Tsunami in Japan 2011: Waves Stirred Up by Earthquake Cause Wide Destruction
Learn about the science behind tsunamis and earthquakes

by Beth Rowen and Catherine McNiff

Japan was hit by a 9.0 magnitude earthquake on March 11, 2011, that triggered a deadly 23-foot tsunami in the country's north. The giant waves deluged cities and rural areas alike, sweeping away cars, homes, buildings, a train, and boats, leaving a path of death and devastation in its wake. Video footage showed cars racing away from surging waves. The earthquake—the largest in Japan's history—struck about 230 miles northeast of Tokyo. The Pacific Tsunami Warning Center issued warnings for Russia, Taiwan, Hawaii, Indonesia, the Marshall Islands, Papua New Guinea, Australia, and the west coasts the U.S., Mexico, Central America, and South America. According to the official toll, the disasters left 15,839 dead, 5,950 injured, and 3,642 missing.

Earthquake Causes Nuclear Disaster

What's more, cooling systems in one of the reactors at the Fukushima Daiichi Nuclear Power Station in the Fukushima prefecture on the east coast of Japan failed shortly after the earthquake, causing a nuclear crisis. This initial reactor failure was followed by an explosion and eventual partial meltdowns in two reactors, then by a fire in another reactor which released radioactivity directly into the atmosphere. The nuclear troubles were not limited to the Daiichi plant; three other nuclear facilities also reported problems. More than 200,000 residents were evacuated from affected areas.

On April 12, Japan raised its assessment of the situation at the Fukushima Daiichi nuclear power plant to Level 7, the worst rating on the international scale, putting the disaster on par with the 1986 Chernobyl explosion. Developed by the International Atomic Energy Agency (IAEA) along with countries who use nuclear energy, the scale defines level 7 as a nuclear accident that involves "widespread health and environmental effects" and the "external release of a significant fraction of the reactor core inventory." Almost two months later, the IAEA called the status of the Fukushima Daiichi nuclear plant "very serious."
At a news conference on March 13, Prime Minister Naoto Kan, who later gave the disaster the name "Great East Japan Earthquake", emphasized the gravity of the situation: "I think that the earthquake, tsunami, and the situation at our nuclear reactors makes up the worst crisis in the 65 years since the war. If the nation works together, we will overcome." The government called in 100,000 troops to aid in the relief effort. The deployment was the largest since World War II.

The tsunami in Japan recalled the 2004 disaster in the Indian Ocean. On Dec. 26, a 9.0 magnitude earthquake—the largest earthquake in 40 years—ruptured in the Indian Ocean, off the northwest coast of the Indonesian island of Sumatra. The earthquake stirred up the deadliest tsunami in world history, so powerful that the waves caused loss of life on the coast of Africa and were even detected on the East Coast of the United States. More than 225,000 people died from the disaster, a half a million were injured, and millions were left homeless.

See statistics on Deadliest Tsunamis and Deadliest Earthquakes.

The Science of Tsunami

A tsunami (pronounced soo-NAHM-ee) is a series of huge waves that occur as the result of a violent underwater disturbance, such as an earthquake or volcanic eruption. The waves travel in all directions from the epicenter of the disturbance. The waves may travel in the open sea as fast as 450 miles per hour. As they travel in the open ocean, tsunami waves are generally not particularly large—hence the difficulty in detecting the approach of a tsunami. But as these powerful waves approach shallow waters along the coast, their velocity is slowed and they consequently grow to a great height before smashing into the shore. They can grow as high as 100 feet; the Indian Ocean tsunami generated waves reaching 30 feet.

Tsunami is the Japanese word for "harbor wave." They are sometimes mistakenly referred to as tidal waves, but tsunamis have nothing to do with the tides. Tsunamis have been relatively rare in the Indian Ocean, and are most common in the Pacific Ocean.

Read more: Tsunami Factfile: Learn about the tsunami that struck Japan in March 2011 — Infoplease.com
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In many ways, Japan is still reeling from the devastating earthquake and tsunami of March 11, 2011, and the nuclear crisis and huge leaks of radiation it set off.

The disaster led to soul searching in a nation already worn down by two lost decades of economic growth, a rapidly aging and shrinking population, political paralysis and the rapid rise of its longtime rival, China.

In September 2012, as tensions rose with China over competing claims on a string of rocky islands in the East Asian Sea, the country’s long-dysfunctional political system seemed close to grinding to a halt.

Prime Minister Yoshihiko Noda fended off a challenge to his party leadership. But his victory was seen as likely to be short-lived amid a parliamentary impasse, a damaging feud with China and dismal poll ratings that bode ill for his party’s fortunes in the next elections. Indeed, Mr. Noda may have been elected simply to spare the Democrats the humiliation of burning through three prime ministers in three years.

He also faces a standoff in Parliament, where the main opposition Liberal Democratic Party has moved to block almost every policy move. He pushed through a contentious increase of the sales tax to 10 percent, but only after promising to dissolve Parliament and call nationwide elections “soon.”

That is a vote that the governing Democratic Party appears unlikely to survive. Mr. Noda’s popularity ratings are in the low 20s, hurt by his failure to break through the parliamentary gridlock, to stimulate the economy and, more recently, to take a decisive stand on Japan’s nuclear energy policy.

The Liberal Democrats in late September chose Shinzo Abe — a former prime minister and hard-line nationalist — to be their leader. As a result, both the Liberal Democrats and Democrats appear set to limp into elections that are shaping up to be a battle to be the least unpopular.

**Recovering From the Dual Disasters**

The road to recovery from the tsunami has been a long one. The northern coastal towns that were flattened by waves have cleaned up millions of tons of debris and are beginning to rebuild.
But it is the nuclear accident at the Fukushima Daiichi Nuclear Power Station that is likely to have a more lasting impact, even though it has yet to claim a single life. Japan is just beginning what promises to be a decades-long radiation cleanup of the evacuated areas around the plant, where nearly 90,000 residents lost their homes. The nation is also groping to find effective ways to monitor health and protect its food supply from contamination by the accident, which government scientists now say released about a fifth as much radioactive cesium as the 1986 Chernobyl disaster.

The crisis began when an earthquake struck off the east coast of Japan, churning up a devastating tsunami that swept over cities and farmland in the northern part of the country and prompting warnings as far away as the West Coast of the United States and South America. Recorded at 9.0 on the Richter scale, it was the most powerful quake ever to hit Japan. The tsunami killed as many as 20,000 people.

As the nation struggled with a rescue effort, it also faced the world’s worst nuclear crisis since Chernobyl. Explosions and leaks of radioactive gas took place in three reactors at the Fukushima Daiichi nuclear plant that suffered partial meltdowns, while spent fuel rods at another reactor overheated and caught fire, releasing radioactive material directly into the atmosphere.

Japanese officials turned to increasingly desperate measures, as traces of radiation were found in Tokyo’s water and in water pouring from the reactors into the ocean.

The ensuing crisis led to a change in leadership, as Japan’s governing Democratic Party elected Mr. Noda as the new prime minister in August 2011. Mr. Noda, a former finance minister, became the sixth person to hold the post in five years. He replaced Naoto Kan, who had failed to galvanize Japan after the disaster and was forced to resign.

Throughout the crisis, both the Fukushima Daiichi plant’s operator, Tokyo Electric Power, or Tepco, and the government were accused of playing down the dangers posed by the meltdown. Subsequent disclosures that the event was indeed far more severe than they let on have badly damaged their credibility, to the point that almost any statement from the authorities is now regarded as suspect by a dubious Japanese public.

For more on the Fukushima disaster and nuclear energy in general, click here.
TOKYO — Rescuers struggled to reach survivors on Saturday morning as Japan reeled after an earthquake and a tsunami struck in deadly tandem. The 8.9-magnitude earthquake set off a devastating tsunami that sent walls of water washing over coastal cities in the north. Concerns mounted over possible radiation leaks from two nuclear plants near the earthquake zone.

The death toll from the tsunami and earthquake, the strongest ever recorded in Japan, was in the hundreds, but Japanese news media quoted government officials as saying that it would almost certainly rise to more than 1,000. About 200 to 300 bodies were found along the waterline in Sendai, a port city in northeastern Japan and the closest major city to the epicenter.

Thousands of homes were destroyed, many roads were impassable, trains and buses were not running, and power and cellphones remained down. On Saturday morning, the JR rail company said that there were three trains missing in parts of two northern prefectures.

While the loss of life and property may yet be considerable, many lives were certainly saved by Japan’s extensive disaster preparedness and strict construction codes. Japan’s economy was spared a more devastating blow because the earthquake hit far from its industrial heartland.

Japanese officials on Saturday issued broad evacuation orders for people living in the vicinity of two separate nuclear power plants that had experienced breakdowns in their cooling systems as a result of the earthquake, and they warned that small amounts of radiation could leak from both plants.

On Friday, at 2:46 p.m. Tokyo time, the quake struck. First came the roar and rumble of the temblor, shaking skyscrapers, toppling furniture and buckling highways. Then waves as high as 30 feet rushed onto shore, whisking away cars and carrying blazing buildings toward factories, fields and highways.

By Saturday morning, Japan was filled with scenes of desperation, as stranded survivors called for help and rescuers searched for people buried in the rubble. Kazushige Itabashi, an official in Natori City, one of...
the areas hit hardest by the tsunami, said several districts in an area near Sendai’s airport were annihilated.

Rescuers found 870 people in one elementary school on Saturday morning and were trying to reach 1,200 people in the junior high school, closer to the water. There was no electricity and no water for people in shelters. According to a newspaper, the Mainichi Shimbun, about 600 people were on the roof of a public grade school, in Sendai City. By Saturday morning, Japan’s Self-Defense Forces and firefighters had evacuated about 150 of them.

On the rooftop of Chuo Hospital in the city of Iwanuma, doctors and nurses were waving white flags and pink umbrellas, according to TV Asahi. On the floor of the roof, they wrote “Help” in English, and “Food” in Japanese. The reporter, observing the scene from a helicopter, said, “If anyone in the City Hall office is watching, please help them.”

The station also showed scenes of people stranded on a bridge, cut off by water on both sides near the mouth of the Abukuma River in Miyagi Prefecture.

People were frantically searching for their relatives. Fumiaki Yamato, 70, was in his second home in a mountain village outside of Sendai when the earthquake struck. He spoke from his car as he was driving toward Sendai trying to find the rest of his family. While it usually takes about an hour to drive to the city, parts of the road were impassable. “I’m getting worried,” he said as he pulled over to take a reporter’s call. “I don’t know how many hours it’s going to take.”

Japanese, accustomed to frequent earthquakes, were stunned by this one’s magnitude and the more than 100 aftershocks, many equivalent to major quakes.

“I never experienced such a strong earthquake in my life,” said Toshiaki Takahashi, 49, an official at Sendai City Hall. “I thought it would stop, but it just kept shaking and shaking, and getting stronger.”

Train service was shut down across central and northern Japan, including Tokyo, and air travel was severely disrupted.

On Friday, television images showed waves of more than 12 feet roaring inland in Japan. The floodwaters, thick with floating debris shoved inland, pushed aside heavy trucks as if they were toys. The spectacle was all the more remarkable for being carried live on television, even as the waves engulfed flat farmland that offered no resistance. The tsunami could be seen scooping up every vessel in the ocean off Sendai, and churning everything inland. The gigantic wave swept up a ship carrying more than 100 people, Kyodo News reported.

Vasily V. Titov, director of the National Oceanic and Atmospheric Administration’s Center for Tsunami Research, said that coastal areas closest to the center of the earthquake probably had about 15 to 30 minutes before the first wave of the tsunami struck. “In Japan, the public is among the best educated in the world about earthquakes and tsunamis,” he said. “But it’s still not enough time.”
Complicating the issue, he added, is that the flat terrain in the area would have made it difficult for people to reach higher, and thus safer, ground. On Friday, NHK television showed images of a huge fire sweeping across Kesennuma, a city of more than 70,000 people in the northeast. Whole blocks appeared to be ablaze. NHK also showed aerial images of columns of flame rising from an oil refinery and flood waters engulfing the Sendai airport, where survivors clustered on the roof. The runway was partly submerged. The refinery fire sent a plume of thick black smoke from blazing spherical storage tanks.

Even in Tokyo, far from the epicenter, the quake struck hard. William M. Tsutsui, a professor of Japanese business and economic history at Southern Methodist University in Dallas, was traveling in Tokyo with a business delegation when the ground began to shake. “What was scariest was to look up at the skyscrapers all around,” he said. “They were swaying like trees in the breeze.”

Prime Minister Naoto Kan said the quake and tsunami caused major damage across wide areas.

The United States Geological Survey said the quake was the most severe worldwide since an 8.8-magnitude quake off the coast of Chile a little more than a year ago that killed more than 400. It was less powerful than the 9.1-magnitude quake that struck off Northern Sumatra in late 2004. That quake set off a tsunami that killed more than 200,000 people around the Indian Ocean.

The survey said that Friday’s quake was centered off the coast of Honshu, the most populous of the Japanese islands, at a point about 230 miles northeast of Tokyo and a depth of about 15 miles below the earth’s surface.

President Obama said the United States “stands ready to help” Japan deal with the aftermath. “Michelle and I send our deepest condolences to the people of Japan,” he said in a statement. He later spoke with Mr. Kan and offered assistance.

American military airfields in Japan began accepting civilian flights diverted from airports that suffered damage, American officials said early Friday.

A spokesman for the American Seventh Fleet in Japan said Naval Air Field Atsugi had received several commercial passenger planes that could not land at Narita airport outside Tokyo. Officials said Yokota Air Base also received civilian flights. Three American warships in Southeast Asia will be ordered out to sea to reposition themselves in case they need to provide assistance, a fleet spokesman said.

The tsunami assaulted Hawaii with seven-foot waves, although it caused little damage. Powerful surges that hit the West Coast of the United States caused boats to sink in Santa Cruz Harbor. The Coast Guard reported that one person was swept to sea near McKinleyville, Calif., while trying to take pictures of the waves, and a search had begun.

In Japan, the Tokyo subways emptied, and airports were closed. Many residents set off on epic journeys home, walking for miles across a vast metropolitan area. As late as Saturday morning, 18 hours after the earthquake, thousands of people in dark suits were still trudging home from the central business district.
In a video posted on YouTube, rumbles shook a supermarket as shopkeepers rushed to steady toppling wares and a classical music soundtrack played.

On Twitter, a person who used the name sinonosama said that students at an agricultural high school in Miyagi Prefecture were fine, but had to take refuge on the third floor after the tsunami flooded the first two floors.

The quake occurred in what is called a subduction zone, where one of the Earth’s tectonic plates is sliding beneath another. In this case, the Pacific plate is sliding beneath the North American plate at a rate of about three inches a year. The earthquake occurred at a depth of about 15 miles, which while relatively shallow by global standards is about normal for quakes in this zone, said Emily So, an engineer with the United States Geological Survey in Golden, Colo.

When such quakes set off a tsunami, the devastation often comes from a succession of waves, which can cross oceans at 500 miles per hour or more.

*Reporting was contributed by Yasuko Kamiizumi from Tokyo; Ken Belson, Maria Newman and Henry Fountain from New York*