



A massive 8.9/9.0 magnitude earthquake hit the Pacific Ocean near Honshu, Japan at around 2:46 PM (Japan Standard Time) on March 11, 2011 causing damage with blackouts, fire and tsunami. The tsunami wave then raced across the Pacific Ocean and arrived at many cities around the Pacific Rim. The map above, produced by the National Oceanic and Atmospheric Administration, shows the predicted arrival times in hours for the tsunami wave.

At 7:46 AM Pacific Standard Time on March 11, it resulted in 2.5 meter (8-foot) waves in some locations in Crescent City, California. Waves as tall as 3.5 meters (11-feet) were recorded in Kealakekua Bay, Hawaii at 3:24 AM Local Hawaii Time on March 11. The distance from the epicenter near Honshu, Japan to Crescent City is 8,020 km; to Kealakekua Bay, Hawaii is 6,640 km.

Because these destinations are not all in the same time zone, we have to also include this information: 6:00 AM (Japan Standard Time) on March 11, is the same as 11:00 AM March 10 (Hawaii Standard Time) in Hawaii, and 1:00 PM, March 10 (Pacific Standard Time) in Crescent City.

**Problem 1** - At what local time and date did the earthquake occur in A) Hawaii?  
B) Crescent City?

**Problem 2** - How long did it take the tsunami to reach each of the landfalls?

**Problem 3** - What was the average speed of the tsunami based on the two estimates?

**Problem 1** - At what local time and date did the earthquake occur in A) Hawaii? B) Crescent City?

Answer: Working with time zone calculations, especially across the International Date Line, can be very tricky, but it is an essential skill in today's world where many people travel around the world for vacations and for their careers.

The earthquake began at 2:46 PM JST on March 11. Using the '24-hour clock' makes the calculations easier, so this becomes 14:46 JST.

Then from

06:00 March 11 (Japan Standard Time) in Japan is the same as

11:00 March 10 (Hawaii Standard Time) in Hawaii, and the same as

13:00 March 10 (Pacific Standard Time) in Crescent City,

The table below shows the relevant calculations and answers converted back to the local 12-hour clock.

Location	Distance	Difference from JST	Local Time	Date
Japan	0	0	<b>2:46 PM (JST)</b>	<b>March 11</b>
Hawaii	6,640 km	-19 hours	<b>7:46 PM (HST)</b>	<b>March 10</b>
Crescent City	8,020 km	-17 hours	<b>9:46 PM (PST)</b>	<b>March 10</b>

**Problem 2** - How long did it take the tsunami to reach each of the landfalls?

Answer: Using the local times for the earthquake calculated in Problem 1, we just take the difference in local time between the landfall time and the earthquake time:

Hawaii: 03:24 March 11 - 19:46 March 10 = **7.6 hours.**

Crescent City: 07:46 March 11 - 21:46 March 10 = **10 hours**

**Problem 3** - What was the average speed of the tsunami based on the two estimates?

Answer:

Hawaii: 6,640 km / 7.6 hours = **873 km / hr.**

Crescent City: 8,020 km / 10 hours = **802 km/hr.**

The average speed is about  $(873 + 802)/2 =$  **837 km/hr.**

Note: The actual distance traveled by the tsunami wave is not exactly a straight line between the epicenter and the destinations. More accurate models by NOAA's Tsunami Forecasting Center predicted a wave speed closer to 800 km/hour.