Tsunamis in the Philippines: Mapping and Assessment in the Last Five Years

2005 Workshop on Tsunami Deposits and Their Role in Hazards Mitigation

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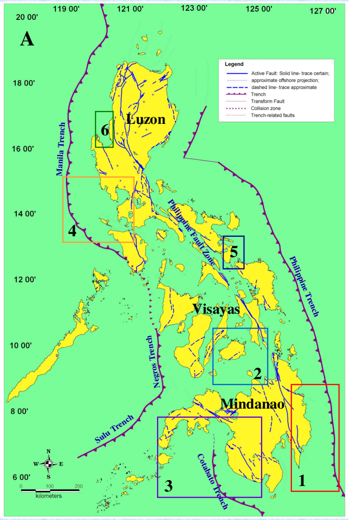
Abstract

Most of the devastating tsunamis in the Philippines were generated from the Philippine trench, Manila trench, East Luzon trough, and the Cotabato trench. However, closer examination of historical and recent field data also shows tsunamigenic earthquake in between the islands in central Philippines. Thus, since 2001 the Tsunami Hazard Assessment and Mitigation Program (THAMP) for Philippines had been initiated to assess and map carefully the tsunami hazards all over the country. Some of the completed works in several areas with different setting are hereby presented. In the past years, at least three focus areas were identified for tsunami hazards assessment. The analysis of historical data and field mapping activities were undertaken in these areas. Other data and information regarding tsunami effects and inundation heights were also gathered from eyewitnesses and survivors through interviews. True tsunami wave heights were measured and/or estimated from the accounts of the interviewees and available landmarks. Existing records from local communities and municipalities were gathered to assess damages related to tsunami inundation.

The level of awareness and preparedness of local inhabitants regarding earthquakes and tsunami are likewise assessed through analysis of the existing municipal and community disaster plans. Aside from tsunami hazards mapping and preparedness plans, research on uplifted marine terraces, recent coral growth, and offshore faults were likewise given much attention. Thus, upon the completion of tsunami hazards assessment and mapping, information was usually conveyed to local planners, engineers, and communities through seminars, workshops and community meetings. The varying reactions from the recent December 2004 Sumatra tsunami gave some gauge on the level of effectiveness of our information campaigns through seminar-workshops, maps, leaflets, and brochures.

INTRODUCTION

The Tsunami Hazard Assessment and Mitigation Program has the following major objectives: 1) Survey and mapping of known areas affected by major tsunami in the Philippines; 2) Delineate tsunami-prone areas through the utilization of available remotely-sensed data; 3) Undertake trenching and coring activities on areas with tsunami deposit; 4) Assess and design tsunami safety structures for local inhabitants; and 5) Incorporate all vital results of the project in educational materials, meetings, and seminar-workshops to inform and educate local inhabitants about their risk in future tsunami events and how they could cope and mitigate possible damages.



Focus areas

1. **Davao Oriental and the 1992 Manay Tsunami**
2. **Bohol island and the 1990 earthquake**
3. **SW Mindanao and the 1976 Moro Gulf earthquake**
4. **Manila Trench tsunamis**
5. **Sorsogon uplifted terraces**
6. **Paraoir porites and uplifted terraces**

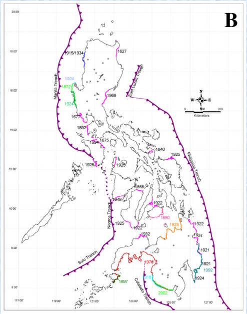


Fig. 1: The Philippine archipelago (A) and the study areas, as indicated by the rectangles. Numbers correspond to tsunamigenic events and/or focus areas. (B) The tsunami affected areas in the country (modified from PHIVOLCS 1996).

Philippine Trench Tsunamis (1)

During the 1992 Bislig earthquake tsunami invaded the eastern coastlines of Mindanao islands several minutes after the strong ground shaking. Seismic records showed that during this quake, two large earthquakes occurred off the eastern Mindanao along the Philippine trench that were only 26 minutes apart. Strong shaking was significantly felt in the towns of Cateel, Baganga, Boston, Caraga, Manay, and Tarragona in Davao Oriental (Figure 1) and caused significant damage. Tsunami simulations coupled with field investigations undertaken in the provinces of Davao Oriental and Surigao del Sur gave interesting results regarding the tsunami damages, tsunami arrival times, and source area.

Figure 3: Map showing the height of tsunami waves that inundated the area. Bunga have the highest tsunami height while Lupon suffered from at least 1m of subsidence.

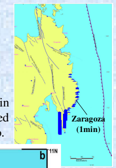


Figure 4: Map showing the relative time (in min.) elapsed before the tsunami wave arrived in the coastal towns/areas in eastern Mindanao.

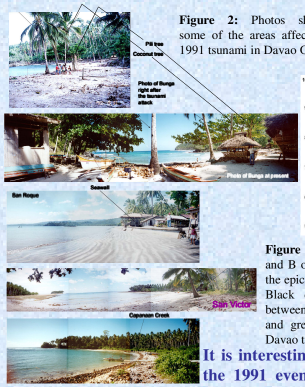


Figure 2: Photos showing some of the areas affected by 1991 tsunami in Davao Oriental.

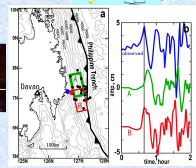


Figure 5: Map (a) showing the fault models A and B of the first event. Blue and red dot shows the epicenter of the 1st and 2nd quake, respectively. Black dots are aftershocks. The comparison between the observed (blue) and computed (red and green) waveforms for fault models at the Davao tide gauge station.

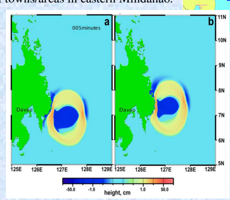


Figure 6: . A snapshot of tsunami propagation at 5min(a) after the origin time of the first event using fault model (A) in Fig. 5. The snapshot of tsunami propagation at 5min (b) after the origin time of the earthquakes using the fault model B at Fig 5.

It is interesting to note that in terms of regional and local geomorphological effects, the 1991 event caused very minor changes. Tsunami sediments were dumped in very few places while coral reefs located between 100-200m from the shore of eastern Mindanao were noted to be the coastal features that most probably attenuate the effects tsunami.

Manila Trench Studies (4)

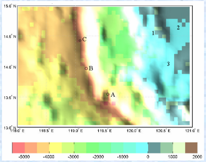


Figure 7: The bathymetry data and computational area from SATBATH. Points A, B and C indicate the location of the different source models and 1, 2 and 3 indicate the three observation points.

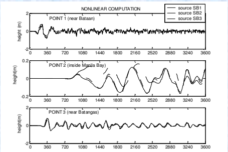
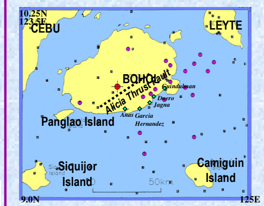


Figure 8: Tsunami time series at observation points 1, 2, and 3.

Tsunami computations for Manila Trench involving varying earthquake locations indicated that the waveforms at the three observation points vary significantly with source location. As expected, the waves at 2 will oscillate during the one hour period of propagation and the first wave is not the wave with the highest amplitude. At points 1 and 3, this through-to-peak amplitude decreases when the source location is moved northward. The first rise at observation points 1 and 3 show very little sensitivity to the dimensions of the rupture plane although there is a noticeable difference in their maximum vertical displacements. The variation between the different solutions due to different model source fault dimensions is largest at observation point 2, located inside the Manila Bay.

Bohol Tsunami (2)

Fig. 8: Map shows the events from 1907-1988 (black squares), the February 8, 1990 Ms6.6 event (red circle), and the aftershocks (February 9-28, 1990) shown in pink circles based on PHIVOLCS network. Green diamonds indicate the areas with observed tsunami during the 1990 investigations.



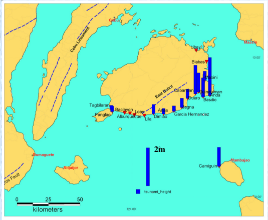


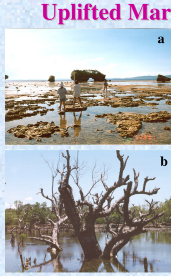
Fig. 9: The height of tsunami that inundated the southwestern portion of Bohol Island.

- **Based on recent field mapping, the southeastern shorelines of Bohol experienced a regional retreat (10-60m) of sea water several minutes after the quake.**
- **Small to moderate tsunami waves (0.2m-2m) affected the SE portion of Bohol island and reached as far as Camiguin island, and caused physical injuries. Tsunami inundation was variable but generally extended a few tens of meters from the present shoreline.**

Figure 10: Photos showing some of the areas affected by 1990 tsunami in Bohol island.

- **Damages, mostly from strong ground shaking, are reported along the municipalities located on the southeastern shorelines of the island.**
- **Prior to and after the 1990 Bohol earthquake, awareness about tsunami hazards of inhabitants along the coastal areas of Bohol remains to be low.**
- **The earthquake was generated from a previously-unrecognized reverse fault located offshore of, and to the east of Bohol island.**

Uplifted Marine Terraces (5 &6) Cotabato Trench (3)



Regional coastal studies were also undertaken for Philippine, Manila and Cotabato trenches. Mapping, assessment, sampling and analysis are done to acquire information about the timing, and extent of subsidence and/or uplift, recurrence interval along the coasts fronting these major subduction zones. At least two sites were identified for excavation and coring for each zones (Sorsogon, La Union and Cotabato).

Figure 11: . Photos showing the large porites and uplifted marine terraces (a) and some of the local trees drowned and flooded by seawater and currently used as fishponds in Sorsogon.

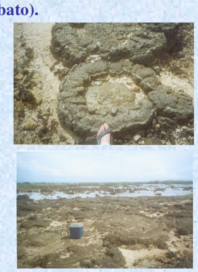


Figure 12: . Photos of porites in La Union in eastern Luzon island. Note the cup-like shape of the this coral indicating several episodes of uplift and subsidence.

The program's results will be incorporated into the city/municipality's emergency plans and early warning system through training, seminars and workshops with the following expected output: 1) map of tsunami-prone areas, 2) determine extent of fault zones and their recurrence interval, 3) design local mitigating measures against tsunami hazards, and 4) better coordination/cooperation with local agencies on the early warning system, 5) incorporation of tsunami hazards information into the educational curriculum and other medium of education.

Acknowledgment: Thanks to the following: The people of Davao, Bohol, Cotabato, Sorsogon and La Union who supported us during our fieldworks and shared with us their experiences and recollections during the tsunamigenic events in the last 4 decades.

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