



# Preparing for coastal change

A guide for local government in New Zealand

New Zealand Government



## Disclaimer

This guide is a summary of *Coastal Hazards and Climate Change*, a 130-page report prepared for the Ministry for the Environment by Doug Ramsay and Rob Bell of NIWA with help on a number of chapters from Robin Britton. Advice and assistance have also been received from a wide range of people from local government, planners, engineers and scientists; and from informal discussions with other organisations and individuals.

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## Source document

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# Introduction

Much of New Zealand's urban development and infrastructure is located in coastal areas, some of which are vulnerable to coastal hazards such as coastal erosion and inundation. In recent years, coastal development and associated infrastructure have intensified, and property values have increased. As development increases, the potential impacts and consequences of coastal hazards also increase. Managing this growing risk now presents a significant challenge for planning authorities in New Zealand.

*Preparing for coastal change* provides information to help local government and others across New Zealand strengthen the integration of coastal hazards and climate change considerations into policy, planning, asset management and decision-making.

Climate change effects are gradual, but have implications for many land-use planning decisions. They have long-term implications because of the long lifetime of structures (eg, buildings, roads, network utilities, residential developments). Considering climate change is not only a requirement of the Resource Management Act 1991, it is also wise and good business practice.

This guide summarises a 130-page technical report, *Coastal Hazards and Climate Change* ('the source report'). Originally published in 2004, the source report was updated in July 2008. This followed the release of the Fourth Assessment Report on the science of climate change produced by the Intergovernmental Panel on Climate Change (IPCC) in 2007. The source report is available in full at: <http://www.mfe.govt.nz/publications/climate/coastal-hazards-climate-change-guidance-manual/>

## The guide comprises three parts:

### Part One – The changing climate:

- discusses how climate change affects sea level
- provides guidance on planning for future sea-level rise in New Zealand
- explains the impacts of climate change on other physical drivers that influence coastal hazards such as high tides, storms, storm surge and storm tides, wave climate and sediment supply to the coast.

### Part Two – Implications for New Zealand's coastal margins:

- outlines some implications of climate change for the risk of coastal inundation and coastal erosion
- recommends how to assess these effects
- outlines the implications for salinisation of surface freshwaters and groundwater covers, coastal defences and inundation by tsunamis.

### Part Three – Responding to climate change:

- covers the legislative context
- suggests mechanisms for managing, avoiding and reducing coastal hazard risks
- deals with managing residual risk and monitoring change
- discusses some challenges in reducing coastal hazard risk.



Six coastal hazard factsheets are included in this guide in a pocket located in the inside back cover. These provide further information on the characteristics of coastal hazards, including:

- sea level
- tides
- storm surge
- waves
- coastal erosion
- coastal inundation.



References to these factsheets are shown in the guide's margins – look for 'FS' and a factsheet number (see example). If you are new to the topic of coastal hazards you may find it useful to refer to the indicated factsheets as you read.

The Ministry for the Environment provides additional guidance on climate change, hazard management and coastal development aspects at <http://www.mfe.govt.nz/publications/climate/#local>

You can also find further information resources in Chapter 7 of the source report.





# Part One

The changing climate

## This part covers:

- causes of sea-level change
- historic sea-level change
- planning for future sea-level rise in New Zealand
- climate change impacts on other physical drivers that influence coastal hazards.

Some climate changes are already occurring. Further changes in several key parameters will occur to differing extents around New Zealand in the 21<sup>st</sup> century and beyond.

One of the most talked about changes is sea-level rise. But climate change will also alter some coastal hazard drivers such as sea level, tides, storms, waves and sediment supply.

## Causes of changes in sea level

Long-term changes or trends in sea level in a particular region are typically a result of a combination of three things:

1. Changes in global average sea level. This results from a combination of:
  - ocean water expanding as it becomes warmer and less salty
  - an increase in ocean mass as land-based glaciers and ice sheets melt and contributions from dams, lakes, rivers and groundwater change.
2. Regional variations in ocean temperature and circulation which cause local departures (positive or negative) from the global average.
3. Local vertical land movements. The land can be stable, sinking or rising.

## Historical sea-level change

New Zealand tide records have been kept at the three main ports: Auckland, Wellington and Christchurch (Lyttelton). These show an average rise in *relative mean sea level* of 1.6 mm per year (0.16 metres per century) over the 20th century (Port of Auckland data shown in Figure 1).



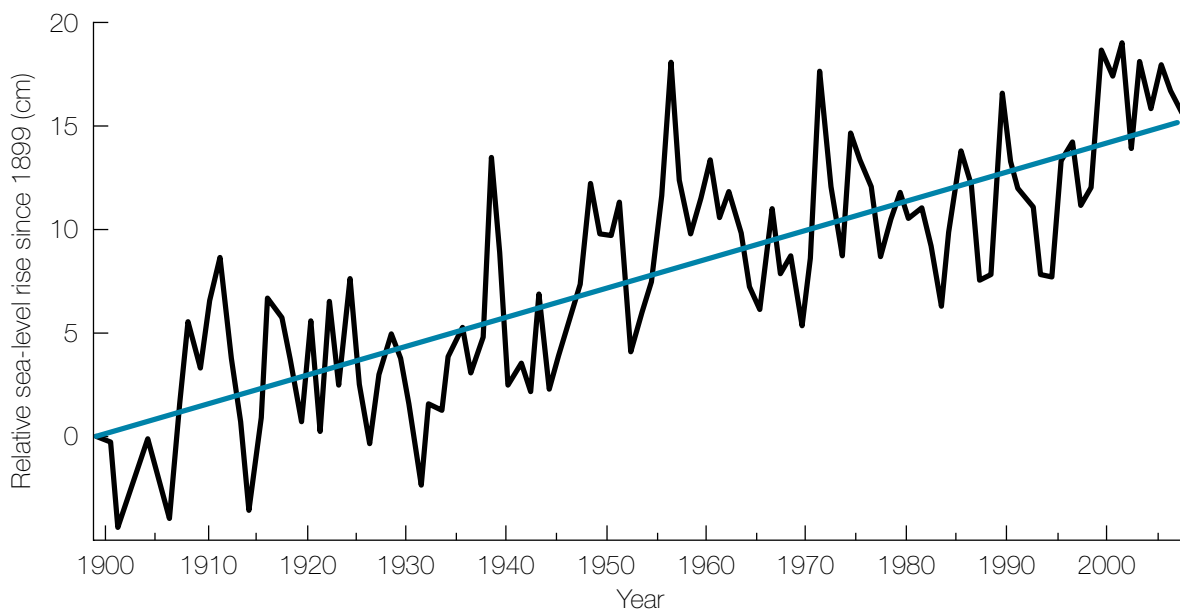


Figure 1: Annual mean relative sea-level data (black line) from the Port of Auckland, Waitemata Harbour, and the sea-level trend line (straight blue line) (1899–2007).

Sea level is also measured at 35 other gauges around New Zealand by agencies such as port companies, NIWA, regional councils and territorial authorities. Unfortunately, most of these records are shorter than 10 years – not enough to discern local variations in sea-level trends. The 33-year record at Mt Maunganui (Moturiki) shows that sea-level changes in the Bay of Plenty are similar to those in Auckland.

## ‘Relative’ and ‘absolute’ sea-level rise

New Zealand-measured rates of sea-level rise, that form the historical record referred to above, are *relative* to the land on which the tide gauges are mounted.

The *relative sea-level rise* for a particular region or location is of prime importance when considering the impacts of climate change at the coast.

For projections of future sea-level rise we need to know the *absolute sea-level rise* for the New Zealand region. An *absolute* value includes the amount the land has risen or lowered over the time of record.

Estimates of regional vertical land movements in New Zealand suggest the land is rising at around 0.5 mm per year. Adding this to the annual average *relative* sea-level rise of 1.6 mm suggests the *absolute* sea-level rise for New Zealand is around 2.1 mm per year. This is at the high end of the observed global average *absolute* sea-level rise of  $1.7 \pm 0.5$  mm<sup>1</sup> per year over the 20th century.

## Future global sea-level change

Global emissions of greenhouse gases have resulted in a warming of the atmosphere, which makes the oceans warm up and expand. Even when the atmosphere above oceans is warm it takes a long time for the sea to warm and for sea levels to rise. This delay in response will result in sea levels continuing to rise for centuries. Even if global emissions were stabilised today, there would be continued thermal expansion within the oceans and melting of ice sheets and glaciers on land well after 2100.

Until about 2050, sea levels will be relatively insensitive to changes in emissions because they are determined mostly by our past emissions. Future changes and trends in emissions become increasingly important in determining the extent of sea-level rise to expect beyond 2050.

<sup>1</sup> This represents a 90 per cent confidence interval.

Therefore, infrastructure that has a long life, or subdivision developments that are considered permanent, will need to consider the implications of sea-level rise in the next century as well.

## Sea-level rise estimates

The Intergovernmental Panel on Climate Change (IPCC) assessed the most recent and authoritative international science on sea-level rise. Its Fourth Assessment Report (2007) stated:

“Because understanding of some important effects driving sea-level rise is too limited, this report *does not assess the likelihood, nor provide a best estimate or an upper bound for sea-level rise.*”

However, the IPCC did report a model-based range of projected sea-level rise: 0.18–0.59 metres by the mid-2090s relative to the average sea level over 1980–1999 (Figure 2). This estimate is based on projections from 17 different global climate models, for six different future emission scenarios. The scenarios consider different combinations of socio-economic profiles, energy use, and transport choices into the future<sup>2</sup>.

Figure 2 (opposite) shows observations of past sea-level rise and the projections of future global mean sea-level rise to the mid-2090s. Historic global sea levels averaged over each decade are shown by the black line in the left-hand side of Figure 2. The grey shading shows the associated uncertainty. Since 1993, global sea levels have been measured by satellite and the averaged data is shown by the short rising red line. For comparison, the green line shows the Port of Auckland data of mean annual *relative sea level* since 1899.

The light-blue shading shows the range in projected mean sea level up until the 2090s. The model estimates (light-blue shading) assume that the contributions from ice flow from Greenland and Antarctica remain at the rates observed for 1993–2003. These rates are expected to increase in the future, particularly if global greenhouse gas emissions are not reduced.

An extra 0.1–0.2 metres rise in the upper ranges of the emission scenario projections (dark-blue shading) would be expected if these ice sheet contributions were to grow in line with global temperature increases. An even larger contribution from these ice sheets, especially from Greenland, cannot be ruled out in the 21<sup>st</sup> century.

<sup>2</sup> A more detailed explanation of these scenarios is contained in Appendix 1 of the Climate Change Effects and Impacts Assessment manual (available at <http://www.mfe.govt.nz/publications/climate/climate-change-effect-impacts-assessments-mayo8/index.html>).

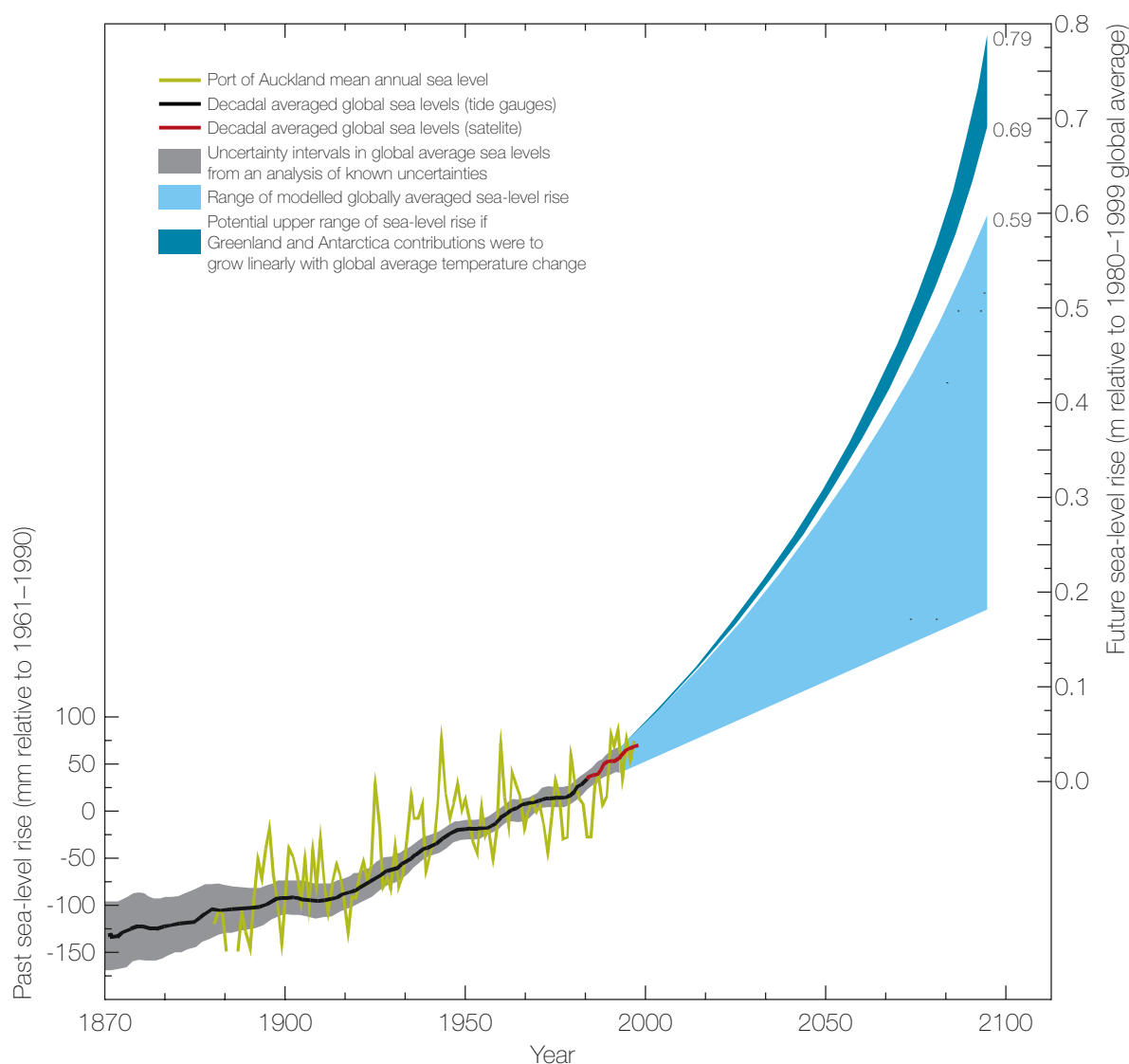


Figure 2: Observations of past sea-level rise and projections of future global mean sea-level rise to the mid-2090s.

## Future sea-level rise advice for New Zealand

There are uncertainties associated with projections of sea-level rise. Nevertheless, individuals, national and local governments must continue to make decisions that either implicitly or explicitly make assumptions about what this rise will be over the lifetime of a particular development, asset or piece of infrastructure.

Risk management is a prudent and pragmatic approach for incorporating uncertainties such as those associated with future sea-level rise. Using a risk management approach involves broad consideration of the potential impacts or consequences of sea-level rise on a specific decision or issue.

It is important to consider not just a single value, but a range of sea-level rise values. This allows you to look at the consequences of higher sea levels, and whether the increased risk from higher sea levels would be acceptable.

Any decision on the extent of sea-level rise to plan for, should consider:

- the possibility and consequences of particular sea levels being reached within the planning timeframe or design life
- the potential costs of adapting to a particular sea-level rise
- how any residual risks would be managed for consequences over and above a particular sea-level rise threshold, or if the sea-level rise that is planned for is underestimated.

Sea-level rise considerations within such a risk assessment are best based on the IPCC Fourth Assessment Report sea-level rise estimates. Consideration should also be given to the potential consequences from higher sea levels resulting from factors not yet included in the current global climate models.

One uncertainty is how fast the Greenland and Antarctica ice sheets will melt. Another uncertainty arises from possible differences in mean sea level when comparing the New Zealand region with global averages.

We recommend that for planning and decision timeframes out to the 2090s (2090–2099):

1. a base value sea-level rise of 0.5 m relative to the 1980–1999 average be used, *along with*
2. an assessment of potential consequences from a range of possible higher sea-level rise values.

At the very least, all assessments should consider the consequences of a mean sea-level rise of *at least 0.8 m* relative to the 1980–1999 average.

For longer planning and decision timeframes beyond the end of this century, we recommend an additional allowance for sea-level rise of 10 mm per year beyond 2100.

Table 1 summarises these baseline sea-level rise recommendations to guide the risk assessment processes for shorter planning and decision timeframes over the 21<sup>st</sup> century. Further guidance on what numbers to use for planning for future sea-level rise is found in section 2.3 of the source report.

**Table 1:** Baseline sea-level rise recommendations for different future timeframes, in metres relative to the 1980–1999 average.

TIMEFRAME	BASE SEA-LEVEL RISE ALLOWANCE (m)	ALSO CONSIDER THE CONSEQUENCES OF SEA-LEVEL RISE OF AT LEAST: (m)
2030–2039	0.15	0.20
2040–2049	0.20	0.27
2050–2059	0.25	0.36
2060–2069	0.31	0.45
2070–2079	0.37	0.55
2080–2089	0.44	0.66
2090–2099	0.50	0.80
Beyond 2100	10 mm/year	

## Impacts of climate change on other physical drivers exacerbating coastal hazards

Climate change not only affects sea levels: it also has an impact on the other drivers of coastal hazards such as tides, storms, waves, swell and coastal sediment supply. We do not know what the effects of climate change will be on all drivers of coastal hazards. An indication of possible effects is provided below.

### Storms

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Changes in storm conditions will affect coastal areas around New Zealand through changes in the frequency and magnitude of storm surges and storm tides, and in swell and wave conditions.

Westerly winds are expected to occur more frequently by 2040 and beyond, particularly in the South Island. However, overall, wind speeds will not necessarily change.

Severe storms may become more intense. But it is not yet clear on how future climate change will influence the frequency, intensity and tracking of:

- tropical cyclones (in the Pacific tropics)
- ex-tropical cyclones (which affect New Zealand)
- extra-tropical cyclones (generated in the mid-Tasman)
- low-latitude storms.



Our general knowledge about future changes to tropical and extra-tropical cyclone conditions is summarised in Table 2. The limited assessment of future tropical cyclone behaviour in the Southwest Pacific provides no clear picture of changes in frequency and tracking, but does indicate increases in intensity.

Two patterns of Pacific ocean water and air movements affect the New Zealand climate: the El Niño-Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation. In the short term, variations in the weather resulting from these two patterns are likely to be more dominant than from climate change. As time progresses, climate change will have a more significant impact on tropical cyclone behaviour. More detail on the El Niño-Southern Oscillation and the Interdecadal Pacific Oscillation can be found in Factsheet 12 of the source report.

**Table 2:** Known changes in global future tropical and extra-tropical cyclone conditions.

CHANGE IN PHENOMENA	PROJECTED CHANGE AND LIKELIHOOD
<b>TROPICAL CYCLONES:</b>	
• Peak wind intensities increase	• over most tropical cyclone areas likely
• Mean and peak rainfall intensities increase	• over most tropical cyclone areas likely
• Frequency of occurrence	<ul style="list-style-type: none"> <li>• fewer weak storms but more strong storms (medium confidence based on some model projections)</li> <li>• fewer when globally averaged. Specific regional changes will depend on sea-surface temperature change (medium confidence based on several climate model projections)</li> </ul>
<b>EXTRA-TROPICAL CYCLONES:</b>	
• Frequency and position change	<ul style="list-style-type: none"> <li>• fewer extra-tropical cyclones likely</li> <li>• slight poleward shift of storm track and associated rainfall, particularly in winter</li> </ul>
• Storm intensity and winds change	• more intense cyclones and associated strong winds likely, particularly in winter over the South Island

## Storm surge and storm tides

It is not just a rise in *mean* sea level that will have an impact on coastal flood and erosion hazards. Any change in the *magnitude or frequency of storm-tide levels* will also be important, which in turn depend on the magnitude and frequency of storm surges – and on storm surge coinciding with high tides.

Changes in storm surge are produced by low barometric pressure and adverse winds. They will depend on changes in frequency, intensity and/or tracking of atmospheric low-pressure systems, and on the occurrence of stronger winds.

Changes in the pattern of tracking of low-pressure systems, ex- and extra-tropical cyclones, may also have an effect on extreme water levels. This depends on the way they interact with the continental shelf and coastline.

We know that changes to individual storm conditions are likely, particularly in their intensity. It is less certain what these changes mean for the magnitude or frequency of storm surges, and how storm-tide levels will change. You can assume that storm-tide levels will rise only due to an increase in mean sea-level rise, until further research and monitoring suggest otherwise.

## Tidal range and relative frequency of high tides

Deep ocean tides will not be affected by climate change. By contrast, tidal ranges (and the timing of high and low water) in shallow harbours, river mouths and estuaries could be altered by changes in channel depth. Channels could get:

- shallower where rates of sediment build-up (from increased run-off due to more intense rainfall events) exceeds sea-level rise
- deeper where sea-level rise exceeds the rate of sediment build-up.



As sea levels rise, more high tides will flood coastal land. This will be a particular problem for coastlines with smaller tidal ranges in proportion to sea-level rise. Also, on sections of the coast where the tidal range is lower, high tides will more often exceed current upper-tide levels.

For the central east coast and Cook Strait/Wellington areas of New Zealand this is pertinent. It means that sea-level rise will have a greater influence on storm inundation and rates of coastal erosion here than it will on coastal regions with relatively larger tidal ranges (such as the West Coast of the South Island).

## Tidal prisms

In estuaries and harbours, the 'tidal prism' is the volume of seawater that flows in on each incoming tide. The tidal prism increases with rising sea levels, causing fringing land to progressively flood during high tides. This applies particularly to low-lying land. Larger tidal prisms in estuaries will result in physical changes to the entrance channel (through higher tidal velocities and scouring) – the volume and height of sand shoals inside and outside these entrances will grow. Such changes have ramifications for the erosion of adjacent open-coast beaches and coastal navigation. At the other extreme, an estuary or fiord shoreline of steep rock walls without intertidal areas will experience little change in tidal prism.

## Wave climate

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The wave climate around New Zealand is affected by changes in atmospheric pressure patterns (wind, storms, cyclones) around New Zealand and in the wider Southwest Pacific and Southern Ocean regions. Changes in wave climate are indicated by mean and extreme wave heights and prevailing directions. They can influence the occurrence of coastal inundation through wave run-up and overtopping of coastal barriers, and significantly influence the patterns and rates of coastal erosion.

In harbours and estuaries protected from open-ocean swell waves, changes in the occurrence and magnitude of wave conditions will be directly related to the changing wind climate over New Zealand. Shallow-water locations are also subject to increases in sea levels. Such changes will be highly localised and require specific studies to quantify the changes in wave climate. For example, modelling of the wave climate of the city frontage of Wellington Harbour showed a possible increase in wave height of up to 15 per cent by 2050 and up to about 30 per cent by 2100.

In open-coast locations, where wave conditions are generated within the wider South Pacific and Southern Oceans, changes in the swell wave climate will dominate.

Coastlines that are particularly sensitive to changes in the wind and wave climate require a more complete analysis. More detail on how winds might change is given in section 2.2.7 of the *Climate Change Effects and Impacts Assessment* manual available at <http://www.mfe.govt.nz/publications/climate/climate-change-effect-impacts-assessments-mayo8>

## Sediment supply to the coast

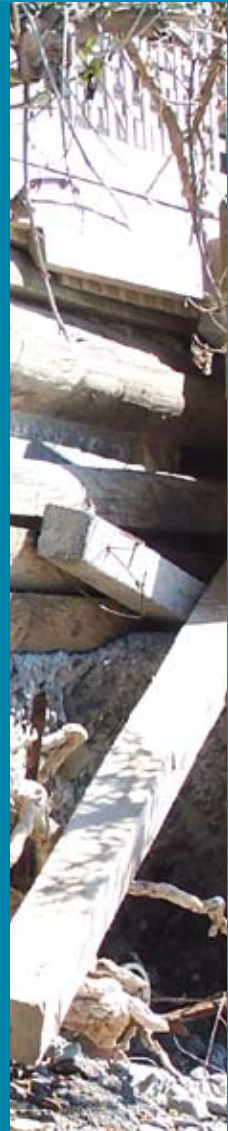
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Climate change will also influence the supply of sediment via rivers and streams to the coast. Rivers contribute much of the present-day sediment to many parts of the New Zealand coast.

In some situations, climate changes could lead to more sediment delivery. For example, greater rainfall volume and intensity will increase the potential for soil erosion and landslips in catchments. The run-off and the capacity for rivers to carry more sediment will also change.

In other situations, climate change could lead to less sediment delivery. For example, less sediment in eastern areas is likely as a result of more droughts (apart from rivers draining the main divide in Canterbury). The potential for change will vary with location around New Zealand. The impacts of a wetter west and a drier east are likely to be significant, as are increased rainfall intensities during severe rain storms.

Specific investigations are needed for each coastal region to assess changes in sediment supply and what that may mean. Studies in the Bay of Plenty region estimated that a projected future annual rainfall between a 15 per cent decrease to a 2 per cent increase would result in a 25 per cent reduction to a 3 per cent increase in average annual sediment supply from rivers. However, this change was relatively small compared to large interannual variability in sediment yield, which could vary by over tenfold in the Bay of Plenty.



# Part Two

Implications for New Zealand's  
coastal margins

## This part covers:

- implications of climate change for coastal inundation risk
- implications of climate change for coastal erosion risk
- salinisation of surface freshwaters and groundwater
- coastal defences
- inundation by tsunami.

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Climate change will not create any new coastal hazards. At many locations it will exacerbate existing coastal erosion or inundation however, and expose other places to coastal hazards where these were no problem before.

Climate change will affect New Zealand's coastal margins by:

- increased coastal erosion
- more extensive coastal inundation
- higher storm surge flooding
- increased drainage problems in adjacent low-lying areas
- seawater reaching further inland in estuaries and coastal aquifers
- changes in surface water quality, groundwater characteristics and sedimentation
- increases in seawater temperatures.

The magnitude of the impacts on coastal margins will differ between regions and even between localities within regions (see Case Study 1). This is because of the complex interactions between the:

- different ways climate change will affect the physical processes that shape the coast
- natural characteristics of the coast
- influence that humans have had or are having on the coast.

## Case Study 1:

### Ohiwa Spit. What goes around...



The patterns of coastal change on Ohiwa Spit in the Bay of Plenty illustrate their effect on coastal development. This provides a good example of the problems in land planning and coastal hazard management around the New Zealand coast.

Ohiwa Spit has a long history of changes in the position of the coastline. Between 1867 and 1911, the coastline of the Spit tended to build seawards, or accrete. In the late 1800s, a hotel was built on the Spit and, in the early 1920s, the area was subdivided. Within a few years, erosion was so rapid that the Ferry Hotel was lost and the township abandoned. A tidal channel ended up where the main street had been.

Further erosion took place until the late 1940s. Then, the Spit appeared to stabilise and during the early 1950s a new subdivision further down the Spit was developed. By 1965 erosion was again affecting property: several houses were lost to the sea over the next decade, despite various attempts to protect parts of the coast with makeshift seawall and railway-iron protection.

A series of storms in the mid- to late 1970s resulted in several properties falling into the sea. Buildings that survived the storms were removed from the coastline in 1976. Some landowners received compensation whereas others retained their titles to the land.

Since these storms, the Spit has been growing, with the beach building in width and dunes that had been lost during the storms, re-establishing. In early 2006, some of the remaining section titles were put up for sale and some have sold.

**Sources:** Richmond, BM, Nelson, CM, Healy, TR, 1984, Sedimentology and evolution of Ohiwa Harbour, a barrier impounded estuarine lagoon in the Bay of Plenty, New Zealand, *Journal of Marine and Freshwater Research*, 18, pp.461–478; Environmental Defence Society 2006, *Society warns against Ohiwa Spit property sale*. Press release 11 January 2006; Environment Bay of Plenty unpublished.

**Photographs:** 1. photograph courtesy of RK Smith; 2. 1976, photograph courtesy of EBoP; 3. 2005, photograph courtesy of Monique Ford.



## Coastal inundation

Climate change will substantially alter the frequency, extent and magnitude of coastal (saltwater) inundation. Interactions between changing sea levels, tidal ranges, changes to the frequency and magnitude of storm surges, and changes in storminess and wave conditions will add to this problem.

An increase in mean sea level will allow the gradual advance of seawater at high tides on low-lying coastal and estuarine land. Unless constrained by coastal protection works, these inundated low-lying areas will eventually become a permanent part of the coastal or estuarine system.



The most damaging inundation tends to occur during storm events that coincide with a reasonably high tide. Sea-level rise will increase the chance of inundation during such storm events, irrespective of any changes in the frequency or magnitude of storm surges, in storminess or wave conditions.

In areas already prone to coastal inundation, climate change means that coastal inundation during storms is more likely than today, given the same ground level or barrier height. Coasts with smaller tidal ranges will be more vulnerable than coasts with higher tidal ranges. The extent of the area at risk of inundation may also increase, depending on the site.

Increased sea levels will also affect rivers and streams, surface and storm water drainage, and sewer systems in low-lying coastal areas. The performance of these systems may be compromised by a back-up of flow due to increased downstream sea levels. Increased rainfall intensities may exacerbate the problem. Low-lying urban areas will be particularly susceptible.

Where overtopping of a coastal barrier is a primary cause of inundation, small changes in wave conditions (swell) may have a significant additional impact on wave set-up and run-up during storms (in addition to rising sea levels). The water tables along coastal margins may rise in response to rising sea levels; this may increase inundation directly, or could increase wave run-up and overtopping.

The potential for inundation may also be increased by coastal erosion. Human-made or natural coastal defences (such as dune systems or gravel barriers: Figure 3) may be lost. Loss of beach may increase the exposure during storm conditions, which is a particular issue in front of hard coastal defences.



**Figure 3: Wash-out of the gravel barrier on the West Coast of the South Island during a storm in 2006.** This has significantly increased the risk of inundation due to wave run-up and overtopping to the properties that back the beach. *Photographs courtesy of Doug Ramsay.*

### Assessing the implications of climate change for inundation risk

To date, there have been few detailed studies on how climate change will affect coastal inundation risk in New Zealand. This is partly because high-resolution topography for coastal margins was lacking. An increasing area of coastal regions is now being mapped with LiDAR (Light Detection and Ranging), providing high-quality topography datasets on which to base such assessments (see Example 1 overleaf).

For assessing or quantifying the potential effects of climate change on inundation, the following factors need to be considered:

- interactions between various coastal hazard drivers (sea level, waves, storms, tides and sediment supply), the impacts of climate change on these individual drivers, and how they together influence inundation. Simply assuming that extreme water levels will always coincide with extreme wave conditions tends to overestimate inundation





- the dynamic nature of inundation over land. Particularly important are flood pathways (ie, how seawater inundates a certain area) and what the storage potential of a flood area is, relative to the volume of inundating water flowing in. Inundation tends to be *overestimated* by a ‘bathtub’ approach – extrapolating the water level landward until it reaches the equivalent height on land (based on a combination of extreme wave and water levels). But where inundation is mainly the result of waves overtopping a barrier, this approach may *underestimate* inundation
- availability and length of record of the datasets for sea level, weather and waves for the locality or region
- uncertainties associated with the assessment methods used, future greenhouse gas emission scenarios and the magnitude of their impact on coastal hazard drivers
- the lack of knowledge of how some of these coastal drivers will change with climate change, and the related sensitivity of inundation risk.

### EXAMPLE 1: Assessing coastal inundation risk in the Otago Region

Otago Regional Council was one of the first regional councils in New Zealand to collect topography data for its entire coastal margin using LiDAR (Light Detection and Ranging). Collected in 2004, the dataset specifies the level of the land, buildings and trees approximately every 1 metre in the horizontal direction, with a vertical accuracy of around  $\pm 15$  centimetres. The dataset has enabled a detailed hydrodynamic model study to be undertaken of the risk of tsunamis and storm-related inundation for the entire region. This includes an assessment of the potential effects of future sea-level rise. The detailed topography permits inundation flow paths over land to be modelled dynamically, providing a realistic representation of the extent and magnitude (depth and volume) of inundation.

## Coastal erosion

In many locations, climate change will influence changes in the position of the coast (and the Mean High Water Springs boundary) through changes to, and interactions between, the following drivers:

- relative sea-level rise
- long-term sea-level fluctuations
- the frequency and magnitude of storm surges
- tidal range (coasts with relatively small tidal ranges could be more vulnerable)
- storminess and wave and/or swell conditions
- rainfall patterns and intensity, and their influence on river and cliff sediment supply.

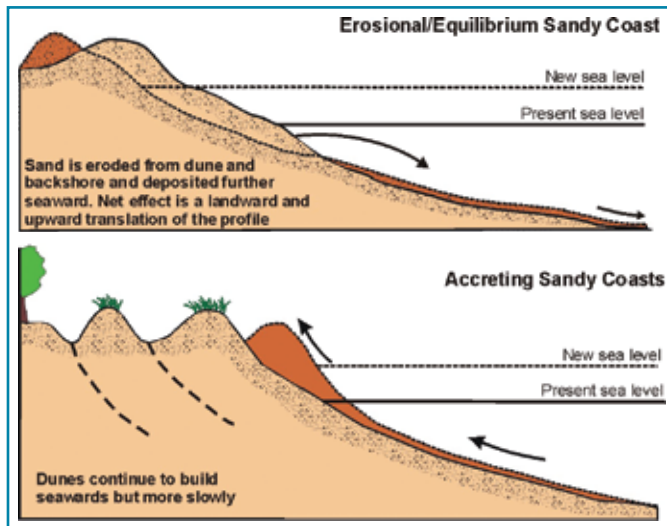
Rates of coastal erosion are not only dependent on these hazard drivers and changes to them. Landforms and geology of the coast, and any modifications that people have made (perhaps indirectly) to the coast, also play a part.

Even more so is the rate of coastal erosion determined by the waves and water levels. Rainfall and drainage patterns can be significant drivers for certain types of coast, such as soft cliffs.

The New Zealand coastline has a wide range of landforms. Yet, the sensitivity of different physical coastal environments to the likely effects of climate change is relatively straightforward and is summarised in Figure 4. Regional and local influences will result in local variations in the rate of coastal change.

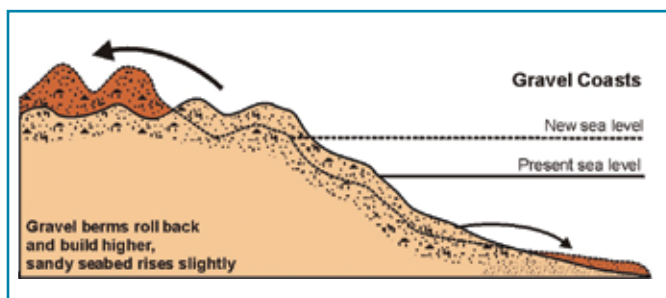
Chapter 3 of the source report provides further discussion on the sensitivity of different coastal environments to climate change.

## Sandy coasts



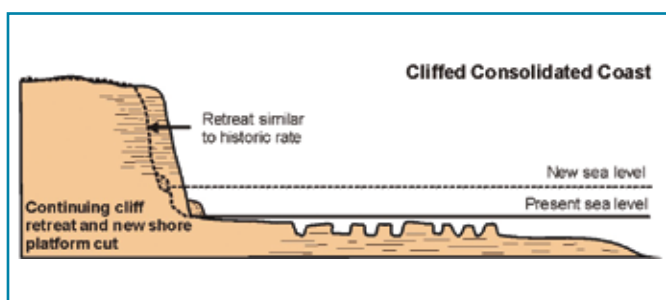
Sea-level rise will provide increased opportunity for waves to attack the backshore and foredunes in many localities.

## Gravel beaches



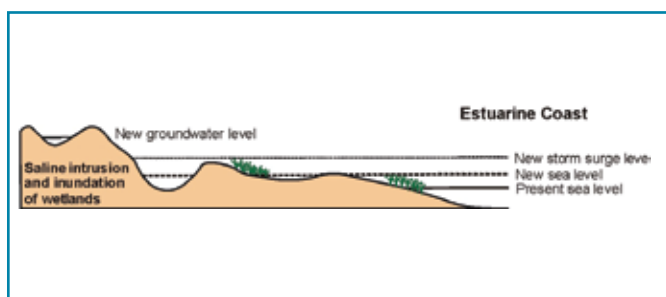
Gravel barriers will tend to retreat, but where there is sufficient gravel, the barrier will increase in height.

## Cliffs



Cliffs will tend to retreat, with the rate of retreat highly dependent on their geological characteristics.

## Estuarine coasts



Retreat of estuarine shorelines will be highly variable.

Figure 4: Generalised impacts of sea-level rise on different types of coastal morphology. These illustrations are only indicative: local geomorphology, human impacts and changes to the sediment supply may produce different responses. Photographs courtesy of Doug Ramsay. 1. Ohope Beach, Bay of Plenty 2. Mokau, Waikato 3. Haumoana, Hawkes' Bay 4. North of Waitaki River, Canterbury 5. Kai Iwi Beach, Wanganui 6. Whatarangi, Cape Paliser, Wellington 7. Manakau Harbour, Auckland 8. Waimea Inlet, Nelson.



## Assessing climate change effects on coastal erosion risk

Quantifying how the retreat and advance of coastlines will be influenced by climate change is extremely difficult, because many processes interact over multiple timescales. These processes include coastal hydrodynamics, morphology, geology, sediment supply and deposition and sometimes human modification.

Assessments of future coastal erosion usually look at the relationship between past erosion rates, the characteristics of the beach profile, and the relative difference between past and future sea levels.

Such simple approaches can provide a broad estimate of the potential for erosion along a coastline but cannot give location-specific assessments of potential change. Their use in predicting the coastline position at some time in the future, and in defining setback lines, should be treated with caution, as the implied level of certainty is rarely justifiable. A much more robust consideration of uncertainties is needed, and of how sensitive coastal change is to these. For example, uncertainty:

- about past erosion rates because of insufficient monitoring data
- in modelling assumptions and assessment methods
- in future emission scenarios, and the associated magnitude of their combined impact on the various coastal hazard drivers
- how some of these coastal drivers will change with climate change.

## Salinisation of surface freshwaters and groundwater

Climate change will also have an impact on the present-day balance between fresh and salty water in coastal margins. For example:

- sea-level rise will cause salty water to encroach further up rivers and creeks
- longer dry or drought periods in eastern areas will lead to reduced river flows, which in turn will enable salty water to advance further up river
- sea-level rise causing higher water levels at the coast, within estuaries and lower parts of rivers, will exert a higher hydraulic head of saline water on unconfined groundwater aquifers.

FS  
6

## Coastal defences

Many existing coastal defences in New Zealand have not been engineered to provide a high standard of protection. Therefore, climate change impacts could substantially increase damage to these defences resulting in reduced protection of the land behind them (Figure 5). If defences have been designed for a particular lifetime, they are unlikely to endure if climate change has not been factored in.

The frequency of defences being overtopped by waves or very high tides will increase as a result of higher sea levels (more so for coasts with smaller tidal ranges). Increased overtopping will not only affect the inundation risk, it will also be important for all coastal structures: it can increase erosion of the protected area behind the defence and can lead to failure of the defence itself.

FS  
1

Increased storm-tide levels will result in deeper water at the defence; this will increase the magnitude of overtopping during storms and exacerbate the above problems. Greater water depths at the structure will also increase the exposure of the defence to larger waves, increasing the risk of damage and failure. For example, the size of rock required for protection is directly related to the significant wave height. Even a small increase in wave conditions at the defence may require a large increase in the size of rock required to achieve the same protection.

FS  
2

Larger waves at the defence are likely to cause greater reflection from defence structures and increased erosion of the beach at the structure's base. This increases the potential for undermining and/or failure of the defence.

Steepening of the foreshore can further increase the vulnerability of defences to overtopping and structural failure. While a defence may constrain the position of the high water mark, the landward retreat of the low-water position may continue as a result.



Figure 5: The level of protection provided by coastal defences will decrease as a result of climate change impacts on coastal hazard drivers, including sea-level rise. *Photographs courtesy of Doug Ramsay.*

## Tsunami inundation

The geological causes of tsunamis are earthquakes, underwater landslides and volcanic activity; these will not be directly affected by climate change. However, the coastal effects of tsunamis will be altered somewhat by sea-level rise, through increasing the risk of coastal inundation. Estuaries and harbours may also become more vulnerable to tsunamis as entrance channels deepen in response to greater tidal water volumes (tidal prism). As always, the most important factor in determining the magnitude of tsunami impact is the height of the tide when the main tsunami wave reaches the coast.





# Part Three

Responding to climate change



## This part covers:

- the legislative context
- key principles for managing coastal hazards
- managing coastal hazard risks exacerbated by climate change
- mechanisms for avoiding and reducing coastal hazard risks
- risk transfer – managing residual risk and monitoring changing risk
- challenges in reducing coastal hazard risks.

For maintaining or developing sustainable and resilient coastal communities, it is fundamental to manage the effects of coastal hazards, and the gradual changes to these hazards as a result of climate change.

While climate change will affect a wide range of local government functions, it should not be treated in isolation. Instead, climate change should be a considered factor in all coastal planning and decision-making.

Risk management is a useful way to assess the climate change impacts and prioritise possible ways to proactively respond to them. This process can enhance our capacity to adapt to the future effects of climate change (ie, building adaptive capacity) through minimising, adjusting to, or taking advantage of, its impacts.

## The legislative context

Regional and territorial authorities have responsibilities and duties relating to avoiding or managing coastal hazard risk. Primarily, the planning framework of the Local Government Act 2002 and the Resource Management Act 1991 (RMA) require this.

The New Zealand Coastal Policy Statement (NZCPS) is a guiding policy under the RMA for managing the coastal environment. The NZCPS guides local authorities in their day-to-day management of the coastal environment. Councils must ‘give effect to’ the NZCPS in planning documents such as district or regional plans, as well as ‘give regard to’ its relevant provisions when considering consent applications.

In 2008, the NZCPS was reviewed to determine what changes were needed in light of experience with the existing statement, and to respond to emerging issues in coastal resource management such as climate change. The Department of Conservation released the ‘Proposed NZCPS 2008’ for public consultation, see [www.doc.govt.nz](http://www.doc.govt.nz)

Another key piece of legislation of relevance to coastal hazard risk management is the Civil Defence Emergency Management Act (CDEM) 2002. The CDEM Act primarily focuses on the sustainable management of hazards and on the safety of people, property and infrastructure in an emergency. The Act recommends an approach based on risk reduction, readiness, response and recovery. Risk reduction is primarily achieved through proactive planning as required by the RMA, the Local Government Act 2002, and the Building Act 2004.

You can find more information on the legislation relevant to coastal hazards and climate change (and on the New Zealand Coastal Policy Statement) in Chapter 6 and Appendix 1 of the source report. An overview of relevant case law is in Appendix 2 of the source report.

# Key principles for managing coastal hazards

Local government must operate under a range of principles as set out in the legislation described in the previous page, or that have evolved through good practice and case law. We recommend incorporating the following principles into all aspects of planning and decision-making about coastal margins:

- **Precautionary approach:** Decision-making takes account of the level of risk, uses existing knowledge and accounts for uncertainties. A precautionary approach should be used when making planning decisions that relate to new development as well as to changes to existing development within coastal margins.
- **Progressive risk reduction:** New developments should not be exposed to, nor increase, the levels of coastal hazard risks over their intended serviceable lifetime. For existing developments the level of risk should be progressively reduced.
- **Importance of natural coastal margins:** The dual role of natural coastal margins as the fundamental form of coastal defence and as an environmental, social and cultural resource must be recognised in the decision-making processes. Consequently, natural coastal margins should be secured and promoted.
- **Integrated, sustainable approach:** An integrated and sustainable approach to the management of development and coastal hazard risk should be adopted. This approach aims to contribute to the environmental, cultural, social and economic well-being of people and communities.

Figure 6 (overleaf) summarises the basic principles for coastal hazard risk management and how they apply to different categories of coastal development.

Examples of applying these principles include:

- working in partnership with coastal communities
- seeking opportunities to incorporate planning for climate change into all new and existing developments at the coast
- incorporating flexibility to deal with changing risks and uncertainties
- recognising the value of no-regrets, low-regrets options to managing climate change risks
- using a risk-based approach to decision-making regarding coastal development
- avoiding actions that make it more difficult to cope with coastal hazard and climate risks in the future.



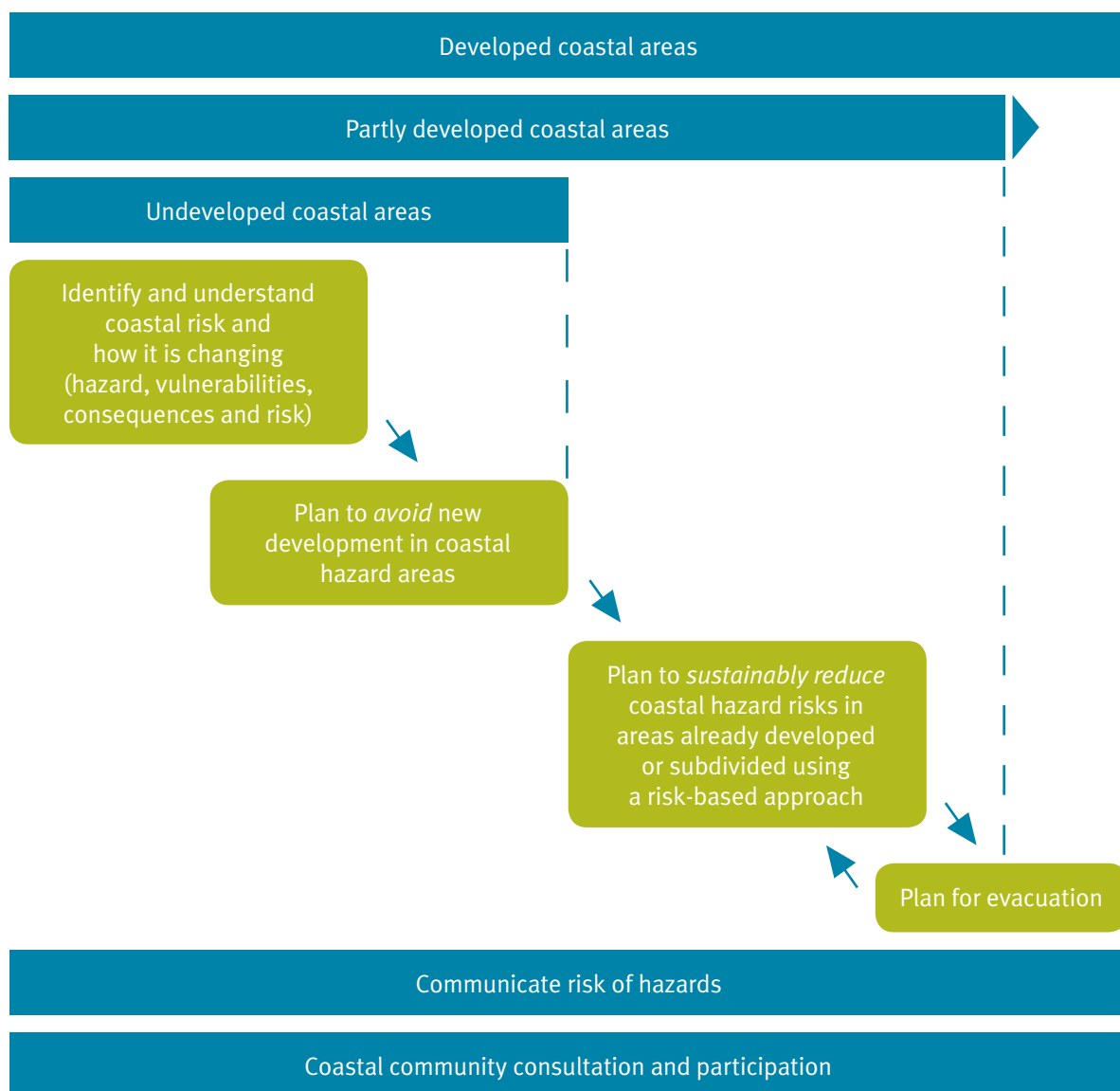


Figure 6: Basic hierarchy of principles relating to managing coastal hazard risk and the different levels of coastal development to which the principles apply.

# Managing coastal hazard risks exacerbated by climate change

It is important to first identify and understand coastal hazards, vulnerabilities and potential consequences within coastal margins. This will provide a foundation for land-use and emergency planning policies to manage the associated risks.

We recommend that you use a process based on the New Zealand Standard for Risk Management, AS/NZS4360. This process fits easily into the plan preparation and review required by the RMA and CDEM Act, at the stages where issues are being identified and a range of possible response options evaluated.

This risk assessment process is not the only one that can be used. Where a local authority already has an existing risk assessment process, climate change should simply be added to it as a factor.

To manage coastal hazard risks, first examine the risk by:

- identifying the coastal margins and describing the local assets or infrastructure that are at risk from coastal hazards
- considering how such risk may be caused or exacerbated by climate change or by changing development in coastal margins
- evaluating the likelihood and consequences of such risk over the timeframes of interest.

The box below provides some questions to help examine the coastal hazard risks.

This process then allows climate change risks and subsequent responses to be prioritised and compared equally with other risks, resource availability and cost issues (including works) that the local authority faces.

## Establishing the context – key considerations

- What problem or objectives need(s) to be addressed?
- Where does the need to make a decision come from?
- What are the primary drivers behind the problem?
- What is the planning timeframe and the realistic ‘permanency’ timeframe?
- What are the boundaries, both spatially (ie, potential area affected by the hazard or decision) and temporally (ie, the period), over which the decision will be applied?
- What constraints and decision criteria can be identified?
- What is the extent and quality of data and information available?
- What is the level of risk analysis to be adopted?
- What legislative or policy constraints or requirements may apply?
- What information on similar decisions and other guidance is available for this issue?
- Have coastal hazards and climate change been incorporated within the decision-making process before, or been accounted for at a higher level (eg, policy or strategic)?
- How will the risk assessment be used within the decision-making process?
- What is the approach to risk, eg, should a precautionary approach be adopted?
- What resources are available to aid the risk assessment and decision-making?

An important part of managing coastal hazard risk is being able to measure whether your planning approaches and the risk-management activities you are doing are effective (see Example 2 overleaf).

In the context of a changing climate, monitoring the drivers of coastal hazards (ie, sea level, waves, storms, tides and sediment supply) and the magnitude of the hazards themselves (eg, surveying coastal retreat rates) is also important. It can help identify which aspects have natural climate variability and which result from climate change.

More detail on the risk assessment process is contained in Chapter 5 of the source report and sections 4.2.3 and 6.5 of the *Climate Change Effects and Impacts Assessment* manual (available at <http://www.mfe.govt.nz/publications/climate/climate-change-effect-impacts-assessments-mayo8>).

## EXAMPLE 2: Monitoring coastal hazard risk in the Bay of Plenty

Environment Bay of Plenty has investigated, developed and trialled a quantifiable process of monitoring coastal hazard risk. It did so in support of its Regional Coastal Environment Plan objective of “No increase in the total physical risk from coastal hazards”.

The process began in 2003 with the development of a set of proposed indicators and a pilot trial of the indicators to assess whether they were workable. This process proved useful as it was found there were some difficulties with gathering the data required for the indicators; many were found to be too complex.

Following the pilot trial of indicators, seven core coastal hazard risk indicators were chosen:

1. Identifiable and/or identified coastal hazard zones that have been included on district planning maps.
2. District rules that support those hazard zones and that are aimed at not increasing the physical risk of coastal hazards (eg, no subdivision rules and building set-backs).
3. Administrative or district plan policies that ensure any building within the coastal hazard zones is subject to controls to reduce risk, such as relocatability and relocation management plans.
4. Average building set-back for the most seaward residential dwellings on residential lots in coastal hazard zones, from the year 2000 datum for base of foredune survey line.
5. Number of residential dwellings in the coastal hazard zones at the date of the most recent aerial photography.
6. Number of residential lots in coastal hazard zones from the digital cadastral database (DCDB) at a date close to the most recent aerial photography.
7. Percentage of new residential dwellings within coastal hazard zones subject to resource consent with building relocation conditions.

## Mechanisms for avoiding and reducing coastal hazard risks

Managing present-day and future risk from coastal hazards through policy development, planning and resource consenting involves a combination of *risk-avoidance* and *risk-reduction* activities.

Taking a precautionary approach to planning new development, infrastructure and services to *avoid* coastal hazards over their intended lifetime is the most effective and sustainable approach in the long term. This approach is relevant to all coastal development situations, from completely undeveloped coastal margins to developed sites or high-density urban areas.

For proposed new development sites, regional and district planning controls can be used to ensure that new development is located beyond (ie, landward of) defined coastal hazard zones.



For already developed sites, a wider mix of mechanisms for avoiding, reducing and managing coastal hazard risk can be useful:

1. information and education
2. risk management through land-use planning
3. management of coastal hazard risk through rules in regional and district plans
4. building controls and consents
5. non-statutory and other supporting measures.

## Information and education

Increased public awareness of coastal hazard risk is typically achieved through making available and/or facilitating and supporting:

- educational material
- natural registers/databases
- hazard maps
- websites
- public talks and meetings
- use of media
- coastcare groups (to build practical community experience and ‘ownership’ of issues)
- technical reports on the extent and significance of coastal hazards (options for reducing risks associated with these hazards are also important).

There are also ways of raising public awareness through statutory mechanisms, such as:

- incorporating hazard and risk information in regional and district plans, and other planning documents (eg, Long-term Council Community Plans, strategic plans and possibly annual plans)
- the Land Information Memorandum (LIM). A LIM can include information on potential erosion and inundation hazards that may affect the site
- placing notices of coastal hazard risk on property titles under sections 73 and 74 of the Building Act 2004.

However, providing information on coastal hazard risks does not always influence people’s decision-making on purchasing or living in property within at-risk areas. It is also unlikely to result in owners proactively and sustainably reducing coastal hazard risk to their property.

Education and the provision of hazard and risk information underpin all aspects of coastal hazard risk management, but are ineffective in managing coastal hazard risk on their own.

## Risk management through land-use planning

Under the RMA, regional councils are responsible for controlling the use of land for the purposes of avoiding or mitigating natural hazards.

Coastal development and the effects of coastal hazards (and the impacts climate change has on these hazards) are primarily managed by regional, territorial and unitary councils through the statutory land-use planning process:

- regional policy statements, regional coastal (environment) plans (see Figure 7 overleaf) and district plans are prepared under the RMA. They must ‘give effect to’ national policy statements and the NZCPS
- subdivision and resource consent considerations must ‘have regard to’ the objectives, policies, methods and rules defined in: the regional policy statement, regional and district plans, and the provisions of the NZCPS, national policy statements and Part II of the RMA.



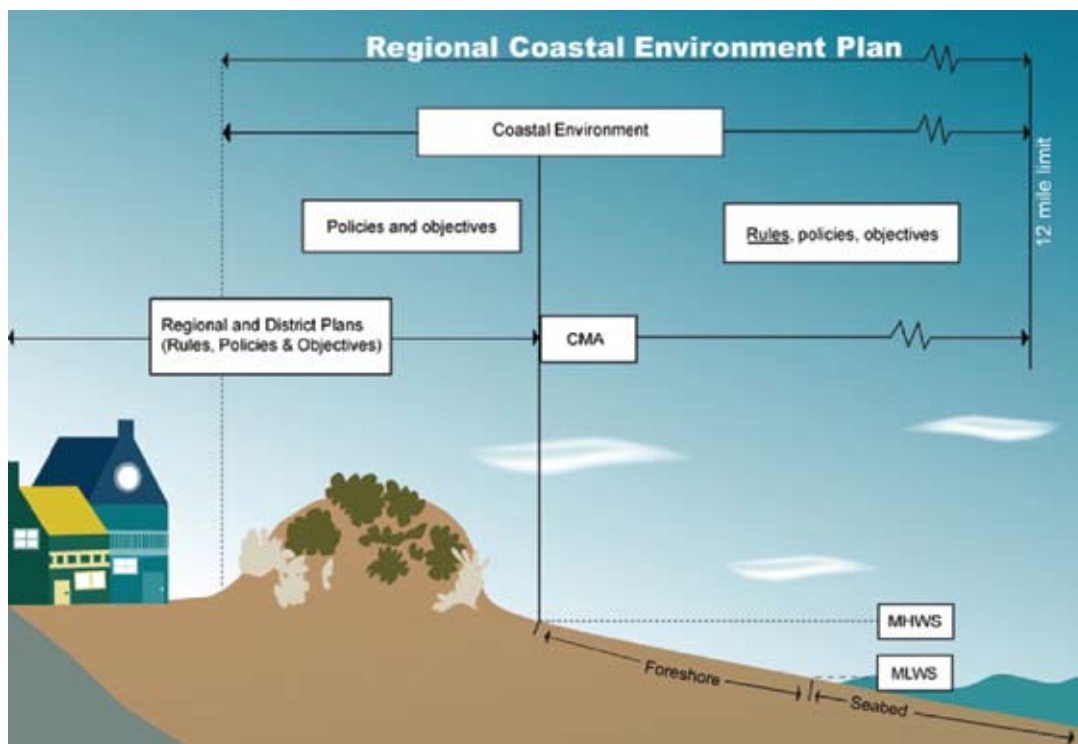


Figure 7: Plan boundaries as defined in *Environment Bay of Plenty's Regional Coastal Environmental Plan*. Several regional coastal plans cover only the coastal marine area (ie, seaward of MHWS), whereas others also include the land–sea interface in the coastal environment. (CMA=Coastal Marine Area, MHWS = Mean High Water Springs, MLWS= Mean Low Water Springs).

The effectiveness of managing coastal hazard risk through the RMA process primarily comes down to:

- how effective the rules in the district plan are in controlling subdivision, use and development activities in coastal hazard areas
- how well the overarching policies and objectives (as defined within the NZCPS, the regional policy statement and regional plans) are encapsulated and specified within the district plans.

The effectiveness also depends on the degree to which compliance with the district plan is monitored and enforced.

### Management of coastal hazard risk through rules in regional and district plans

Requirements will vary between districts and regions, but effective regional and district plans that relate to managing coastal hazard risks, and the effects of climate change, should include rules and other methods that:

- encourage early proactive action
- recognise the importance of coastal set-back zones for coastal hazard areas covering a lengthy planning horizon such as 100 years
- state a preference for risk avoidance for new development, and risk reduction for existing developed areas
- do not lock in future generations to particular or restrictive approaches to risk management; nor reduce the range of risk-management approaches that are available at present
- encourage no-regrets, low-regrets and win–win solutions to reducing risks and building long-term community resilience
- place a strong emphasis on integrated planning across the mean high water springs boundary
- maintain and/or improve the natural coastal defences and buffers

- strategically identify in the regional and district plans (or, where appropriate, in other non-statutory plans or strategies) where certain management approaches (such as defensive, ‘hold the line’ approaches) may be appropriate and acceptable
- are specific about what is not permitted in district plans in relation to new or intensified coastal development in coastal hazard areas, and/or building new or upgrading coastal protection works within the coastal environment
- are based on a combination of coastal hazard risks, rather than treating coastal erosion, storm inundation and tsunami risk independently
- identify and allow a mix of complementary statutory and non-statutory risk-reduction activities
- facilitate ongoing research and understanding of coastal hazards, vulnerabilities and potential consequences within coastal margins, how these are changing and what is driving these changes.

## Building controls and consents

Section 71 of the Building Act 2004 requires district and city councils to refuse a building consent if the following applies:

- the land is subject to one or more natural hazards
- the building work is likely to accelerate, worsen or result in a natural hazard on that land or any other property – unless adequate provision is made to protect the land or restore the damage.

Under section 72 of the Building Act, district and city councils must issue building consents on land that is at risk from coastal hazards, or any other hazard, provided that the building complies with the Building Code and that the building itself does not accelerate or worsen or extend the hazard to another property.

Land Information Memoranda (LIMs) and Project Information Memoranda (PIMs) are key elements in providing known site and hazard risk information to someone interested in a particular piece of land. A LIM states all the information a council holds about a piece of land; it generally provides a more up-to-date and detailed source of hazard information than will be contained in a district plan. The information provided by the LIM can also become the basis for liability actions (see section 4.3 of the source report).

A PIM notes the requirements of other Acts that might be relevant to proposed building work. It also includes information likely to be relevant to the proposed work, such as potential erosion, subsidence, slippage and flooding.

## Non-statutory and other supporting measures

A range of other tools and techniques can be used to support the main statutory measures for managing coastal hazard risks and to promote awareness and understanding among the public. Their use will vary between regions and include the following:

- *Dune restoration initiatives* (eg, Coastcare) have proven to be highly successful in enhancing the buffer provided by the natural dune system. They are an effective way of empowering a community and raising their awareness of coastal hazard issues.
- *Structure plans and growth strategies* provide direction for integrated urban growth. These can be used to avoid development and infrastructure being located in areas prone to coastal hazards. However, they have no legal effect, unless they become part of a document such as a plan developed under the RMA.
- *Design guidelines* promote good practice for things like subdivision layout, development location and building design. Design guidelines can be used to avoid and reduce the potential impact of coastal hazards on structures, and also help emergency management through designing for evacuation. They also have no legal effect unless incorporated into a RMA plan.
- *Community- or issue-based strategies* can provide long-term direction for, and identification of, the range of issues relating to coastal development.



- *Iwi management plans* or other documents identify important issues relating to Māori. Any relevant planning document recognised by an iwi authority and lodged with the territorial authority needs to be taken into account in RMA planning documents and consent processes.
- *Financial measures* can be provided by the council (eg, rating relief or grants – which may include land management agreements), by organisations such as Queen Elizabeth II National Trust (encouraging rural landowners to maintain undeveloped coastal areas and/or to assist with land management for conservation purposes), or by the government (eg, through reserves).

### Dealing with residual risk

Risk management measures will never completely remove coastal hazard risks. The left-over component is referred to as the residual risk, which typically means living with it and accepting it. Any associated consequences can then be dealt with via emergency management (under the CDEM Act 2002) or by signalling risk through the insurance process.

Insurance signals may include increased premiums or the refusal to continue insurance cover based on previous losses incurred. These can provide a disincentive for asset investment within high-risk hazard areas that have previously suffered financial loss. However, this can result in extreme pressure on councils to provide ‘protection’ against the hazard. Alternatively, insurance companies can work in partnership with councils to identify sustainable options for managing hazard risks. Such an approach has been adopted in the Coromandel in response to developing sustainable options for managing river flooding.

## Challenges in reducing coastal hazard risk

There are some significant challenges in achieving effective risk reduction through the land-use planning framework. These relate particularly to relocating property at risk and managing existing use rights, the management of esplanade reserves on eroding coastlines, and managing the ongoing pressure for coastal protection works to ‘hold the line’ on eroding coasts.

### Planned or managed retreat

‘Managed retreat’ is defined as any strategic decision to withdraw, relocate (see Figure 8 below) or abandon private or public assets that are at risk of being impacted by coastal hazards.

The alternative would be a considerable increase in the scale of hard coastal protection works that are installed. This may be an appropriate long-term strategy in certain (exceptional) circumstances, but does not fit comfortably with the values and principles of sustainably managing coastal margins.



Figure 8: Relocation of a property back from the eroding coastline on the West Coast.

*Photographs courtesy of Doug Ramsay.*

## Existing use rights

A significant coastal hazard issue for practitioners relates to existing use rights under section 10 of the RMA. This provision allows property owners to construct a replacement building on the same site, provided the effects of the new building/use are the same as or similar to the existing building/use. However, reliance on section 10 to safeguard existing use rights does not extend to uses of land managed through regional plans for the purposes of controlling hazards or restricting the use of the coastal marine area under section 12 of the RMA. So if someone wants to rebuild in a hazard zone, an integrated approach to manage existing use rights in coastal hazard zones may be required (see Example 3). In addition, using a district plan to control existing use rights in coastal hazard zones can be a problem where existing buildings are not altered.

### EXAMPLE 3: Management of existing use rights in the Canterbury Regional Coastal Environment Plan

The *Canterbury Regional Coastal Environment Plan* is one of the few regional plans that currently contain specific rules controlling existing use rights within defined coastal hazard zones. The rules permit existing uses to continue, but control the reconstruction or replacement of structures within the coastal erosion hazard zone. For all reconstruction and replacement activities, rules require specifications to be similar to those of the existing structure, they control the location relative to the existing structure, and they prevent any increase in floor area of any habitable building. (The exception is a number of defined areas where an increase in floor area of up to 25 square metres is permitted relative to the floor area that existed at 1 July 1994.)

Where a building is damaged or destroyed by the sea, rules also control the minimum section size upon which reconstruction or replacement is permitted. Hence, the plan also provides the scope to roll existing unaltered development landward, should the need arise.

## Esplanade reserves and strips

The RMA enables territorial authorities to create esplanade reserves or strips at the time of consent for new subdivision. These contribute to the protection of conservation values, enable public access to or along the coast, and enable public recreational use adjacent to the sea.

Although they provide a buffer at the coast, reserves or strips are not a complete solution for reducing coastal hazard risk. They can assist in managing natural hazards while protecting conservation values and enabling public access and compatible recreational use.

Esplanade reserve land is often backed by houses, or infrastructure serving residential development. Ongoing coastal erosion can cause the progressive loss of the reserve, leading to the potential loss of legal public access to the coast.

In many places, there is also considerable pressure on councils from owners of property that back onto a reserve, to protect it. Front-row property owners may also have constructed un-consented protection works on public reserves. However, councils do not have responsibility to protect reserves as a means of protecting private property.

## Coastal protection structures

Where development takes place in coastal hazard zones, there is likely to be pressure on local authorities from property owners for hard structures to protect private properties. Such coastal hazard structures include seawalls, groynes and dykes which impact on other values such as amenity, public access, and natural character. Many private property owners believe it is within their rights to protect their property (under common law property rights) even if this has adverse effects on adjacent land.





Most constructed coastal defences on New Zealand's coastline that protect residential property will have a limited lifetime – at best, probably 10–20 years. Generally, they are not constructed to a standard to withstand the significant storm events that may occur. They are usually not as permanent as the residents who are 'protected' by them assume. On coastlines that are retreating, the effectiveness of such defences is continually being reduced while the potential negative impacts caused by the defences often increases. This process is likely to be accelerated by climate change.

There may or may not be specific rules in regional and district plans (see Example 4 below) that control the use of coastal protection works. Regardless, there will continue to be considerable pressure on councils to give consent to protection structures – particularly in the aftermath of storm events where retreat or inundation has occurred. There is a temptation to use coastal protection works as a short-term measure to 'buy some time' (so that long-term options can be explored and implemented). In reality, once defence works are in place, it is extremely difficult to remove them.

In some locations, ongoing coastal protection is a long-term option (typically in highly developed urban areas with a long history of coastal protection). Regional and district plans could strategically identify where 'hold the line' options may be appropriate, and make hard protection works a prohibited activity outside these areas. While the introduction of such measures can be challenging, the complications that arise from not managing coastal development and protection works are far more complex and expensive in the long run.

#### EXAMPLE 4: Hard protection works to become non-complying activities in Whakatane District

Whakatane District Council is currently undertaking a variation to their district plan to better manage coastal hazards in the Whakatane District. As part of the variation, hard protection works to protect private or public land anywhere in the defined coastal erosion risk zone (to 2100) are classified as non-complying activities. For public roads, 'protection' is classified as a restricted discretionary activity, as are 'softer' protection options such as beach nourishment and 'sand sausages'. The provisions have resulted in considerable community concern. The district council, with support from Environment Bay of Plenty, has been working through these concerns with the communities. As part of this process, the council commissioned an assessment of the economic costs and benefits of the proposed variation as required under section 32 of the RMA.

## Conclusion

Climate change will not introduce any new types of coastal hazards. Yet it will exacerbate existing coastal hazards by changing some of the hazard drivers (ie, sea level, waves, storms, tides and sediment supply). In addition to causing sea-level rise, climate change will exacerbate coastal erosion and inundation in many parts of the New Zealand coast. This further increases the risks for coastal developments.

Coastal hazard risks are increasing and more of New Zealand's urban development and infrastructure is being located in coastal areas. Therefore, it is important that coastal hazards are managed in a proactive and timely way. Planning is more effective and less costly over the long term, than reacting to events when they occur.

The RMA provides an array of options for managing coastal hazard risks, from raising public awareness through the use of building consents to setting rules in the land-use planning framework. The best solutions will consider the needs of future generations and not lock communities into a future of increasing risks from coastal hazards.

By responding to climate change impacts now, councils can help their communities to be better placed to cope with risks from coastal hazards at present and into the future.



