# Progress from catastrophe

Natural disasters can devastate local communities. However, these rare events also often trigger new ways of thinking, and provide a treasure trove of data that must be used to reduce vulnerability.

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The triple blow of the Japan earthquake, tsunami and nuclear disaster in March 2011 was catastrophic. Six years on, communities in eastern Japan are still recovering, large volumes of tsunami-generated debris remain in the Pacific Ocean[1] and radioactive water is still being released from the Fukushima Daiichi nuclear site[2]. The quake was not the strongest ever recorded, but it was probably the best measured and generated an unprecedented volume and quality of data that can inform our preparation and response to future events. The catastrophe sparked a wealth of research — including two studies in this issue — on tsunamigenic earthquakes and tsunamis, a topic that entered centre stage on the research agenda only a few years earlier, in the wake of the Indian Ocean tsunami in December 2004.

Japan sits on the Ring of Fire, a circum-Pacific, almost continuous loop of ocean trenches and volcanoes that mark the subduction of tectonic plates. Japan is no stranger to seismicity — earthquakes regularly occur as the oceanic plates jostle their way into the mantle — and the country is one of the best seismically instrumented in the world. Following the 2011 disaster, many scientists turned their attention to tsunami-generating earthquakes.

The work sparked by this catastrophe has revolutionized our understanding of the planet's largest earthquakes. Before 2011, many thought that earthquakes within subduction-zone segments have a characteristic maximum size and recurrence time, and that these seismic ruptures are mostly confined to relatively deep parts of the plate boundary. But the Tōhoku-oki event defied this framework: at magnitude 9 it was uncharacteristically large for northeastern Japan and ruptured all of the way to Earth's surface.

Seismic images from the region reveal a series of large branching faults that extend from the surface, through the continental crust and connect to the boundary with the subducting Pacific Plate below[3]. Movement on these shallow splay faults probably contributed to the colossal size of the ensuing tsunami. On page 609 of this issue, Bécel *et al.* identify similar structures in the Alaskan subduction zone, implying that this region, too, may have potential for a large tsunami.

As the waves from the Tōhoku tsunami receded, much of the wreckage washed into the Pacific Ocean. Carried by surface winds and ocean currents, the debris began to appear on North American shores within just nine months. As reported by Matthews *et al.* on page 598 of this issue, the cross-Pacific journey of some of this material may have been accelerated by the presence of oil and other contaminants that help smooth the sea surface and invigorate surface-wind transport of the debris plumes.

Radioactive isotopes from the Fukushima Daiichi nuclear plant, though at levels considered safe, were also detected offshore from British Columbia within 15 months of the tsunami-triggered nuclear meltdown[4]. Of course, pollution and radioactive contamination of the food web are significant concerns. But the debris and radioactive nuclides also act as rare tracers. In particular, the radionuclides provide unique tracers of deeper ocean currents, including the North Atlantic Deep Water that lies almost 2 km beneath the surface[5]. So far, the tracers show that water moves more slowly from Asia towards North America than some ocean circulation models had predicted[6].

There are other examples where catastrophic earthquakes have reinvigorated investigations. Nepal, too, is a country vulnerable to natural disasters. The 2015 Gorkha earthquake that wreaked havoc on Kathmandu focussed seismologists' attention on Himalayan earthquakes, and supplied a wealth of measurements to work with. It emerged that earthquakes in this region may not typically rupture all of the way to the surface, meaning that strain in the crust generated by India colliding with Asia is not fully released. Instead, this strain may accumulate to fuel future earthquakes[7].

The 2015 Nepal earthquake also put a spotlight on the societal impacts of natural disasters. Analysis of mobile-phone data shows that 390,000 people left the Kathmandu Valley in the weeks following the 2015 Nepal earthquake, but around 85% of these people returned within about three months[8]. Such data, analysed and made available in near-real time, enable a more effective humanitarian response, allowing agencies to quickly pinpoint where aid should be directed in the immediate aftermath of an event, as well as identify areas experiencing slow recovery.

The human and environmental impacts of natural disasters are devastating, but they cause policymakers, funders and scientists to focus their efforts and thereby reduce our future vulnerability to the forces of nature. ❐

## References


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