COASTAL STORMS

This factsheet provides information on the nature and impact of coastal storms on the Coromandel Peninsula, with a focus on significant historical storms and future storminess. It is intended as a guide only.

EXTREME TIDES AND STORM SURGE

Every day, sea level changes with the tides, but not all tides are the same. Tide height varies with the lunar cycle, and every fortnight spring tides, coinciding with the full and new moons, produce higher and lower tide heights than the intervening neap tides.

Extra-high tides known as king tides, occur a few times each year during spring tides.These are the result of the moon's 29-day elliptical orbit around the earth acting together with the gravitational pull of the sun. King tides are predictable and provide a useful indicator of the risks of coastal inundation now and into the future, as they raise the 'normal' water level, increasing the risk of inundation. King tides are known to cause nuisance flooding in low-lying areas even during fine weather.

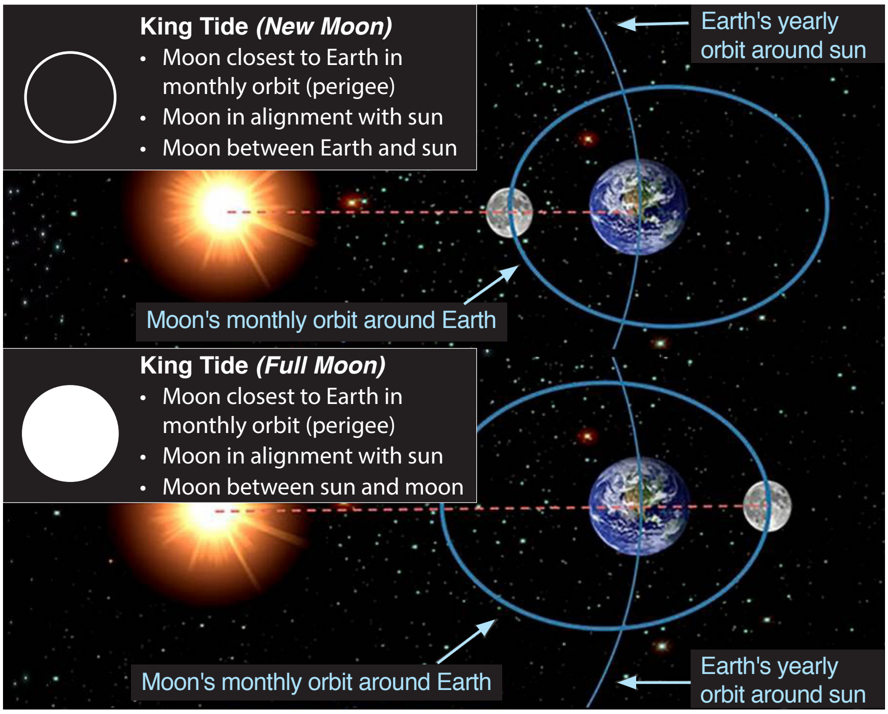


Figure 1 The process of king tides related to the sun and moon (source: http://kingtides.net/king-tides-explained/)

The trouble really arrives when a large storm event, with associated storm surge (SS), coincides with a spring or king tide. Storm surge results from the combination of low atmospheric pressure and stress from winds which elevates the water level above the predicted tide. The combined elevation of the predicted tide and storm surge is known as the storm tide.

COASTAL STORMS DRIVE COASTAL HAZARDS

Riding high on the back of a long-term trend of increasing sea level are elevated water levels associated with storms and waves, which exacerbate coastal inundation and coastal erosion.

Coastal inundation of low-lying land is most likely to happen during spring tides and when low pressure weather systems and wind pile water up against the coast (see Figure 2). This will also be influenced by changes in regional sea level caused by El Niño and La Niña, discussed below. Sea water can wash over dunes and seawalls, surge up streams and waterways, flow up drains and impact our roads and buildings. When a storm surge and river or surface water flooding combine, coastal inundation impacts can be further exacerbated.

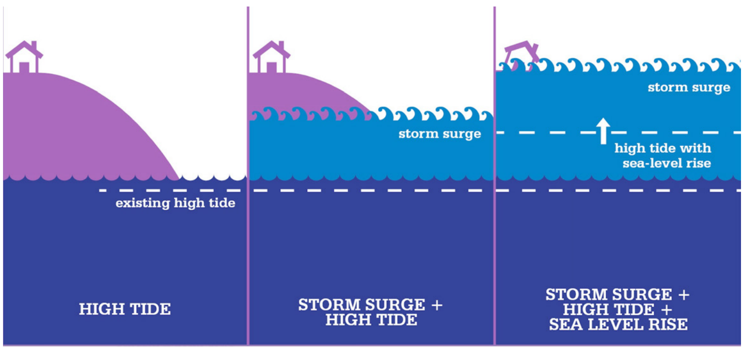


Figure 2 The relationship between high tides, storm surge and sea level and their influence on coastal inundation. Source: Climate Commission Australia

Analysis of sea level records at Tararu and Whitianga reveal differences in storm surges between the west and east coasts (see Table below) of the Coromandel Peninsula:

- Storm surges in Whitianga are influenced by the combined effects of onshore winds and a drop in barometric pressure typically associated with mid-latitude winter storms from the west or fast-moving weather systems from the north; for example, the March 2015 Cyclone Pam (see Figure 4).
- Storm surges in the Firth of Thames (Tararu) are influenced by intense low pressure system storms moving from the west or north; which direct waves and wind down the Firth from the north; for example, the January 2018 'Tasman Tempest' (see Figure 5).

Both records indicate that the Coromandel Peninsula is susceptible to weather events both early in the year (ex-tropical intense low pressure systems) and in winter (mid-latitude storms; for example August 2009) that effect the coast from the west, north and east. The events listed in the Table below show that predicted tide forms the largest contribution to the peak measured sea level. The timing of a major storm surge (SS) with the king tide during the Thames 2018 event led to one of the largest measured coastal inundation events at Thames with an estimated Average Recurrence Interval (ARI) of approximately 200 years.

Description	2015 (March) Event Whitianga Level (m)	2018 (January) Event Whitianga Level (m)	2009 (August) Event Thames Level (m)	2018 (January) Event Thames Level (m)
Peak Measured Sea Level (Relative to Mean Sea Level)	1.18 (<1-year ARI)	1.45 (18-year ARI)	1.34 (<1-year ARI)	2.71 (200-year ARI)
Predicted Tide at Peak Level	0.81	1.15	0.94	2.02
Storm Surge at Peak Level	0.23	0.21	0.36	0.58
Sea Level Anomaly	0.125	0.083	-0.057	0.092
Maximum Storm Surge During Event	0.37 (3-year ARI)	0.21 (<1-year ARI)	0.60 (5-year ARI)	0.58 (4-year ARI)

INFLUENCE OF EL NIÑO SOUTHERN OSCILLATION (ENSO) ON COASTAL STORMS

ENSO is a naturally occurring global climate cycle, comprising of El Niño and La Niña phases that alter rainfall, temperature, and wind patterns (including storms). These phases occur every few years and may last a year or two. The El Niño phase means New Zealand experiences more frequent wind and wave energy from the west in summer and south in winter. This phase would tend to exacerbate coastal inundation and coastal erosion on the west coast of the New Zealand but has little impact on the west coast of the Coromandel. This is because the El Niño patterns are blocked by New Zealand's west coast. The La Niña phase means New Zealand experiences more frequent and stronger wind and wave energy from the Northeast and east. This phase would tend to increase the frequency of coastal inundation and exacerbate coastal erosion on the east coast of the Coromandel.

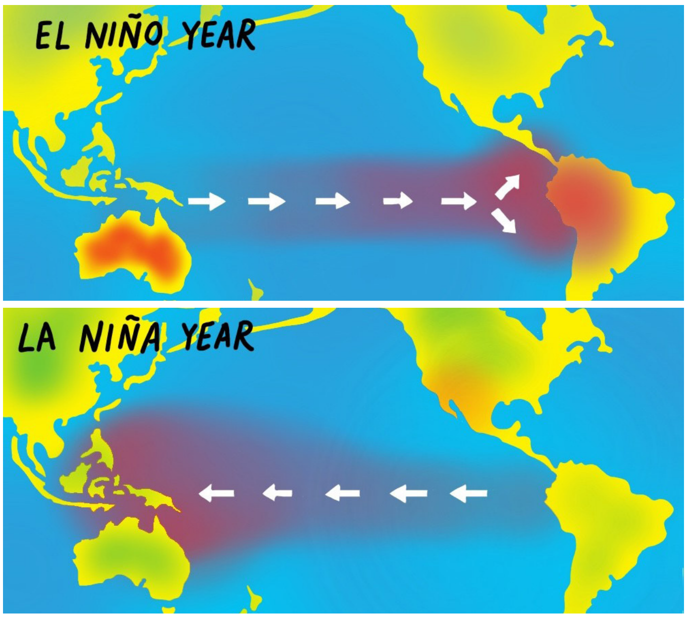
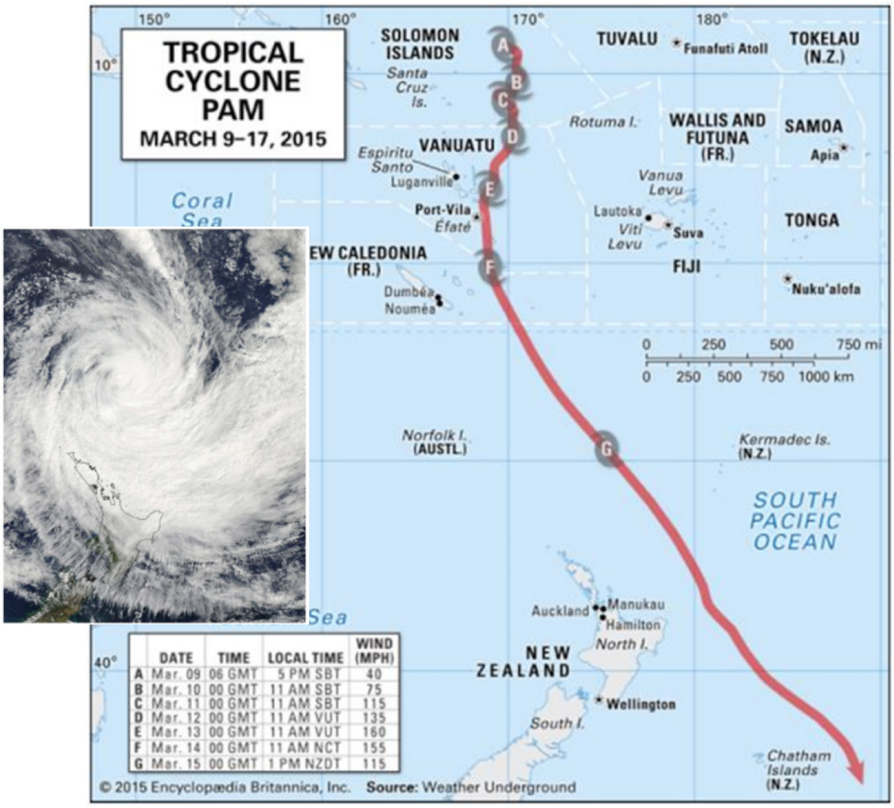


Figure 3 The difference in circulation patterns for the two ENSO climate phases, with El Niño showing a westerly flow pattern and La Niña showing an easterly flow pattern (source: CSIRO https://blog.csiro.au/el-nino-southern-oscillation/)

The summer of 2020/2021 has been officially declared as La Niña, meaning we would expect there to be more frequent storms affecting the east coast, with the potential for increasing coastal hazards. During the 2020 winter the east coast of the Coromandel experienced a cluster of storms from the east and northeast, leading to severe erosion at several beaches:

- Pauanui north lost around 100 m of beach at the mean high-water springs level, and around 45 m of upper foredune
- Buffalo Beach lost on average 0.9 m of dune over a 52-day period
- Tairua south lost around 15 m of upper beach face

Whilst not directly linked to La Niña, the occurrence of back to back storms during the 2020 winter is a snapshot of the potential storm activity during a La Niña phase.



	DATE	TIME	LOCAL TIME	WIND (MPH)
A	Mar. 09	06 GMT	5 PM SBT	40
B	Mar. 10	00 GMT	11 AM SBT	75
C	Mar. 11	00 GMT	11 AM SBT	115
D	Mar. 12	00 GMT	11 AM VUT	135
E	Mar. 13	00 GMT	11 AM VUT	160
F	Mar. 14	00 GMT	11 AM NCT	155
G	Mar. 15	00 GMT	1 PM NZDT	115

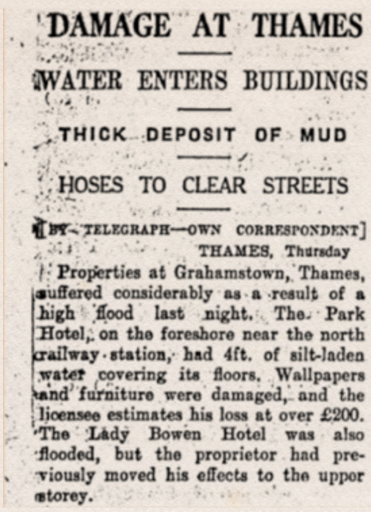
Figure 4 Tropical Cyclone Pam's track and an aerial image of it passing New Zealand

SIGNIFICANT HISTORICAL STORMS

The characteristics of previous coastal storms that have 'hit' the Coromandel have been studied in detail by Stephens *et al.* (2020)[1]. They conclude that those events are rare but sensitive to small changes in sea level and, often, occur during times of the year when sea level is higher than normal. Understanding these events is thus critical to understanding how even small changes in sea level will drive the frequency and magnitude of coastal hazards, like erosion and flooding.

4-5 MAY 1938

Strong north-east gales and moderately higher tides resulted in a significant surge of water down the Firth of Thames. Combined with heavy rain, the resultant flooding covered significant portions of the lower Hauraki Plains, estimated to be 35,000ha. Several breaches in the shoreline stopbank between Waitakarau and Kopu resulted in extensive areas of land being flooded. The water extended inland to Ngatea, 7.5km from the coast. The total elevation of the sea level, including tide, storm-surge and wave set-up, was about 3m.



DAMAGE AT THAMES

WATER ENTERS BUILDINGS

THICK DEPOSIT OF MUD

HOSES TO CLEAR STREETS

[BY TELEGRAPH—OWN CORRESPONDENT]

THAMES, Thursday

Properties at Grahamstown, Thames, suffered considerably as a result of a high flood last night. The Park Hotel, on the foreshore near the north railway station, had 4ft. of silt-laden water covering its floors. Wallpapers and furniture were damaged, and the licensee estimates his loss at over £200. The Lady Bowen Hotel was also flooded, but the proprietor had previously moved his effects to the upper storey.

[1] Stephens, S.A., Bell, R.G. & Haigh, I. (2020). *Spatial and temporal analysis of extreme storm-tide and skew-surge events around the coastline of New Zealand*. Natural Hazards and Earth System Sciences, 20, 783-796.

5-6 JANUARY 2018

The 5 January 2018 storm resulted in some of the highest water levels in recorded history for the Firth of Thames region. This storm developed in the North Tasman Sea from 3 January and rapidly intensified as it crossed the North Island. A central low pressure, strong northerly winds, heavy rain and large waves caused damage over many parts of the island, but particularly down the Firth of Thames. The key ingredient in this was the timing of the weather event, occurring at the same time as very high tides; the highest of the year. Indeed, the surge experienced in the 1938 event was larger than that of the 2018 event.

Wind speeds within the Firth of Thames (climate station C75241) reached 70km/hr, the pressure dropped to 987hPa and, in combination with the predicted high tide of 2.1m (relative to the Moturiki Vertical Datum 1953, or MVD-53), the peak water level measured at the Tararu tide gauge was 2.98m (MVD-53). The total storm surge height was estimated to be 0.88m NIWA (2015)[2], which correlates to a 50-year return period storm surge. In fact, with the combination of storm surge and the tide, such a water level would be associated with a 1 in 100-year event.

The main communities impacted were Miranda, Kaiaua, Little Waikawau, Te Puru, Tararu and Thames. At least 391 properties were damaged across the Hauraki and Thames-Coromandel Districts, of which 81 were described as being moderately damaged and only partially habitable. Over 20km of State Highway 25 was severely impacted, including seawalls and revetments[3]. The impacts of the storm severely tested the readiness and coping capacity of Coromandel's coastal communities and infrastructure.

The storm was a timely reminder of the need to prepare coastal communities for changing coastal risks.

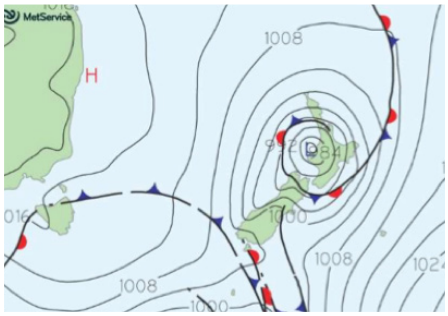


Figure 5 weather chart from 1pm 5 January 2018

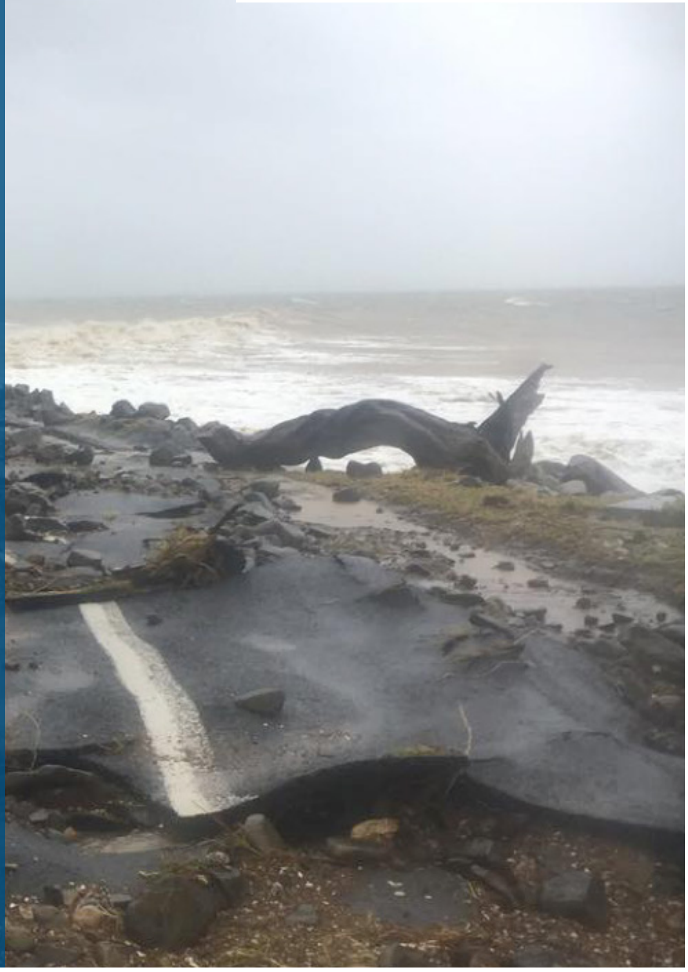


Figure 6 Damage to State Highway 25 at Ngarimu Bay on 5 January 2018. Credit: Jason Thomsen

[2] NIWA (2015) Analysis of Whitianga, *Tararu amd Kawhia sea-level records to 2014*.
[3] From CDEM joint committee report of 26 March 2018.