# 2 New Zealand's Coastal Scene

New Zealand has about 18,000 km of coastline, indented by some 350 estuaries, harbours, inlets, bays or fiords. Coastal margins are the transition between the ocean and the land, and the place where seawater mixes with freshwater and interacts occasionally with the fringing low-lying land during storms or extreme tides. Climate change impacts will vary locally as a result of local and regional differences in both the physical forcing functions (for example, waves, winds, currents, sea level) and coastal types. A broad-scale distribution of New Zealand coastal types, distinguishing 'bold' (steep, rocky), headland-bay, low-cliffed, depositional (mobile sediments) and beaches is shown in Figure 2. Estuaries and their associated low-lying margins (coastal plains, wetlands, salt marshes) are particularly vulnerable to climate change.

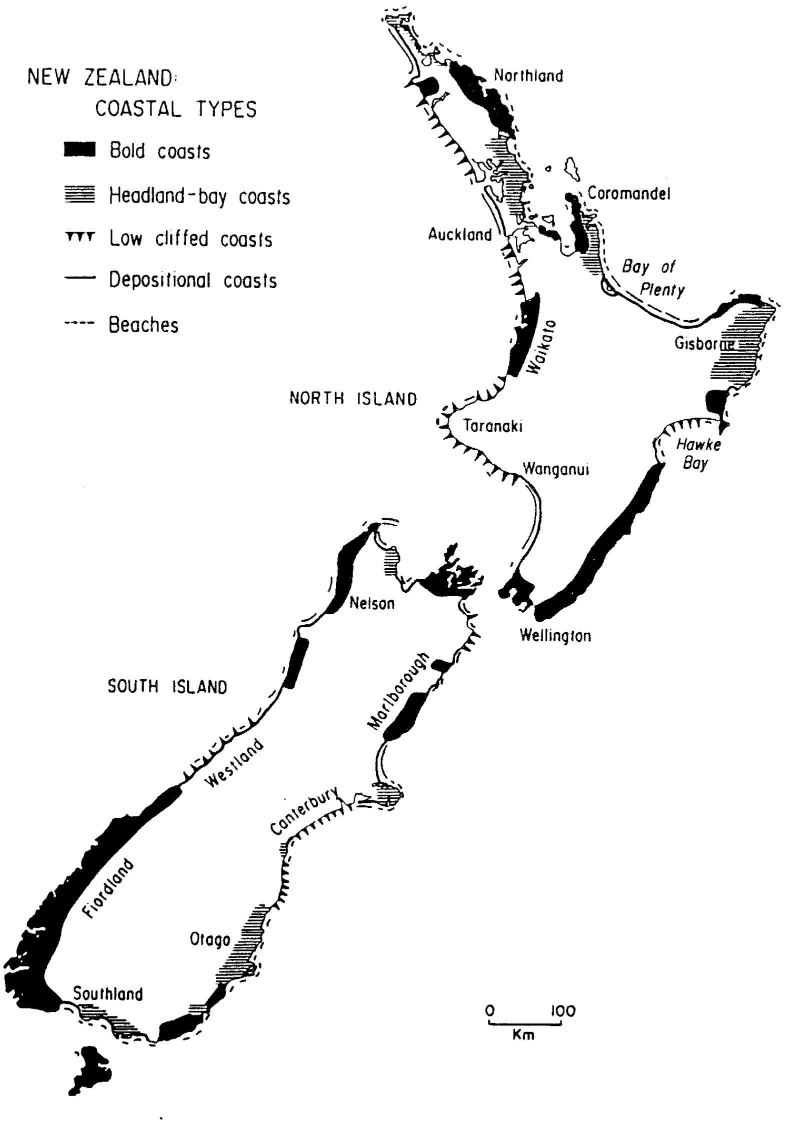


***Figure 2:*** *Geomorphic types around the New Zealand open coast (after McLean, 1978). Climate change and sea-level rise impacts would be least on bold coasts and greatest on depositional coasts and beaches.*

A quick glance at Figure 2 may suggest that New Zealand's vulnerability to rising sea levels is low, due to the extensive lengths of high rocky or cliffed coast. But there are two types of coastline at risk. Some cliffed coasts are eroding at high rates, such as the unconsolidated alluvial cliffs in the Canterbury Bight, which may worsen with increased storminess and sea-level rise. However, the most vulnerable areas are where our urban centres, ports and holiday resorts cluster around low-lying portions of the coastline, such as harbours, estuaries, beaches, inlets and bays. They are there because these types of coastal environments are attractive aesthetically, places for recreation and access to the sea, or are functional as sheltered vessel moorings and ports.

Coastal environments already vulnerable to erosion or flooding hazards are most at risk from the impacts of global warming, but at least in these localities there is some residual knowledge of the potential hazards. For instance, coastal erosion can result in loss of dunes and beach area when seawalls are built (Cooks Beach, Figure 1), or damage and loss of property (Ohiwa Spit, Figure 3). Many coastal communities in low-lying coastal margins that have little history of erosion or coastal flooding may be more vulnerable in the long term because of greater resistance to precautionary response and adaptation plans. Territorial authorities have had a major struggle to get coastal hazard set-back zones accepted in established communities (for example, Papamoa Beach and even the more erosion-prone Waihi Beach), especially when home-owners find they are located seaward of the proposed set-back boundary.

***Figure 3:** Catastrophic erosion at Ohiwa Spit west of Opotiki (Bay of Plenty) in April 1976 showing the futile efforts to defend the shoreline. Over the last two decades, the spit has subsequently built out seaward by around 200 m to cover the railway-iron protection seen offshore.* [Photo: RK Smith]

Maori have a special affinity for both the land (whenua) and the sea (moana), where fish and seafoods (kaimoana) are prized. As a consequence, there will be cultural impacts of global warming for Maori, especially with respect to any loss of land (and associated marae, middens and urupa) from erosion or flooding, and loss of habitat for kaimoana.

The spectrum of marine ecosystem habitat types around New Zealand ranges from exposed and wild cliff-lined or rocky coasts, through to quiescent waters within a mangrove stand or salt marsh at the upper reaches of an estuary. Coastal ecosystems are threatened by sea-level rise because extensive areas of wetlands, salt marsh and intertidal habitats lie at or just above sea level. But in some respects New Zealand is fortunate. Being a steep landmass with relatively narrow coastal margins, we are not vulnerable to the kinds of massive disruptions from global-warming impacts faced by countries such as Bangladesh (where 16% of rice-growing land is lower than 1 m above high tide), the Netherlands (increasingly more land below sea level) and some of our Pacific Island neighbours who live on low-lying atolls.

Along New Zealand's coastal margin the most serious impacts induced by climate change will be sea-level rise (permanent or storm sea flooding) and changes in climate and weather patterns, which may alter coastal sediment budgets ('sand in the bank'). Even minor shifts (positive or negative) in sediment delivered to the coast from the adjacent catchments could create long-term shifts in coastline movement.

Historical rates of erosion and accretion around New Zealand's open coastline are shown in Figure 4. While this nearly 20-year-old database desperately needs updating, it provides a picture of a patchy spatial distribution of shorelines that are advancing and eroding. Sea-level rise and climate change is likely to lead to markedly more eroding areas on the coast, particularly where sand or gravel supplies to the coastline are reduced by changes to rainfall, river flow, windiness, and storm frequency and intensity caused by global warming. There will very likely be areas where sediment supply or availability increases above historical rates, particularly if storm rainfall intensity increases, leading to advancing shorelines. Sea flooding and rising sea and estuary temperatures will also have significant impacts on ecosystems.

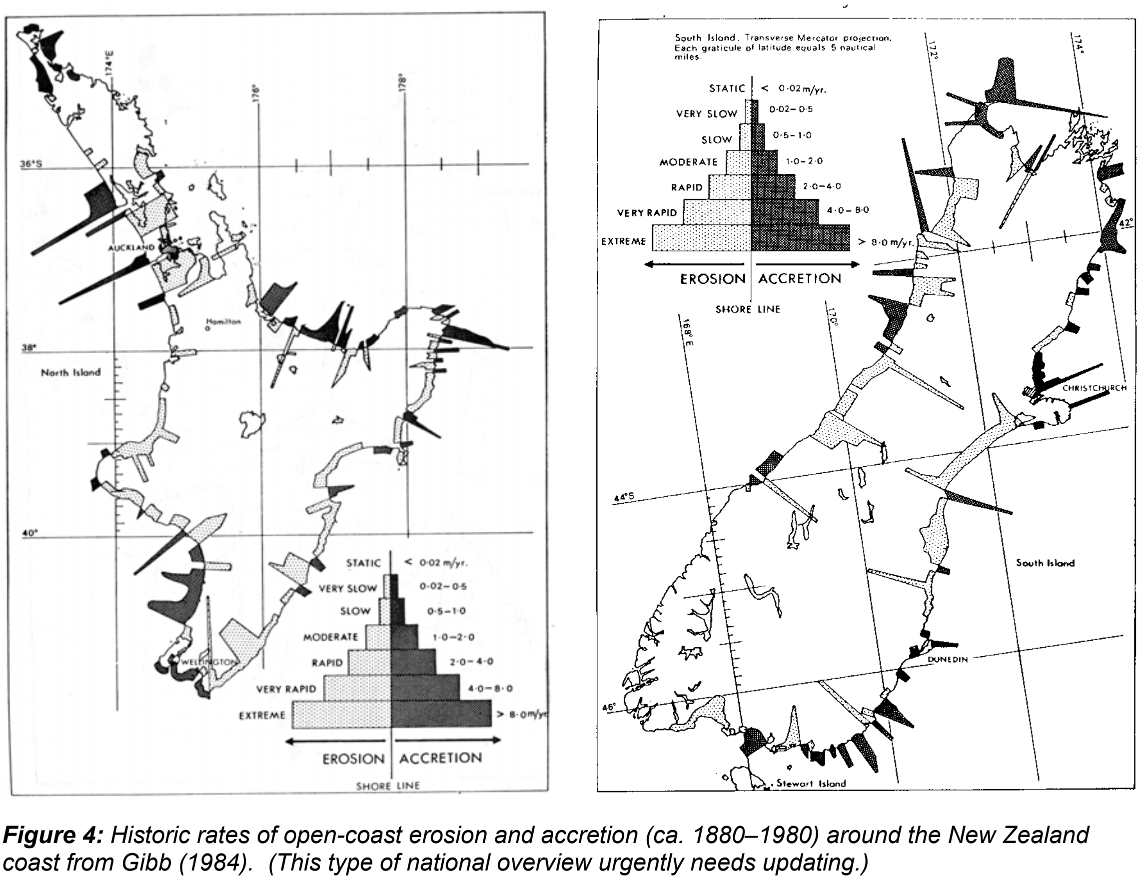


*Figure 4: Historic rates of open-coast erosion and accretion (ca. 1880–1980) around the New Zealand coast from Gibb (1984). (This type of national overview urgently needs updating.)*

The variability of New Zealand coastal types and different exposures to physical forcing functions (such as east versus west coasts) means that mitigating or adapting to the impacts of climate change for such a wide range of environments will entail different local investigations and solutions.

A warming world has already caused changes. Sea level around New Zealand has risen on average around 0.3 m since the mid 1800s (Bell *et al*., 2000), and coastal sea-surface temperatures have risen by around 0.4 to 0.5°C since 1870 (Folland and Salinger, 1995).

- **Developed areas are mostly near desirable beaches, estuaries and harbours, but by their very low-lying, accessible nature are vulnerable to the effects of global warming.**
- **Parts of the coastline have historically been eroding or retreating, and climate change will exacerbate these trends in some locations.**
- **Diversity of coastal and catchment types requires local or regional investigations and solutions.**
- **The sea level has risen 0.3 m since the mid-1800s and the sea temperature by 0.4 to 0.5°C since 1870.**

# 3 Setting the Scene: Climate Change and Coastal 'Drivers'

## 3.1 Some key definitions

Some working definitions for terms we use are important to avoid misunderstandings. Other terms are listed in the Glossary.

*Climate* is the 'average' state of weather in a region over periods of seasons or longer. *Climate change* refers to any significant change or trend in climate over time, either the mean state of climate and/or its variability (for example, extremes of temperature or rainfall, the retreat or advance of glaciers, the El Niño–Southern Oscillation). The Intergovernmental Panel on Climate Change (IPCC), which was formed jointly by the United Nations Environment Programme and the World Meteorological Organisation to regularly assess global climate change, investigates climate change due to both *natural variability* and as a *result of human activity*.

*Global warming* is often used synonymously with *climate change due to human activity*, the former being an expression the public identify with more readily (UMR Research Ltd, 2001), although climate change will incur more than just a rise in temperature, which is implicit in the term global warming. At times there can be uncertainty on whether climate change of a particular variable has occurred, because a small long-term trend or change must be distinguished from regular natural variability in any set of measurements.

*Climate projection* is a projection of the response of the climate system to emission scenarios of greenhouse gases and aerosols and other radiative forcing, usually based on simulations by a numerical climate model. Climate projections are distinguished from *climate predictions*, to emphasise that projections depend on model assumptions and the particular scenarios used, which in turn are based on assumptions concerning future socioeconomic trends, emission rates and technological developments, that may or may not be completely realised. Thus every climate projection must be seen as a *plausible* future development that is *consistent with a certain set of assumptions*, not a scientifically stated certainty.

*Global* sea-level rise refers to the average vertical rise across the world's oceans. *Relative* sea-level rise is the net rise relative to the landmass in a region, which is the sum of the local subsidence (or uplift) of the coastal margin and the *absolute* sea-level contribution in that region (which may in itself depart from the *global average* value in different regions). Tide gauges around the open coast and inside harbours measure *relative* sea level. Why the distinction? Because the long-term projections of sea-level rise made every five years by the IPCC are *global average absolute* rates, but in any particular region or locality it is the *relative* sea-level rise that determines the long-term susceptibility to coastal flooding and erosion. Therefore, the projected IPCC global rates need to be translated into relative rates for each region.

This is made somewhat easier in New Zealand because, by and large, our relative sea-level rates at the major ports are similar to the global average. However, it is unlikely that these relative sea-level rates apply everywhere around New Zealand all the time. Along some New Zealand coasts, seismic events can cause rapid or unsteady changes in relative sea level over localised areas. It is impossible to know when, where, and by how much, but research and monitoring of land movements can usefully pinpoint areas that are more vulnerable to either seismic uplift or subsidence. This irregular or episodic shift in the local landmass is usually impossible to quantify in order to combine with the trend of increasing global sea level to produce a reliable figure for any given area.

## 3.2 The role of the oceans in climate change

The ocean is a key player in the global climate system, moderating atmospheric temperature rises and absorbing $CO_2$. Oceans are large reservoirs of heat, and they change their temperature only slowly, but over time the cumulative effects of warmer air temperatures are manifested by thermal expansion of warmer upper-layer seawater and extra water volume from glacier and ice cap melt, causing the sea level to rise. The sheer size of the ocean heat reservoir means, even given a curtailment of greenhouse gas emissions, that several centuries may pass before rising sea level due to thermal expansion slows down (IPCC, 2001a).

Over the past few decades, public awareness raising about the effects of climate change on coastal margins has been entirely focused on the rise in sea level. However, other changes in climate (temperature, rainfall, wind flows, ocean currents and El Niño) and weather (storms, winds and waves) will also pose additional issues for the coast, either directly or indirectly. For example, a change in rainfall patterns in the Southern Alps will affect flows in the main Canterbury feeder rivers, how much is abstracted for irrigation, and therefore how much sand and gravel is supplied to the coast.

## 3.3 'Drivers' of coastal change

It is important to distinguish the different physical 'drivers' or forcing agents (Figure 5) of physical and ecological change in coastal margins. Climate change will eventually affect all these drivers, either directly, or through their interaction with other drivers. For example, global ocean tides will be unaffected directly, but tidal propagation characteristics in shallow estuaries and rivers may be altered by deeper or shallower water depths (caused by changes in sediment supply) and/or a higher sea level.

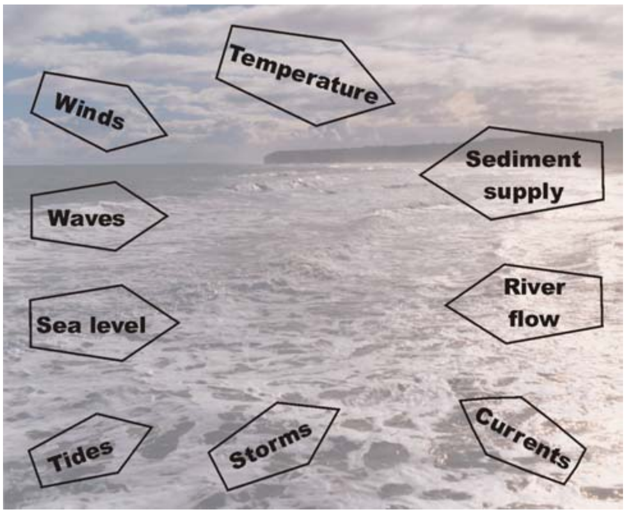


*Figure 5: The key physical "drivers" or forcing agents that govern change in coastal and estuarine systems. Climate change will eventually affect all these drivers either directly or indirectly.*

Sediment supply can be affected by a myriad of catchment and ocean factors including:

- catchment geology and rainfall
- river flows
- frequency and magnitude of storms
- river controls (for example, dams, abstraction for irrigation)
- sand and gravel extraction for aggregate
- ocean wave climate
- prevailing winds
- alongshore currents
- the type of foreshore and its sedimentary composition.

The next section describes expected changes in some of these physical drivers as a result of global warming, based on historical data and future regional climate projections. Most is known about sea-level rise and temperature; we are less certain about other drivers of coastal change because of complex interactions between drivers and climate changes, and about specific regional variations compared to global or hemispheric averages.

- **Climate change is any significant change or trend in climate, natural as well as human-induced, and includes global warming.**
- **Regional sea-level rise relative to the landmass is what will affect us locally, rather than the average global sea-level rise.**
- **Oceans are a vast heat reservoir, so that it will take centuries to cool and slow down sea-level rise, even if greenhouse gas emissions are curtailed immediately.**
- **Climate change – not just sea-level rise – will affect most physical drivers that shape coastal margins and ecosystems.**