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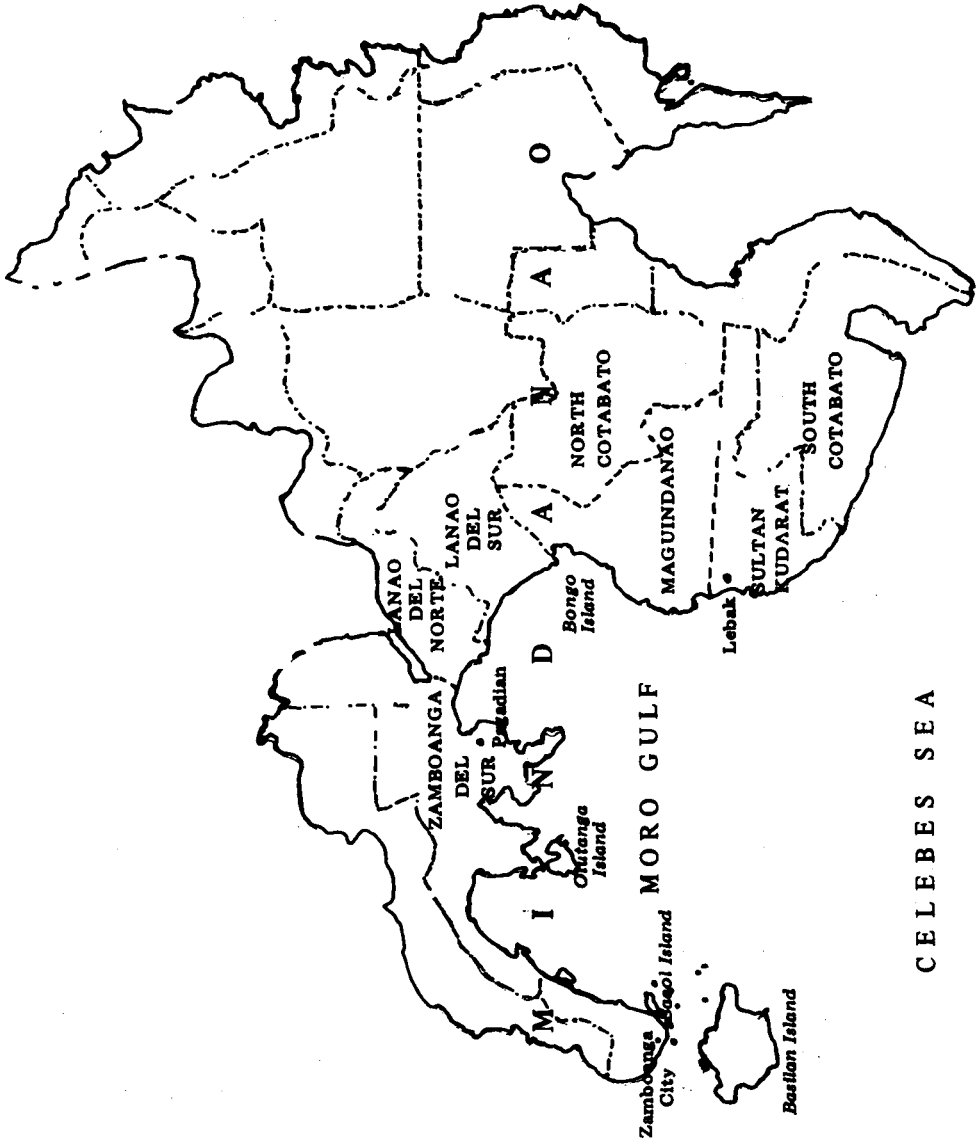
Notes and Comments

The Moro Gulf Tidal Wave of 17 August 1976

VICTOR L. BADILLO, S.J.

Eleven minutes after midnight on 17 August 1976, a violent earthquake severely damaged Cotabato City. Just 10 minutes later, tidal waves spawned by the earthquake ravaged 700 km of coastline bordering Moro Gulf. When the sea had spent its fury, 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. Relief and rehabilitation efforts were organized without delay by government and private agencies.

A tidal wave does not occur as often as typhoons, floods, earthquakes or conflagrations. One consequence of this is the lack of information and interest on the part of those who would suffer from the next one. One year after the event, on the first anniversary of the tidal wave, there was not a single line in the Manila papers, except for a full page ad by the Bureau of Fisheries and Aquatic Resources detailing the progress of rehabilitation on Bongo Island. The purpose of this paper is to present findings about this tidal wave so as to understand it better, and encourage steps that may be taken to lessen the loss of lives and property from future tidal waves. This focusing of purpose is deliberate: much work has already been done on earthquakes and earthquake engineering; moreover, the earthquake damage caused by the events of August 1976 was confined to Cotabato City and has been amply documented. Hence this paper restricts itself to the tidal wave and its effects. Only those aspects of earthquakes that are needed to understand tidal waves will be considered.


MINDANAO
NORTH COTABATO
MAGUINDANAO
SOUTH COTABATO
SULTAN KUDARAT
LANAO DEL NORTE
LANAO DEL SUR
ZAMBOANGA DEL SUR
Bongo Island
Lebak
Pagadian
Olutanga Island
Zamboanga City
Basilan Island
MORO GULF
CELEBES SEA

THE EARTHQUAKE

The earthquake responsible for the tidal wave occurred beneath the Moro Gulf, 40 km off the shores of Sultan Kudarat province. It was a shallow earthquake of magnitude variedly determined between 7.9 and 8.2 on the Richter scale. The highest intensity determined, VII in the Rossi-Forel scale, was felt in the crescent-shaped coastal regions of the gulf. Those were the regions that felt the force of the ensuing tidal waves. The earthquake was strong enough to wake people, and to make it difficult to stand or walk. This is nature's built-in warning to inhabitants of coastal regions. However, with very few exceptions, no one made the connection between the severe earthquake they felt and probable tidal waves to follow. After feeling the quake, they just stayed where they were. Tragically, some ran shoreward, closer to water. Besides the tidal waves, the earthquake also generated a seaquake and a lake seiche.

Analysis of seismograms indicate that part of the sea bed, about 150 km in length, was lifted upward by 2.5 meters. This movement generated water waves spreading in all directions, like waves generated by a pebble dropped into a smooth body of water.

In deep water, waves travel fast, but they slow down when the depth is shallow, as on beaches, for example. The result is an increase in the height of the waves. This can be visualized by an example: if vehicles were to stop suddenly on a superhighway there would be a pile-up of other speeding cars forced to stop. Thus a major problem is one of forewarning. With present equipment and analytic methods, tidal wave warnings cannot be given to coastal inhabitants within 15 minutes after the earthquake. The sole warning so far available is that provided by nature.

Some nine tidal waves have been generated in the Moro Gulf alone since 20 September 1897. This gives a frequency of one tidal wave every nine years. A statistical study of tidal waves in the Philippines indicates that the Moro Gulf area is the area most prone to tidal waves, followed by eastern Mindanao, and then by western Luzon.

SEAQUAKE

Seaquake damage that is severe is rare. Mention is made of this

phenomenom since there is not much public consciousness of it. Even those who felt the quake did not recognize it for what it was. Since in some past tidal waves, seaquakes were reported, an effort was made in 1976 to determine if a seaquake had been observed. This would help in the compilation of an historical list of tidal waves. Earthquakes are felt over very wide areas, but tidal waves are felt only in coastal areas, and cannot be recorded when these coastal areas are uninhabited. This makes the compiling of a complete list difficult.

The captain of the *Alfredo*, a passenger ship shuttling between Zamboanga City and Olutanga Island, felt the ship shudder sometime in the night of 17 August 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. Furthermore, in that general neighborhood, some ships had wanted to send S.O.S. signals when they felt as if their propellers were turning in sand.

The *Don Luis*, of the Aboitiz Lines, cruising on a calm sea, was about 4 km from Punta Flecha when it started to rock and the mast began to creak. Its position was almost directly on top of the rupture line of the sea bed. Coincidentally, some 340 years before, in that same area at about midnight, Spanish ships had felt a similar experience.[1]

The M/V *Guimaras* of Compañia Maritima, located 1 km from the shores of Parang, Maguindanao, seemed to have run aground. The mast shook for a minute. Dishes and an electric fan fell from the table. It seems clear that a seaquake was experienced by *Alfredo, Don Luis,* and *Guimaras.*

LAKE SEICHE[2]

In Surallah, South Cotabato, water movements were reported in Lake Sebu, suggesting the occurrence of a seiche. Waves generated in a closed body of water, for example, by rocking a basin rhythmically, constitute a seiche. Lakeshore residents did not specify the number of waves which hit the shore. Wave heights

1. William C. Repetti, "Catalogue of Philippine Earthquakes, 1589-1899," *Bulletin of the Seismological Society of America* 36 (1946): 144-45.

2. 'Seiche' is defined as "an oscillation of the surface of a lake or landlocked sea, varying in period from a few minutes to several hours."

were about 1.5 meters high and inundated an area up to 5 meters inland from the shore.

Twenty-three years earlier, a seiche occurred in Lake Lanao as a result of the Lanao earthquake of 1 April 1955. The water, rising up to 3 meters high swept water lilies to rice paddies located as far as 300 meters from the water's edge.

DESCRIPTION OF THE WAVES

At the time of the earthquake, the last quarter moon was some 30 degrees above the eastern horizon, so there was enough light to see by. The appearance of the incoming waves varied. At Sacol Island and Bongo Island, it was a wall of water, advancing like a bore. At Pagadian, a backward tilting wall of water straightened up and crashed down, like a breaker. At Lebak the water level just kept rising, like a tide. The variety of sea bottom configurations would explain the variety of appearances. Whatever the appearance, damage was inflicted.

Wave heights varied from place to place. This was due to each locality's having a different coastline configuration and seashore bottom topography. Wave heights cannot yet be predicted; thus empirical observations are needed which can be used for disaster planning, for drawing up inundation maps, and so on. In general, wave heights did not exceed 4.3 meters. But there were exceptions where wave heights exceeded 5 meters: Linek (Maguindanao), Kalanganan (Cotabato City), Pagadian City, Sacol Island (Zamboanga City), and Lebak (Sultan Kudarat). At Lebak the waves may have been as high as 9 meters.

The majority of observers reported three or four waves. One thing is definite: there was more than one wave. The interval between waves was about five minutes. Lack of knowledge that a tidal wave is a series of waves resulted in death for those who returned to the shore after the first wave had come and receded.

A common observation was a deep recession of the water before the arrival of the first wave. The water receded much further than usual, and exposed features like islands not normally seen, so that this feature of the tidal wave was noted. At Lebak the sea receded as much as 2 km. A recession leaves fish flapping helplessly on the sand, an invitation to disaster. Yet a four-minute miler (24 km/hr) would despair of outrunning the 80 km/hr wave

following the recession.

Another common observation was a loud roaring that preceded the arrival of the waves. People living by the sea are familiar with the different sounds of the sea, and can distinguish among them. Several people 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 loud, too. At San Jose, 1 km 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.

How far inland did the waters go? Predictably, a great variety of answers was obtained, since much depended on whether the land sloped gently or steeply. Maximum run-up reported was 2 km.

How soon after the quake did the first waves arrive? The waves reached the eastern borders of the gulf in about 5 minutes, the northern borders in about 10 minutes, and the western borders in about 15 minutes. Clearly, no human agency could have sent useful warnings to all coastal inhabitants.

To summarize, the sequence of events was as follows: first, a shock violent enough to awaken coastal residents and make standing or walking difficult; then a strong strange, prolonged approaching sound variously described as cascading rain, rumbling of many trucks, a strong wind, boiling water, and so on; finally, the arrival of waves within five minutes, preceded by an unusually deep recession of the sea. Two or three waves followed the first.

All those factors need not be present in every tidal wave. But there are several distinct precursory indicators that could serve as natural warnings of a probable tidal wave. Five minutes is enough time to run to higher ground.

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 was uprooted, but an entire grove. A tree one meter in diameter was uprooted. Cars were smashed. The water rushing up a river in Pagadian damaged a bridge. Wharves were damaged by boats dashed against them, or by erosion of

foundations. Bancas and commercial fishing boats were sunk. Fish corrals, oyster farms, and seaweed farms were destroyed or damaged. Inland fishponds were either flooded or emptied of water. Partially concrete houses, schools, public buildings, factories, and so on, were reduced to a few concrete slabs, wooden stumps, and twisted steel. At Port Lebak, a veneer factory was damaged by the battering-ram effect of floating logs and debris. At Lebak, the barge M/T *Provider* was carried inland and then brought out to sea again; on the other hand, a pumpboat in Zamboanga was left high and dry 1 km inland. Against such fury, what chance did frail makeshift homes have?

CASUALTIES AND DAMAGE

The toll of lives is given in Table 1 for Regions IX and XII respectively. Other regions were little affected, or not at all. Reports from Region XII distinguish deaths caused by the earthquake from those resulting from the tidal waves. But since the localities in Region IX are on the coast, and the structures destroyed did not involve residents, we may consider that 95 percent of the casualties there were due to the tidal waves. While no breakdown is given in the tables according to sex or age, casualties were mainly children and women, and the children-to-adult ratio was four to one.

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 by holding to something firm that prevented their being swept out to the open sea. This was a case where the waves caused more damage as they left than as they arrived. One father said he had clung to a tree, while his children in turn clung to him. When the waves receded, he was alone. This was a tale repeated many times over. While swimming may be as natural as breathing to seashore dwellers, in Pagadian the tidal waves churned the water and slum sediments into a batter of mud that choked the victims.

A tabular presentation of damage according to categories is given in Table 2. 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, the damage is more equally distributed. The total picture is that of

Table 1. SUMMARY OF CASUALTIES/VICTIMS IN REGIONS IX AND XII
As of 31 August 1976

REGION IX	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
Zamboanga City	111	87	198	151	1,908[a]
Basilan	187	15	202	20	777[b]
Sulu	113	26	139	122	150
Total[c]	1,440	909	2,418	7,701	49,848

REGION XII	Dead		Missing		Total		Injured		Homeless persons
	Quake	Wave	Quake	Wave	Quake	Wave	Quake	Wave	
Sultan Kudarat	79	229	32	51	111	280	18	141	6,486
Maguindanao	103	1,815	28	793	131	2,608	70	606	16,967
Cotabato City	110	57	93	21	203	78	422*	21	3,474
Lanao del Sur	41	755		180	41	935	41	285	5,237
Lanao del Norte		162		181		343	18	605	11,370
Total[c]	333	3,018	153	1,226	486	4,244	569	1,658	43,534

SOURCES:
Bureau of Fisheries and Aquatic Resources; Department of Public Works, Transportation, and Communications; Mindanao Sulu Secretariat for Social Action; Office of the Civil Defense; Philippine Air Force; and Provincial Disaster Coordinating Council.

a – estimated at 6 persons per family.
b – reported subtotal could not be reconciled with the sum of reported items.
c – sum of subtotals.

Table 2. SUMMARY OF DAMAGES FOR REGIONS XII AND IX
As of 6 September 1976

Place	A	B	C	D	E	F	G	H	I	J
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 and 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

SOURCES:
Dept. of Natural Resources/Bureau of Fisheries and Aquatic Resources; Dept. of Public Works, Transportation and Communications; Office of Civil Defense; and Philippine Air Force.

*Data on Pagadian City not available.

A – Houses
B – School buildings
C – Public buildings
D – Airports
E – Ports/Wharves
F – Roads/Bridges
G – Bancas (native boats)
H – Commercial Fishing Boats
I – Gear/Corrals/Nets and Fish Dryers
J – Fishponds/Seaweed and Oyster Farms (hectares)

severe and widespread destruction. Estimated values of damages have been ₱230 and ₱180 million for Regions XII and IX respectively.

SUMMARY AND RECOMMENDATIONS

The Moro Gulf tidal wave of 17 August 1976 was the most destructive tidal wave recorded in Philippine history. Past tidal waves may have been more severe, but areas hit were less populated and had fewer man-made 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 and power plants. Offshore, there will be not merely seaweed and oyster farms and fish corrals, but also storage facilities, tank farms, and the like. Thus a tidal wave-prone coast is potentially a great disaster area. Such is the Moro Gulf coastline.

That an area is prone to tidal waves must be related to the geophysical and geological structures of the locality. Hence to arrive at a more accurate tidal wave risk map, besides historical research further seismological, geophysical, and bathymetric studies are needed. Since the art of tidal wave warning is improved 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 or greater. On being informed about the probable occurrence of a tidal wave-generating earthquake, coastal inhabitants and local authorities could at least review disaster procedures. These are long-range goals.

An immediate and easily realizable goal is to require local officials to prepare local inundation maps. Basically, this is a street map of a town in which the dangerous areas to be evacuated are crosshatched. These maps can be drawn empirically by knowing which areas were inundated by past tidal waves. If there are contour maps available, one can indicate 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-user 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 tidal wave generated by a local earthquake. It would be fatal to wait for a radio broadcast, or a siren or similar warning before moving into action. But there is a warning available, one provided by nature herself – the violent shock of an earthquake. If the shock is violent enough to make standing or walking difficult, then that is the time for coastal residents to seek higher ground. Going to higher ground does not mean traveling long distances. For if local inundation maps exist and are known, it could mean traveling only a short distance. Of course, it is one thing to have these maps, and quite another for people to use them. What becomes clear is that education is needed, an extremely difficult and never-finished task.