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PLANNING ON RISING SEA LEVEL?

SEA LEVEL IS RISING - WHAT'S IN STORE FOR COASTAL COMMUNITIES?

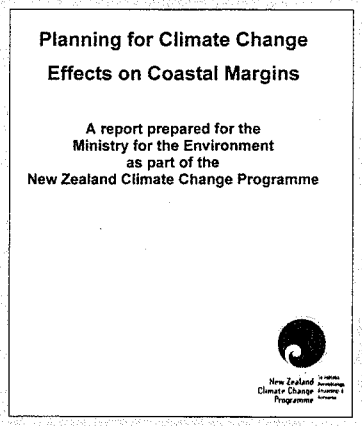
New Zealanders love their coast, and when you love something, you want to be close to it - sometimes too close. That's one of the reasons why settlements in many parts of the world are located around the low-lying margins of harbours, estuaries and bays. Sea level has been rising around New Zealand since the early to mid 1800s (not everyone knows this) and, given projections for an acceleration in sea-level rise this century, we can expect increased sea flooding, storm-wave damage and coastal erosion. Recent wave damage along our eastern coastline from two events on Waitangi Day and the week after Easter, are timely reminders of the potential impact of existing coastal hazards. Increasingly, settlements in our coastal margins will be "squeezed" as they swell with more residents, while sea-level rise and associated coastal hazards will often act to restrict activities and properties from the seaward side.

Widespread education and awareness of coastal hazards and the pending effects of global warming are needed to help manage this growing problem of "coastal squeeze". This article outlines the latest findings on global warming, how it may affect coastal margins, and how that information can used to support long-term planning.

PLANNING FOR CLIMATE CHANGE IN THE COASTAL MARGINS

Some of the material for this article has been extracted from our recent publication by the Ministry for the Environment that describes the effects of climate change on coastal margins along with various approaches to respond and plan for such eventualities.

It is available as two pdf files at: http://www.climatechange.govt.nz/sp/resources/resources_publications_a lt.htm



PAST AND FUTURE SEA-LEVEL RISE

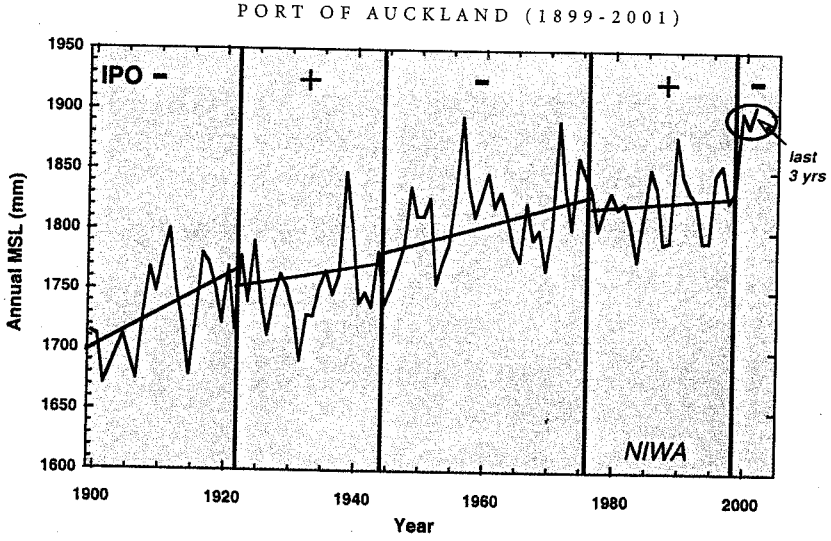
Over the 20th century, global sea level rose at an average rate of 1.8mm per year, which is close to the average rate recorded by tide gauges at New Zealand's main ports.[1] That doesn't sound much, but is nearly 0.2m since 1900, which is significant for low-lying coastal margins such as those around Thames. Our longest record is from the Port of Auckland, which has been recording since 1899 (Figure 1) and is located on a stable landmass. There is clear evidence that sea level is rising around New Zealand.

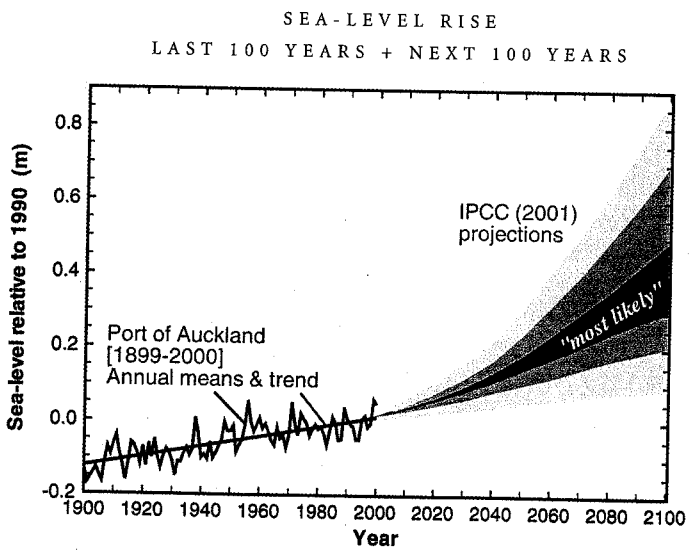
What is causing this rise in sea level? A variety of factors, but mainly higher ocean temperatures and melting land ice, driven by "natural" and greenhouse-related climate change. Higher water temperatures increase the volume of the ocean by thermal expansion (remember those radiator boil-overs?) without changing the mass of seawater. Meltwater from glaciers and non-polar ice caps contribute by increasing the mass of water in the ocean. Other minor contributions have been identified, but there remains some uncertainty about why the historic rate of sea-level rise since the mid 1800s is as high as it is. Most scientists agree that the movement of ice sheets off the Antarctica landmass are not expected to contribute until at least next century.

How might sea level change in the future? Every five years, since 1990, an international group called the Intergovernmental Panel on Climate Change (IPCC), produce an assessment report on the state of global climate change. It concludes with projections on air temperatures, greenhouse gas levels and sea-level rise for the next 100 years. Previous assessment reports were produced in 1990

Below: Table 1: Projections and uncertainty ranges (Figure 2) for future global sea-level rise (SLR) from the IPCC (2001) up to years 2050 and 2100, compared with a continuance of the NZ-average rise in relative sea level from 1900s with no acceleration. Suggested global projections to work with are shaded.

Scenario	Climate factors	SLR by 2050	SLR by 2100
Average linear NZ trend continues (+1.7 mm/yr)	Sea-level trend over the 1900s continues on	0.09m	0.17m
IPCC (2001) "Most likely" mid-range	Average of climate models & socio-economic scenarios	0.14-0.18m	0.31-0.49m
IPCC (2001) Uncertainty ranges	Intermediate zones Upper & lower limits of entire range of IPCC projections	0.10-0.24m 0.05-0.31	0.21-0.70m 0.09-0.88m





Above: Figure 2. Future global sea-level responses projected by IPCC (2001), which are computed relative to the 1990 sea level. Most agencies adopt the "most likely" projections of sea-level rise (central darker zone), which represents the average of several climate models and the most likely socio-economic and greenhouse-gas emission changes. Last century's trend in sea level for Auckland from Figure 1 (but relative to the 1990 sea level) has been grafted onto the IPCC projections for this century

and 1995. The Third Assessment Report (TAR) was released early in 2001.[2]

IPCC projections for global average sea-level rise out to 2100 are shown in Figure 2, in the context of the past 100-year record from Auckland. IPCC projections indicate a doubling of the sea-level rise this century (>0.4 m), compared with approximately 0.2m experienced last century (Figure 2). Further, beyond this century, IPCC project that sea-level rise is expected to continue on for at least several centuries because of the huge delay in the response of the world's oceans and ice contributions from Antarctica and Greenland.

PROJECTIONS FOR NEW ZEALAND COASTS

For long-term planning decisions, such as consideration of minimum building floor levels in hazard-prone coastal areas under the Building Act (1991) or for various regional and local statutory plans, information is required about future rates of sea-level rise. The "most likely" scenario is illustrated in Figure 2, and defined in Table 1 for 50- and 100-year planning horizons. Clearly, an acceleration in the rise of sea level is being projected, even by 2050. To date, we have been unable to detect any acceleration at New

Right: Historic unsuccessful attempts at stabilising shorelines at Ohiwa Spit (above) and Bowentown (below) in the Bay of Plenty. [Photos: R.K. Smith]
Left: Figure 1. Annual mean sea level (AMSL) at Port of Auckland since 1899. The overall trend has been a rise of 1.4mm per year. The sea-level record is sub-divided into segments fitted to successive phases of the 20 to 30 year cycles of the Interdecadal Pacific Oscillation (IPO). [Data source: Ports of Auckland Ltd., Prof. J. Hannah (University of Otago), NIWA]

Zealand sea-level gauges. (To find out why, check out the NIWA website at: http://www.niwa.co.nz/pubs/wa/09-4/move.) Annual mean sea levels over the past 3 years around New Zealand have been the highest yet e.g., Port of Auckland (Figure 1). These higher levels would need to persist for at least two decades before we could categorically state that sea-level rise was accelerating, or that the effect is due to natural climate cycles such as the 20-30 year Pacific-wide cycle, called the Interdecadal Pacific Oscillation or IPO (see Figure 1 for the IPO phases).

Generally the "most likely" IPCC projections for sea-level rise should be adopted for planning purposes, because sea-level rise (relative to our landmass) in New Zealand has been similar to the global average rates. (Note that the oft-quoted sea-level rise of 0.88m by 2100 is a worst-case socio-economic, emissions and global warming scenario.) IPCC projections are now routinely modified every 5 years, as scientific understanding and modelling of climate-ocean systems improves. Further work is then necessary to "tailor" the IPCC global projections to the New Zealand scene as new local and regional information comes to light e.g., vertical stability of the landmass and regional sea-level response.

CLIMATE-CHANGE IMPACTS

While sea-level rise is the most tangible impact of the greenhouse effect, there will be other negative impacts on coastal margins. For instance, climate projections for 2080 by NIWA indicate drier conditions on east coasts and wetter on west coasts, together with higher intensities of rainfall during storms. This will affect sediment delivery to coasts and ultimately beach stability. Beach stability will also be affected by changes in the intensity of severe cyclones and storms that hit our coastline each year. Riding on the back of a higher sea level, storms will progressively cause more breaches or overtopping of current beach[3] or estuary defences-natural or artificial, leading to more problems with coastal flooding and drainage. Also, changes in wind directions could subtly alter wave directions along the coast, leading to

MANAGED (OR PLANNED) RETREAT

This means progressive abandonment of threatened land and structures by long-term strategic retreat from or prevention of future development in coastal areas that may be affected by ongoing coastal erosion and sea-level rise. It is based on the premise that land loss and coastal flooding should be allowed to occur naturally. The antithesis is defensive protection of coastal sections by a seawall, for example. In New Zealand, little progress has been made on long-term implementation of managed retreat for erosion hotspots, apart from recent "greenfields" coastal subdivisions such as Omaha South, where a prior "retreat" step has been included in the form of a generous coastal buffer zone.

Rather, the norm for established communities has been "involuntary" retreat where ad-hoc defences have been unsuccessfully tried until the sea finally wins the day. Examples are Aotea Harbour (south of Raglan) and Mokau (north of New Plymouth), where around 20 and 11 sections respectively have already gone since 1963. Environment Waikato is actively working with the Mokau community on measures such as moving houses to the back of the section and ultimately relocation options. The vulnerable foreshore at Mokau is under constant observation by a remote video camera to assist research efforts and provide a focal point for community education (http://www.niwa.co.nz/services/cam-era/).

increased erosion compared with historic rates. While sea-level rise on its own seems small, when combined with these other impacts there will be an increasing threat to coastal communities that will continue for several centuries from now. Consequently, there is no long-term silver lining arising from global warming for coastal margins.

THE COASTAL PLANSCAPE

Despite the fact that the effects of climate change will manifest themselves slowly at coastal margins, there is an urgent need to start planning now for these eventualities, given the longevity of modern houses, coastal communities and infrastructure such as roads and carparks.

Regional councils and territorial authorities currently have a range of statutory and non-statutory procedures within regional, coastal, and district plans, the latter often including a coastal hazard zone boundary. Under the umbrella of the Resource Management Act (1991) and the NZ Coastal Policy Statement (1994), plans and regional policy statements must explicitly recognise sea-level rise, along with other natural hazards, (e.g. dealing with erosion, sea flooding, too much sand from dune blow-outs), and take these into account when developing plans for coastal margins. Plans must also take into account environmental values such as the preservation of the natural character of the coast and maintenance and enhancement of public access to and along the coast, and amenity values (RMA, Sections 6 &7).

Holding to such environmental values has seldom been evident in the historic management of coastal erosion or sea-flooding hazards. Ad-hoc emergency works in the form of dumping rocks or car bodies, and the construction of sea-walls to defend property boundaries, bear testimony to this past lack of environmental consideration. With the projected acceleration in sea-level rise and increasing threat of erosion and flooding, our collective will to hold on to such environmental values (natural character and public access) will be severely tested by established coastal communities where "coastal squeeze" starts to bite. What's more, the lifespan of protection offered by coastal protection works will decrease with climate change. This will create increasing pressure and need for expensive maintenance and upgrades, as well as new protection structures.

Realistically and under the present statutory framework, coastal defences or "hard" engineering protection works are not a favoured or indeed a long-term solution. One difficult option for some existing coastal communities will be to plan long term for a gradual "managed retreat" of buildings and infrastructure from the frontline. Managed retreat has become a pragmatic reality in some areas around the world already impacted by a high rate of relative sea-level rise (i.e. where the landmass is sinking, such as in parts of England). In New Zealand, the tenacity of coastal dwellers to hold on to eroding coastal sections at considerable cost still dominates, so the approach to date has been "involuntary" retreat, rather than strategically planned retreat. However, abandoning shores is seldom practical for large coastal communities and certainly not popular with "front-row" property owners, who may stand to lose out from decisions being made in the interest of coastal communities as a whole.

Alternative solutions include "adaptation" responses, such as lifting houses on poles or dune protection and vegetation, or "soft" protection measures such as beach re-nourishment with external supplies of suitable sand. Beach nourishment is unlikely to be sustainable over large stretches of coastline or in the long-term (50+ years).

At the end of the day, the response depends on the community's ability to pay for protection or compensation. Community "buy-in" to any action to adapt or cope with climate-change impacts (or indeed existing coastal hazards) is crucial for any planning to succeed. Improving the public awareness and knowledge of future impacts of climate change is a key step in this process.

In essence, decision making to mitigate the effects of climate change has been, and will continue to be, a sequential process. Fortunately, the uncertainty of the likely impacts of global warming on vulnerable coastal margins is decreasing. "The challenge is not to find the best policy today for the next 100 years, but to select a prudent strategy and to adjust it over time in the light of new information." (IPCC)

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FOOTNOTES

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