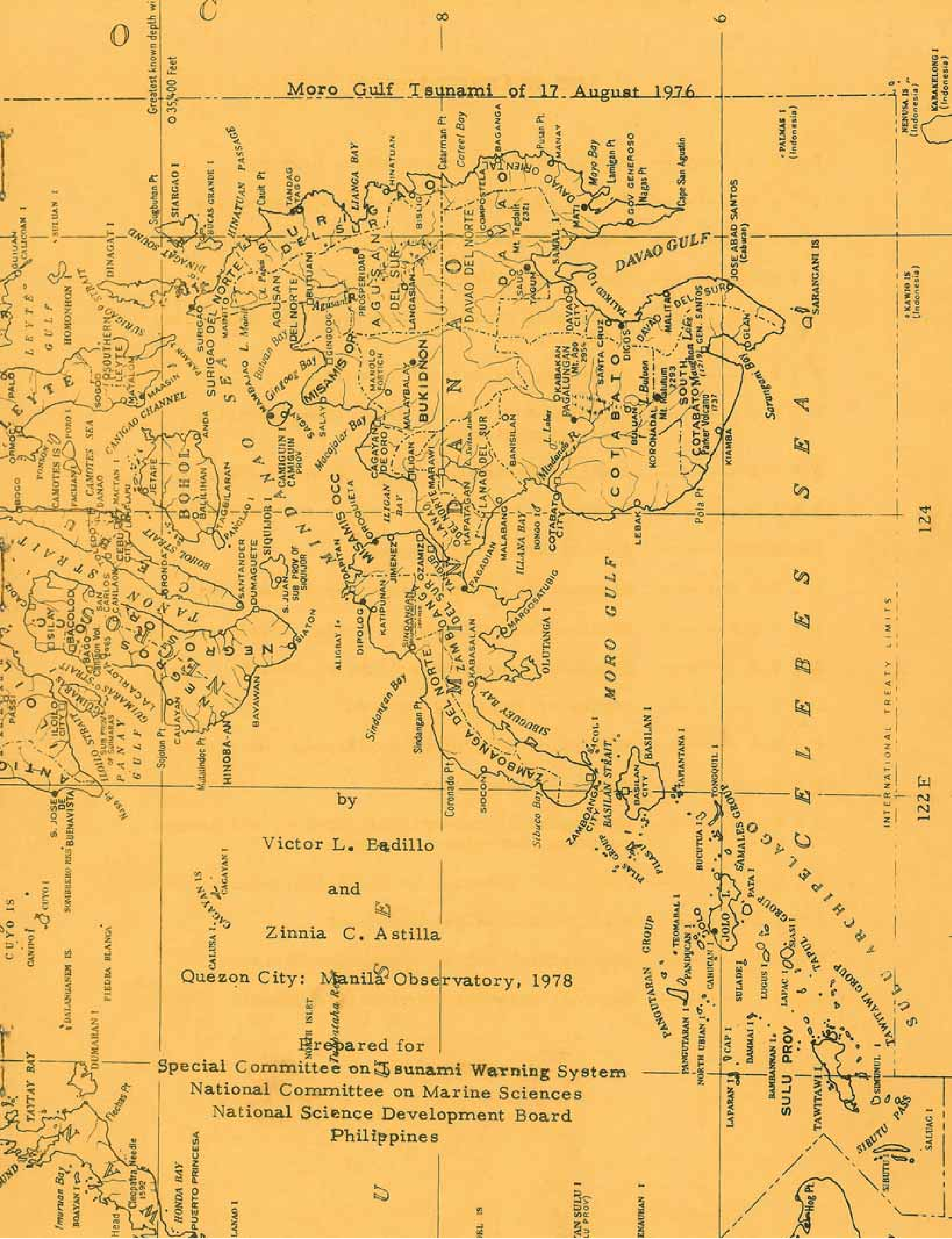
Moro Gulf Tsunami of 17 August 1976



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1. Introduction

A few minutes after midnight on 17 August 1976, a violent earthquake originating beneath Moro Gulf spawned a tsunami that affected 700 km of coastline bordering Moro Gulf. Residents in those areas experienced what seemed to be the longest thirty minutes of their lives.

When the sea had spent its fury and rolled back to its normal cadence, the survivors looked upon scenes of death and destruction. About 8,000 were dead or missing. About 10,000 were injured and about 90,000 were homeless. The disaster received more than ample media coverage, local and international. Priority was given to relief and rehabilitation efforts, to help the living rebuild lives and livelihoods. Little noticed were the tsunami studies jointly made by PAGASA and ITIC scientists.

A tsunami does not come as often as typhoons, earthquakes or conflagrations. One consequence is lack of information and interest on the part of the general public. One year after the event, on the first anniversary of the tsunami, there was not a single line in the Manila papers, except for a full page ad by BFAR detailing rehabilitation progress in Bongo Island. The purpose of this study is to present findings about this tsunami for a better understanding of it and that steps may be taken to lessen loss to lives and property in future tsunamis. Since much work has already been done on earthquakes and earthquake engineering, emphasis will be put on the tsunami. Only those aspects of earthquakes that are needed to understand tsunamis will be considered.

2. The Earthquake

The earthquake responsible for the tsunami occurred a few minutes after midnight (120° East local time) beneath Moro Gulf, 40 km off the shores of Sultan Kudarat province. G.M.T. time of occurrence was 16:11:07.2 on 16 August 1976. It was a shallow earthquake of magnitude variedly determined between 7.9 and 8.2, whose epicenter was 124.E, 6.3N. The isoseismal zones determined by PAGASA using the Rossi-Forel scale (Kintanar 1976) is shown in Fig. 1. VII, the highest intensity determined, was felt in the coastal regions of the crescent shaped gulf. These were the regions that felt the force of the ensuing tsunami. While not the highest intensity possible, it was enough to waken people and to render standing straight difficult. Useful and vital effects to remember by people in coastal areas. Almost universally, no one made the connection between the severe earthquake and probable tsunami. They just stayed where they were. Tragically some ran to the shores. Besides the tsunami, the earthquake also

generated a seaquake and a lake seiche to be discussed below.

Useful data for the understanding of this tsunamigenic earthquake and of the tsunami itself have been provided by Su (1978). A. From a study of the aftershocks from August 1976 to April 1977 it is concluded that: (1) the slippage was along a fault surface that was nearly vertical and almost north-south or trending NW-SE, i.e. N35W. (2) rupture length was 160 to 180 km; (3) rupture depth was 70 to 80 km. B. The seismic moment calculated from a surface wave magnitude of 7.9 was 2.38×10^{28} dyne-cm. C. The average fault displacement (sea-floor displacement) calculated from A and B above was about 2.5 meters. D. Focal mechanism solution shows that NE side of the fault had moved up relative to the SW side. In Figure 1 are sketched the epicenter, rupture line and aftershocks area (elliptical shape). The pattern of aftershocks helps to determine the orientation of the fault surface, since the hypocenters of the aftershocks are usually scattered about the fault surface. In terms of plate tectonics, the slippage is that attributed to one plate subducting under another.

The characteristics of this tsunamigenic earthquake are then: great magnitude, shallow hypocenter, beneath a body of water, large rupture length, dip slip faulting or vertical displacement. With present equipment and analytic methods, epicenters and magnitudes may be determined within fifteen minutes but much time is needed to determine the nature of the fault slippage. Clearly, seismic data alone cannot be used to provide warning to people about to be hit by a tsunami within 15 minutes. The exception is that severe quakes can be nature's warning to coastal area residents.

Many submarine shallow earthquakes of great magnitude (7.9 or greater) occurred in the Mindanao area (Richter 1958). Beneath the Moro Gulf area or the immediately neighboring Celebes Sea alone five great earthquakes have occurred since 1897, or roughly one every 16 years. They are listed below and appear as "x" in Fig. 1.

date	magn.	North	East	Ref.
20 Sep 1897	8.6	6.	122.	S
21 Sep 1897	8.7	6.	122.	I, S
14 Mar 1913	8.3	4.5	126.5	I ?
15 Aug 1918	8.3	5.5	123.	I, S
16 Aug 1976	8.2	6.3	123.7	

Tsunamis have been caused in this area by submarine earthquakes of smaller magnitude which are listed below and appear "o" in Fig. 1.

date	magn.	North	East	Ref.
21 Dec 1636		7.	123.5	R
5 Feb 1889		7.	123.5	R
21 Aug 1902	7.25	7.5	123.5	I, S
31 Jan 1917	7.	5.5	125.	S
2 Mar 1923	7.25	6.5	124.	S
19 Dec 1928	7.25	7.	124.	I, S

(References: I - Iida et al. 1967; R - Repetti, 1948; S - Soloviev and Go, 1969, 1974)

Some doubt about tsunamis may be cast on the first two, but in both cases seaquakes were distinctly felt (indicative of a submarine epicenter). Even excluding these two, the frequency of tsunamis is raised to one every nine years. What becomes apparent is that the Moro Gulf area has been the most tsunami prone area of the Philippines. In a statistical study of tsunamis in the Philippines, Nakamura (1977) finds the Moro Gulf area to be the most tsunami prone, followed by Eastern Mindanao, then by Western Luzon. Further geological and seismological studies should indicate prospects of future activity in this area..

3. Seaquake

In some past tsunamis, seaquakes were also generated by the earthquake. Thus an effort was made to determine if a seaquake had been observed. This would help in the compilation of tsunami catalogs in cases where absence of coastal residents made reporting of innundation impossible. The captain of Alfredo, a 20-meter long passenger ship shuttling between Zamboanga City and Olutanga Island, felt the ship shudder sometime in the night as though it had hit a log (golpe de troso). It was only on reaching land at 4:00 a.m. and seeing the destruction at Subanipa, Olutanga that he connected the earlier event with the earthquake. In Figure 1, letter α indicates the estimated position of the ship during the shudder. Furthermore, in that general neighborhood some ships had wanted to send an S.O.S. signal when they felt as if their ship's propeller was turning in sand.

The Don Luis of Aboitiz Lines, cruising on a calm sea in a north-south direction from Pagadian City, was about four km from Punta Flecha when it started to rock and the mast began to creak. The captain thought that the ship had run aground. There was no damage, nor did objects fall. The position then of the 1,256 ton, 68-meter long ship is indicated by letter β in Fig. 1., almost directly on top of the rupture line. Three hundred forty years before, in that same

area at about midnight, Spanish ships had felt a similar experience.

The Kahuna of Lusteveco, a 133-meter long tugboat, was anchored a few meters from a wharf in General Santos, South Cotabato when small waves rocked the ship. The crew attached no significance to these until they learned of the damage on shore due to the earthquake. The position of the ship then is indicated by letter γ in Fig. 1. (A seiche was reported in Lake Sebu indicated by letter δ in Fig. 1.)

A list of ships scheduled to have been in the Moro Gulf at the time of the earthquake had been compiled, but it has been very difficult to contact crew men who were in Manila for less than three days before embarking for another long two week interisland duty. It seems clear that a seaquake (shock wave) was experienced by Alfredo, Don Luis and the other unnamed ships, all positioned far from shore. In the first two cases, at least, the surface of the water was undisturbed. The waves experienced by Kahuna serves to indicate that the tsunami (water waves) had at least gone that far. They may have been observed even farther, as far as Davao. It also shows how the disturbance, albeit practically harmless by now, had curved into the sheltered bay.

4. Lake Seiche

In Surallah, South Cotabato, water movements were reported in Lake Sebu (position δ in Figure 1) suggesting the occurrence of a seiche. Lakeshore residents do not specify the number of waves which hit the shore. The estimates of wave heights have been consistently set at 1.5 meters. Persons awakened by the earthquake estimated about a two-minute delay before the first wave. It inundated an area up to five meters from the shoreline. The incoming wave was preceded by a recession of the water. Casualties and damage to houses were reported but figures were not given.

Twenty three years earlier, a seiche occurred in Lake Lanao as a result of the Lanao earthquake of 1 April 1955. (The earthquake did not have an underwater epicenter). The water, rising up to three meters high, swept water lilies from the lake to rice paddies located up to 300 meters from the water's edge (Kintanar 1955).

5. Description of the Waves

For a better understanding of the effects of the tsunami a bathymetric map of Moro Gulf, Figure 2, was studied. It is quite interesting. Depth slopes are steeper due east than due west, while great depths of about 5 km are in elongated area running north-south. The fracture

zone runs parallel to this short trench. The bathymetric data was used to compute travel times of the waves. Wave velocity, V, varies with depth, D. In practical units we have

$$V(kph) = 356\sqrt{D(km)}.$$

For the depths involved, the velocity would vary from 800 kph at the deepest part to about 80 kph as the shore is reached. A four-minute miler (24 kph) would despair of outrunning such waves. Total travel times were obtained by stepwise summation over the different depth intervals. Theoretical isochronal travel times at five minute intervals are shown in Figure 3. Indicated too are some places that were hit by the tsunami. We have assumed a point source at the epicenter taken to be 123.7E, 6.3N. Reported arrival times after the shock for various places are listed in Table 1. The sequence of the places listed follows their geographical location. Listed too are theoretical delay times. Discrepancies may be harmonized if travel times were computed using a line source running along the rupture line. In any case, some shores were hit within five minutes. A rather short time - but long enough for those who take proper action instinctively. For the future, plans should aim for evacuation to higher ground within five minutes of a violent earthquake. The travel time curves would be basically the same as long as the source is in Moro Gulf. Two factors worked to make the travel time to Lebak very short, the short distance and the great depths.

As the waves approached the shore, the wave heights increased. Measured and estimated values of wave heights by PAGASA/ITIC never exceeded 4.3 meters. As expected these values are less than those given by survivors, considering their state of mind at the time. Estimates of wave heights had to be based on qualitative descriptions of the waves being as tall as a coconut tree, a two storey house, twice a man's height, etc. or had to be deduced from photographs of damaged structures. A listing of wave heights at various localities is given in Table 1. Places where waves were reported to be higher than five meters are: Linek (Maguindanao), Kalanganan (Cotabato City), Pagadian City, Sacol Island (Zamboanga City) and Lebak (Sultan Kudarat). At Lebak waves may have been as high as nine meters. At the time of the tsunami, the water level was almost exactly between high and low tide. The normal water level would have been 0.9 meters above mean lower low water level. If the tsunami had occurred three hours earlier (later) the resulting wave heights would have been greater (less).

That wave heights varied from place to place is ultimately a function of local bottom topography and coastline configuration. But the immediate reason is not yet fully known. But these empirical obser-

vations are immediately useful as a basis for disaster planning such as the delineation of areas to be evacuated. Figure 4 shows such an inundation map drawn up for Makaha, a coastal town in Hawaii (Cox, 1961). It has the virtues of simplicity and ease of understanding. Local officials in affected coastal strips around Moro Gulf can easily make them. With such maps the population would have a clear idea of where to go and precious moments would not be lost.

That there were three or four waves were indicated by the majority of respondents. The largest number was seven, reported by one person. One thing is definite - there was more than one wave. Majority of respondents estimated the interval between waves to be between one to five minutes. As many considered the first wave to be the most destructive as considered it was the third. At the time of the earthquake the last quarter moon was some 30 degrees above the eastern horizon, so that there was enough light to see.

Information was also sought on runup or extent of horizontal inundation. How far inland did the waters go? A listing of values for the different places is given in Table 1. Predictably, a great variety of answers were obtained since much depends on whether the land slopes gently or steeply. Maximum runup reported was two kilometers.

A common observation at widely scattered places was a deep recession of the water before the arrival of the first wave. A listing of the places is given in Table 2. The water receded much farther than usual and thus merited notice. At Lebak the sea receded as much as two kilometers, far enough to leave an island standing like a mesa. At one place the recession was accompanied by a sucking sound. Some persons ran out to the newly exposed sea bottom out of curiousity or to pick up stranded fish.

Another common observation was a loud roaring that preceded the arrival of the waves, a loud sound that kept getting closer. A listing is given in Table 2. People living by the sea are familiar with the different sounds of the sea and can distinguish between them. Several independently had the same reaction at different places. On hearing what seemed like cascading rain, they looked up and wondered why the sky was clear. It was an unusual sound. And a loud one too. At San Jose, one kilometer inland from Pagadian, the sounds of the sea are not heard, but this roar was distinctly heard. In short, the sound was strange, strong and frightening. While it is clear that the sound was coming from the incoming waves it is not clear what specifically was causing the sound.

Information was obtained too about the appearance of the incoming

waves. At Lebak the water level just kept rising - like a tide. At Sacol Island and at Bongo Island, it was a wall of water advancing - like a bore. At Pagadian, a tilted wall of water straightened up and crashed down - like a breaker. The variety of bottom topography would explain the variety of appearances. Whatever the appearance, damage was caused.

The sequence of events then was as follows. A shock violent enough to awaken coastal residents and make standing or walking difficult. A strong, prolonged, approaching sound different from familiar sea sounds, a frightening sound variedly described as cascading rain, rumbling of many trucks, etc. Arrival of waves within minutes, preceded by an unusually deep recession of the sea. Two or three waves following the first. Thus there were several distinct precursory indicators that could serve as natural warnings of a probable tsunami. They need not all be present in every tsunami. In fact, histories of other tsunamis make little mention of the strange sound preceding the waves.

6. Effects of the waves

A description of the waves would be incomplete without a listing of their effects. In Linek a medium sized grader was moved a few meters. In Pagadian it was a bulldozer. At Lebak inhabitants found the shore strewn with meter sized rocks dragged in by the sea. Not one coconut tree but a grove was uprooted (Photo 6). A tree one meter across was uprooted (Photos 5, 7). Cars were battered (Photo 11). A bore rushing up a river in Pagadian damaged a bridge. Wharves were damaged by boats dashed against them or by erosion of foundations (Photo 8). Bancas (native boats) and commercial fishing boats were sunk. Fish corrals (Photo 10), oyster farms (Photo 9) and seaweed farms were destroyed or damaged. Inland fishponds were either flooded or emptied of water (!). Partially concrete houses, schools, public building, factories, etc. were reduced to a few concrete slabs, wooden stumps and twisted steel (Photo 13). At Port Lebak a veneer factory was damaged by the battering ram effect of floating logs and debris. At Lebak the barge M/T <u>Provider</u> was carried inland and then brought out to sea again, but not sc the pumpboat in Photo 12. Against such fury what chance did frail makeshift homes have? (Photos 2, 3, 4, 14, 15, 16)

7. Casualties and Damages

The toll of lives is given in Tables 3 and 4 for Regions IX and XII respectively. Other Regions were little or not affected by the tsunami. It is important to give the breakdown according to localities to discern

any pattern such as directivity in the spread of energy. Reports from Region XII distinguishes death caused by the earthquake from those caused by the tsunami. But since the localities mentioned in Region IX are on the coast and since the structures destroyed did not involve resident persons, we may consider that 95% of the casualties were due to the tsunami. No breakdown is given according to sex or age. But a reliable source has stated that casualties were mainly children and women, and that children to adults ratio was four to one.

To make comparisons between affected areas, scales were devised. A simple scale of three was used for casualties. A separate scale for destruction was obtained by adopting that of Seiberg. The listing of the places with their double ratings are given in Table 5. Among those given a "c" rating, 10 are found in Region XII compared with 9 in Region IX. All of these are in immediate vicinity of the fracture line. There is some indication of directivity, more in the direction perpendicular to the fracture line than parallel to it. In the perpendicular direction, more to the east of the line than to the west. And in the parallel direction more to the north than to the south.

A bit puzzling is the great number of casualties in Maluso. It is on the west side of Basilan, on the side facing away from fracture line. Similarly puzzling is Wigen's finding that the time delay between earthquake and tsunami was much shorter in the western villages of Basilan than on the eastern ones. This amplifies somewhat the entry in Table 1.

Deaths were caused by drowning. With the collapse of their homes around midnight, the victims found themselves in dark, turbulent waters. Those who survived managed to do so because their grip on something firm prevented their being swept out to the open seas. This is a case where the waves accomplished more damage as they left. One father had clung to a tree and his children in turn clung to him. When the waves receeded, he was all alone. This was a tale that was repeated many times over. While swimming may be as natural as breathing to sea dwellers, in Pagadian the tsunami had churned the waters and slum sediments into a batter of mud that choked victims.

A tabular presentation of damages according to various categories is given in Table 6. Earlier above a pictorial presentation was given. The sources do not segregate damage caused by the earthquake from that caused by the tsunami. The figures under column 1 may be considered due to the tsunami. There is a correspondence with the casualty figures. Other categories that may be directly linked to the tsunami are those in columns 5, 7, 8, 9 and 10. In Region XII the greatest overall damage is clearly seen to be that suffered by Maguindanao province, whose coastline runs parallel to the fracture line. In

Region IX no overall leader stands out clearly. The sources for figures in this Table provided totals per province without breakdowns for localities. However other sources made it possible to give ratings according to the Seiberg scale to localities and these are given in Table 5. There is no rating below 3 for Regions IX and XII. Maguindanao, Sultan Kudarat and Lanao del Sur abound in 6s and 5s. Severity in Zamboanga del Sur is just a bit less. The distribution of ratings support the conclusions above concerning the directivity in the spread of energy derived from the distribution of casualties. The total picture is that of severe and widespread destruction. Estimated peso values of damages have been 230 and 180 million for Regions XII and IX respectively.

8. Summary and Recommendations

The Moro Gulf tsunami of 17 August 1976 was the most disastrous tsunami experienced by the Philippines. There have been more severe tsunamis, but areas hit were less populated and had less manmade structures. A natural disaster is not merely a geophysical event but a human one as well. If any projection can be made it is this. What is now barren will be densely populated. Empty beaches will be filled with residences, tourist facilities, hotels, factories, power plants, etc. Offshore, there will be not merely seaweed and oyster farms and fish corrals but also storage facilities, tank farms and the like. Thus a tsunami prone coast is potentially a great disaster area. Such is the Moro Gulf coastline.

That an area is tsunami prone must be related to the peculiar geophysical and geological structures of the locality. Thus to arrive at a more accurate tsunami risk map, besides historical research what are needed are further seismological, geophysical and bathymetric studies. The art of tsunami warning is advanced by advances in the art of predicting earthquakes. It is a desirable goal to be able to predict when a coastal area will be hit by an earthquake of magnitude 6.5 and greater. On being informed about the probable occurrence of a tsunamigenic earthquake, coastal inhabitants and local authorities could at least review disaster procedures. These are long range goals.

An immediate and realizable goal is to require local officials to prepare local inundation maps. Basically this is a street map of a town with dangerous areas to be evacuated crosshatched. These maps can be drawn empirically by knowing which areas were inundated by past tsunamis. If there are contour maps available, one can determine all areas below a chosen height above sea level, for example six meters, as places to be evacuated. Incidentally these maps would be of use

also to engineers, architects, land use planners, building code drafters, insurance agencies and the like.

It is impossible for a national agency to provide warning to inhabitants about to be hit by a tsunami generated by a local earthquake. It would be fatal to wait for a radio broadcast and the like before moving into action. There is already a warning available, one provided by nature herself - the violent shock of an earthquake. If the shock is violent enough so that it is difficult to stand or walk, then it is time to seek higher ground at once. Going to a higher ground will not mean going a long distance if local inundation maps exist and are known.

It is one thing to have these maps and quite an altogether different thing for people to use them. What becomes clear is that education is needed, an extremely difficult task, a never finished task.

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EXCERPTS FROM PERSONAL ACCOUNTS OF SURVIVORS OF THE 1976 MINDANAO TSUNAMI

Soldiers of the 31st Infantry Battalion in Lebak and Malabang were roused by roaring sounds that seemed to come from underground. The roaring was followed by whizzing sounds which steadily grew louder and louder... The soldiers were able to save themselves by clinging to mangroove trees when washed inland and into the swamps by the tidal waves. Their equipments, including a two-way radio were lost.

De Vera, J., "Dead In Quake," Bull. Today, Aug. 19, 1976.

A housewife of Pagadian City said that at about 12:15 A.M. the earth started to move. She woke up her 10 children to evacuate to higher grounds knowing that a tidal wave would follow a powerful tremor. Five minutes later, giant waves roared half-a-kilometer inland washing away hundreds of houses along the coast.

Eyewitnesses (in Pagadian City) said they saw a towering reddish light in the horizon immediately after the tremor. Then the waves came, washing away thousands of persons and houses.

Cal, R.B., "Pagadian Residents Pick Up The Pieces," Phil. Daily Express, Aug. 19, 1976, 1,8.

Aside from the powerful bulldozer, Charlie Company of the 512 Engineering Battalion in Linek also had three dump trucks, a grader and a heavy all-steel roller treated as toys (by the tidal wave) and now lie against the base of the hill on which the company headquarters is located... The smashed remains of two passenger jeepneys... the pre-fab school building now a crumpled mass of twisted steel girders and galvanized iron sheets... the (other) wreckage of the village lie scattered over a one hectare area.

Allan, A.D., "Once, A Village Flourished Here," Phil. Daily Express, Aug. 20, 1976, 1,8.

"I couldn't stand up, was dizzy and nauseated on feeling the earthquake. After a while talking with fear-striken people, I went to my room but came down at once upon hearing a loud rumbling like many trucks together. Someone shouted it was the surf. The noise had been the roar of a giant wave which swept little huts on stilts."

Aguinalde, J. Fr., Asian Report, Sept. 15, 1976.

"We were asleep. I woke up as the house rocked like a boat caught in a storm... We all rushed out of the house... for safer ground. Seconds after, the killer wave engulfed our house." It was a nightmare beyond belief. (Warlito Fausto, 33, route helper)

Jolted from bed, F. Basibas ran to the porch and saw the sea heave up into a huge wave. He herded his family and just ran while the wave roared behind (them).

When the water receded, their house was found several meters away from where it once stood.

Finding the house intact after the earthquake stopped, Teodoro Blasco went to a nearby store to buy some cigarettes. Suddenly he heard frantic shouts: "Tidal waves! Tidal waves!" He gathered his family and ran. About 15 meters away, the waves engulfed his house and came rushing at them.

He went back to their house... to retrieve some belongings. He jumped out when he heard the already familiar roar from the sea.

Romeo Yamit was just going back to bed (after the last strong tremor) when he heard knocks on the door, and people shouting: "Ang dagat! Ang dagat! (the sea! the sea!) He heard the sound of wind and rushing water.

Del Mar, S., San Miguel Corp.'s Kaunlaran, Aug. 1976, 9-12.

In the vicinity of Linek, visited by the writer, about 100 km. from the epicenter, all nipa shacks and houses within 200 meters of the coastline numbering into hundreds were completely demolished by the tsunami. Accoring to the surviving eyewitnesses, the quake woke them up, then they heard the sound of cascading rain but there was no rain and then the tsunami came within five to ten minutes.

Hizon, A., Observations, 1977.

The sitio where they (Mrs. Usop's family of Kalanganan) live is 100 meters from the beach. Together with the other residents, they boarded a banca when they saw the ground by their feet cracking. Then they heard a loud roaring sound from afar like a very strong rain coming. Within about two minutes, the first wave struck, followed by six more. According to her, "The waves rose over the roof tops... The waves dashed us over the swamps. I must have lost consciousness. For then, I found myself about two kilometers from our sitio."

"At the first strong tremor, we ran to the mosque about 50 meters away along the road... we heard a strong sound like that of the six by six army truck. Then, one girl peeped out and saw the wall of water dashing in. All ran to the hill about 250 meters away. But the sea was too fast for us. I found myself in swirling water... 20 feet deep... was able to grasp a coconut tree." (Ms. Alibay Benito, school teacher at Linek Elem. Sch.)

"Death Came Close But they Escaped," Mindanao Cross, Aug. 21, 1976.

A family from Pagadian relate that they heard an unasually strong, strange roar coming from the sea. "With half moonlight, we saw giant waves as high as 50 feet fast approaching the shore. Tidal wave! I exclaimed... I had not run 60 meters when I saw my wife and three kids

being engulfed by waves as high as a building... A giant wave fell on me and after a minute another big wave rolled on me..."

Rimando, A., "God Why Did This Disaster Happen to Us?" Phil. Daily Express, Aug. 21, 1976, 6.

"There was an interval of about 15 minutes after the quake before water from the sea swept inland and flooded a stretch of about 500 meters. The tidal waves followed immediately after." (Laureano Tan of Magsaysay and Sons Veneer Factory, Lebak, Sultan Kudarat).

"Water from the sea rose and flooded the street knee deep. When I looked back while running I saw a tidal wave as tall as a house. The wall of water was accompanied by loud sounds like boiling water. I saw about 3 tidal waves." (Herson Pineda of Magsaysay & Sons Veneer Factory)

Philippines Daily Express, Aug. 23, 1976.

"When waves swept us out together with our house, I found that my arms (previously holding 5 kids) were empty... then I saw my little girl, her small fingers disappearing into the water, waving for help that never came." (Gloria Bitancor, 35)

"I was asleep... then everything hit my head... the water, the walls... about 5 minutes in the water, grabbing anything." (Cara Gausman, 22)

"My father was swept out to the sea, then swept back in again alive with the next wave." (Anonymous woman)

"The Fates Are Angry." Time Magazine, Aug. 30, 1976, 44, 47.

It was nearly midnight when I was awakened by a loud strong roar that seemed to come from the sea. I was about to go back to sleep when a strong tremor shook our house... We were on our way to a safer place when we heard the strong roar again. Some said it was made by big waves from the sea, but most people did not pay attention to it... which was unfortunate for then we found ourselves in swirling water.

Translated into English from a letter by Ismael Ibrahim to the BFAR staff.

A strong earthquake roused the residents of the village. It was past midnight but the moon was bright. Hence, some saw the sea recede about two kilometers and left exposed an island nearby. Then they heard a loud sound likened to that made by a train.

Mr. Isidro Fernandez, in an interview held at Sta. Clara Lumber Co., Makati, Nov. 3, 1977.

The residents were caught unaware by the tidal waves, which also brought big rocks to shore. According to the victims, a loud roaring sound preceded the arrival of the waves.

Mr. Art Herrera, in an interview held at the BFAR, Quezon City, Dec. 6, 1977.

Table 1

WAVE HEIGHTS, DELAY TIME, NUMBER OF WAVES AND EXTENT OF WATER PENETRATION

Place	Source	Wave Hts. (Meters)	Delay Time (Minutes) @	Delay Time (Minutes) #	No. of Waves	How Far Inland (Km)
<u>South Cotabato</u>:						
Lake Sebu, Surallah	b	1-1.5		2-3		.5
<u>Sultan Kudarat</u>:						
Lebak	a	*3.4	5			
	d	4.6-9.0			3	1
<u>Maguindanao</u>:						
Resa	a	4.3				
	c	3.7	11	2-9	4	1-2
Kinimi	a	4.3	11			
Cusiong	c	3.7	15	10-20	3	1-2
Linek	a	4.3				
	c		15	5		
	d	6.1				.25
Pinansaran	a	4.3	12			
Upi	c	3.7	15	5-10	3	1-2
Parang	b	3.7	25	10		
	c	3.7		5-10	3	1-2
Magsaysay	c	3.7		5-10	3	1-2
Bongo Island	a	4.3				
	b	4.6		10		
	c	4.6	10	2-9	3	1
<u>Cotabato City</u>:						
Kalanganan	c	5.5-6.1	23	2-9	3	1-2
Buaya-buaya	b	3.7		2		2
	c	3.7		2-9	2	1-2
<u>Lanao del Sur</u>:						
Malabang	d	4.5	25			
<u>Pagadian City</u>	c	5.4		15	3	.8
	d	4.5-5.5	25	3-10	3	.5

Table 1 --Continued

Place	Source	Wave Hts. (Meters)	Delay Time (Minutes) @	Delay Time (Minutes) #	No. of Waves	How Far Inland (Km)
San Pedro	a	4.3				
	d	4.6				
Sta. Lucia	d	3.7-4.6		3-10		.1
Zamboanga del Sur:						
Malangas	c	4.0	23	10		
Tabina	a	2.7	15			
Alicia	a	*4.1				
	d	4.6	20			
Zamboanga City:						
Sacol Island	a	*3.0	23			
	c	5.5-6.1				.1
	d	5.4-6		23		
Bolong	a	3.0				
	c		25	10		
Recodo	c		27			
Basilan:						
"Basilan"	d			20		
Lamitan	b	5.5	18		3	.12
Tuburan	a	*3.1	16			
Bohelebong	a	*4.3	15	5-10		
Ubbong	c		15	10		
Maluso	a	*2.1	27			
Barrios on the West Coast	c		27	1(!)		
Sulu:						
Tongquil Island	b	3.1	20	1	3	.05
	d	5.4				

* - Measured
@ - Computed delay time
# - Estimated delay time

a - PAGASA/ITIC
b - Questionnaire
c - Interviews
d - Published articles

Table 2

SELECTED OBSERVATIONS IN AFFECTED AREAS

Place	Observed	Sounds preceding waves like:
South Cotabato:		
Bo. Lake Sebu, Surallah	Recession before waves.	Boiling water; Water flowing.
Sultan Kudarat:		
Lebak	Recession before waves.	Boiling water; A train.
Maguindanao:		
Resa	Recession before waves.	Strong wind.
Kinimi		Strong wind; Jet plane.
Buaya-buaya, Dinaig		A train.
Kidama, Matanog	Recession before waves.	Strong wind; A train.
Cusiong & Linek	Recession before waves.	Strong wind; A train; Cascading rain; Army trucks.
Magsaysay, Parang	Recession before waves.	Strong wind; Hundred thousand motorcycles revving up.
Bongo Island	Recession before waves.	Strong wind.
Cotabato City:		
Kalanganan	Recession before waves.	Strong rain; Strong wind; A train.
Lanao del Sur:		
Malabang		Roaring & whizzing sound that seemed to come from underground.
Pagadian City	Recession before waves. Waves somewhat reddish at the crest.	Strong wind; Rushing water.
Zamboanga del Sur:		
Malangas		Approaching rain with intensity like 40 pumpboats.
Alicia		Loud rumbling of many trucks together.
Basilan:		
Lamitan	Recession before waves.	Hissing sound of a strong wind.
Sulu:		
Tongquil		Strong wind.

Table 3

NUMBER OF CASUALTIES/VICTIMS IN REGION IX
As of 31 August 1976

Place	Dead	Missing	Total	Injured	Homeless Persons
Pagadian City	447	229	746	2,500	23,880
Zamboanga del Sur	582	552	1,134	4,908	23,133
Tukuran	5	11	16	231	600
Labangan	19	9	28	100	400
Ramon Magsaysay	21	16	37	7	
Dumalinao	15	14	29	170	300
San Pablo	16	5	21	10	400
Dimataling	52	5	57	1,500	500
Tabina	25	22	47	1,200	9,149
Margosatubig	9	7	16	8	1,892
Lapuyan	8	29	37	27	272
Kumalarang	8	3	11	6	130
Buug	2	2	4	20	100
Malangas	42	8	50	32	4,080
Alicia	213	200	413	1,000	2,500
Olutanga	21	110	131	82	500
Mabuhay	105	92	197	500	1,590
Kabasalan				3	470
Naga	6	6	12	12	250
Ipil	3	13	16		
Limaong	12		12		
Zamboanga City	111	87	198	151	1,908[a]
Bolong	6	2	8		270[a]
Sangali (Da-ap)	39		39		708[a]
Manicahan	1		1		240[a]
Sacol Island	65	85	150		600[a]
Recodo					90[a]

Table 3 --Continued

Place	Dead	Missing	Total	Injured	Homeless Persons
Basilan	187	15	202	20	777[b]
Bohelebong	12		12		
Tipu-tipu	30		30		
Maluso	108		108		90[a]
Basilan City	37	15	52	20	
Sulu	113	26	139	122	150
Tongquil Island	26	11	37	15	
Tawi-tawi	87	15	102	107	150
Total[#]	1,440	909	2,418	7,701	49,848

a - estimated at 6 persons per family
b - reported sub-total could not be fully accounted for
\# - sum of sub-totals

N.B. It is estimated that about 95% of casaulties were due to the tsunami.

Sources: Bureau of Fisheries & Aquatic Resources
Department of Public Works, Transportation, & Communications
Office of Civil Defense
Philippine Air Force
Provincial Disaster Coordinating Council

TABLE 4

NUMBER OF CASUALTIES/VICTIMS IN REGION XII
As of 30 August 1976

Place	Dead		Missing		Total		Injured		Homeless
	Quake	Wave	Quake	Wave	Quake	Wave	Quake	Wave	Persons
SULTAN KUDARAT	79	229	32	51	111	280	18	141	6,486
Palimbang	3	1			3	1	8	7	1,728
Lebak	25	160		42	25	202	3	42	1,500
Bagumbayan	1				1		1		
Isulan	2				2				
Kalamansig	47	50		9	47	59		47	2,358
Mariano Marcos							2	15	
Lutayan	1	18	32		33	18	4		900
MAGUINDANAO	103	1,815	28	793	131	2,608	70	606	16,967
Buluan	9				9		9		
Ampatuan							4		
Maganoy	5				5		5		
Matanog		72		8		80		145	864
Dinaig	2	280	10	182	12	462		140	1,800
Datu Piang	15	49			15	49	4		1,925
Linek		160		182		342			
Upi		462		138		600		200	5,300
Tumbao									253
Sultan Kudarat	72	29	18	5	90	34		18	2,825
Parang		409		19		428	30	103	4,000
Bongo Island		354		259		613			
Buldon							18		
COTABATO CITY	110	57*	93	21	203	78	422*	21	3,474*
Tamontaka									744
Kalanganan		24		9		24	8		438
Buaya-buaya		22		12		22	12		137

TABLE 4 --Continued

Place	Dead Quake	Dead Wave	Missing Quake	Missing Wave	Total Quake	Total Wave	Injured Quake	Injured Wave	Homeless Persons
LANAO DEL SUR	41	755		180	41	935	41	285	5,237
Balabagan		350		80		430		176	2,100
Malabang	38	208		50	38	258		60	3,000
Ganassi	1				1		3		51
Pualas	2				2		16		
Pagayawan							16		
Masiu							3		86
Palapagan		197		50		247		49	
LANAO DEL NORTE		162		181		343	18	605	11,370
Karomatan		77		162		239		470	5,740
Kapatagan		10				10	15	105	2,300
Kauswagan									2,300
Lapinig									1,000
Sapad		75		19		94	3	30	30
Total #	333	3,018	153	1,226	486	4,244	569	1,658	43,534

* reported sub-total could not be reconciled with the sum of reported items

\# sum of sub-totals

Sources: Department of Public Works, Transportation, & Communications
Mindanao Sulu Secretariat for Social Action
Office of the Civil Defense
Philippine Air Force

Table 5

EVALUATION ACCORDING TO SEVERITY
OF CASUALTY (a to c) & DAMAGE (1 to 6)
OF AFFECTED AREAS IN REGIONS XI, XII & IX

Region XI:

SOUTH COTABATO

a3 Lake Sebu, Surallah

a2 General Santos

Region XII:

SULTAN KUDARAT

a5 Palimbang

a5 Kisek

c6 Lebak (Salaman)

a4 Tibpuan

c6 Kalamansig

a5 Kidama

a4 Lutayan

MAGUINDANAO

b5 Resa

b5 Kinimi

c5 Matanog

c6 Dinaig

- Dimapatoy
- Lasdon
- Badak
- Tabang

a5 Pinansaran

a5 Cusiong

c6 Linek

c6 Upi

a6 Sultan Kudarat

c6 Parang

- Pulloc
- Magsaysay
- Bongo Island
  - Litayen
  - Tuca-maror
  - Limbayan
  - Tagodtongan
  - Bucana

COTABATO CITY

a4 Tamontaka

a5 Kalanganan

a5 Buaya-buaya

a4 Banalipa

LANAO DEL SUR

c6 Balabagan

a4 Lalabuan

c6 Malabang

a3 Matimus

LANAO DEL NORTE

c6 Karomatan

b5 Kapatagan

a4 Picalawag

a3 Tagalo

a4 Kauswagan

a4 Malico

a3 Margo

Table 5 --Continued

Region IX:

ZAMBOANGA DEL SUR		a3	Taluksangay
c6	Pagadian City	b6	Sacol Island
	Sta. Lucia		Bullog
	San Pedro		Intosan
	Lacuran	a4	Pangapuyan Island
	White Beach	a5	Tictauan (Tictabon)
	Kawit	a4	Malanipa Island
c5	Tukuran	a3	Sta. Cruz Island
b5	Labangan	a5	Recodo
c5	Dumalinao	a3	Mampang
a5	San Pablo	a3	Arena Blanco
c5	Dimataling	BASILAN	
c5	Tabina	a3	Malamaui
a5	Margosatubig	a3	Lamitan
a4	Lapuyan	a3	Tuburan
a5	Kumalarang	a4	Bohelebong
a4	Buug	a6	Tipu-tipu
b6	Malangas	b5	Maluso
c6	Alicia	SULU	
a3	Litayen	c5	Tawi-tawi
c4	Olutanga	a3	Kalang Mono-mono
c5	Mabuhay	a3	Halo Bangkaw
a3	Kabasalan	a3	Tulingan
a3	Naga	a4	Look Bisaya
a4	Ipil	a3	Kalang Piliso
a3	Buluan	a3	Bato-bato
a3	Limaong	a4	Ubbong
ZAMBOANGA CITY		a3	Tabing
a3	Buenavista	a3	Mina
a3	Curuan	a5	Tongquil Island
a4	Bolong		
a4	Sangali (Da-ap)		
a3	Manicahan		

Table 5 --Continued

Casualty Scale:

		No. of persons:
a	-- slight	(less than 100)
b	-- moderate	(100 - 150)
c	-- severe	(more than 150)

Modified Sieberg Tsunami Intensity Scale (Ambraseys 1962)

1- Very light. Wave so weak as to be perceptible only on tidegauge records.

2- Light. Wave noticed by those living along the shore and familiar with the sea. On very flat shores generally noticed.

3- Rather strong. Generally noticed. Flooding of gently sloping coasts. Light sailing vessels carried away on shore. Slight damage to light structures situated near the coast. In estuaries reversal of the river flow for some distance upstream.

4- Strong. Flooding of the shore to some depth. Light scouring on man-made ground. Embankments and dikes damaged. Light structures near the coast damaged. Solid structures on the coast injured. Big sailing vessels and small ships drifted inland or carried out to sea. Coasts littered with floating debris.

5- Very strong. General flooding of the shore to some depth. Quay-walls and solid structures near the sea damaged. Light structures destroyed. Severe scouring of cultivated land and littering of the coast with floating items and sea animals. With the exception of big ships all other type of vessels carried inland or out to sea. Big bores in estuary rivers. Harbour works damaged. People drowned. Wave accompanied by strong roar.

6- Disastrous. Partial or complete destruction of man-made structures for some distance from the shore. Flooding of coasts to great depths. Big ships severely damaged. Trees uprooted or broken. Many casualties.

Table 6

SUMMARY OF DAMAGES FOR REGIONS XII & IX
As of 6 September 1976

Place	1	2	3	4	5	6	7	8	9	10
Region XII:										
Sultan Kudarat	671	59	2			9	132		5	579
Maguindanao	2,926	51	43		1	3	620	3	19	703
Cotabato City	1,300	8	4	1	1	3	312			233
Lanao del Sur	750	17	3	1	1	3	288		3	
Lanao del Norte	1,458	26	1			2	199	2	15	2,083
Sub-Total	7,105	161	53	2	3	20	1,551	5	42	3,598
Region IX:										
Pagadian City	3,500	28		1	2	1	*	*	*	*
Zamboanga del Sur	1,945	115	28	1	10	15	508	3	1,485	275
Zamboanga City	318	12	2			1	540	5	466	373
Basilan	382	4			2	1	914		290	59
Sulu & Tawi-tawi	25	127	15	1	10	1	5		1	
Sub-Total	6,170	286	45	3	24	19	1,967	8	2,242	707
Total	13,275	447	98	5	27	39	3,518	13	2,284	4,305

* Data on Pagadian City not available

1 - Houses
2 - School buildings
3 - Public buildings
4 - Air Ports
5 - Ports/Wharves
6 - Roads/Bridges
7 - Bancas (native boats)
8 - Commercial Fishing Boats
9 - Gear/Corrals/Nets & Fish Dryers
10 - Fishponds/Seaweed & Oyster Farms (ha.)

Sources: Dept. of Natural Resources/Bu. of Fisheries & Aquatic Resources
Dept. of Public Works, Transportation & Communications
Office of Civil Defense
Philippine Air Force

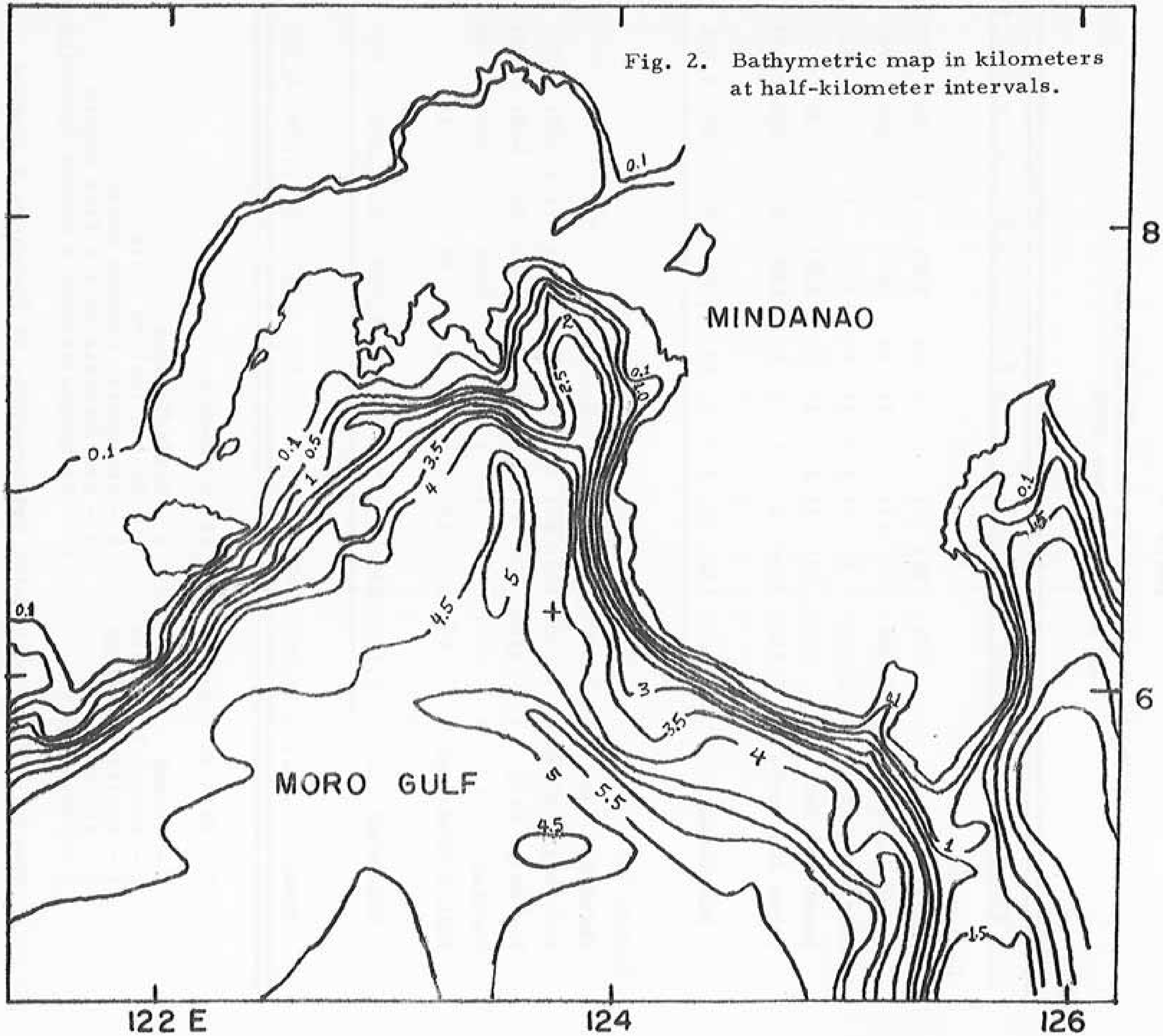

Fig. 2. Bathymetric map in kilometers at half-kilometer intervals.

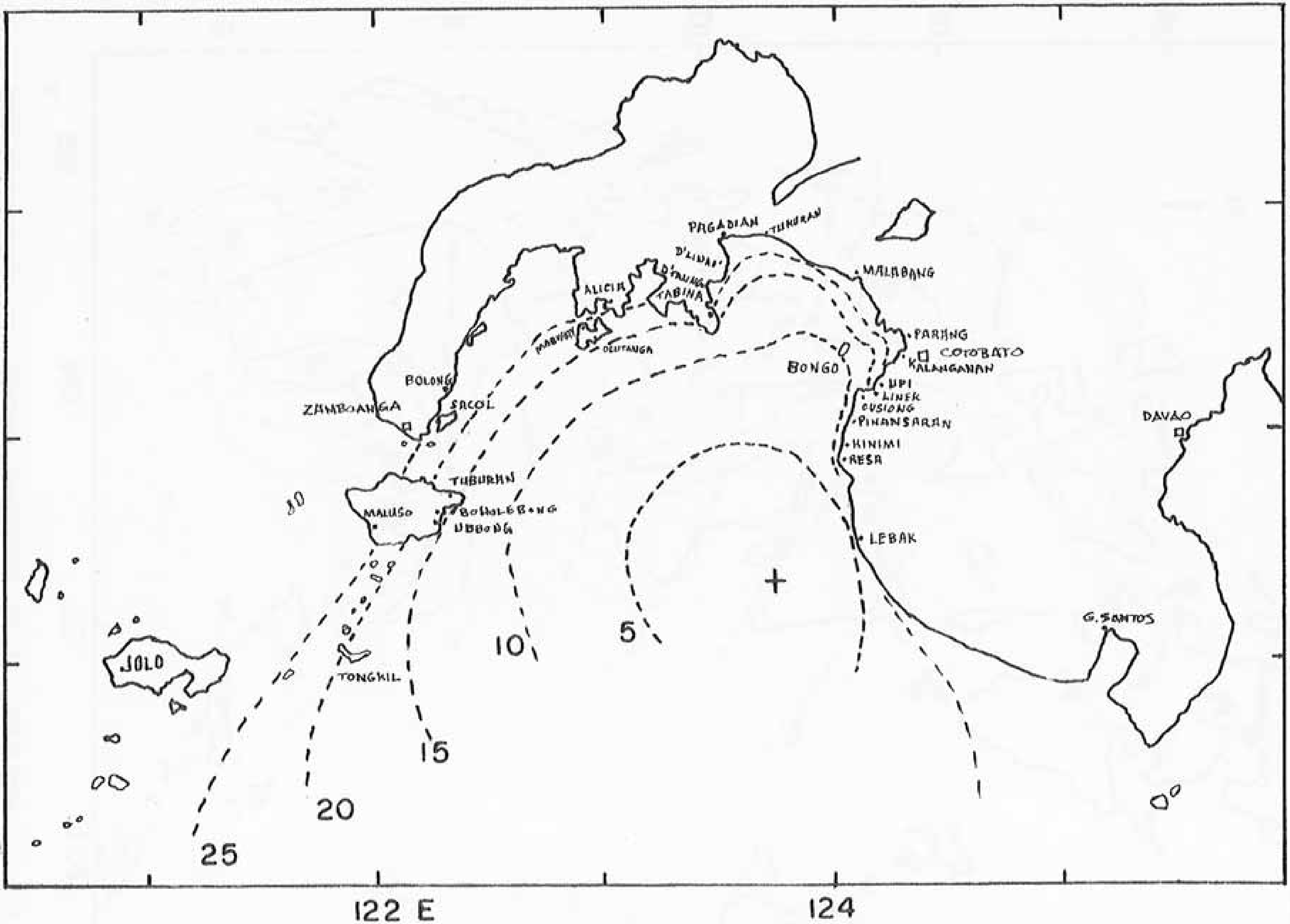

Fig. 3. Theoretical isochronal travel times in minutes at five minute intervals of 17 August 1976 tsunami.

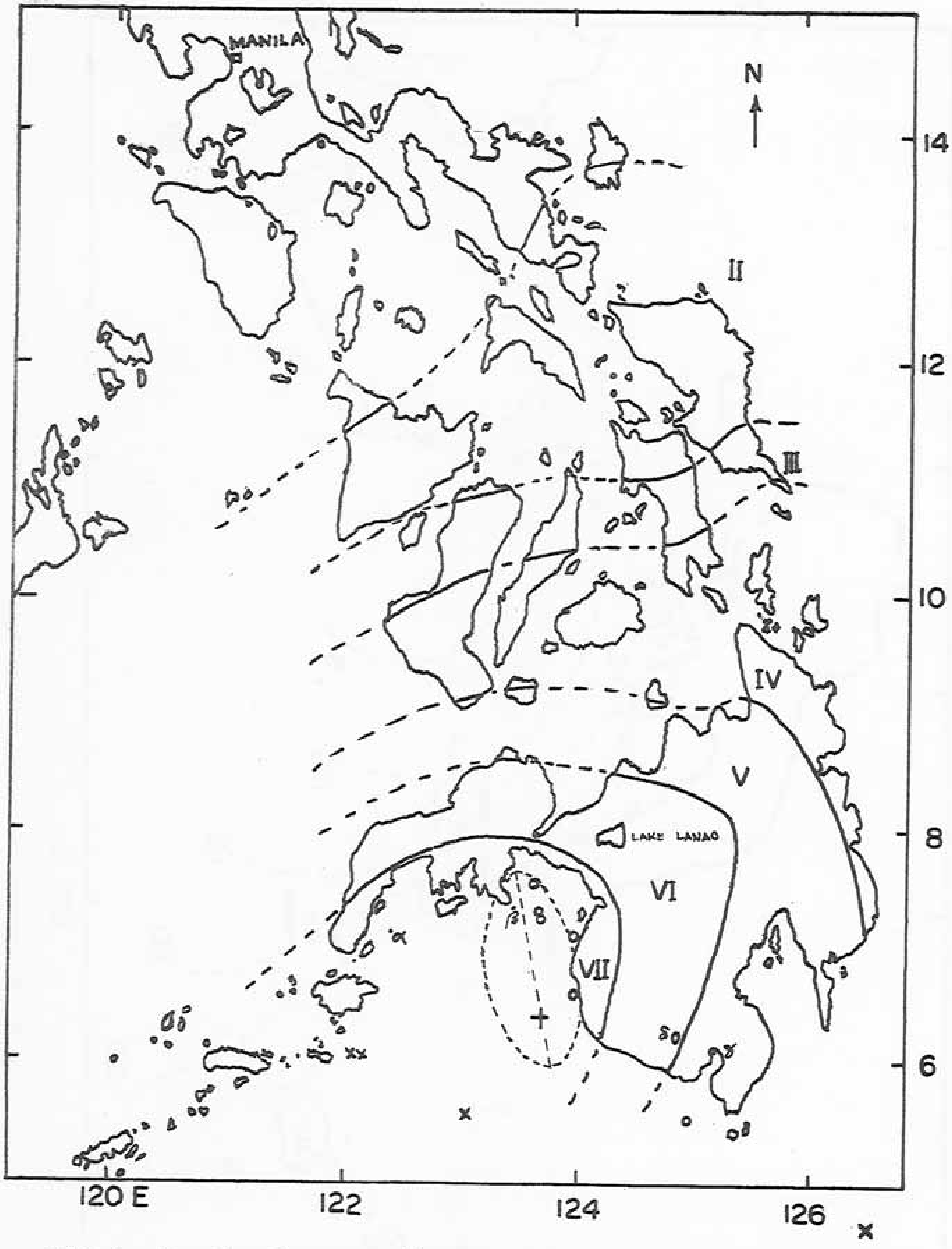

Fig. 1. Isoseismal zones, epicenter, rupture line, aftershocks area of 17 August 1976 quake in Moro Gulf.

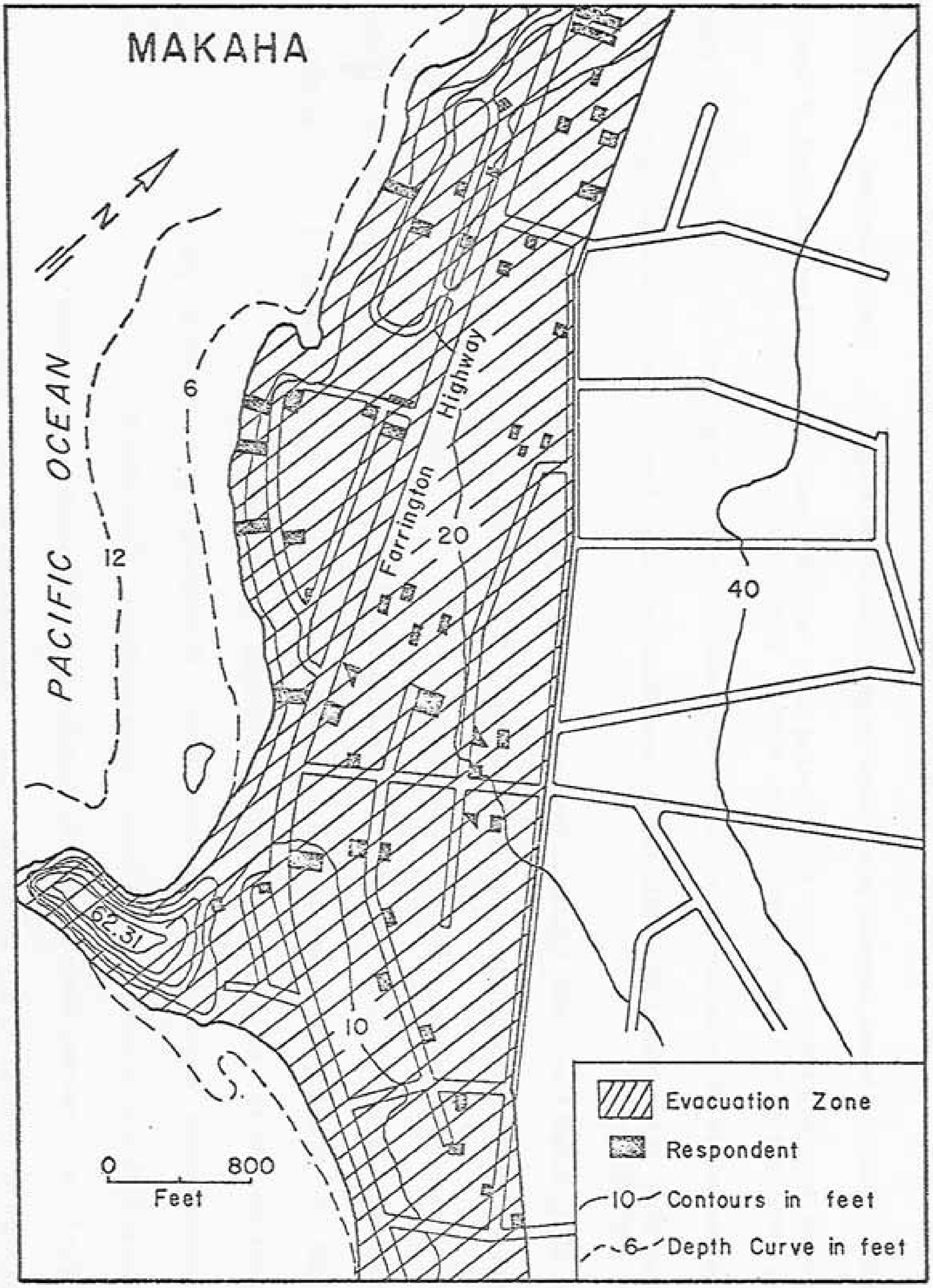

Figure 4. Makaha Evacuation Area

Captions for Photos

1. The human spirit - after the tsunami. Samals of Pagadian. (Noli Yamsuan, Jr. photo)
2. Partially concrete house reveals power and height of waves in Pagadian. (Noli Yamsuan, Jr. photo)
3. Untouched Pagadian houses though surrounding ones have disappeared. Shows erratic path of destruction. Shows construction of house on stilts above water. (Noli Yamsuan, Jr. photo)
4. Wooden house survives amidst shamble of surrounding houses. (Pagadian - Noli Yamsuan, Jr. photo)
5. Children play where giants have fallen. Coconut falls one way, tree one meter across falls other way. (Linek - BFAR photo)
6. Grove of uprooted trees with boulders brought in by sea. (Linek - BFAR photo)
7. Coconut and other trees fall in opposite directions. (Linek - BFAR photo)
8. Wharf damaged by tsunami. (Linek - PAF photo)
9. Oyster farms built like these with strong bamboo poles were damaged in Zamboanga del Sur. (BFAR photo)
10. New fish corral using whole bamboo poles to replace one swept away in Cotabato. (BFAR photo)
11. Smashed jeepney in Linek shows strength of tsunami. (BFAR photo)
12. Pumpboat carried one km. inland in Sacol Island. (Zamboanga del Sur - BFAR photo)
13. All that is left of a sawmill in Resa, Upi. (Maguindanao - OCD photo)
14. Desolate view of coastal slum section in Pagadian. (Noli Yamsuan, Jr. photo)
15. Aerial view of coastal village along Moro Gulf. (Zamboanga del Sur - PAF photo)
16. Aerial view of coastal village with mosque. (Sta. Lucia, Pagadian - PAF photo)


1


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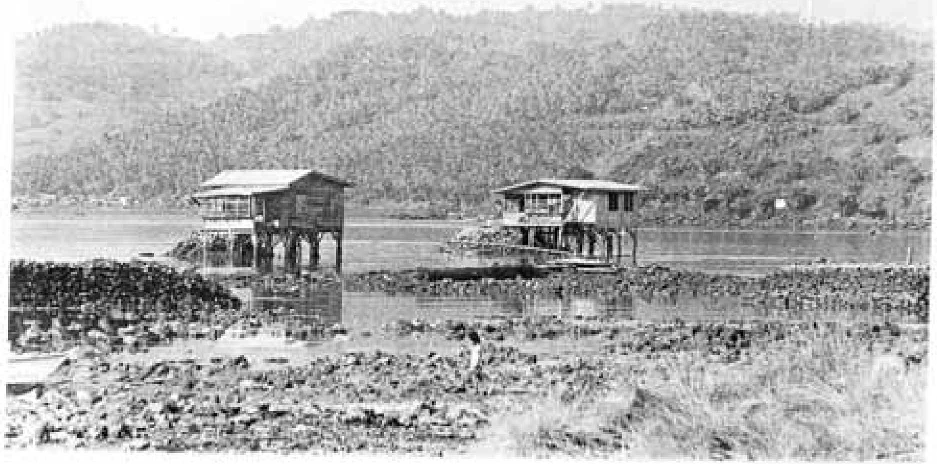
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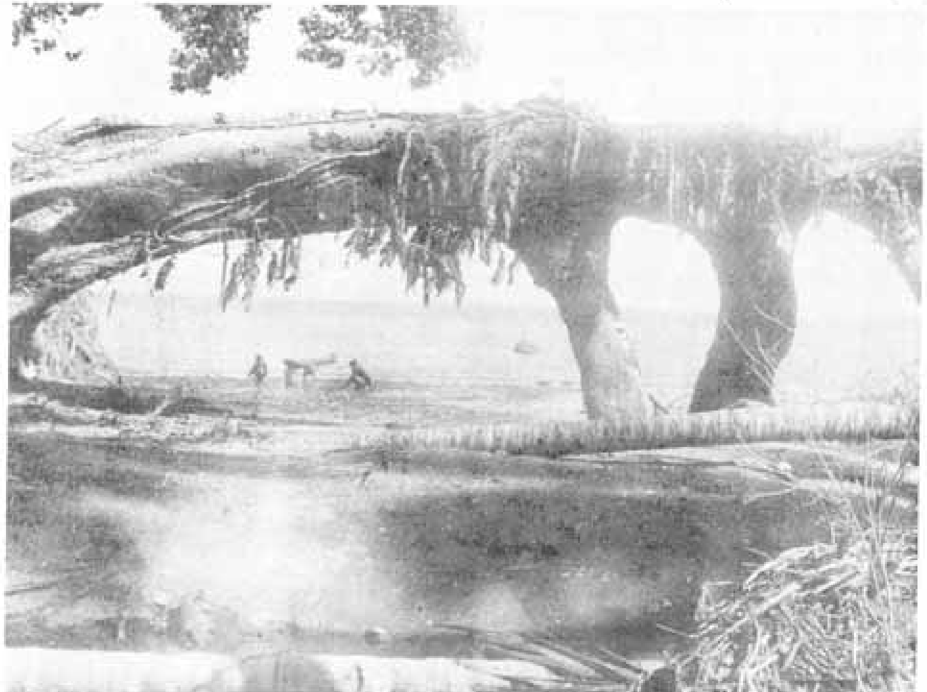

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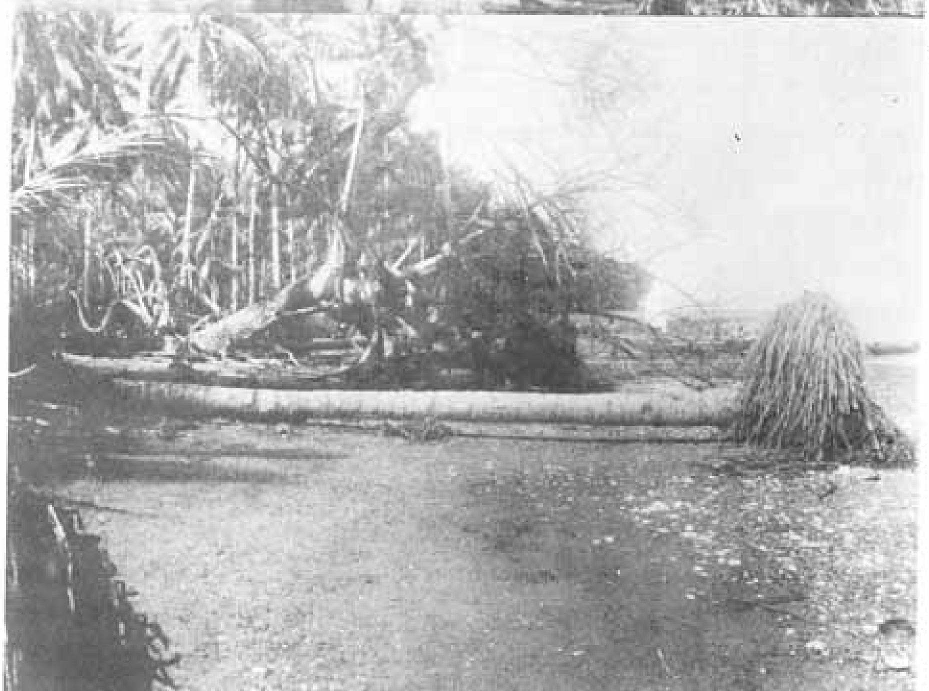

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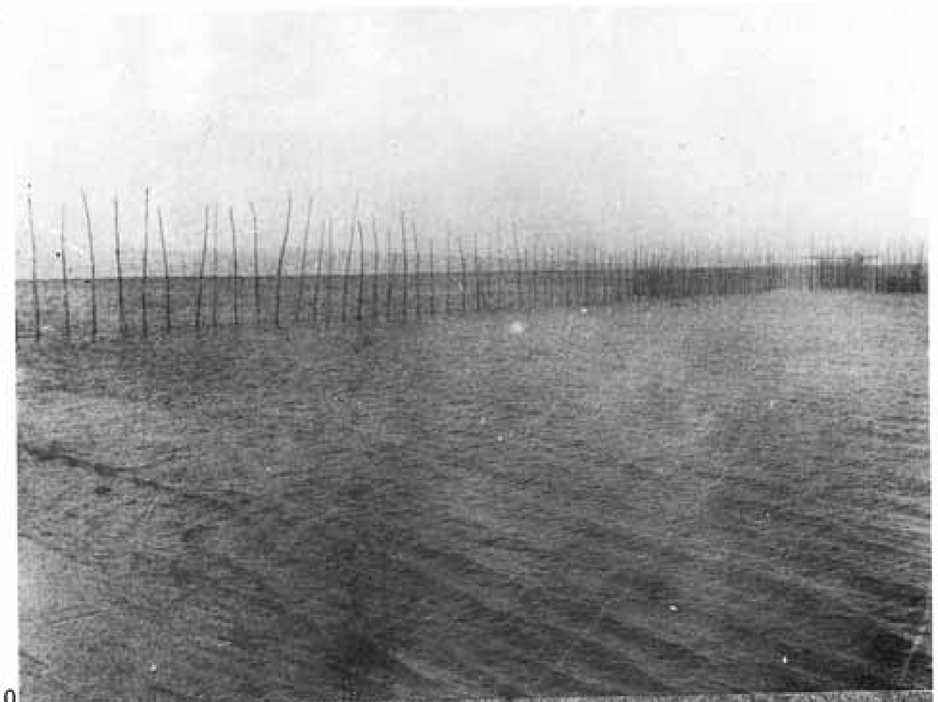

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LIST OF ABBREVIATIONS

B C G S --------	Bureau of Coast and Geodetic Survey
B F A R --------	Bureau of Fisheries and Aquatic Resources
C E M C O M ----	Central Mindanao Command
C O W S --------	Committee on Warning System
D L G C D ------	Department of Local Government and Community Development
D N R ----------	Department of Natural Resources
D P W T C ------	Department of Public Works, Transportation and Communications
D R O C --------	Disaster Relief Operations Center (PAF)
D S S D --------	Department of Social Services and Development
LUSTEVECO ------	Luzon Stevedoring Company
M I S S S A ----	Mindanao Sulu Secretariat for Social Action
N A S S A ------	National Secretariat for Social Action
N D C C --------	National Disaster Coordinating Council
O C D ----------	Office of the Civil Defense
P A D A --------	Philippine-Australian Development Assistance
P A F ----------	Philippine Air Force
P A G A S A ----	Philippine Atmospheric Geophysical and Astronomical Services Administration
P D C C --------	Provincial Disaster Coordinating Council (NDCC)
P N R C --------	Philippine National Red Cross
P R O D --------	Presidential Relief Operations Division
R D C C --------	Regional Disaster Coordinating Council (NDCC)