Objectives of Beach Monitoring

- Understand the dynamics of sand movement.
- Provide a bench mark of sand elevations to assess the performance any physical structures added to the beach.
- Provide coastal managers and government authorities with timely information about the coast.

This document describes the science behind beach measurements and two important discoveries by the

Port Fairy Coastal Group

Three key objectives of Beach Monitoring.

Coastal Engineers have general knowledge and understanding of beach and coastal processes but to optimize the response to storm surges and sea level rise, we need a specific understanding of the systems at work around our local coast.

Formal documentation of our beach system provides a reference against which we can compare results after physical prevention strategies are implemented to confirm a positive result with minimal adverse side effects.

Coastal managers must have relevant data in order to make the best decisions about coastal protection strategies and formulate a practical response to issues related to climate change.

Port Fairy and the beauty of East Beach.

Beach Monitoring takes place over 4.5 kilometres of Port Fairy's East Beach. This area is also mapped with a drone as part of the Victorian Coastal Monitoring Program (VCMP) sponsored by the Department of the Environment Lands Water and Planning. (DELWP)

The central area of the bay encompassing the former land fill sites was of special significance during 2013 when unusual erosion was detected and the Moyne Shire alerted by the Port Fairy Coastal Group.

Refer to pages 4 – 15

This area is also of interest in our analysis of the phase changes in the periodic sand height cycles and is providing evidence that seasonal changes in sand level have now become quite random and more extreme, most likely as a result of climate change.

Refer to pages 23 – 26.

The Reference Post system used by the Port Fairy Coastal Group allows standardized measurements of sand levels at high risk sites around the coast.

East Beach (Posts 1 – 19, 12 installed)

South Beach (Posts numbered 20 – 29, 3 installed)

Port Fairy Bay (Locations numbered 30+ where point 30 is the reference point at the old Tide Gauge site) A plan to install an electronic tide gauge has been abandoned because of the advances in satellite monitoring of sea level rise.

The top inset shows detail for the Gully measurements (Used when race horses were exercised on the beach) using posts 9 & 10. The right inset shows the Wave Energy Dissipation structure using posts 7.4 to 8.6. Both of these methods were replaced by VCMP drone mapping in 2018.

See pages 17, 18 & 19 for a description of the system of measurement and how the post is used as a height reference.

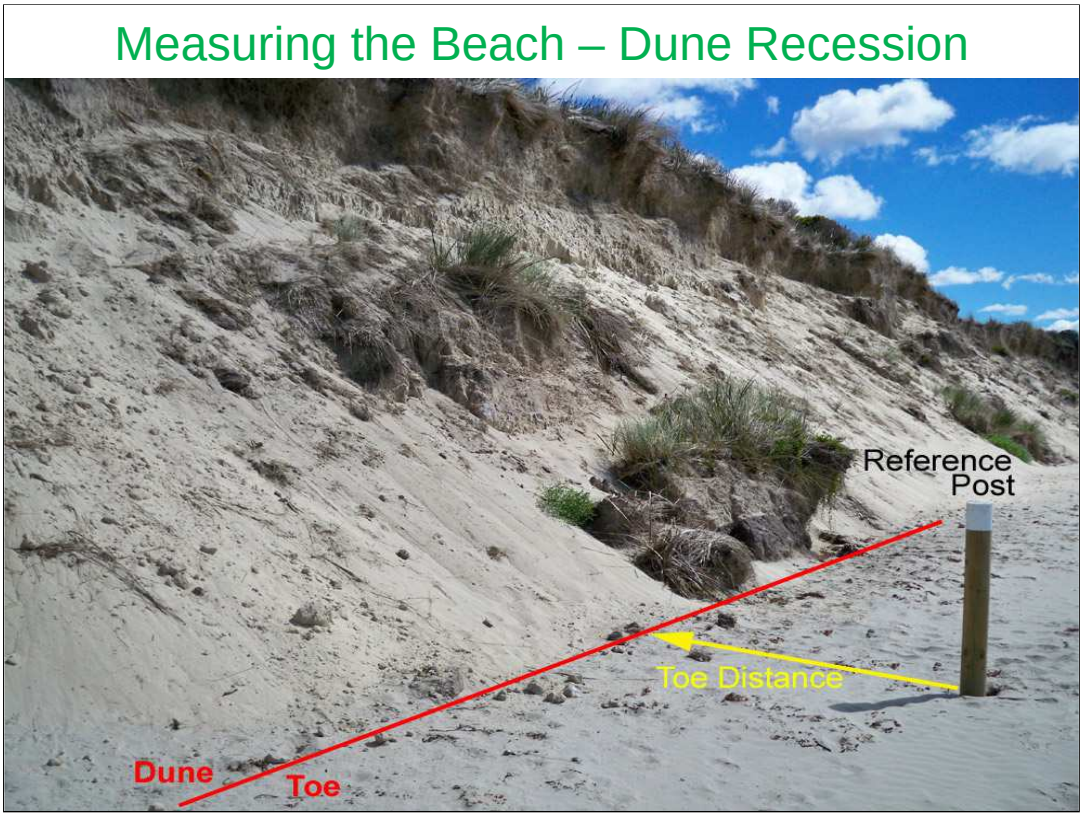
All height measurements are in centimetres and read directly from the laser measuring staff. No calculations are performed on the beach and tasks are minimized to enable the most measurements while the tide is lowest. This ensures the greatest number of measurements can be collected at each profile.

Port Fairy beaches are mostly flat with very little surface detail worth recording so a fixed distance increment is used for the horizontal axis labels of the profile.

Surveyed heights of Reference Posts are known as the Post Elevation and always quoted in metres.

Sand height is always quoted relative the Australian Height Datum (AHD).

Tide heights are also measured relative to AHD.



Measuring the Beach – Dune Recession

Detecting dune recession involves one of the simplest types of beach measurement. A fixed reference point is established and the distance measured to the toe of the dune face at a regular time interval.

For the majority of the reference posts, the scene above is typical.

A periodically collapsing dune crest, a sloping dune face and previously collapsed sections of dune vegetation migrating down the dune face to a relatively level beach.

Some distance in front of the dune toe is the reference post.

This technique allowed the Coastal Group to find abnormally high dune toe recession that only occurred at post 8 during May and June of 2013.

The process of dune recession

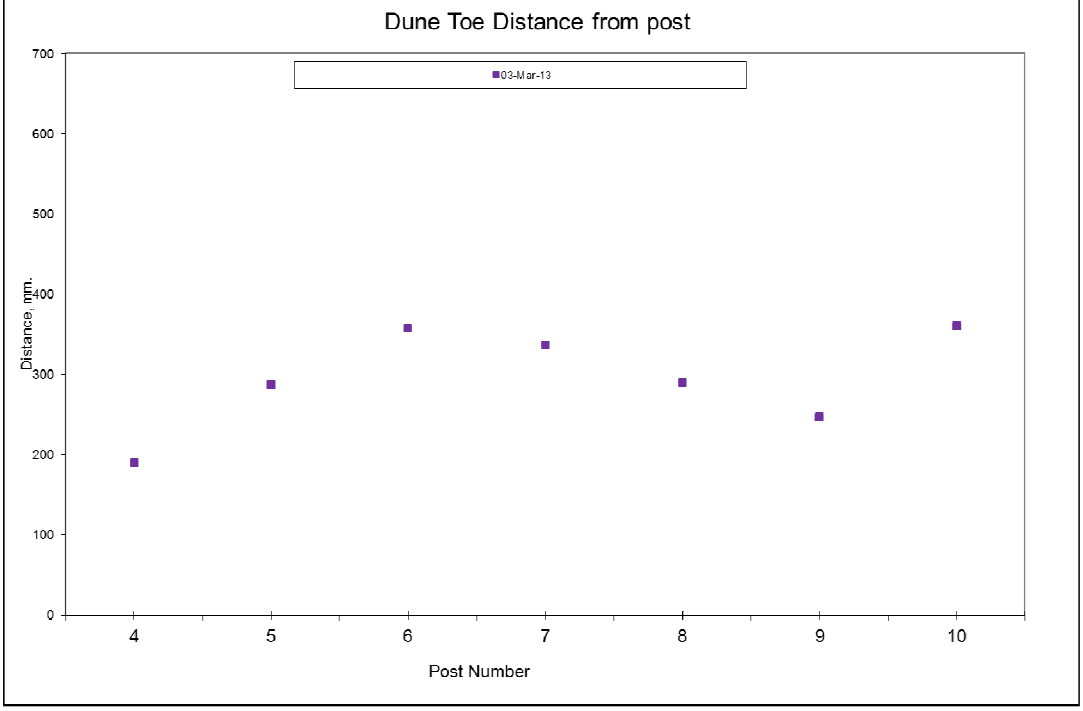
Water erosion by wave action starts at the toe and undermines the dune face. Sand then slumps down the face to replace the sand washed away. Eventually, the crest of the dune is undermined to such an extent that the dune crest shears off and migrates down the dune face also to be washed away.

Dune erosion also occurs when heavy rain causes water to run down he dune face.

The dune face maintains an angle between 30 and 40 degrees to the horizontal depending on grain size and moisture content.

Erosion of the dune face is also caused by wind action and dune recession can still occur albeit at a much lower rate than with water erosion.

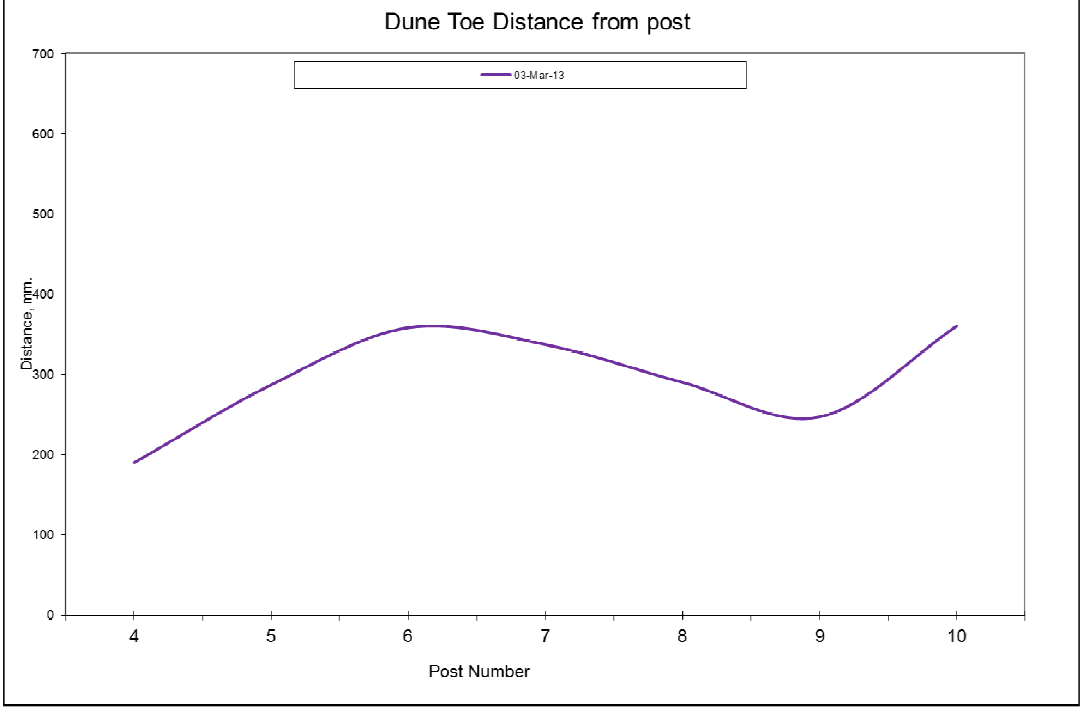
Dune Toe Distance - Dune Recession



In order to quantify dune recession, the distance of the dune toe from the reference post has been monitored. Dune toe distance monitoring is easily achieved with just a simple tape measure.

A history of measurements is needed to establish any trend in dune toe erosion.

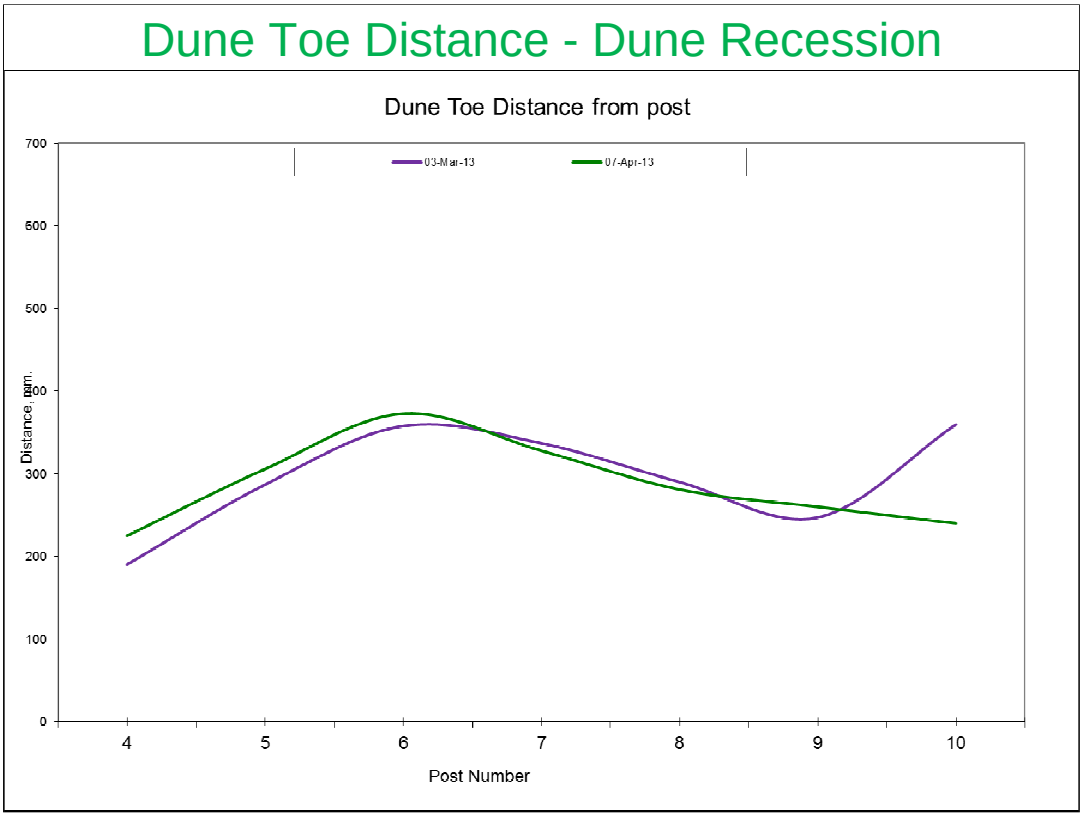
Dune Toe Distance - Dune Recession



Joining up the measurement points makes the chart easier to follow as more data is added.

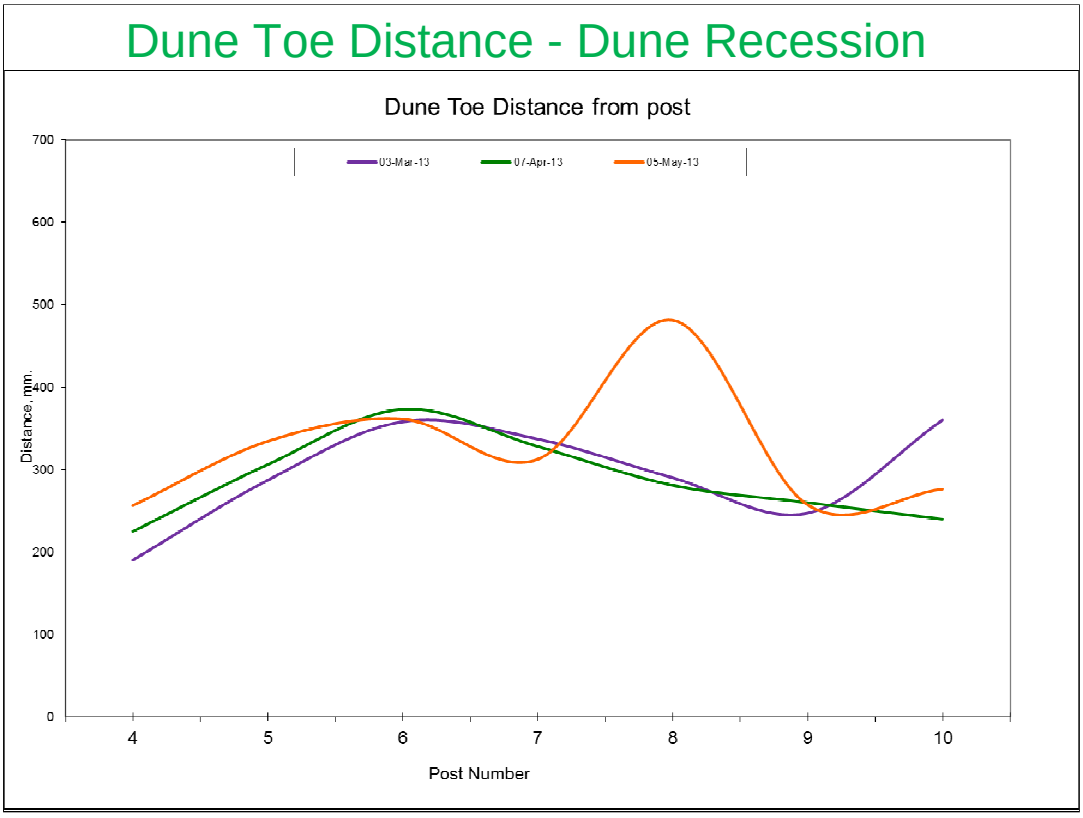
Many readings over time are needed to give a history and to be able to interpret changes detected in future measurements.

Dune Toe Distance - Dune Recession



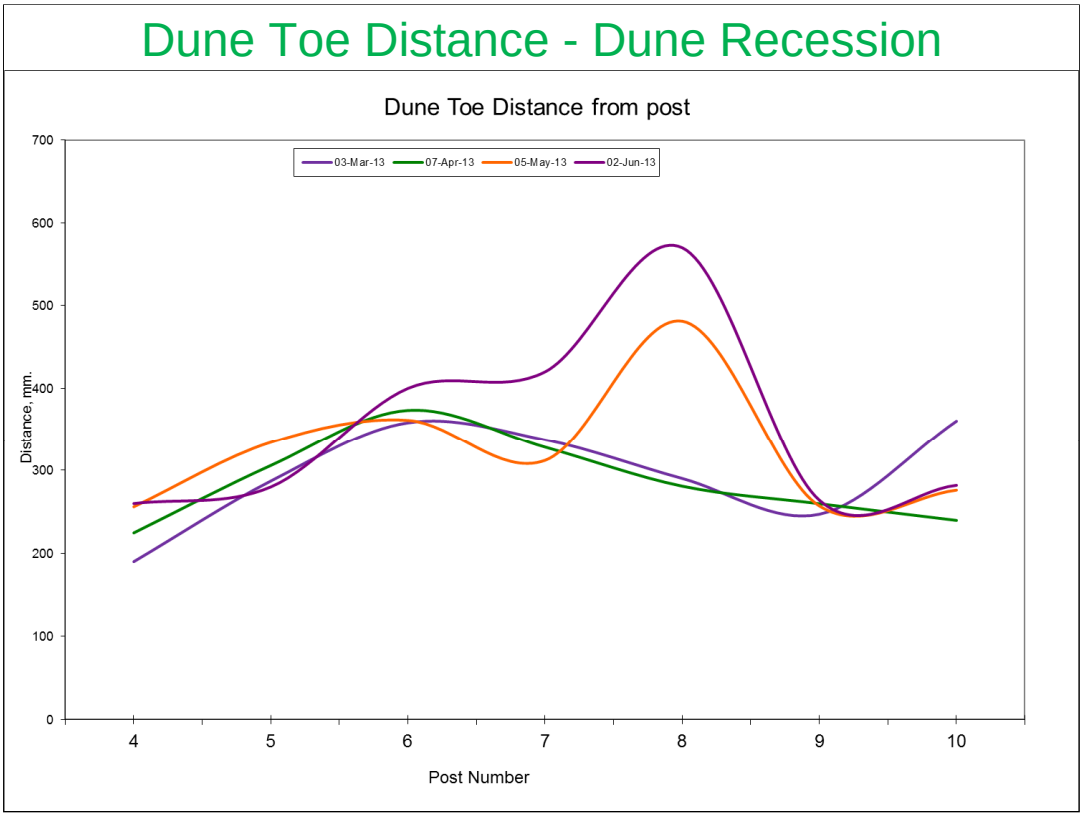
One month later, the toe measurements were repeated with excellent consistency shown at six of the seven points. At post ten, a minor sand slumping event brought some of the dune face to the beach level and shortened the toe distance.

Dune Toe Distance - Dune Recession



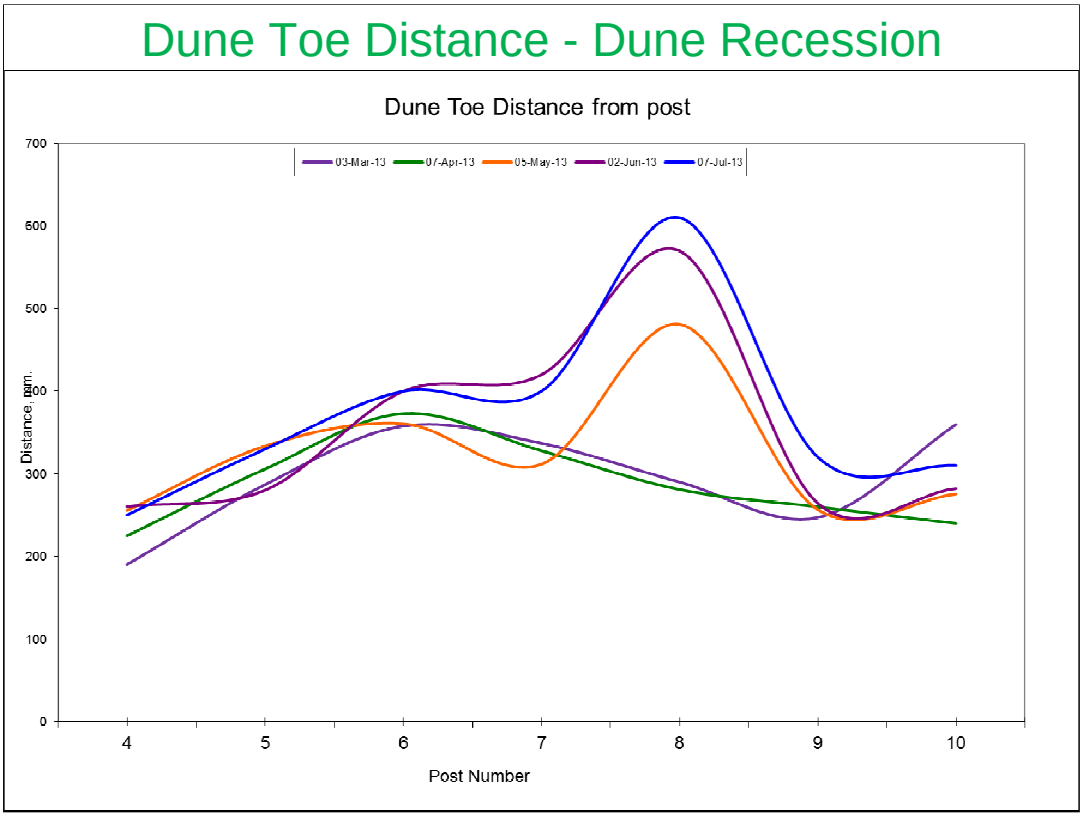
The toe measurements in May 2013 showed an uncharacteristic change at post 8 with a jump in the toe distance of approximately 20cm. At the time, no special cause was evident as this was only our third attempt at monitoring and experience was limited.

Dune Toe Distance - Dune Recession



The measurements in June of 2013 confirmed further toe recession at post 8 and new erosion at the adjacent post 7.

Dune Toe Distance - Dune Recession



The July measurement in 2013 confirmed serious erosion activity at the dune face of the decommissioned land fill tip site.

The Coastal Group showed the data to Moyne Shire who made independent measurements of the distance between the dune face and the known location of the land fill waste.

This revealed there was considerably less sand shielding the tip site than had been anticipated.

Coastal engineers designed a structure of large rocks to be placed on the beach in front of the tip site and the Moyne Shire sought additional funding from the state government.

Wave Energy Dissipation structure

The result was the design and construction of a rock wall to dissipate wave energy and protect the dune toe from further erosion.

The structure was completed just prior the winter storm event in late June 2014.

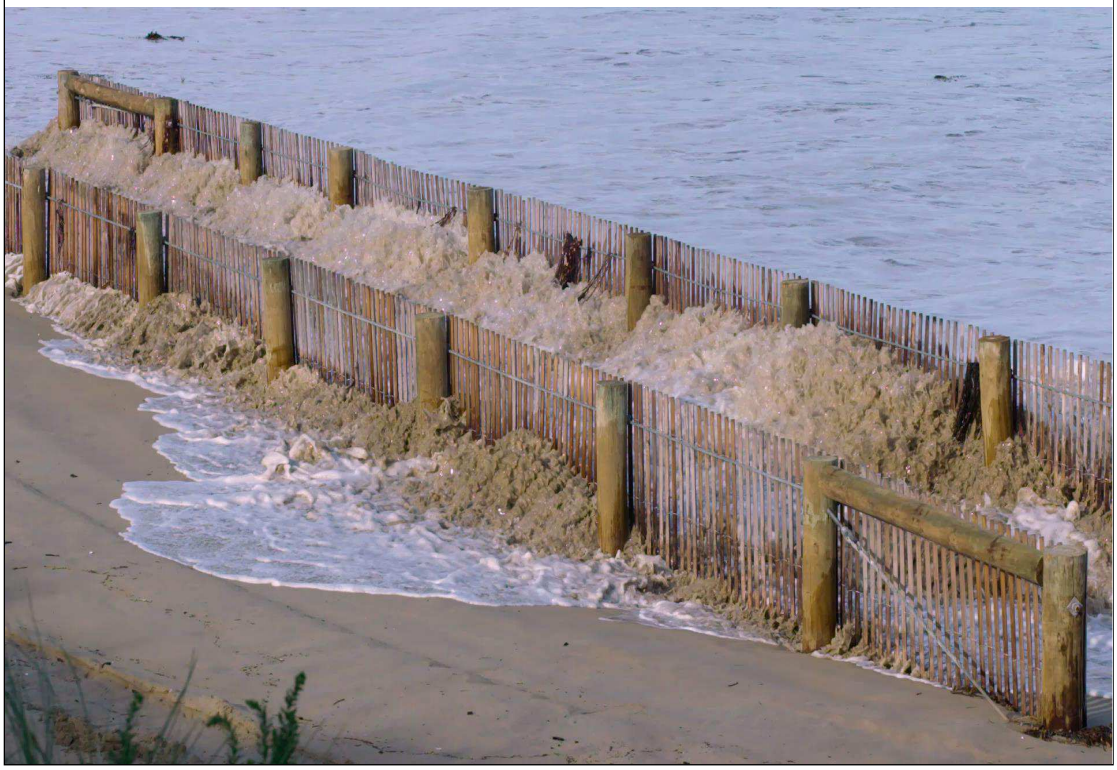
Subsequent photographs and measurements confirmed excellent performance from the Wave Energy Dissipation structure.

After the June storm event, some sand had been lost from behind the ends of the wall and some undercutting of the dunes at the end of the wall was also expected. However, the majority of the sand was retained by the wall affording almost complete protection to the dune containing the old land fill site at post 8.

The high altitude photograph shows the large area of dry sand behind the wall, indicating sand height had been retained for most of its length.

Some increase in dune erosion at the ends of the wall were expected from the pressure wave that builds along the face of the wall and flows around behind the ends.

The double sand trap fences at work



Following the success of the wall, it was extended to protect more of the dune face.

Double sand trap fences were also added to minimize washouts at the ends.

The sand trap fence known as Wattle and Wire is more sophisticated than just a large picket fence.

Each picket is a flattened diamond shape which is oriented side on to the prevailing water/wind and generates turbulence to convert its kinetic energy into heat as the *fluid passes between the pickets, almost independent of the angle of approach.

Wave height is reduced as it passes through each fence so that in a relatively short distance, a large wave is reduced to lower energy foam to minimize damage the dune toe.

By dissipating most of the wave energy, the high sand levels nearer the dune toe are preserved for longer to provide some resistance against the larger waves.

Sand trap fences are also designed to provide wind protection and work well in dry sand due to the picket's special shape.

When operated as a wind break, the Wattle and Wire fence is said to have a high protection ratio; that is for every metre of fence height, several metres of distance behind the fence will have an effective wind break.

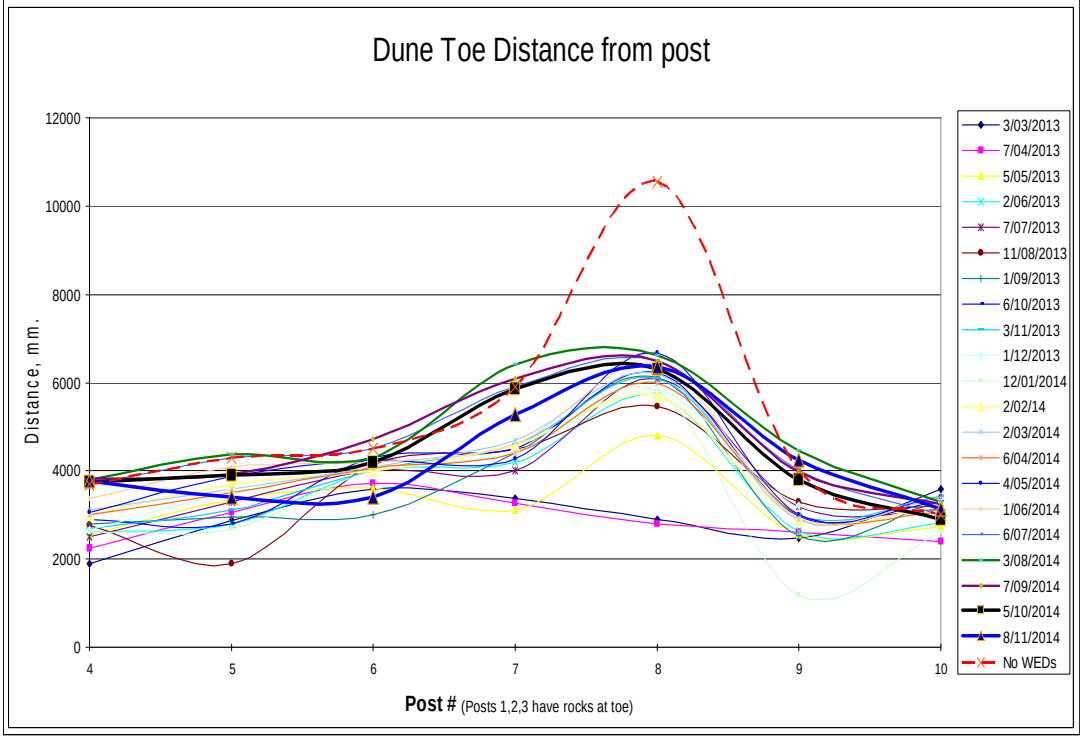
Performance of the rock wall and the sand fences continues to be monitored by the Coastal Group.

The above image is a clip from the video "Defend Port Fairy" by Power House Productions and is available at:

https://www.youtube.com/watch?v=eGqFJZ-bew4

* In thermodynamics, a fluid can be either liquid or gas but in common usage the word fluid is often incorrectly substituted for liquid.

Prediction of Erosion without Rocks



By studying the relation between dune toe movement at adjacent posts, it was possible to work out a correlation between changes in dune toe at post 7 and dune toe changes at post 8.

Based on this correlation, the predicted sand loss at the post 8 dune toe could have been as large as 4m if the rock wall not been in place for the storm event in late June 2014.

Measuring the Beach – Sand Height

As well as the dune toe measurements from the post, sand height readings are also taken each month.

The reference post is placed deep into the sand and is capable of surviving the worst of storm events. Once the post is installed, it is surveyed by engineers with enhanced GPS technology to establish not only its position on a map (Eastings and Northings) but its height relative to the Australian Height Datum is also measured.

The post elevation above the datum is critical information for accurate beach monitoring.

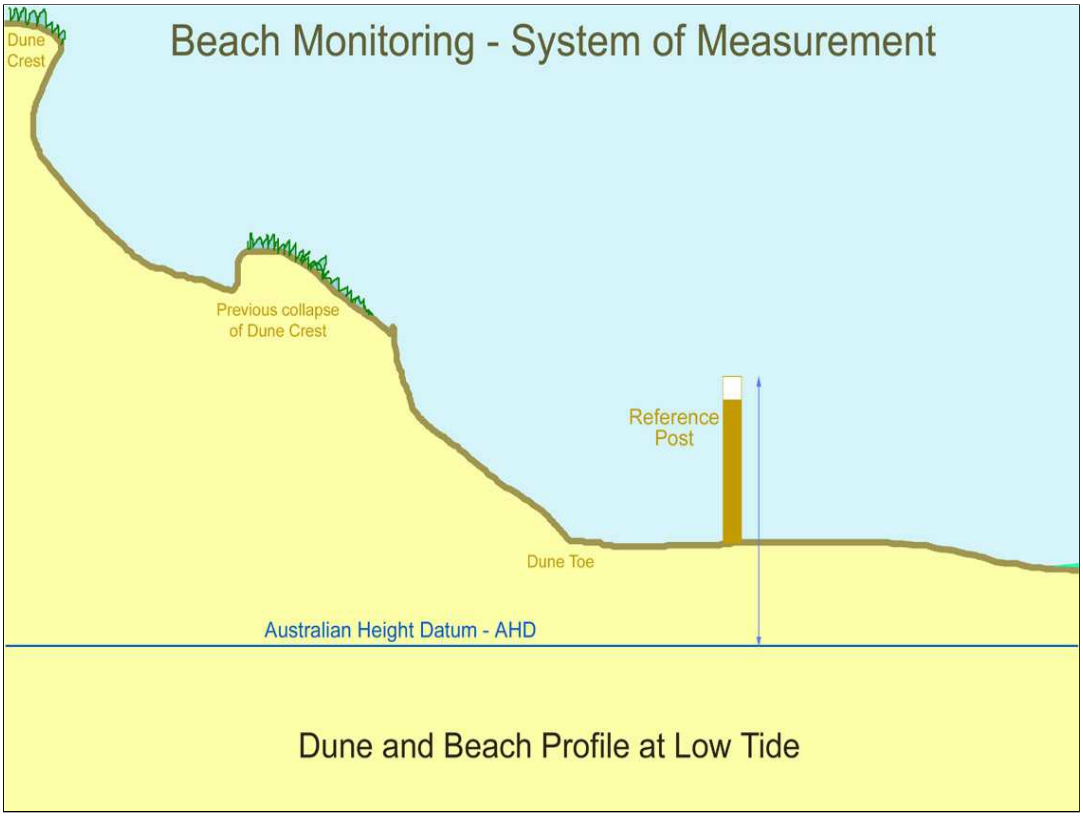
Parts of the beach monitored by drone mapping use portable automated electronic targets that provide similar accuracy of position and beach elevation. Initial drone mapping required ten targets spread along the beach but with advances in drone navigation ability, only two targets are required near the launch point.

The drone conducts autonomous photographic runs at 100m above the ground in multiple flights lasting less than 20 minutes each so it is unlikely that you will ever hear or see the drone in operation.

To map the area from the last House on East Beach to the Parks Vic. car park, the drone will take around eight hundred 20 megapixel images. After processing the images, the 3D model gives us sand elevation in places like the dune toe, face and crest that are difficult to monitor safely with the laser level.

Drone mapping is also used to assess dune erosion at posts 9 and 10.

Having actual sand elevation data enables the PFCG to track sand quantities and provide accurate information to coastal managers.

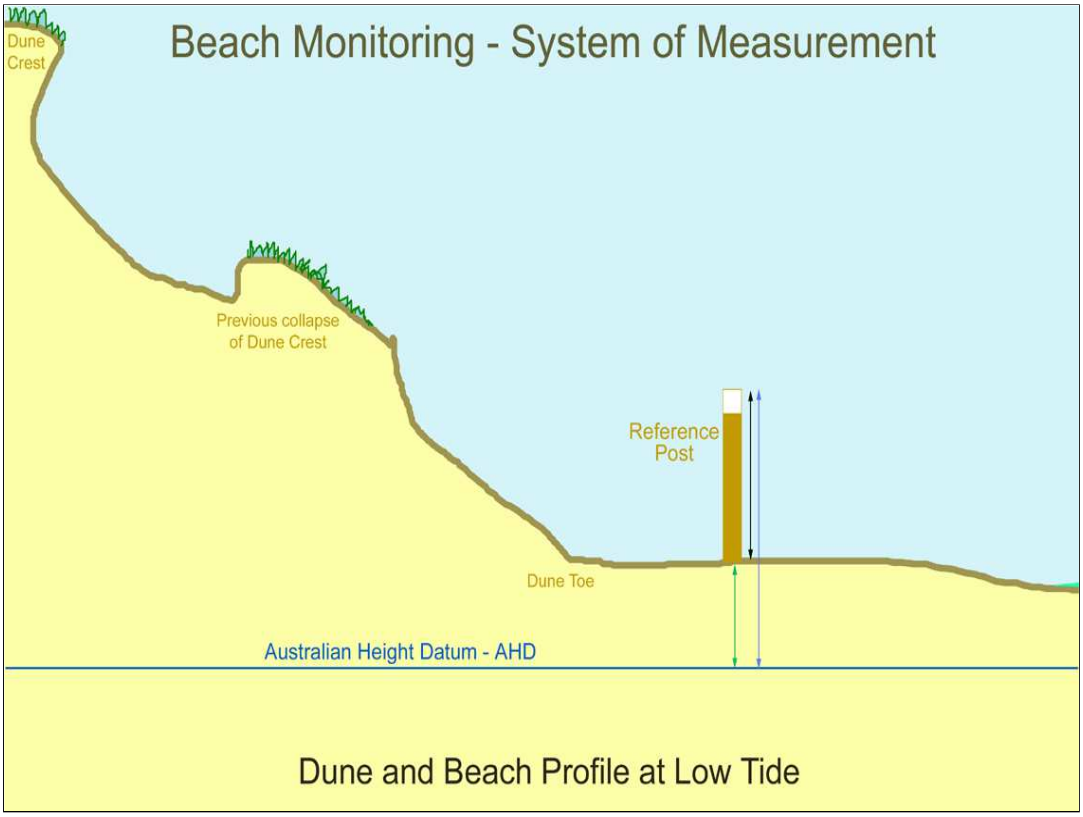


Australian Geoscience has established a reference level known as the Australian Height Datum which is accessible by surveyors around Australia.

For our beach monitoring at Port Fairy, it enables our charts to show relative sand heights anywhere along our coast line.

Surveyors determine the height of each reference post above the datum.

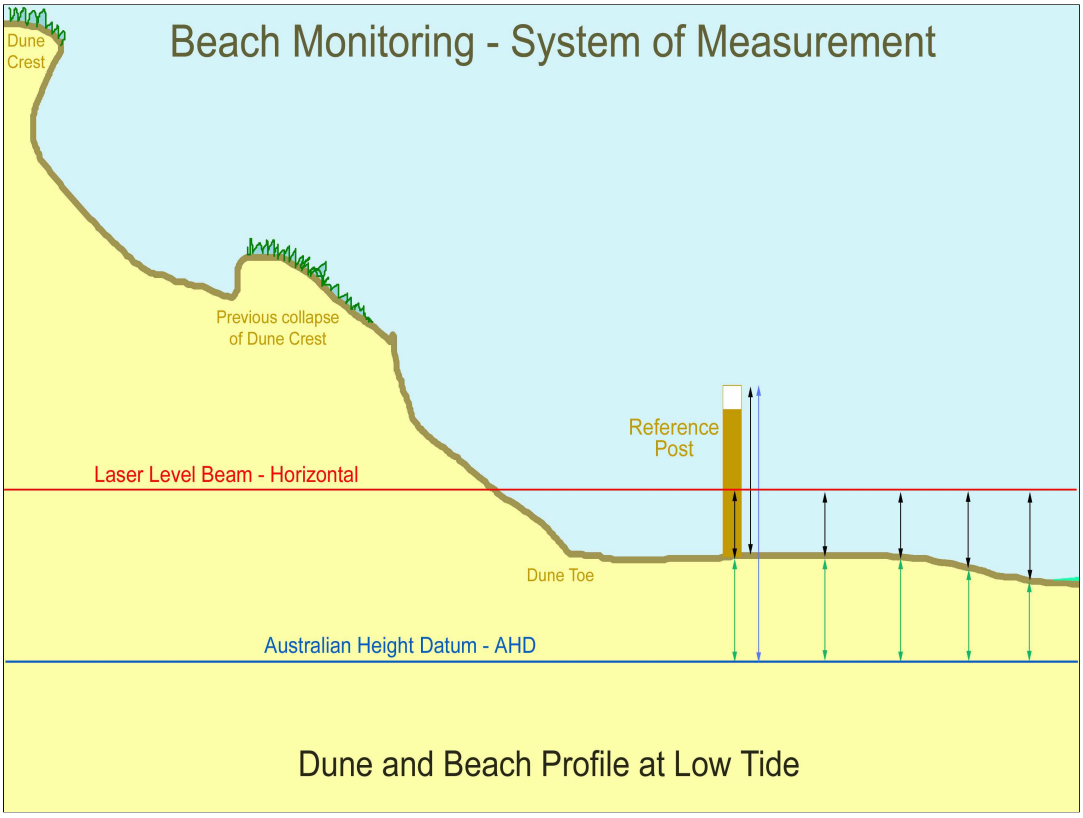
Recent advances in Geoscience provide a datum that is independent of tectonic plate movement on the earths surface.



If the post height above the datum is known and the length of post above the sand measured, the sand height above the datum is calculated. This sand height can then be compared anywhere along the beach.

All beach height measurements by the Port Fairy Coastal Group are referenced to the Australian Height Datum.

Lower parts of the beach are then identifiable as potential areas of greater erosion.



Unlike the dune toe measurements, sand height measurements for beach profile determination involve more readings and the use of a builders laser level to provide a height reference above the sand and parallel to the Australian Height Datum.

Height measurements from the sand to the laser reference can then be used to calculate the height of the sand surface above the datum.

A cross section profile of the beach can then be charted for a visual comparison of the current sand height with previous measurements and historical statistics.

East Beach Monitoring – Laser Level Measurement

Monthly, the beach monitoring team of volunteers conduct measurements at 12 posts along 4.5 kilometres of beach. Members from the Port Fairy Surf Lifesaving Club also assist by transporting bulky measuring equipment in their All Terrain Vehicle.

A beach monitoring team consists of only three people:

One PFSLSC registered driver who also scribes the measurements onto the data collection sheet.

Two PFCG members who operate the laser level to measure sand height and photograph beach condition around each measuring post.

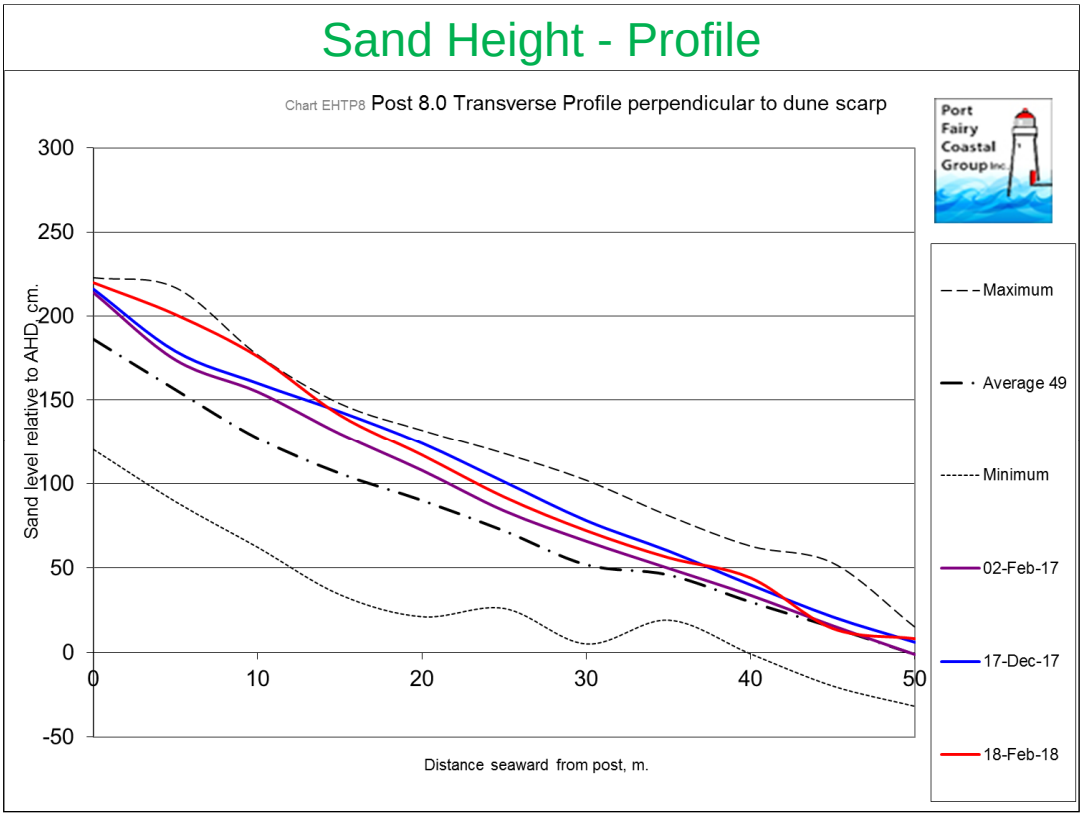
An experienced team usually complete an East Beach monitoring in under two hours.

Laser and drone monitoring are best completed during the lowest of tide events in order to be able to measure sand heights over the greatest expanse of the foreshore. A suitably attired person can take measurements in shallow water only (Knee height) but drone measurements become unusable in any shallow water.

Regular measurements conducted by the year 6 students under the guidance of the Port Fairy Coastal Group provide advanced warning of any changes in sand conditions and give the students unique work experience.

After a year of beach monitoring, students from the Port Fairy Consolidated School apply their own solution to the problem of measuring a beam height of 230 cm near the water's edge.

The beam height in some areas range from the beach surface to over 4m above the beach. Such a large range requires special monitoring equipment.



A typical East Beach profile.

The red line is always the last reading while the blue line is always the previous reading.

The chart above shows how the sand levels are currently moving and indicate a gain in sand on the beach nearer the post but there has been a slight loss of sand down to the water's edge compared to the previous measurement.

The purple line shows the reading from about one year ago and in this case, sand heights are still higher than twelve months ago.

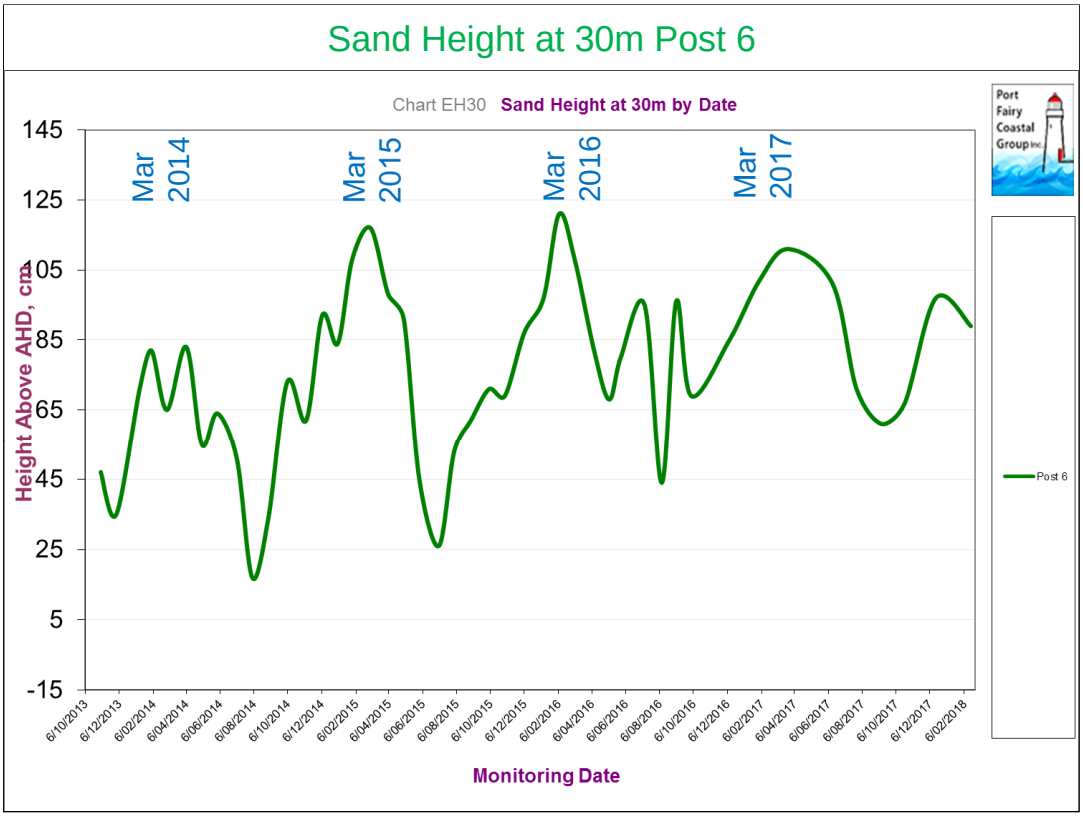
The dotted lines are history derived from all but the last reading and show minimum, average and maximum values at each distance.

Current and recent sand heights are above average so we know the beach sand level is good.

The historical statistics calculation does not include the last reading so that if the last reading exceeds any previous maximum or minimum, it is immediately obvious on the chart.

Coastal engineers can also use beach profiles to calculate sand volumes which is another parameter used in beach systems.

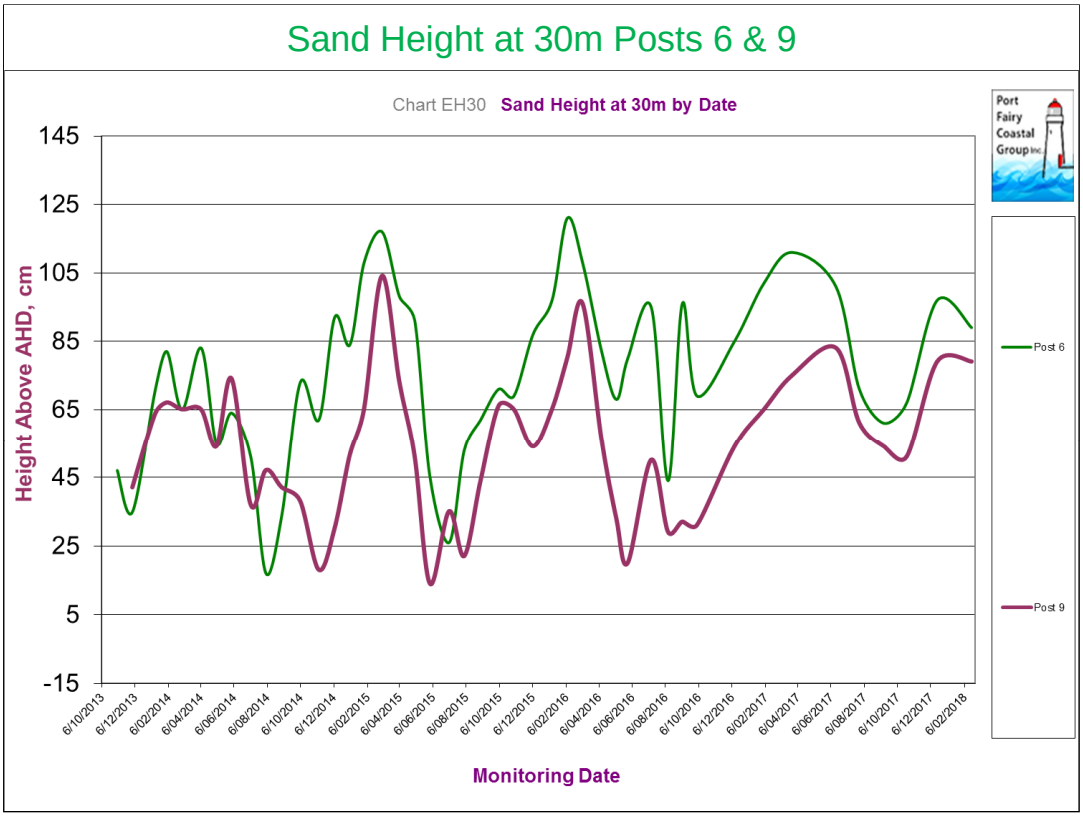
We have found that sand height changes become more variable as the distance seaward from the post increases. Not only is there increased variation but the phase of the variations change with time and the position around the bay.



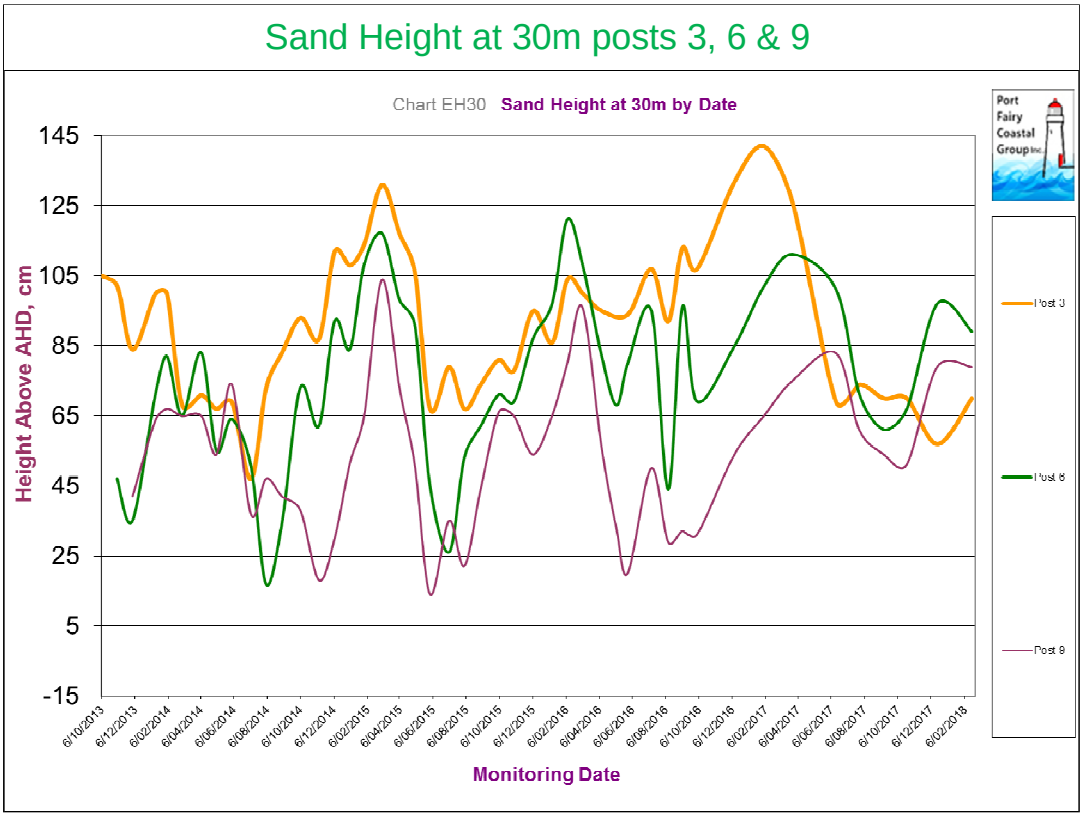
Climate scientists generally agree that previously known cyclic sand movement has become less seasonally dependent and more random in occurrence.

Using the profile data from the 30m point at post 6 on East Beach near the bay centre, we see a cyclic annual pattern of sand height which peaks around March each year.

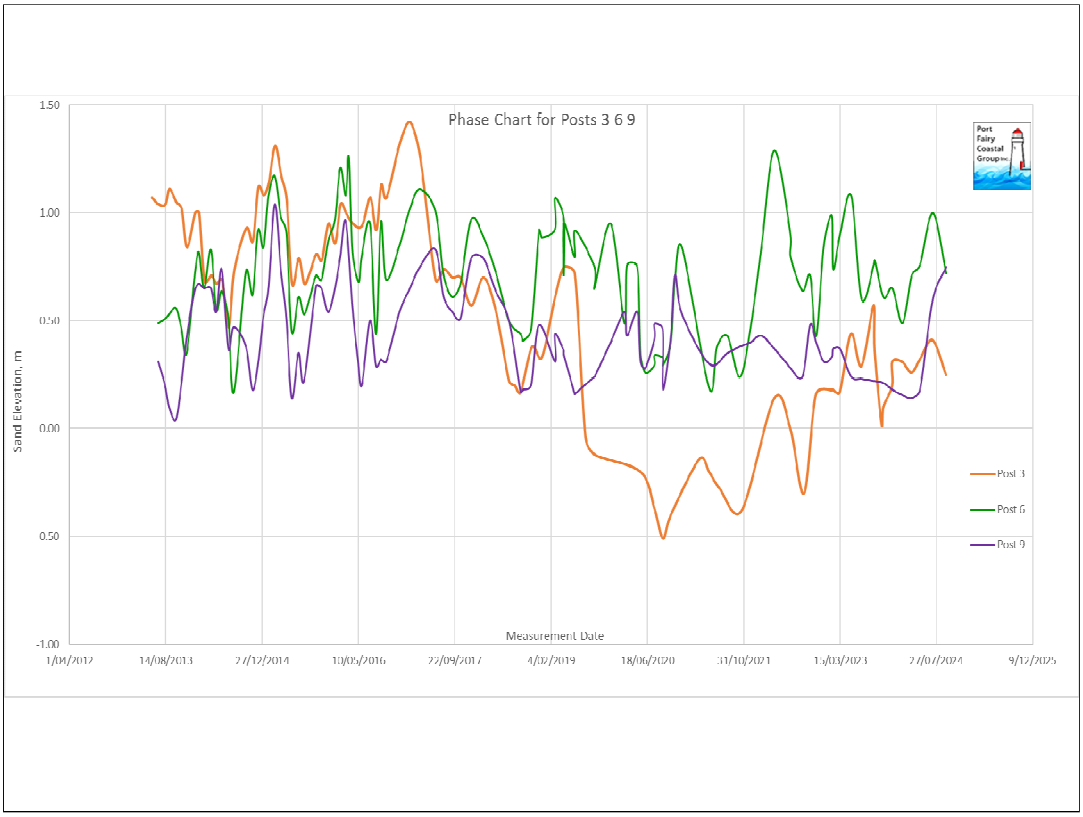
The situation becomes interesting when we add 30m data from post 9 which is 1092m to the North East.



Comparing post 9 with post 6, we see the sand height peaks are coincident in March 2015 but by 2017 there is a clear difference in time when peak sand height occurs.



Adding the data from Post 3 (1154m to the South West of post 6) confirms the phase change in sand height peaks as the distance around the bay increases in 2017 compared to 2015.



The following chart taken over a longer period up to more recent times confirms a significantly more random appearance to the beach sand cycle; evidently as a result of climate change.

It was expected that over the next few years the cycle may repeat, however when new data was added, it shows a more random pattern with a large sand loss confined to the populated part of the bay at post 3 while the coast in front of the old land fill sites (posts 6 & 9) showed only minor sand loss in the same period.

This study is ongoing and it may take many years to confirm if there is a connection between sand height phases around the bay and storm events.

If storm surges can be predicted with reasonable certainty, budgeting for Climate Change Adaption works can be more timely with a more efficient use of financial resources.

Future Coastal Group Projects

- Continue sand height monitoring.
  - provide coastal managers with accurate data.
  - Increase the availability of data from UAV Mapping with the Victorian Coastal Monitoring Program. (Done in 2023 with the introduction of the Quick Summary Table.)
- Determine if there is a correlation between sand height phase change and extreme weather events.
  - Prediction of storm surges?
    - Timely budgeting for Climate Change Adaption projects
- Extend sand height monitoring into Port Fairy Bay.
  - Complete the sand budget process; where does the sand go when it leaves the beach?

Our sand height monitoring provides current data on coastal erosion which must be the basis for responsible decisions around coastal management.

With climate change upon us, we regret not having started data collection decades earlier however, modern technology such as drone based mapping of sand volumes and the beach history that we do have will ensure the best possible management decisions for our coast and for future generations.

Editor's Note.

The charts in this document are taken from the PFCG spreadsheets that record all beach measurements. The charts were current at the time this document was first produced, so it may not reflect the current status of the beaches. Presentation of historical data should only be interpreted as an example of how to understand the process of beach monitoring. For the latest beach results, please refer to www.pfcg.org.au and the Quick Summary Table (QST) and its associated profile charts.

The group attempts to add new monitoring data monthly however, the timing is subject to sea conditions and availability of personnel and equipment.

September 2013.

Last major revision: August 2018.

VCMP added November 2018.

Minor additions November 2020, October 2024.

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