



Fig 4.

Table 1. Summary of Observed Tsunami Effects

<u>LOCATION</u>	<u>OBSERVED EFFECTS</u>	<u>SITE CHARACTERISTICS</u>
1. Boca del Rio Matina	Water retreats about 400 m 180 m runup. 2 drown in canal	Beach and Rivermouth
2. Boca del Pantano	Water recedes about 100 m, returns within 3 min without flooding	Beach
3. 12 Millas de Moin	2 m wave, 30-70 m runup. Sand movement	Beach
4. 6 Millas de Moin	Water slowly retreats 20 m	Beach
5. Moin	Water recedes about 200 m, sea wave overtopped 3 m dikes in Moin River	Rivermouth
6. Westfalia	Water retreats about 200 m. Sand movement	Beach
7. Cahuita	Water recedes rapidly returns slowly after 1 hr, no flooding	Reef
8. Puerto Viejo	Water recedes about 100 m followed seconds later by a large wave, water recedes again, returns with 30 - 70 m runup.	Reef

9. Final de Cocles	Water retreats about 20 m, returns slowly (5-6 min) to previous level	Beach and Cliff
10. Punta Uva	Water retreats 400 - 600 m	Beach
11. Manzanillo	Water retreats about 150 m returns 5 min later with 30 - 70 m runup, sand movement	Beach
12. Gandoca	Water retreats about 300 m returns 5 min later with 70 m runup	Beach
13,14. San-San Natural Refuge	Waves deposit 1 m of sand, created dunes, covered turtle nests	Beach
15. Julio Abrego Beach	Water recedes 3 to 6 times minutes after quake, 100 m runup after last wave	Beach
16. Changuinola River and Tiribibi Pt.	Sand deposition, high energy current	Beach
Isla Colon		
17. Lime Point	Sea receded 6 times, exposed reefs, water flooded coastal road	Reef
18. West Knapp Hole	Great turbulence observed minutes after quake, strong current, 5 - 10 m runup	Beach on Bay

19. Ground Creek	Water receded, returned as strong current 0.6 m high, 10 m runup	Creek on Bay
20. Punta Cauro	Water receded 5 times, last wave about 2 m high	Beach next to Cliffs
21. Boket Bay	2.5 - 3 m wave 10-15 min after quake	Cove
22. Bocas del Toro	Water receded 10 min after quake, exposed offshore sand bar usually 0.6 m deep, waves runup 10-15 m	Cove
23. Nancy Key	Water receded several times, returns as strong current	Point
24. San Cristobal Is.	Sea recedes several meters for 45 min, water returned as a slow wave	Creek
25. Carenero Is.	Sea receded 15-20 min after quake, remained out for 15 min returns as gentle wave with 100-150 m runup	Beach
26. Bastimentos Is.	Sea receded 10-15 min after quake, returned gently	Reef

Appendix 1

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U.S. Geological Survey
National Earthquake Information Center



TSUNAMI QUESTIONNAIRE

USGS NEIC

The USGS is interested in understanding wave-related effects of the recent earthquake; what happened, and where they happen. Please help us by answering a few questions:

- 1) Did you or someone with whom you spoke notice any unusual wave activity near the date and time of the earthquake?

_____ Yes _____ No

If No go to question 13

If Yes go to question 2

- 2) If Yes, about when was it noticed?

- 3) Please tell us where you were when the wave activity was observed.

- 4) Tell us about what you saw or heard that happened.

- 5) In what capacity did you observe the wave?

_____ My job _____ Where I live

_____ Activity: surfing, jogging, walking, fishing, other (Explain)

- 6) What did you see?

_____ Turbulence _____ Choppy water

_____ Water went out _____ Water came far inland

- 7) Was there a direction to the wave/unusual water behavior?

- 8) Was there any damage? _____ Yes _____ No

- 9) If Yes, what kind?

10) About how far from the usual high tide were the buildings or structures that were damaged?

- At the shoreline Less than 50 ft
 Between 50 and 100 ft Between 100 and 200 ft
 More than 200 ft

11) What else did you notice?

- Sand moved around Effects on marine life
 Other (Explain)

12) Do you know of any injuries or fatalities associated with the wave?

- Yes No
If Yes, how many injuries? Fatalities?
Circumstances?

13) Did you receive a tsunami alert, information bulletin, watch or warning?

- Yes No
If Yes, indicated type and at what time(s):
_____ Alert
_____ Bulletin
_____ Watch
_____ Warning

If Yes, how did you learn of the alert, warning, bulletin, or watch?

- Stren Radio T.V. Civil Defense
 Fire Dept. Police Other (Explain)

What was your response to the alert, warning, bulletin, or watch? (if more than one, please indicate order)

- Did nothing Evacuated
 Waited for further instructions Other (Explain)

In case we need to contact you again, please list your name and telephone number:

Name: _____ Telephone: _____

Appendix 2: Summary of Tsunami Observations

Costa Rica

Rio Matina (#1 [10.11 N, 83.18 W])- Mr. J. Navarro reports two drownings in the canal near Matina. Ms. P. Arce reported that the water retreated 400 m followed by large waves that flooded 180 m inland. Widespread liquefaction. Dead fish were observed following the tsunami.

Bocas del Pantano (#2 [10.07 N, 83.15 W]) - Ms. U. Hucker reports that the water first receded 100 m and then returned within 3 min without flooding.

12 Millas de Moin (#3 [10.05 N, 83.13 W])- Mr. J. Sanchez reports that two minutes after the earthquake he observed a 2 m wave, which flooded 30 to 70 m inland. Sand movement.

6 Millas de Moin(#4 [10.08 N, 83.11 W])- Mr. J. Navarro reports that the water slowly retreated about 20 m. Runup height:135 cm (Plafker and Ward, 1992)

Moin (#5 [10.00 N, 83.08 W])- Mr. Rodriguez reports that the water retreated about 200 m. A seawave overtopped 3 m dikes in the Moin River. Runup height: 65-70 cm (Plafker and Ward, 1992).

Westfalia (#6 [9.94 N, 83.01 W])- Mr. L. Miranda reported that the water retreated about 200 m and returned to the shoreline without appreciable runup or flooding. Sand movement. Runup height: 60-170 cm (Plafker and Ward, 1992).

Cahuíta (#7 [9.73 N, 82.85 W])- Ms. A. Lopez noted that the sea receded 75 m then returned slowly to a level lower than previous. Dead fish were observed.

Puerto Viejo (#8 [9.66 N, 82.76 W])- Mr. A. Guithrig reports that the sea receded 100 m and returned in a large wave with 30 to 70 m runup, sand movement and dead fish were also noted. Runup height: 155 cm (Plafker and Ward, 1992).

Final de Cocles (#9 [9.64 N, 82.73 W])- Mr. J. Taylor noted that the sea receded 20 m, then returned slowly with no runup.

Punta Uva (#10 [9.64 N, 82.69 W])- Mr. A. Trejors reports that the water retreated 400 to 600 m. Runup height: 200 cm (Plafker and Ward, 1992).

Manzanillo (#11 [9.63 N, 82.67 W])- Mr. B. Apu notes that the sea receded 180 m and returned in 5 min to flood 30 to 70 m inland, Sand movement and 1.5 m mounds deposited. Runup height: 80-130 cm (Plafker and Ward, 1992).

Gandoca (#12 [9.59 N, 82.61 W])- Mr. C. Rojas reports that the sea receded 300 m in 5 min and returned to flood about 70 m inland. Sand movement. Runup height: 125 cm (Plafker and Ward, 1992).

Panama

San-San Natural Refuge (#13 [9.54 N, 82.53 W], & #14 [9.51 N, 82.49 W])- Tsunami waves deposited a great deal of sand on the beach near the mouth of the San-San river, a wildlife refuge near the Costa Rican border, creating dunes which covered numerous turtle nests with approximately 1 m of sand and caused a decrease in the number of newborn turtles. An areal photo from location 13 is shown in Figure 3

Julio Abrego Beach (#15 [9.43 N, 82.41 W])- A farmer reports that before the quake occurred the sea was very quiet. Minutes after the event the sea receded between 3 and 6 times. The last wave was the largest, and the water penetrated 100 m inland.

Beach between the mouth of the River Changuinola and Tiribibi Point (#16 [9.42 N, 82.38 W])- From helicopter view in Figure 4, palm trees and other types of vegetation are seen surrounded by sand. Some deposition structures, presumably caused by a high energy current, can also be seen.

Isla Colon

Lime Point (Boca del Drago) (#17 [9.41 N, 82.33 W])- Every person interviewed at this location reports that the sea was very quiet before the earthquake, but one to 1/2 hour before the event the sea was unusually warm. Mrs. T. Serracin reports that the water had such an uncomfortable temperature she decided not to take her daily bath. Here the sea receded approximately 6 times out to the coral reefs (approximately 100 m from shore) which looked like a stone wall. All 6 times the sea returned with a great roar and noise. Mrs. Serracin also reports having seen the last wave from her house and estimated the wave to be 2 m high. This estimate was verified in the field by one of the authors (E. Camacho). Mr G. Sanchez could see how his small boat, which was standing in the water in front of his house, would sometimes lie in dry sand and after some minutes, would hit a tree branch some 1.5 m above the pre-tsunami water surface. The last wave was approximately 2 m high and water flooded parts of the coastal road in front of his house. The following day, Mr W. Serracin reports that the Boca del Drago passage had many dead fish floating in its waters.

West Knapp Hole Point (#18 [9.41 N, 82.33 W])- This site is located in the coast facing Almirante Bay. Mr. R.D. Vega reports that before the earthquake the sea was calm. Minutes after the quake he saw a great turbulence in the sea, similar to rapids or the strong current of a river. The strong current flooded the part of the beach in front of his house. The water flooded from 5 to 10 m of the beach.

Ground Creek (#19 [9.40 N, 82.31 W])- This place is also located in Almirante Bay. Here Mr. J. Tapp reports that the sea was quiet before the quake. He observed how the water receded several times and returned as a strong river current approximately 0.6 m high. Many fish were deposited along the banks of the creek by the strong current. The banks got flooded in some parts up to 10 m inland because of the strong current.

Punta Cauro (#20 [9.43 N, 82.32 W])- This site faces the Caribbean Sea. Mrs. P. Duncan reports that the sea was quiet before the earthquake. From her house on top of a hill she observed how the sea receded five times and returned making great noise. She left some clothes drying on a rock some 2 m or more above the surface of the water near a cliff. After the high waves ceased, she returned to get her clothes, and discovered they had been taken by the waves. She thinks the last wave was the one that took her clothes. A few days later, she recovered her clothes, they may have been brought back by the sea currents. This is a zone where there are strong sea currents which run parallel to the coast.

Boket Bay (#21 [9.43 N, 82.30 W])- This site also faces the Caribbean Sea. Ten to fifteen minutes after the earthquake, Mr. Samaniego reports having seen a wave between 2.5 and 3.0 m high, accompanied by a strong noise. This high crested wave was observed from a house standing on top of a hill.

Bocas del Toro (#22 [9.34 N, 82.24 W])- The sea was quiet before the earthquake. Ten minutes after the event, the sea receded approximately 400 m from the cove facing the town. The sand bar, Las Delicias (Grassy Bank), which is usually covered by 0.6 to 0.7 m of water, emerged and remained subareal from 5 to 7 minutes. After this period, several waves from 0.6 to 0.7 m started to enter the cove with great force. The water was full of sediments and flooded 100 to 150 m inland, mainly in the north part of town, which is located in an extremely flat area.

Nancy Key (Solarte Island) (#23 [9.33 N, 82.22 W])- From Hospital Point, Mr. C. Stephens observed 10 to 15 minutes after the earthquake how the sea receded several times and returned as a strong river current, from Bocas del Torro passage.

San Cristobal Island (#24 [9.28 N, 82.27 W])- In the northwest portion of the island, in the mouth of Paloma Creek, the sea receded several meters for approximately 45 minutes. Many fish got trapped in the dry terrain. The water returned as a slow wave covering back the areas that had emerged minutes before.

Carenero Island (#25 [9.34 N, 82.23 W])- 15 to 20 minutes after the earthquake, the sea receded and the usually submerged sand bank Las Delicias could be seen for about 15 minutes. The sea returned with just one very gentle wave. The sea penetrated 100 to 150 m inland crossing the southern tip of the island, which is an extremely flat area. The inhabitants that remained in the island report that the water reached up to their knees. This southern portion of the island remained flooded for approximately 20 minutes and when the sea receded back to its original stage, it did so with great strength.

Bastimentos Island (#26 [9.34 N, 82.22 W])- In the northwest portion of the island, also known as Old Bank, 10 to 15 minutes after the earthquake it was observed how the sea receded several meters for approximately 15 minutes. Some submarine vegetation could be seen during this period of time. Once the sea started to return, it did so in a gentle manner.