AUCKLAND: A CASE STUDY in the REGIONAL ASSESSMENT of LONG TERM SEA LEVEL CHANGE

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INTRODUCTION

- Projected sea level change is a vital issue in assessing the hazards associated with coastal zone management.
- New Zealand has one of the best long term sea level records in the Southern Hemisphere. Auckland’s record is the best of all.

**WHAT CAN WE REASONABLY EXPECT by 2100?**

- Future projections for sea level change are predicated upon many imprecisely known quantities. These include:
  - Our understanding of the past changes in climate.
  - Our projections for future changes in climate.
  - How earth systems will respond to these changes.
THE PAST
What do we think we know – Pt I?

Geologists believe that over the last 1.7 Million Years (ma) there have been several cycles of global sea level fluctuations (each greater than 100 m) caused by cyclic glacial-interglacial periods.

![Graph showing sea level fluctuations](image)

This general pattern is largely inferred from the last glacial-interglacial cycle dated between 20 – 128 ka year before present.

At the last interglacial maximum (~ 120 ka BP) global sea levels appear to have been 2 – 5 m higher than at present.

It is generally thought that sea levels rose from well below present levels at ~20 ka BP to near present levels between 7 to 6 ka BP ~ 9 mm/yr on average.

THE PAST
What do we think we know – Pt II?

Holocene sea level changes in the Auckland region (i.e., from 12 ka BP to the present) broadly seem to follow the trends observed globally.

![Graph showing Holocene sea level changes](image)

Taken from Gibb, 1986
THE PAST
What do we think we know – Pt III?

The important takeaways:

- At times in the past sea levels appear to have risen very rapidly (by more than 15 mm/yr).
- Sea levels have fluctuated by about 1.0 m around present levels for the last 6,500 yr.
- A period of higher sea level is recognised in the Pacific and east Australia around 3.4 ka BP, but is more variable in NZ. Best estimates suggest a maximum sea level elevation in NZ at this time of between 0.5 – 1.0 m above present levels. THIS IS CRUCIAL.
- Global average surface warming of 2.4 – 6.4°C for 2100 essentially returns the earth to its mid Holocene state. THIS IS ALSO CRUCIAL.

THE PRESENT
What do we really know – Pt I?

Auckland

- Auckland has the most reliable long term sea level record in NZ and is one of the best in the Southern Hemisphere.
- The pattern of sea level rise is similar to results from other NZ gauges, as well as other reliable gauges from around the world. It parallels the results from Freemantle.
THE PRESENT
What do we really know – Pt II?

<table>
<thead>
<tr>
<th>Port</th>
<th>Relative sea level change (linear trend)</th>
<th>GIA Correction</th>
<th>GIA corrected sea level trend</th>
<th>Local Tectonic Motion from cGPS data</th>
<th>Absolute sea level trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auckland</td>
<td>+1.50 (0.09)</td>
<td>+0.30</td>
<td>1.80</td>
<td>-0.1</td>
<td>+1.4</td>
</tr>
<tr>
<td>Taranaki</td>
<td>+1.24 (0.32)</td>
<td>+0.33</td>
<td>1.57</td>
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<tr>
<td>Wellington</td>
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<td>+0.30</td>
<td>2.30</td>
<td>-1.4</td>
<td>+0.6</td>
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<tr>
<td>Lyttelton</td>
<td>+1.90 (0.10)</td>
<td>+0.29</td>
<td>2.19</td>
<td>-0.2</td>
<td>+1.7</td>
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<tr>
<td>Dunedin</td>
<td>+1.18 (0.09)</td>
<td>+0.22</td>
<td>1.53</td>
<td>-0.2</td>
<td>+1.1</td>
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<tr>
<td>Mean</td>
<td>1.6 mm/yr</td>
<td>1.9 mm/yr</td>
<td>1.4 mm/yr</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From tide gauge records
From an earth model
From 10 yrs of cGPS obs.

Lyttelton Tide Gauge Site

Tide Gauge Hut and GPS antenna

Structure Stability Problems on Wooden Wharf?
NZ’s tectonic setting

Central South Island experiences oblique continental collision at about 40 mm/yr

Shortening component normal to Alpine fault is about 10 mm/yr

Are There Other, Independent Measurement Techniques?

  - Shows a global (open ocean) sea level rise of 3.2 ± 0.2 mm/yr over the last 16 yrs.
  - Poor estimates close to the coast.
  - Ocean models indicate significant spatial variability.
  - Global water budget can account for a rise of 2.8 ± 0.35 mm/yr.
Summary of our Present Knowledge

- Auckland’s linear sea level trend = +1.5 mm/yr since 1901. Best GIA corrected global estimate = + 1.7 0.3 mm/yr (95% confidence)
- cGPS results suggest little or no vertical tectonic movement of any description at Auckland.
- The tide gauge record shows NO evidence of any acceleration in sea level rise. This is consistent with results from the UK and Australia. **Question:** Doesn’t the Satellite altimetry data imply an acceleration in sea level rise over the last 17 yrs? **Not necessarily:**
  (a) Could be due to periodic effects (= time frame problems)
  (b) Could be due to reference frame problems (there are uncertainties at the sub-millimetre level)
  (c) Could be due to spatial variability

THE FUTURE
What would we like to know?

2. The response to Greenland and the Antarctic to this heating. Thermal expansion and mid-latitude glacier contributions are well known.
3. A better understanding of sea levels in New Zealand during the Holocene period.
4. A better understanding of the errors in our measurement systems (GPS and altimetry).
PULLING IT ALL TOGETHER
What to expect by 2100

IPCC 2007 report: Allow for a global sea level rise of 18 cm – 59 cm with the possibility of a further 10 – 20 cm.

Min. of Environment: Plan for 50 cm and assess sensitivity of activity to a possible 80 cm by 2090.

BUT pressure is building to increase these numbers!

Given what we know about the mid-Holocene maximum, and present trends, the MoE advice is more than appropriate – even out to 2100. Present knowledge does NOT warrant any change!!