# 5. Discussion

Inundation of 15 Northland communities from three tsunami scenarios at two different sea levels has been modelled. The scenarios were a remote South American tsunami, representing the most probable tsunami risk facing Northland and two regional events caused by subduction zone earthquakes in the Tonga-Kermadec Trench which represent worst case scenarios for Northland's tsunami risk. The scenarios were run with an undisturbed sea level equivalent to MHWS, in order to provide an estimate of the flooding if the arrival of the tsunami coincided with high tide. Scenarios were also run with an undisturbed sea level of MHWS + 50 cm, representing the 100 year projection for sea level rise as assessed by the IPCC Fourth Assessment Report.

The remote South American tsunami is seen as the most probable event, with a return period on the order of 50 years. In general, for the communities considered here, this event poses the least risk. There is, however, still significant inundation predicted for the communities of Hihi and Ruawai, south of Dargaville. There is also appreciable tsunami risk along the shoreline and in low-lying areas close to rivers, estuaries and creeks along which a tsunami can propagate.

A tsunami from South America takes about 15 hours to reach New Zealand (Lane et al., 2007), sufficient time for contingency plans to be implemented, provided that early warning of the approaching wave is received.

The Tonga-Kermadec subduction zone $M_w$8.5 event generally resulted in a similar level of inundation as the South American event, slightly less severe inundation for some communities, such as Ruawai near Dargaville, and significantly more for others, especially those in Whangaruru Harbour and Whangaroa Bay. The communities most at risk from this event were Bland Bay and Helena Bay in Whangaruru Harbour, and Taupo Bay and Tauranga Bay in Whangaroa Bay. Inundation depths were up to 4 m in places, and maximum current speeds reached 5 m $s^{-1}$, leading to a high risk of shoreline erosion during an event.

It is notable that for some communities, the predicted impact of the TKSZ $M_w$8.5 event was worse than for remote tsunami, whereas for others the South American event caused greater inundation. The effect of tsunamis on coastal bays depends on the characteristics of the incoming wave, the physical characteristics of the bay, and the interaction between the two (Walters and Goff, 2003). Coastal bays have a natural resonance period and length scale, so that if an incoming wave has similar

characteristics, then large amplification of the incident wave can be expected i.e. the height of the wave at the coastline can be significantly greater than its height as it enters a bay. Resonance in some Northland coastal bays, therefore, will be triggered by the longer period, longer wavelength tsunamis arriving from South America, whereas in other bays the response to the shorter period, shorter wavelength waves arriving from the Tonga-Kermadec Trench will be stronger. The results here demonstrate that the amplitude of the incoming wave is not the only factor in determining the severity of the eventual impact.

The height of the incident wave, though not the only factor affecting the extent and severity of inundation, is an important one, and the most severe inundation for almost all communities occurred following the Tonga-Kermadec subduction zone $M_w$9.0 event. This event resulted in severe inundation at many of the 15 locations considered here, with particular impacts at Bland Bay, Helena Bay, Tauranga Bay, Taupo Bay, Te Ngaire and Hihi. With such a large event, maximum current speeds were very high, often exceeding 7.5 m $s^{-1}$, posing a serious damage and erosion hazard. Tsunamis arising from Tonga-Kermadec subduction zone earthquakes take 70-80 minutes to reach the east coast of Northland, providing much less time for local emergency teams to react.

In addition to inundating land areas, tsunamis elevate current speeds substantially above normal values for short periods of time and can, therefore, cause significant scouring and erosion in estuaries, beaches and dunes, and affect structures such as piers and bridges.

The effect of sea level rise, when included in all the simulations, was generally to increase the extent and depth of inundation, and to increase the maximum current speeds. The implication is that tsunami impacts are likely to become more severe in future.