaki, 0.5 m; Kesen-numa, 0.28 m; Miyagi-Enoshuma, 0.2 m; Naha, 0.1 m; Omaezaki, 0.25 m; Ofunato, 0.15 m; Tosa-Shimizu, 0.3 m.
PDE.
Validity 4.

#155. 2002 March 5. A strong Mw 7.2 earthquake occurred in the Mindanao region of The Philippines on March 5, 2002 21:16 UT. The epicenter was at 6.10N 124.15E. The earthquake killed eight people and injured 100 on the southern Philippine island of Mindanao. The quake originated from offshore 500 miles south of Manila. The quake also triggered a landslide and a moderate tsunami on nearby Sarangani Island where hundreds of villagers fled the coastal towns of Kiamba and Maitum after the sea rose by 1.5 meters. More than 5,000 villagers on Sarangani Island fled to high ground minutes after the quake struck, fearing tidal waves as the sea swelled by three meters (nine feet), the military said.
PDE; CNN.com.
Validity 4.

#156. 2002 March 26. A Mw 6.4 earthquake occurred at 03:45 in the southwestern Ryukyu Islands of Japan. A tsunami affected several islands in the southern Ryukyu Islands.
PDE; SBN.
Validity 3.

#157. 2002 March 31. An earthquake (Mw 7.3) occurred in Taiwan. At least five people were killed and 200 injured. A 20 cm tsunami was recorded on Yonaguni-jima, Ryukyu Island in I-lan; in Miao-li and Hua-lien; in T'ai-pei, T'ai-chung, Nan-t'ou and Yun-lin; in Chia-I and T'ai-tung Count on Yonaguni-jima. Another source reported that a small tsunami also occurred at Ishigaki Island.
PDE; CNN.com.
Validity 4.

SUMMARY

This catalog contains data on 157 tsunamis that occurred during the period from 1983 to 2001. Of these, all but nineteen events were in the Pacific region including Indonesia. These nineteen events include two in the Indian Ocean, nine in the Mediterranean Sea, one from the Gulf of Aqaba off the Red Sea, one at Hanian Island in the South China Sea, one in the Marmara Sea (Bay of Izmit) and five in the Caribbean Sea. These are listed in Table 1.

Of the 157 tsunamis that occurred during this period, 30 caused damage and 16 caused fatalities. Table 2 lists the tsunamis that caused damage. Tsunamis that also caused damage at teletsunami distances (more than 1000 km) are listed in Table 3. Table 4 lists the 16 tsunamis that caused fatalities (a total of 5,562 fatalities). Table 5 lists all the events included in this catalog with their source parameters and maximum runup for each event (as described by the text in this catalog).

Table 1
Tsunamis out of the Pacific Area

Date	Location	Damage & Effects
Aug. 6, 1983	Aegean Sea	Weak wave.
Nov. 30, 1983	Seychelles Is., Indian Ocean	Wave damage near the southeastern tip of the island.
Feb. 11, 1984	West Corinthos Gulf – Greece	Intensity 3 tsunami at Sergoula.
Mar. 16, 1985	Leeward Islands	Small tsunami at Basse Terre, Guadeloupe.
Apr. 20, 1988	Tyrrhenian Sea	A wave 5.5 meters in height was seen in the Porto di Levante.
Nov. 1, 1989	Puerto Rico	Small tsunami in Cabo Rojo.
Dec. 13, 1990	Italy	Road flooded at Augusta.
Jan. 4, 1991	Karia Island, Greece	Tsunami intensity of 3 at Evdilas.
Apr. 22, 1991	Costa Rica	Tsunami effects from north of Limon to Panama, 2 m in Cahuito Puerto Viejo, Costa Rica.
Jan. 5, 1992	Hainan Island, China	A number of waves up to 80 cm damaged fishing boats. Effects at Beibu Bay, and Sanya Port.
May 7, 1993	Greece	Aseismic tsunami or storm surge at Leros Island.
May 13, 1995	Greece	Earthquakes caused ship to move in harbor near Gevena-Kozani. No runup reported on land.
Jun. 15, 1995	Gulf of Corinth, Greece	Tsunami had a height of 0.4 to 0.5 m at Eratini. Probably a landslide tsunami.
Nov. 22, 1995	Aqaba, Jordan	Possible tsunami from Egypt earthquake.
Dec. 31, 1995	Western Corinthos Gulf	Heights of 1.5 to 2 m at Aeghio City. Flooded cultivated areas.
Jul. 9, 1997	Tobago, Venezuela	Large wave observed.
Dec. 26, 1997	White River Valley, Montserrat	Eruption generated a tsunami that was 3 m at Old Road Bay.
Aug. 17, 1999	Bay of Izmit	150 deaths from tsunami. Waves up to 2 meters.
Jun. 18, 2000	South Indian Ocean	30 cm tsunami in the Cocos Islands.

Table 2
Damaging Tsunamis

Date	Location	Damage & Effects
May 26, 1983	Minehama, Japan	Tetrapods scattered and broken.
	Noshiro, Japan	Caissons translated and dislocated, 40 ships destroyed, houses destroyed.
	Oga Peninsula	Much damage.
	Total for Japan	52 homes washed away, 3,513 homes destroyed, 225 vessels sunk, 251 vessels washed away, 1,187 vessels damaged $800 million total damage.
	Korea	70 boats damaged, numerous roads and dwellings damaged and boats damaged. $500,000 damage.
	Primorsky Russia	Several small fishing boats washed ashore. Some ships had lines broken. Boxes and barrels washed ashore.
Nov. 30, 1983	Diego Garcia Island, Indian Ocean	Significant damage.
Sep. 19, 1985	Lazaro Cardenos, Mexico	1,500 m of railway destroyed, bridge washed out, fishing boats missing.
	Michoacan, Mexico	Palapa restaurants washed away.
	Playa Azul, Mexico	Other restaurants and hotels flooded.
	Ixtapa Zihuatenejo, Mexico	Many beach front restaurants destroyed.
Oct. 16, 1987	New Britain	Wharf destroyed, 2 jetties damaged.
Aug. 10, 1988	Solomon Islands	100 homes washed away in 13 villages.
Apr. 22, 1991	Limon, Costa Rica	7,439 homeless and severe damage in the Limon-Pandora area.
Jan. 5, 1992	Hainan Island, South China Sea	Damage to fishing boats.
Apr. 25, 1992	Trinidad, California	Boats flooded, vehicle stuck in sand.
Sep. 2, 1992	El Transito, Nicaragua	80% of buildings were swept away.
	El Popoyo, Nicaragua	Damage.
	Marsella, Nicaragua	Scoured beach.
Dec. 12, 1992	Riangkroko, Indonesia	Village destroyed.
	Pagaraman, Babi Islands, Flores	Settlement destroyed.
	Maumere	Minor damage.
	Pmoana Besar Island	Villages flooded.
	Sumba Island	Damage.
	Wuring	80% of stilt houses collapsed.
	Sumba Island	Damage.
	Lewobele	Damage.
July 12, 1993	Sea of Japan	Destroyed several hundred homes and caused 1.2 billion dollars in damage. 71 ports were damaged.
	Aonae, Japan	340 homes destroyed by flames spread by waves.
	Inaho, Okushiri Island	All houses destroyed.
	Kamenka, Sakhalin	Factory damaged.
	Vladivostok, Russia	Damage ($6.5 million).
	Korea	$0.5 million damage.
Aug. 8, 1993	Guam	Washed truck into Papo Bay and other vehicles washed into Klig Bay.

Jan. 21, 1994	Halmahera, Indonesia	Two meter damaging tsunami.
Feb. 15, 1994	Sumatera, Indonesia	$169 million US.
Jun. 2, 1994	Area south of Java, Indonesia	Several villages destroyed.
Nov. 4, 1994	Skagway, Alaska	$25 million damage.
Nov. 14, 1994	Mindoro Is., Philippines	804 houses destroyed, 3,288 damaged.
May 14, 1995	Flores Sea, Indonesia	Homes and fishing boats destroyed.
Jul. 30, 1995	Northern Chile	$131,000 damage.
Oct. 9, 1995	Jalisco, Mexico	Extensive damage in Manzanillo Bay.
Dec. 31, 1995	Western Corinthos Gulf	Flooding, road partially destroyed.
Jan. 1, 1996	Sulawesi, Indonesia	9 killed by wave at Tonggolobibi.
Feb. 17, 1996	Irian Jaya, Indonesia	Tsunami damaged 5,043 houses.
Feb. 21, 1996	North coast of Peru	Tsunami destroyed 15 houses, & 2 boats, killed 12.
Apr. 21, 1997	Santa Cruz Islands	7 houses washed away.
Jul. 17, 1998	NW coast of Papua New Guinea	Two villages destroyed.
Aug. 17, 1999	Izmit Bay, Turkey	Several coastal villages incurred damage.
Nov. 26, 1999	Vanuatu	Baie Martelli village destroyed.
Nov. 16, 2000	New Ireland PNG	Tsunami damage on SW shore of New Ireland.
Jun. 23, 2001	Southern coast of Peru	Tsunami swept over the town of Camana.

Table 3
Damaging Teletsunamis

Date	Generating Location	Affected Location(s)	Damage
May 26, 1983	Sea of Japan	Korea	70 boats damaged, numerous roads and dwellings damaged $500,000 damage.
		Russia	Fishing boats washed ashore, Ship lines broken.
July 12, 1993	Sea of Japan	Korea	$0.5 million damage.
July 30, 1995	Northern Chile	Tahauku Bay, Marquesas islands	Sank 2 boats.

Table 4
Fatalities from Tsunamis

Date	Location	Fatalities[+]
May 26, 1983	Japan	100
	South Korea	3
Aug. 10, 1988	Solomon Islands	1
Sep. 2, 1992	Nicaragua	169
Dec. 12, 1992	Indonesia	2, 080
July 12, 1993	Sea of Japan	[*]330
Feb. 15, 1994	Sumatera, Indonesia	7
Jun. 2, 1994	Area south of Java, Indonesia	223
Nov. 4, 1994	Skagway, Alaska	1
Nov. 14, 1994	Mindoro Is., Philippines	*87
Jan. 1, 1996	Sulawesi, Indonesia	9
Feb. 17, 1996	Irian Jaya, Indonesia	108
Feb. 21, 1996	North coast of Peru	12
Jul. 17, 1998	NW coast of Papua New Guinea	2,182
Aug. 17, 1999	Izmit Bay, Turkey	150
Nov. 26, 1999	Vanuatu	5
Jun. 23, 2001	South Peru	96
TOTAL		**5,562**

[+]Includes missing
*Earthquake and tsunami

Table 5
Origin Source Parameters for Tsunamis 1982-2002

Event #	Year	Month	Date	Hour (UT)	Minute	Second	Latitude	Longitude	Depth (km)	Max runup (m)
1	1982	1	11	6	10	8	13.732	124.358	46	0.1
2	1982	2	24	4	22	40	4.374	97.755	52	0.1
3	1982	3	11	10	32	27	-9.265	118.479	33	0.1
4	1982	3	21	2	32	8	42.158	142.361	44	1.3
5	1982	7	23	14	23	53	36.194	141.702	37	0.4
6	1982	12	19	17	43	54	-24.133	-175.864	33	0.2
7	1982	12	25	12	28	3	-8.405	123.08	33	0.1
8	1982	12	28	6	37	42	33.826	139.434	22	0.4
9	1983	3	12	1	36	36	-4.056	127.924	17	3.0
10	1983	3	18	9	5	50	-4.883	153.581	89	0.3
11	1983	5	26	2	59	60	40.462	139.102	24	14.9
12	1983	6	9	12	49	4	40.237	139.023	31	0.6
13	1983	6	21	6	25	27	41.346	139.099	10	1.0
14	1983	8	6	15	44	51	40.142	24.766	2	0.1
15	1983	8	17	10	55	54	55.867	161.287	63	0.1
16	1983	8	17	12	17	56	18.231	120.86	29	0.1
17	1983	10	4	18	52	13	-26.535	-70.563	15	0.2
18	1983	11	30	17	46	1	-6.852	72.11	10	1.5
19	1984	1	8	15	24	0	-2.9	118.7	95	0.1
20	1984	2	11	8	2	51	38.396	22.094	29	0.1
21	1984	3	24	9	44	3	44.117	148.192	44	0.2
22	1984	6	13	2	29	25	31.448	140.036	41	0.1
23	1984	8	6	19	6	38	32.386	131.945	46	0.2
24	1984	9	18	17	2	44	34.006	141.5	48	0.1
25	1984	12	28	10	37	54	56.194	163.46	33	0.2
26	1985	3	3	22	47	7	-33.135	-71.871	33	3.0
27	1985	3	16	14	54	1	17.013	-62.448	13	0.1
28	1985	4	13	1	6	0	-9.245	114.185	99	2.0
29	1985	7	3	4	36	52	-4.439	152.828	46	1.3
30	1985	9	19	13	17	47	18.19	-102.533	28	3.0
31	1985	9	21	1	37	13	17.802	-101.647	31	2.5
32	1986	5	7	22	47	11	51.52	-174.776	33	1.4
33	1986	10	20	6	46	10	-28.117	-176.367	29	0.2
34	1987	2	6	13	16	18	36.988	141.689	48	0.1
35	1987	2	8	18	34	0	-6.1	147.7	62	1.5
36	1987	3	5	9	17	5	-24.388	-70.161	62	0.2
37	1987	3	18	3	36	30	32.034	131.837	54	0.1
38	1987	3	24	12	49	47	37.447	137.865	23	0.1

Event #	Year	Month	Date	Hour (UT)	Minute	Second	Latitude	Longitude	Depth (km)	Max runup (m)
39	1987	6	18	14	3	15	-10.707	162.326	73	0.1
40	1987	7	6	2	49	43	-14.074	167.828	48	0.1
41	1987	10	6	4	19	6	-17.94	-172.225	16	0.3
42	1987	10	12	13	57	5	-7.288	154.371	25	0.1
43	1987	10	16	20	48	2	-6.266	149.06	48	0.1
44	1987	11	17	8	46	53	58.586	-143.27	10	0.1
45	1987	11	26	1	43	14	-8.247	124.155	33	0.1
46	1987	11	30	19	23	20	58.679	-142.786	10	0.9
47	1988	2	5	14	1	3	-24.753	-70.433	37	0.1
48	1988	3	6	22	35	38	56.953	-143.032	10	0.4
49	1988	4	20	0	0	0	40	13	10	5.5
50	1988	6	24	2	6	26	18.606	121.013	53	0.6
51	1988	7	5	20	32	7	-5.964	148.78	53	0.1
52	1988	8	10	4	38	26	-10.366	160.819	34	0.2
53	1989	5	23	10	54	46	-52.341	160.568	10	0.2
54	1989	6	26	3	27	4	19.362	-155.083	9	0.6
55	1989	9	4	13	14	58	55.543	-156.835	11	0.1
56	1989	10	18	0	4	15	37.036	-121.883	19	0.4
57	1989	10	29	5	25	38	39.571	143.333	10	0.1
58	1989	11	1	10	25	52	18.986	-68.833	26	0.1
59	1989	11	1	18	25	35	39.837	142.76	29	0.9
60	1990	2	20	6	53	39	34.706	139.252	14	0.3
61	1990	3	25	13	16	6	9.814	84.828	27	0.3
62	1990	4	5	21	12	36	15.125	147.596	11	0.6
63	1990	5	0	0	0	0	7	126	0	0.1
64	1990	9	23	21	13	7	33.267	138.643	10	0.2
65	1990	12	13	0	24	25	37.3	15.438	11	0.1
66	1991	1	4	0	0	0	38	27	0	0.1
67	1991	2	9	16	18	58	-9.929	159.139	10	0.1
68	1991	2	16	1	23	40	48.268	154.238	39	0.1
69	1991	2	21	2	35	34	58.427	-175.45	20	0.3
70	1991	4	22	21	56	52	9.685	-83.073	10	2.0
71	1991	10	14	15	58	12	-9.094	158.442	23	0.2
72	1992	1	5	14	30	0	19	109	0	0.8
73	1992	4	25	18	6	4	40.368	-124.316	15	1.8
74	1992	5	17	10	15	31	7.191	126.762	33	0.1
75	1992	5	27	5	13	39	-11.122	165.239	19	0.1
76	1992	7	18	8	36	59	39.419	143.33	29	0.3
77	1992	9	2	0	16	2	11.742	-87.34	45	10.0
78	1992	12	12	5	29	26	-8.48	121.896	28	26.2
79	1993	2	7	13	27	42	37.634	137.245	11	0.5
80	1993	5	7	0	0	0	38	26	0	0.5
81	1993	6	8	13	3	36	51.218	157.829	71	0.1

Event #	Year	Month	Date	Hour (UT)	Minute	Second	Latitude	Longitude	Depth (km)	Max runup (m)
82	1993	7	12	13	17	12	42.851	139.197	17	10.0
83	1993	8	8	8	34	25	12.982	144.801	59	2.1
84	1993	11	13	1	18	4	51.934	158.347	34	0.1
85	1994	1	17	12	30	55	34.213	118.537	18	0.1
86	1994	1	21	2	24	30	1.015	127.733	20	2.0
87	1994	2	15	17	7	43	-4.967	104.302	23	0.1
88	1994	4	8	1	10	41	40.608	143.683	13	0.2
89	1994	6	2	18	17	34	-10.477	112.835	18	9.5
90	1994	6	3	21	6	59	-10.362	112.892	26	3.7
91	1994	6	4	0	57	51	-10.777	113.366	11	3.0
92	1994	9	1	15	15	53	40.402	-125.68	10	0.1
93	1994	9	19	0	0	0	-4.238	152.214	0	1.2
94	1994	10	4	13	22	56	43.773	147.321	14	11.0
95	1994	10	8	21	44	7	-1.258	127.98	17	3.0
96	1994	10	9	7	55	40	43.905	147.916	33	0.2
97	1994	11	5	4	10	0	59.5	-135.32	0	2.0
98	1994	11	14	19	15	31	13.525	121.067	32	7.3
99	1994	12	28	12	19	23	40.525	143.419	27	1.1
100	1995	1	16	20	47	52	34.583	135.018	22	0.2
101	1995	4	7	22	6	57	-15.199	-173.529	21	0.3
102	1995	4	21	0	34	46	12.059	125.58	21	0.2
103	1995	4	21	5	17	1	12.047	125.92	27	0.2
104	1995	5	13	8	47	13	40.149	21.695	14	0.1
105	1995	5	14	11	33	19	-8.378	125.127	11	1.5
106	1995	5	16	20	12	44	-23.008	169.9	20	0.5
107	1995	5	27	13	3	53	52.629	142.827	11	0.1
108	1995	6	15	0	15	49	38.401	22.283	14	0.5
109	1995	7	30	5	11	24	-23.34	-70.294	46	3.0
110	1995	8	16	10	27	29	-5.799	154.178	30	0.6
111	1995	9	14	14	5	31	16.779	98.597	23	0.4
112	1995	10	9	15	35	54	19.055	-104.205	33	5.1
113	1995	10	18	10	37	26	27.929	130.175	28	2.6
114	1995	10	19	2	41	36	28.094	130.148	20	1.5
115	1995	11	1	0	35	32	-28.906	-71.417	20	0.1
116	1995	11	22	4	15	12	28.826	34.799	10	0.1
117	1995	12	3	18	1	9	44.663	149.3	33	1.1
118	1995	12	31	0	0	0	38.1	22.4	0	2.0
119	1996	1	1	8	5	12	0.724	119.981	33	2.9
120	1996	1	2	15	40	0	54.45	159.318	33	30.0
121	1996	2	17	5	59	30	-0.95	137.027	33	7.7
122	1996	2	21	12	51	4	-9.62	-79.568	33	5.1
123	1996	2	25	3	8	16	15.978	-98.07	21	0.1
124	1996	6	10	4	3	35	51.564	-177.632	33	1.0

Event #	Year	Month	Date	Hour (UT)	Minute	Second	Latitude	Longitude	Depth (km)	Max runup (m)
125	1996	6	10	15	25	56	51.478	-176.847	26	0.3
126	1996	9	4	18	16	2	31.555	139.931	33	0.3
127	1996	9	5	8	14	14	-22.118	-113.436	10	0.2
128	1996	10	18	10	50	21	30.568	131.093	10	0.2
129	1996	10	19	14	44	41	31.885	131.468	22	1.1
130	1996	11	12	16	59	44	-14.993	-75.675	33	0.4
131	1996	12	2	22	17	59	31.789	131.314	49	0.2
132	1997	4	10	0	0	0	13.1	-87.6	49	15.0
133	1997	4	18	15	6	0	-29	167.6	49	0.1
134	1997	4	21	12	2	26	-12.584	166.676	33	1.0
135	1997	7	9	19	24	13	10.598	-63.486	20	1.0
136	1997	10	14	9	53	18	-22.101	-176.772	167	0.1
137	1997	12	5	11	26	55	54.841	162.035	33	1.5
138	1997	12	15	15	0	0	54.841	162.035	33	8.0
139	1997	12	26	8	0	0	16.7	-62.2	33	3.0
140	1998	3	25	3	12	25	-62.877	149.527	10	0.1
141	1998	5	3	23	30	22	22.306	125.308	33	0.1
142	1998	7	17	8	49	13	-2.961	141.926	10	15.0
143	1998	11	29	14	10	31	-2.071	124.891	33	2.8
144	1999	8	17	0	1	39	40.748	29.864	17	2.5
145	1999	11	26	13	21	16	-16.423	168.214	33	6.6
146	2000	1	26	0	0	0	5.2	120.3	26	20.0
147	2000	3	29	0	0	0	38	-123.2	26	15.0
148	2000	5	4	4	21	16	-1.105	123.573	26	6.0
149	2000	6	18	14	44	13	-13.802	97.453	10	0.3
150	2000	7	1	7	1	56	34.221	139.131	10	0.1
151	2000	11	4	0	0	0	43	-127	10	7.0
152	2000	11	16	4	54	56	-3.98	152.169	33	1.0
153	2000	11	16	7	42	17	-5.233	153.102	33	1.0
154	2001	6	23	20	33	17	-16.1	-73.4	33	4.0
155	2002	3	5	21	16	9	6.17	124.28	114	1.5
156	2002	3	26	03	:45		23.47	124.06	33	0.1
157	2002	3	31	6	52	50	24.4	122.21	42	0.2

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