5. Discussion

Inundation of fifteen 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 local/regional events caused by subduction zone earthquakes in the Tonga-Kermadec trench which represent worst case scenarios for Northland's tsunami risk. The sea levels were current MHWS and MHWS with a sea level rise of 50 cm, representing the 100 year projection for sea level 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 posed the least risk. There was, however, significant inundation predicted for the communities of Waipu Cove and Marsden Point. In most locations, the tsunami risk is greatest for settlements closest to the shore or close to rivers, estuaries and creeks along which the incoming tsunami can propagate. The tsunami elevates current speeds substantially above normal values for short periods of time, and can therefore cause significant scouring and erosion in estuaries, beaches and dune. A tsunami from South America takes over 15 hours to reach New Zealand (Lane et al., 2007), sufficient time for contingency plans to be implemented provided early warning of the approaching wave is available.

The Tonga-Kermadec subduction zone M_w8.5 event generally resulted in a similar level of inundation as the South American event, slightly less severe inundation for some communities and slightly more for others. The communities most at risk from this event were Matapouri, Pataua South and Matauri Beach. Inundation depths were up to 3 m in places, and maximum current speeds were in excess of 2.5 m s^{-1}.

It is notable that for some communities, the predicted impact of the M_w8.5 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; if an incoming wave has similar characteristics, then large amplification of the incident wave can be expected. Resonance in some

Northland coastal bays, therefore, will be triggered by the longer period, longer wavelength tsunamis arriving from South America, whereas other bays will respond more strongly to the shorter period, shorter wavelength waves arriving from the Tonga-Kermadec Trench. 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 size 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_w9.0 event. This event resulted in severe inundation at almost all of the fifteen locations considered here. 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. These regional tsunami have arrival times of the order of one hour following the fault rupture, providing much less time for local emergency teams to react.

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

The return period of a large event, such as the TKSZ M_w9.0, is estimated at about 2000 years (Lane et al., 2007; Goff, 2008), and the risk is therefore very low. However, the potential impacts, as predicted here, are very severe for coastal communities in the region, and contingency planning needs to be informed by realistic worst case scenarios. The simulation results presented here cover the likely range of tsunami that might be expected in Northland, increasing from the relatively common but smaller South American tsunami to the largest likely event emanating from the Tonga-Kermadec subduction zone, and therefore provide information on the likely range of impacts on which to base local contingency planning.

The modelling performed here is dependent on, and therefore limited by, a number of factors. In particular, the initialisation of the tsunami for each earthquake source is based on theoretical analysis and is difficult to establish by observation. The simulation of inundation is strongly dependent on the quality of the LiDAR topographic data and also on the quality of bathymetric data in inshore waters. These latter data are sometimes relatively scarce and of poor quality, which may have some influence on the exact water depths and speeds presented here. Nevertheless, we believe that the current modelling exercise provides the best possible estimate of inundation in Northland from remote and regionally sourced tsunamis available to date.