**Revealing the Unseen Threat**

# Tsunami sources in the Bay of Plenty

*By comparing the record of past events with results from a computer model,* ***James Goff*** *and* ***Roy Walters*** *are discovering how tsunamis could affect the Bay of Plenty in the future.*

Beyond its obvious blessings of fine weather and beautiful scenery, the Bay of Plenty on the North Island's east coast harbours a wide range of potential tsunami sources: local geological faults, subduction zone fault ruptures, volcanic eruptions, collapsing seamounts, and submarine landslides. Geological, geomorphological, and cultural evidence tells us that large tsunamis have inundated the coastline in the past, in some instances by over 6 m above mean sea level. Based on this evidence, we know that the region's growing population and a flourishing agricultural economy are at risk from future flooding from the sea. On behalf of the local authority, Environment Bay of Plenty, scientists at NIWA have combined modelling and evidence of ancient tsunamis (palaeotsunamis) to answer two important questions:

- *What are the most likely sources for generating a catastrophic tsunami?*
  and
- *Can we link the palaeotsunami evidence with a specific source?*

To evaluate the most likely sources for catastrophic tsunamis, we use data on prehistoric events in conjunction with computer modelling. For the Bay of Plenty, we employed NIWA's RiCOM model to simulate tsunamis from a suite of different potential sources. Then we compared the results with our palaeotsunami database across the whole region, compiled from records of palaeotsunami deposits: marine sediments deposited inland by past tsunamis. We simulated the largest possible events from the sources that seemed to offer the most concern. Then, if the modelled tsunami was too large to match the palaeotsunami data, we could always scale down the event, or else look to other sources to see if they offered a better match.

## Local faults

To begin with, we chose to model tsunamis generated by three local sources: the Astrolabe, Volkner, and White Island faults. These are all 'normal faults', in which one part of the seabed slips downward. When we run the model, the tsunami waves separate from the point of rupture and propagate away from the fault in opposite directions. Each of these separate waves has different characteristics. The part of the tsunami propagated on the side of the fault that went downwards moves away from this starting point with a trough (negative wave) in front of it. The peak (positive wave) that follows along behind is is amplified and runup in local areas is up to 2 m. While potentially damaging, this is far too small to match up with the palaeotsunami record of the region's largest inundations.

**Past tsunamis guide our future response**

- Sediments, landforms, and cultural evidence record the impact of past tsunamis
- Simulating tsunami waves from a variety of sources helps match sources to the record of past tsunamis.
- Identifying the main sources lets us model the likely impacts and guide our response to future tsunamis

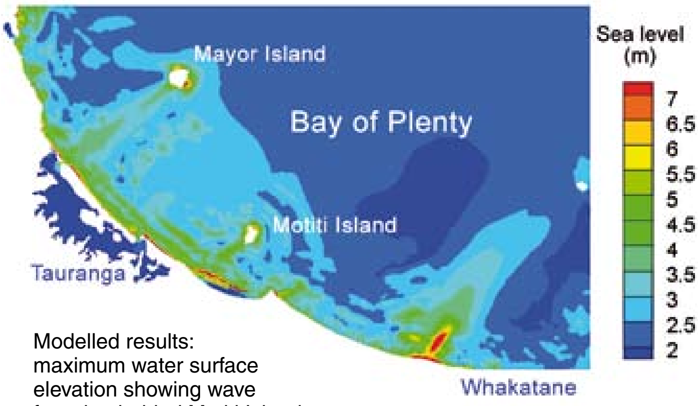
## Collapsing seamounts

An alternative option for matching the data for larger tsunamis is the collapse of a seamount or submarine volcano. However, these are point sources and the resultant tsunami tends to diminish rapidly as it moves away from the source. Important factors that control the size of a tsunami in these cases are the volume of the material that collapses, and the direction and depth of the collapse. For example, we modelled an entire collapse of Tumokemoke Knoll, the nearest large seamount to the Bay of Plenty coast. The knoll is about 4 km in diameter at the base, about 300 m high from its base, and 200 m below mean sea level. The volume of material that collapses in the simulation is about 1.2 cubic km. As expected, the tsunami decays rapidly with distance from the seamount source and the wave height is less than 1.5 m when it reaches the nearest shore. This is potentially damaging, but would be unlikely to leave any geological evidence. So, what else is out there?

## Subduction zone earthquakes

Most of the Bay of Plenty is directly exposed to tsunamis generated by earthquakes in the Tonga-Kermadec Trench, the subduction zone immediately north of East Cape. To create the most likely maximum event, we modelled a Magnitude 8.5 fault rupture in the trench, timed to strike the coast at Mean High Water Spring. The results of this model run are shown below.

As with our local-fault scenarios, the initial wave separates into two: one moving onshore and the other propagating offshore to become a remote tsunami elsewhere. The wave directed onshore is partially refracted around East Cape and comes ashore in the Bay of Plenty. The main part of the wave travels westward to the area around Tauranga and to the north. In the central part of the Bay of Plenty, the wave crest is stretched by refraction into the bay. Waves converge around Motiti Island and other islands, amplifying the tsunami on the adjacent coast. The tsunami crests at 2–3 m in the southeast part of the Bay of Plenty with height increasing toward the northwest to 5–7 m. For example, maximum tsunami runup




Modelled results: maximum water surface elevation showing wave focusing behind Motiti Island.

height in the central portion is 5.4 m onshore from Motiti Island, arriving about 70 minutes after fault rupture. Waves breach the coastal sand dunes at this location.

## Matching the model with the geological record

For this simulation, the patterns of wave height along the whole of the Bay of Plenty shoreline are a good match for what we found in the palaeotsunami database. This represents a catastrophic event for the Bay of Plenty. By combining the interpretation from the numerical model RiCOM and palaeotsunami data, we've identified the most likely source for generating a catastrophic tsunami – the Tonga-Kermadec Trench. When combined, the two datasets show remarkable agreement. Our results suggest that, for the Bay of Plenty, subduction zone earthquakes are the most significant tsunami source over timescales of 500–1000 years.

## Putting new knowledge to good use

From a planning perspective, this type of information is invaluable for local authorities. It can help them guide future coastal development to ensure the safe and appropriate use of their shoreline. The data can be used to enhance civil defence activities, such as planning evacuation routes, and community education and awareness. The results from this type of work highlight particular areas of coastline that need more detailed study, guiding the effective and strategic use of limited public funds.

This study was primarily related to issues for Environment Bay of Plenty but the outcomes also have significance for another local authority, Environment Waikato, in particular for the eastern Coromandel coast. Environment Waikato have worked in conjunction with Environment Bay of Plenty on several stages of a related tsunami inundation study in order to achieve a comprehensive understanding of the hazard. Ultimately it is this type of work, and collaborative thinking, that will help ensure that New Zealand and New Zealanders are better prepared for the next tsunami. W&A

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This graph compares past wave heights from the geological record (the height above sea level of marine sediment deposits and the height of the waves that would have dropped the sediment) with maximum wave heights predicted by the model for different locations along the Bay of Plenty coastline.