Underappreciated Atlantic tsunami risk

To the Editor — North Atlantic tsunamis are rare, but they can be devastating. For example, the tsunami associated with the 1755 Lisbon earthquake killed thousands and was observed from England to Brazil[1]. An event of comparable magnitude today would have a much more devastating impact on the North Atlantic seaboard: risk awareness is low in the region and protection for the highly populated coastal communities is low, even though the North Atlantic coasts are a vital component of the global economy. North Atlantic tsunami risk — dependent on both likelihood and exposure — is therefore significant. We argue that preparedness can be much improved by combining existing coastal flood defences for more frequent events, such as storm surges, with tsunami contingency plans.

Comparison of two catastrophic tsunamis, generated in the Indian Ocean in 2004 and off Japan in 2011, shows that mitigation can save hundreds of thousands of lives. In both cases, large waves broke on the shoreline within 20 minutes of the triggering earthquake, sea water inundated the coast several kilometres inland and the surge reached onshore elevations of more than 30 m (refs 2,3). Nonetheless, the loss of life was much lower in Japan, thanks to long-established, high-quality hazard education, coastal defences and evacuation plans[2] alongside the efficient Pacific tsunami warning system. Tsunami damage is not determined solely by the magnitude of the wave; density and vulnerability of the coastal population are at least as important.

Tsunamis are less frequent in the North Atlantic than in the Pacific and Indian oceans; taking into account the incomplete records, it seems that Pacific tsunamis are about eight times more frequent than Atlantic ones. North Atlantic tsunamis can be triggered by a variety of mechanisms, including Caribbean and mid-Atlantic volcanism, earthquakes and submarine landslides. One of the largest known Atlantic tsunamis was caused by the massive Storegga submarine landslide 8,200 years ago and decimated Mesolithic coastal settlements all around the Norwegian Sea and the North Sea[4]. Risks are posed also by meteorologically triggered tsunamis in the North Atlantic, caused by rapid disturbances in air pressure. For example, in 1992 a meteotsunami reached elevations 3 m above the high-tide mark and injured

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Lisbon burning. Hand-coloured woodcut of the earthquake and tidal wave causing the destruction of buildings in Lisbon, Portugal in 1755.

75 people in Florida; a smaller event was observed on the south coast of England in 2011 (ref. 5).

Tsunami risk has two main components: likelihood, that is, the annual probability of a tsunami; and impact, the degree of destruction — of lives, property, infrastructure, and so on — that is to be expected. Analysis of data from the National Geophysical Data Center[6] indicates that tsunamis that reached onshore elevations of at least 2 m above sea level have occurred approximately every 15 years in the North Atlantic basin since 1755, some affecting multiple locations. The impact of these past events does not provide a good indication of potential future damage. This is because the North Atlantic seaboard communities are increasingly vulnerable, as a result of population growth in coastal locations as well as urbanization and the construction of key infrastructure, such as airports and power stations. According to a tsunami risk assessment by the UK Department for Environment, Food and Rural Affairs, in Cornwall, southwest England, a Lisbon-type event could cause coastal wave heights of 2 to 4 m, reaching onshore elevations that may be three times as high[7].

In the UK at present, however, there is no mechanism for disseminating tsunami warnings. In addition, people are often unaware of the appropriate response to a hazard warning: even with comparatively well-known hazards, levels of personal preparedness may be very low[8,9]. As shown in Japan, ingraining appropriate hazard awareness and response into a culture can help to save hundreds of thousands of lives.

North Atlantic tsunami risk mitigation may be most critical in the far field. With the exception of southern Iberia and the Moroccan Atlantic coast, the largest population centres on the North Atlantic coastline are not found near locations where tsunamis have been triggered repeatedly. However, long-distance oceanic propagation means that urban centres far from the tsunami source can be affected by such a wave.

Staying alert to the possibility of a rare event is difficult: it is impractical to construct and maintain a tsunami warning system (and staff it on an effective local level) that may be called into action once in 50 years. However, the North Atlantic coasts must become more resilient to flooding anyway: if there is no curb to carbon dioxide emissions, sea level is projected to rise by up to 1 m by the end of the century[10]. The physical impacts of an inundation by seawater — be it from a tsunami or a storm surge — are very similar, and therefore mitigation strategies are similar, too.

Coastal flood defence plans should therefore include contingency plans and warning dissemination systems for the rarer tsunami event, too. Flood protection requires adequate funding and long-term investment that defends against increasingly likely storm surges as well as rare tsunamis. Participatory evacuation exercises could be held and mass-alert systems trialled. The main additional challenge for tsunami warnings is one of timing: a storm surge is often forecast days in advance — a tsunami may come within an hour. For tsunamis, people must be made aware that there is very little time. So don't pack, just go. ❐

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