Tsunami ‘Guardian’ passes test
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Rotorua Daily Post, Page 8, Section: News
Thursday 2 October 2025
1634 words, 900cm² in size

A July 30 earthquake caused coastal inundation at Severo-Kurilsk, Paramushir Island in the far east of Russia, and sparked tsunami warnings across the Pacific. Photos / Getty Image

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Alerts allow scientists to analyse data and assess threats to coastlines

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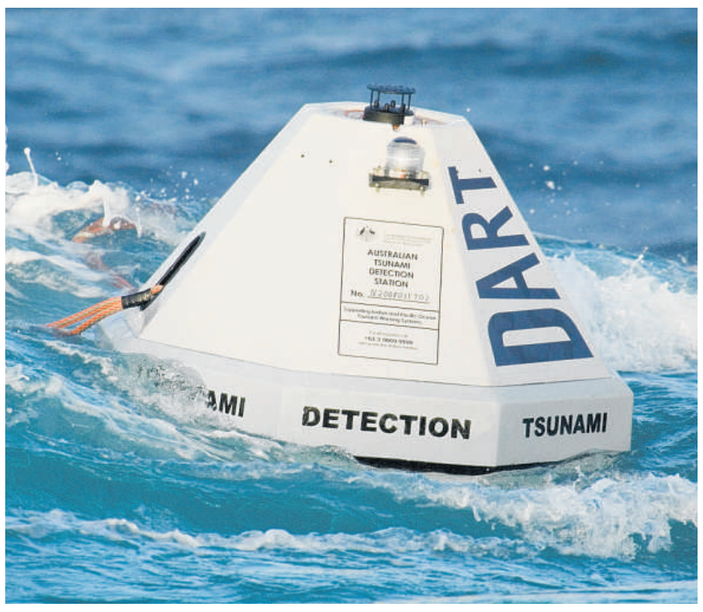

Dart buoys are positioned around the Pacific, providing real-time tsunami data (left). The tsunami buoy transmitting and receiving systems and sensors are tested and configured before deployment.

About 11.30am on July 30 a powerful earthquake struck the Kamchatka Peninsula on Russia’s far eastern northern Pacific seaboard.

Moments later, alarms went off at the Pacific Tsunami Warning Centre (PTWC) alerting people to the massive quake, among them Dr Bill Fry, New Zealand’s head of the rapid characterisation of earthquake and tsunami (Rcet) programme at Earth Sciences NZ.

“With any tsunami-generating event, we are racing the clock to get as much science as possible done to get the best information to the people who need it, including our friends around the Pacific ring,” Fry told the *Herald*.

“Kamchatka was no different. As soon as we received the alerts, we got to work to analyse the data with the tools and expertise we have available and assess the threat to NZ.”

As chairman of the IOC-Unesco (The Intergovernmental Oceanographic Commission of Unesco) working group in charge of tsunami forecasting in the Pacific, he has the responsibility of interpreting reams of data on any potential hazardous event and getting warnings out as soon as his team can manage.

Fry’s people quickly worked out that the reported magnitude 8 quake was significantly larger, with magnitude estimates upward to M8.5, calculated minutes after the event.

“Our early analysis correctly identified that a tsunami had very likely been generated, grabbing our attention very quickly,” he said.

Currently scientists use seismic data from an earthquake as a proxy for assessing tsunami generation and magnitude with data arriving almost immediately. But interpretations are conservative until more data can be processed to gradually build a more accurate picture.

The gold standard detection of tsunami comes from a network of deep-ocean assessment and reporting of tsunami (Dart) buoys positioned around the Pacific Ocean providing physical real-time data on a tsunami. However, Darts are expensive and relatively sparse.

Now, however, scientists have a new fast and accurate tool in their hands designed to boost tsunami early warning systems. It had been switched on the day before the Kamchatka quake, giving scientists valuable time to determine the situation and the likelihood of destructive waves.

The GNSS Upper Atmospheric Real-time Disaster Information and Alert Network, known by the acronym Guardian, quickly detected distortions in the atmosphere that could indicate a rapidly moving tsunami only 20 minutes after the Kamchatka quake confirming waves approaching 30 to 40 minutes before making landfall in Hawaii and other areas of the Pacific.

Those extra minutes of knowing something is coming could make a real difference when it comes to warning communities in the path.

“This is where Guardian adds real value,” Fry said. “Its wide spatial coverage — detecting tsunami 200 to 1500km offshore — means we can complement those early seismic estimates with near real-time physical observations that can be targeted to provide a safety net around New Zealand coastlines,” he said, adding that the more points of tsunami observations we have in the open ocean, the higher chance of an earlier warning and the more points of data from multiple sources, the greater accuracy we have for rapidly forecasting tsunami and their impacts.

So what is Guardian and how does it work?

Fry explains that, for decades, the world has been improving GPS positioning (how we use satellites to measure where we are) by enhancing signal processing algorithms. Among other things, this involves removing distorted radio signals, or “noise”, caused by disturbances that pass through the atmosphere to low-Earth orbiting satellites.

“It was about four years ago when data analysts at Nasa-JPL (Jet Propulsion Laboratory in California) realised this noise could tell us something about the planet,” Fry reveals. “When tsunami occur, large areas of water rise and fall, creating disturbances in the atmosphere above. This creates a change in the density of electrons in the ionosphere (the large outer layer of our atmosphere that is strongly affected by solar radiation).

“By measuring these shifts, we can effectively ‘see’ the tsunami wave field from 200 to 1500km offshore, extending the reach and sensitivity of traditional monitoring instruments.”

Using Guardian and traditional seismic tools, Fry’s team was able to accurately predict the tsunami’s path across the Pacific a full seven hours before the waves reached New Zealand.

“We also had the advantage of improving our estimates with more data as the wave travelled toward us and passed multiple Dart stations and tsunami gauges around the Pacific,” Fry said. “Our time-dependent forecasts told us this would be a long duration threat as reflected waves from the Americas sent a second round of tsunami waves our way, particularly to the East Coast and the Chatham Islands.”

New Zealand’s National Emergency Management Agency (Nema) kicked into gear sending text alerts and getting the message out via media to people around the motu who were warned to stay away from coastal areas.

Guardian passed its first test providing proof of concept — that the technology can be used to complement our tsunami early warning system, Fry said.

“The Guardian success was ‘detection and warning’,” he said. “Currently the technology acts as a red flag that something has happened, but it can’t tell us what the impact will be.

“Now we need to roll up our sleeves and do the hard yards of using the approach to improve our forecasting of the impacts of tsunamis: things like how big it will be, how much on-land flooding might occur and when and how long will the threat last.”

By using existing infrastructure Guardian is low cost, too. The Kiwi scientists can freely access available geodetic data, including GeoNet’s GNSS network, underlining the importance of open-source data to help solve global challenges, Fry said.

He added that the additional stream of real-time data strengthens multi-source analysis, helping Rec issue earlier and more accurate warnings, especially for locally generated tsunami that can strike within 45 minutes of an offshore earthquake.

“The next step is to refine how Guardian data is translated into physics-based tsunami outputs that can be fed directly into forecast models. Once integrated, it could become a powerful complement to New Zealand’s existing monitoring network,” Fry said.

“The real success story was that the Kamchatka event was Guardian’s first successful automated detection and alert for a tsunami. Guardian is ultimately about time, giving people and emergency managers crucial extra minutes to act before a tsunami strikes.

“For those in harm’s way, it could mean earlier warnings that reach communities before destructive waves arrive, more accurate forecasts about the size and timing of the tsunami, reducing false alarms and unnecessary evacuations, better informed decisions for emergency managers and lives saved and reduced impacts on infrastructure livelihoods, and communities.”