T019 Wave behaviour

Syllabus statement

At the end of this topic you should be able to ...

Recall

wave formation processes (e.g. fetch, relationship of wave height and type to water depth and wave celerity), barometric pressure)

Recall

-remember;

-present remembered ideas, facts or experiences;

-bring something back into thought, attention or into one's mind.

Objective

Use the following terms to recall common ocean wave characteristics.

A. Fetch, wave crest, trough, length, height, orbit field, lip, whitewater and face

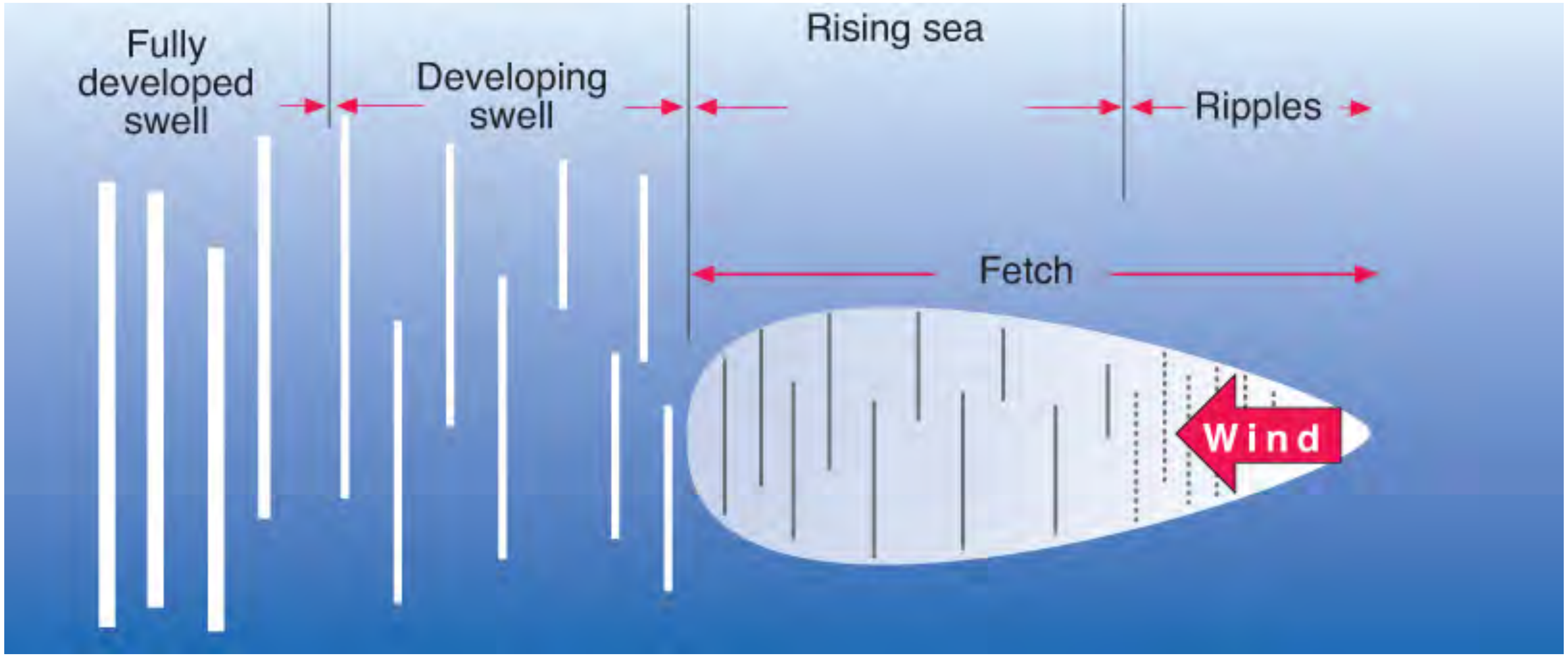
B. Wave height to water depth relationships

C. Wave speed, wave period

Fetch

Wave formation depends on wind speed, length of time the wind blows, the distance over which the wind travels, and the depth of the water.

A fetch is the distance over which the wind travels.



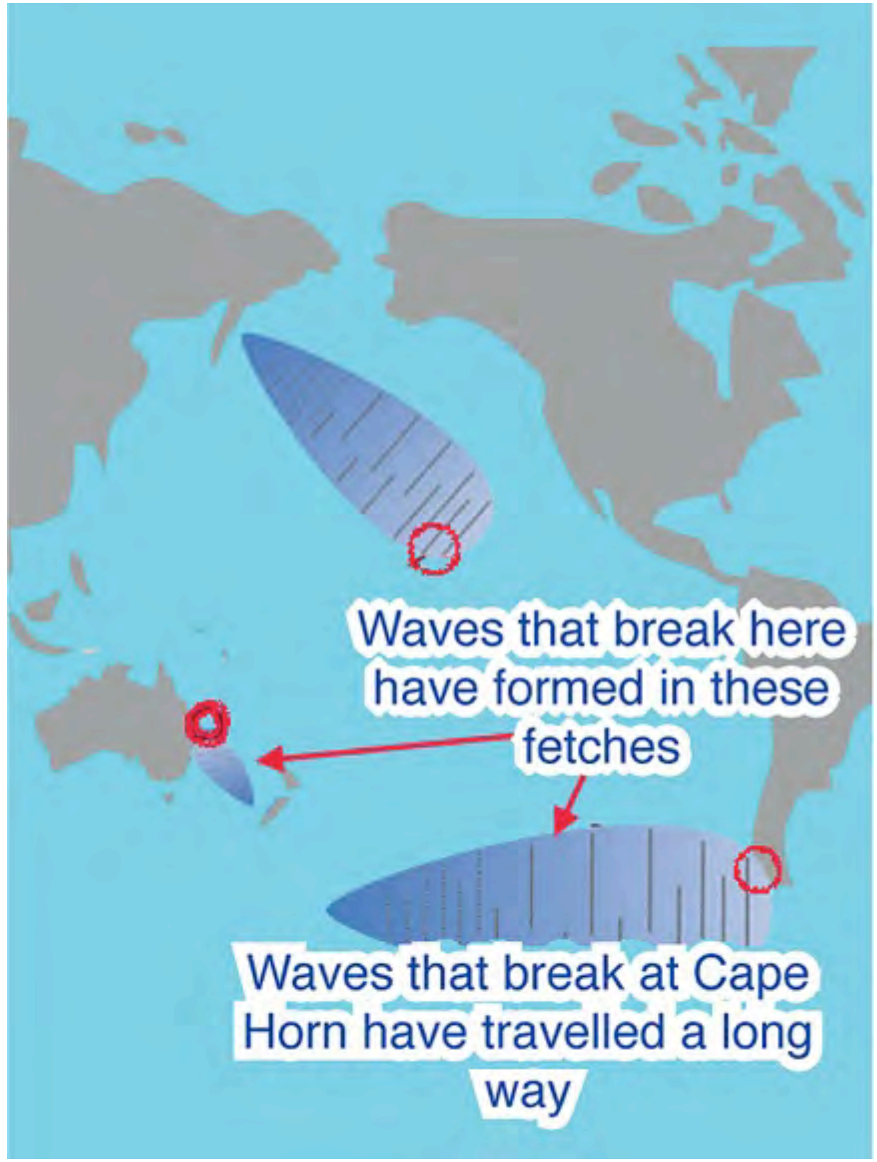
Fetch

Illustration Bob Moffatt

Winds initially produce small ripples.
As these ripples join together, they form waves in a rising sea.
Finally the waves move out of the fetch zone and become ocean swells.

Ocean swells
Photo Bob Moffatt

The length of the fetch zone determines shape of ocean waves.

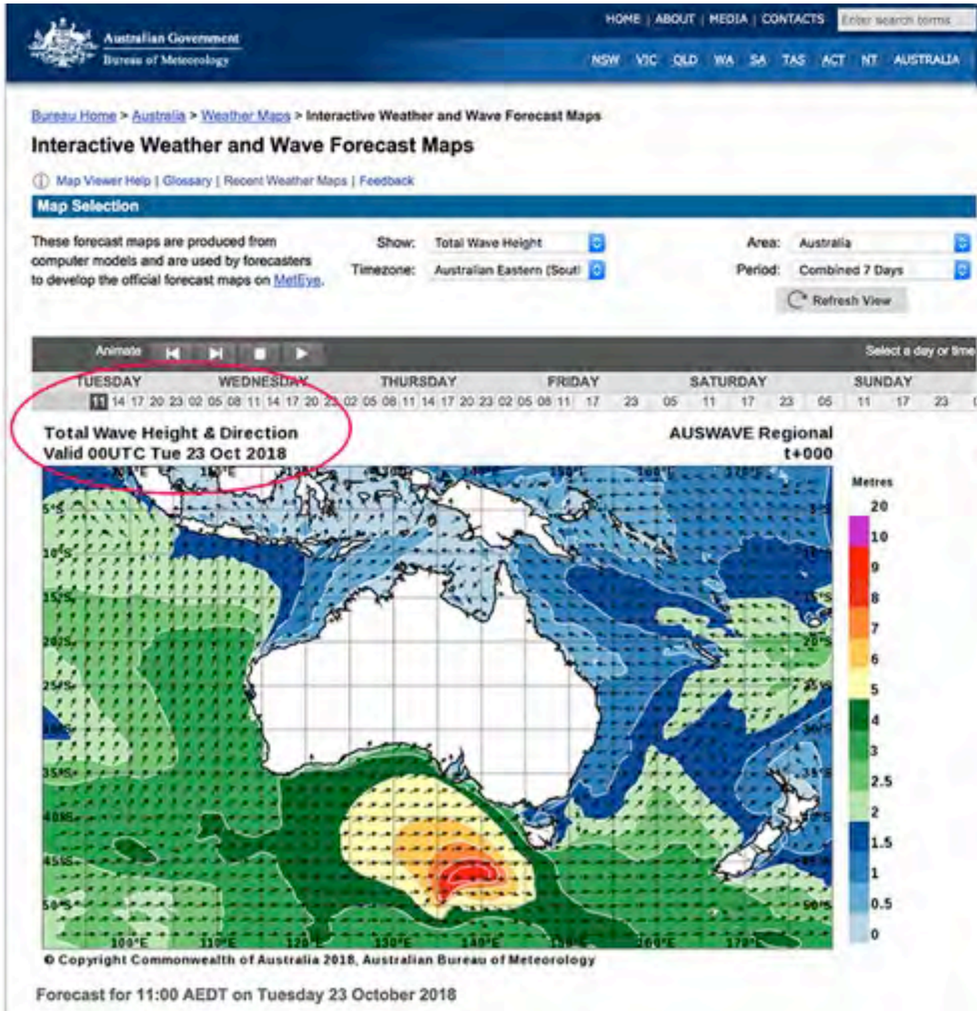


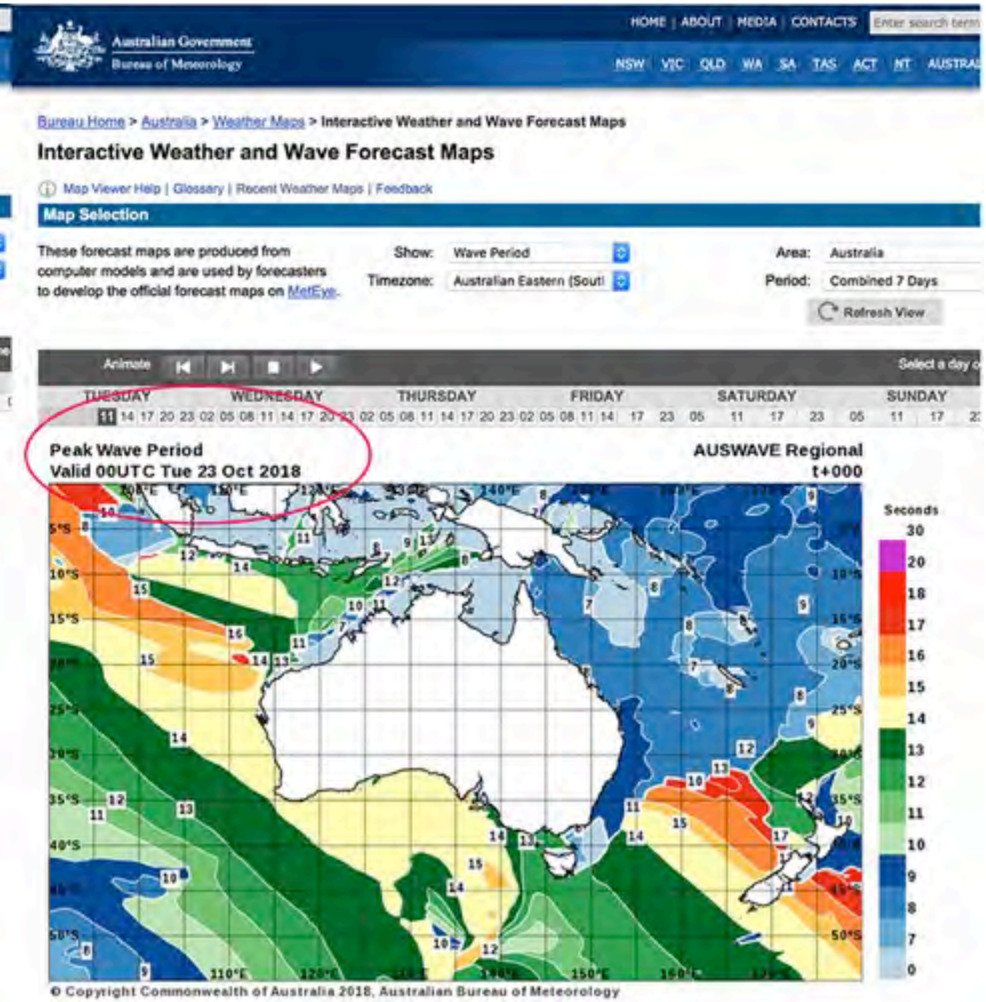
Fetch sizes

Illustration Bob Moffatt

The bureau of meteorology publishers interactive wave height and period charts on their web site.

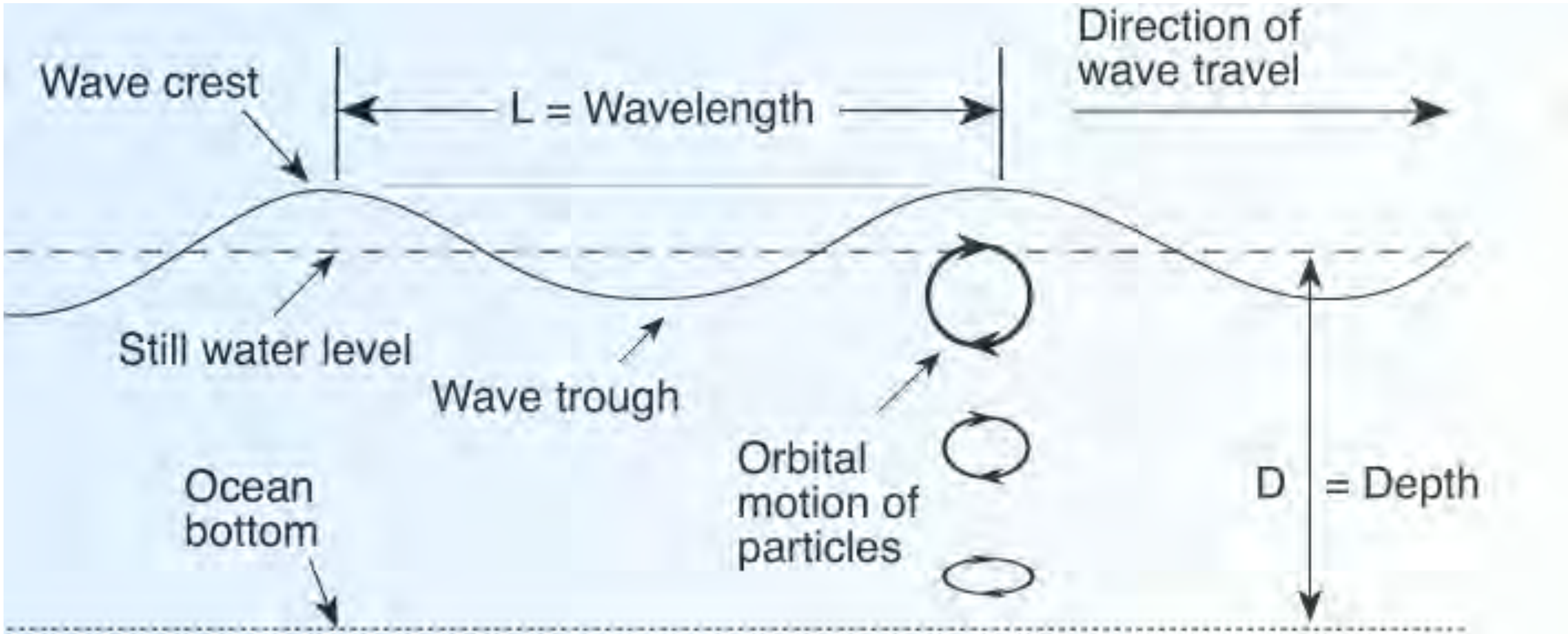
http://www.bom.gov.au/australia/charts/viewer/index.shtml?domain=combinedW&type=sigWaveHgt





Australian government bureau of meteorology

Waves have a length, height and length as show in the diagram below.



Wave characteristics

Illustration Bob Moffatt

Oceans waves are simply energy moving through the water.

They do not take the water with them.

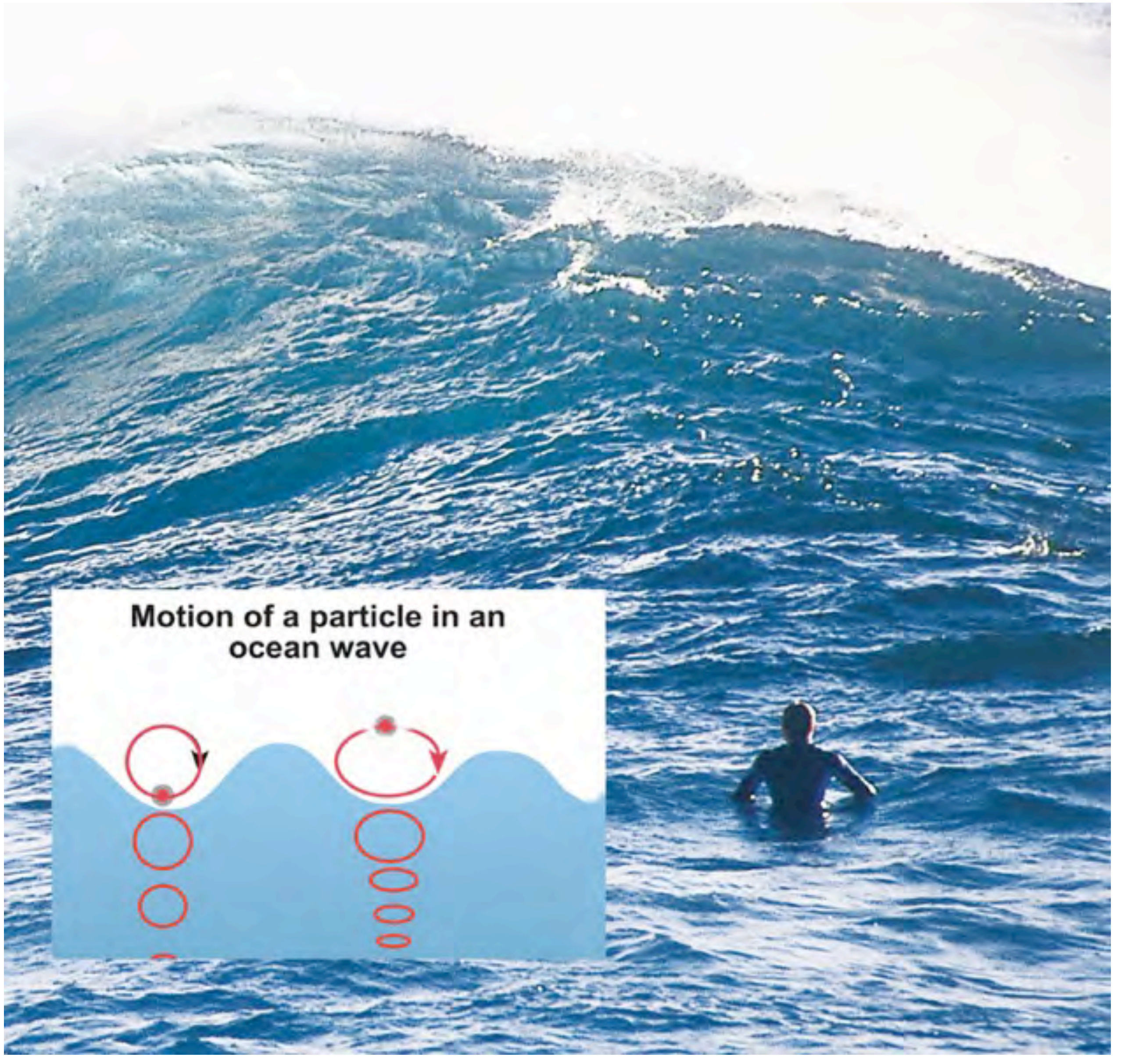
As the wave arrives it lifts water particles.

These travel forward and circle back in an orbital motion.

The surfer will just go up and down as the wave passes.

Surfer in orbit field

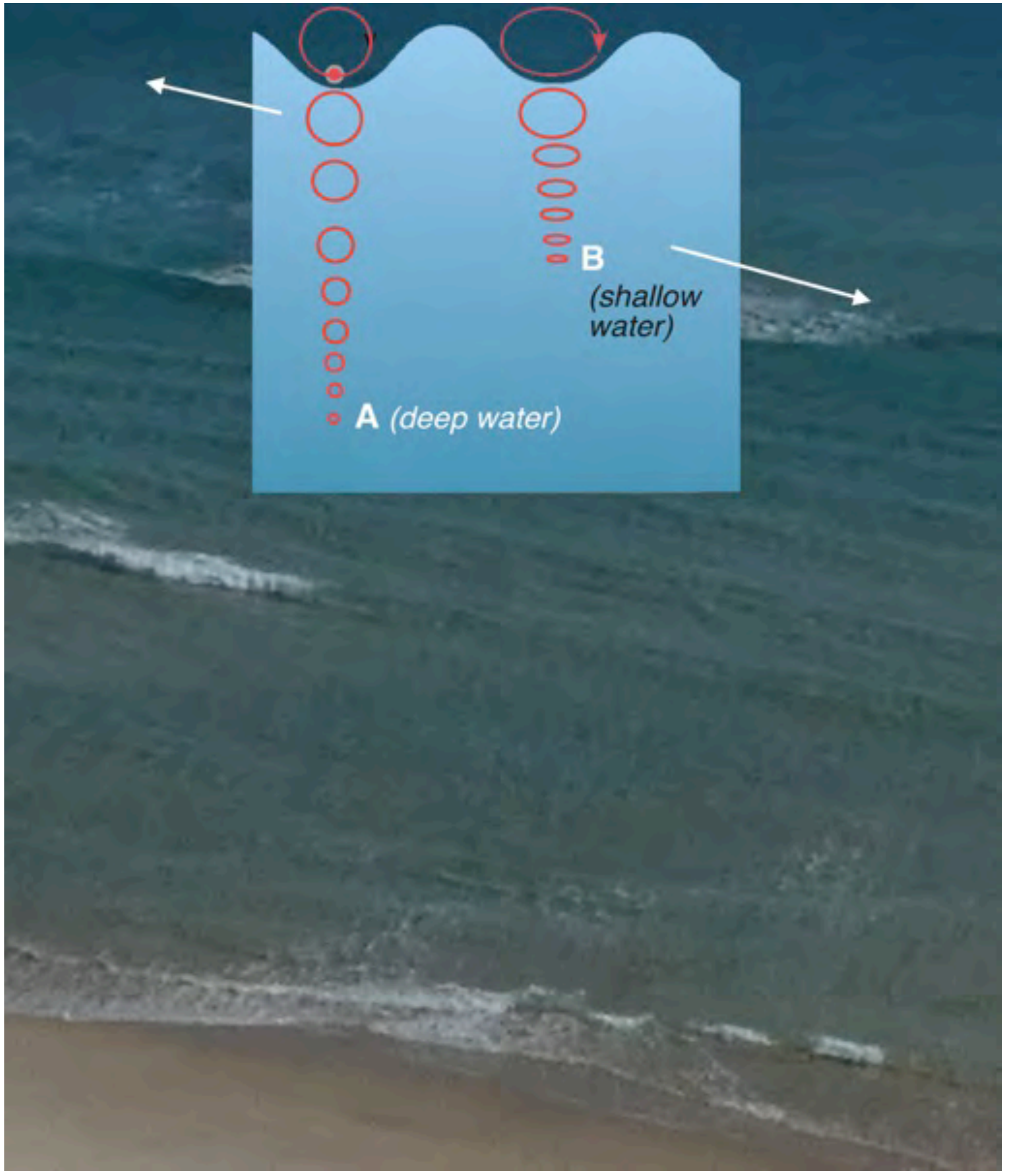
Photo Bob Moffatt



The circling water near the surface sets off smaller circling movements below them.

In deep water the orbital motion of fluid particles decreases rapidly with increasing depth below the surface.

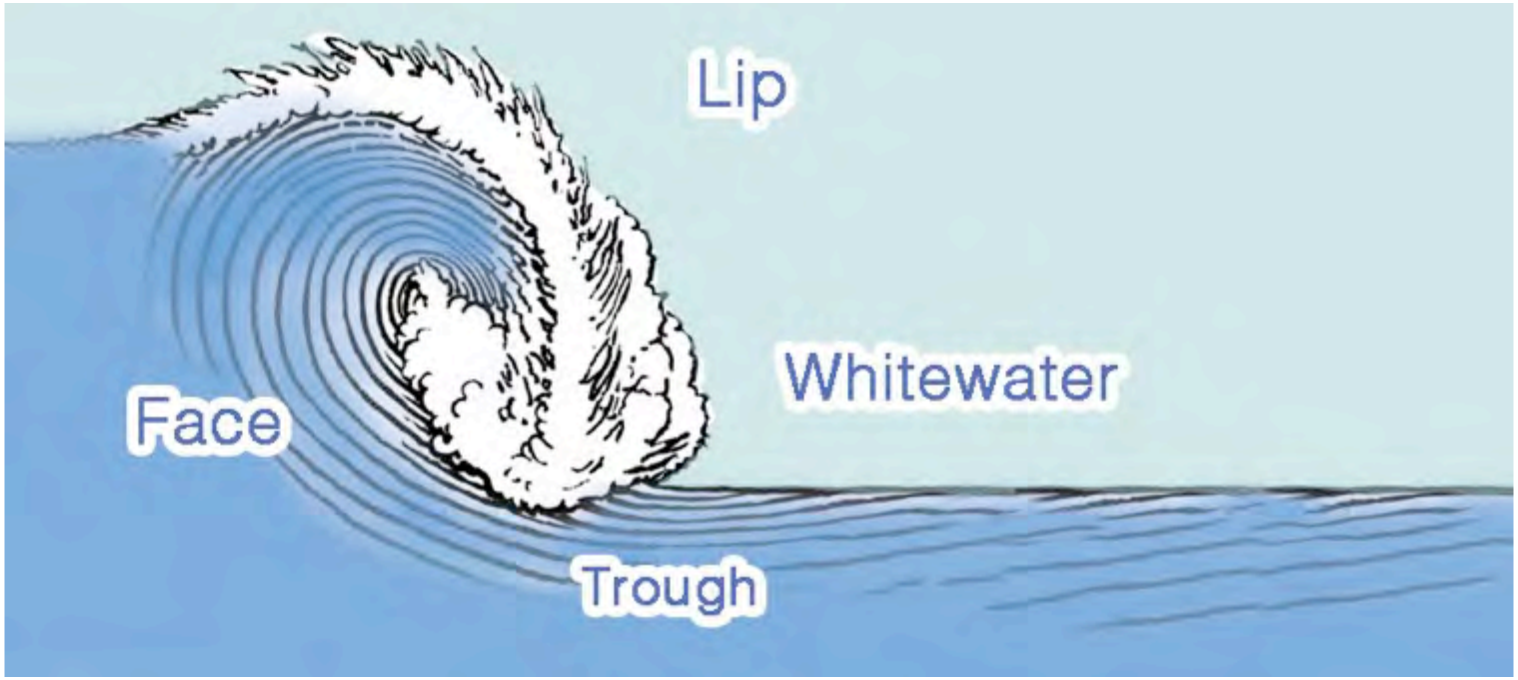
In shallow water, the elliptical movement of a fluid particle flattens with decreasing depth.



Orbit fields deep and shallow water

Photo and Illustration Bob Moffatt

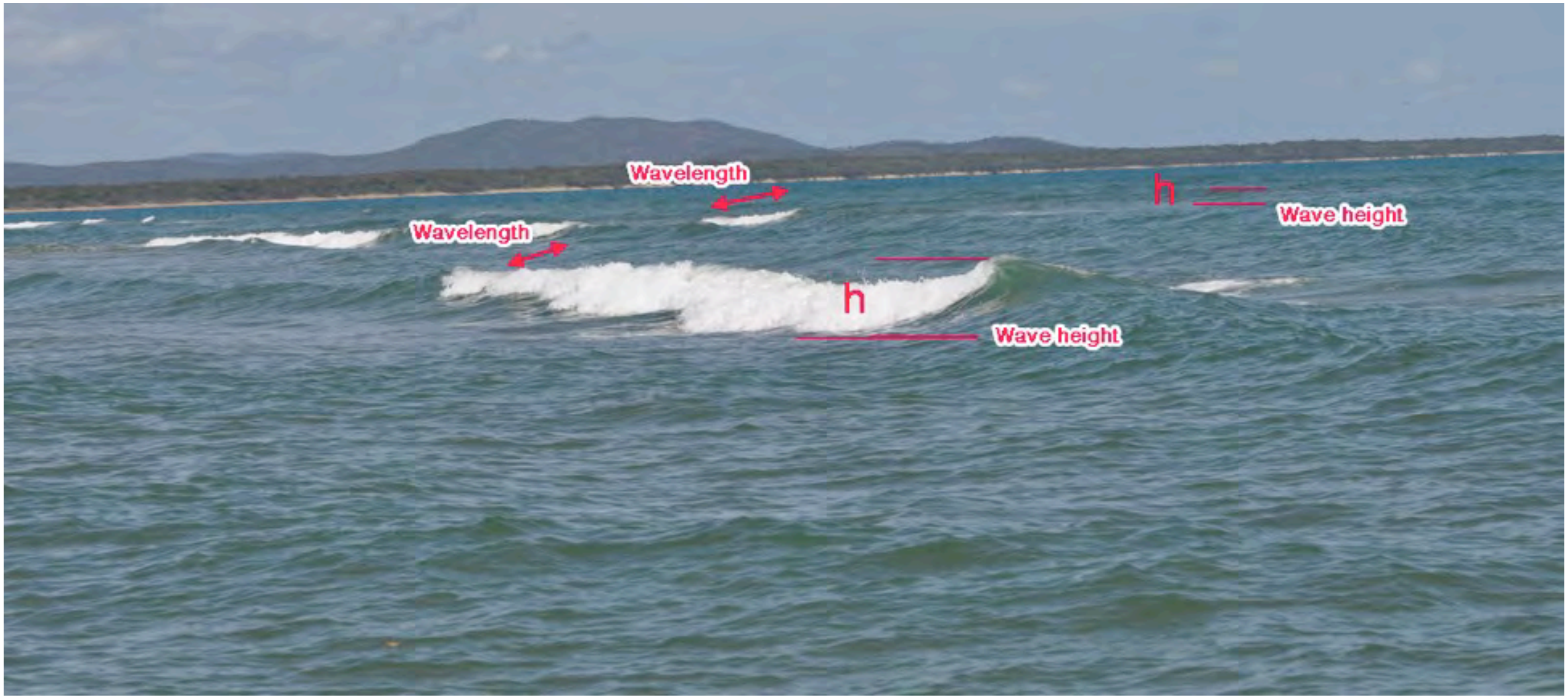
A breaking wave is called a shoaling wave having the characteristics of a lip, face, whitewater and trough.



Parts of a shoaling wave
Illustration Bob Moffatt

Wave height to water depth relationships

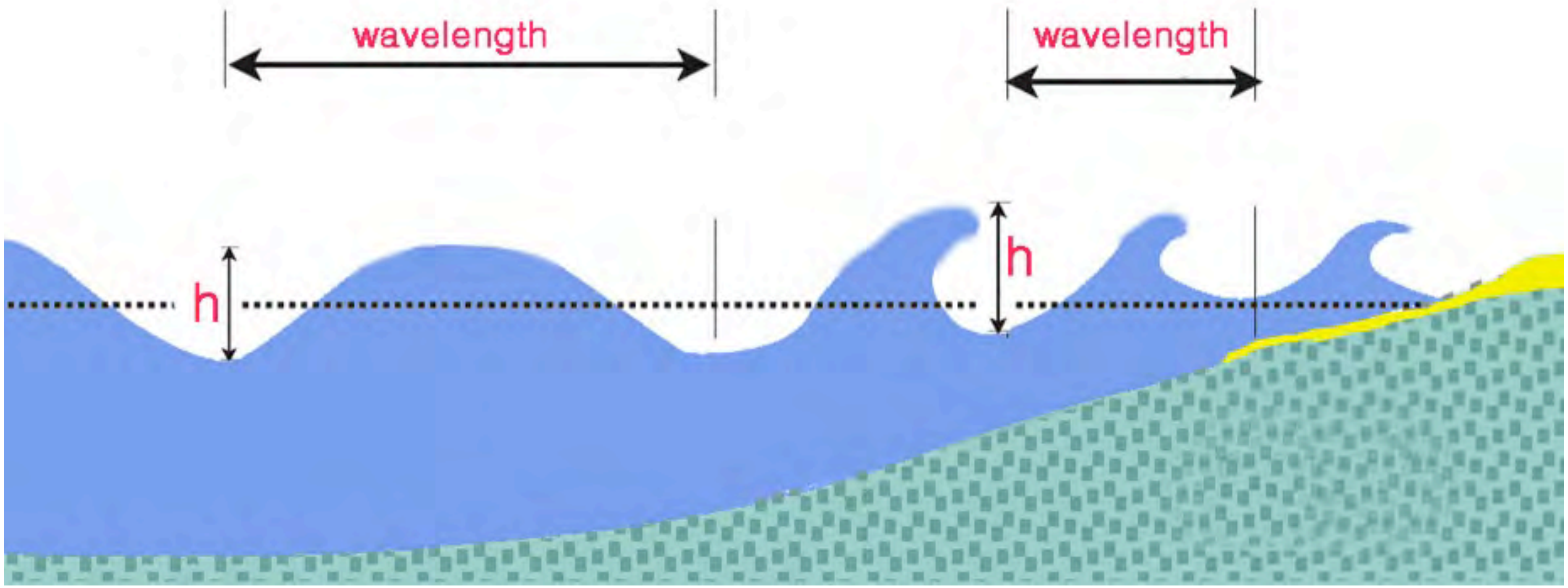
Waves approaching a shore are called shoaling waves.



Shoaling waves

Illustration Bob Moffatt

Shoaling waves become breaking waves and height increases and wavelength decreases because the orbit field interacts with the seafloor, hence the wave slows down.



Waves as they approach a shore

Illustration Bob Moffatt

Three types of wave can form depending on the bathymetry of the ocean floor.

Spilling waves are normally associated with gently sloping beaches where the top of the wave “spills” down the face of the wave.

Spilling wave
Photo Bob Moffatt

Plunging wave or "barrels" occur more commonly at low tide when the water is shallower.

Surfer in barrel

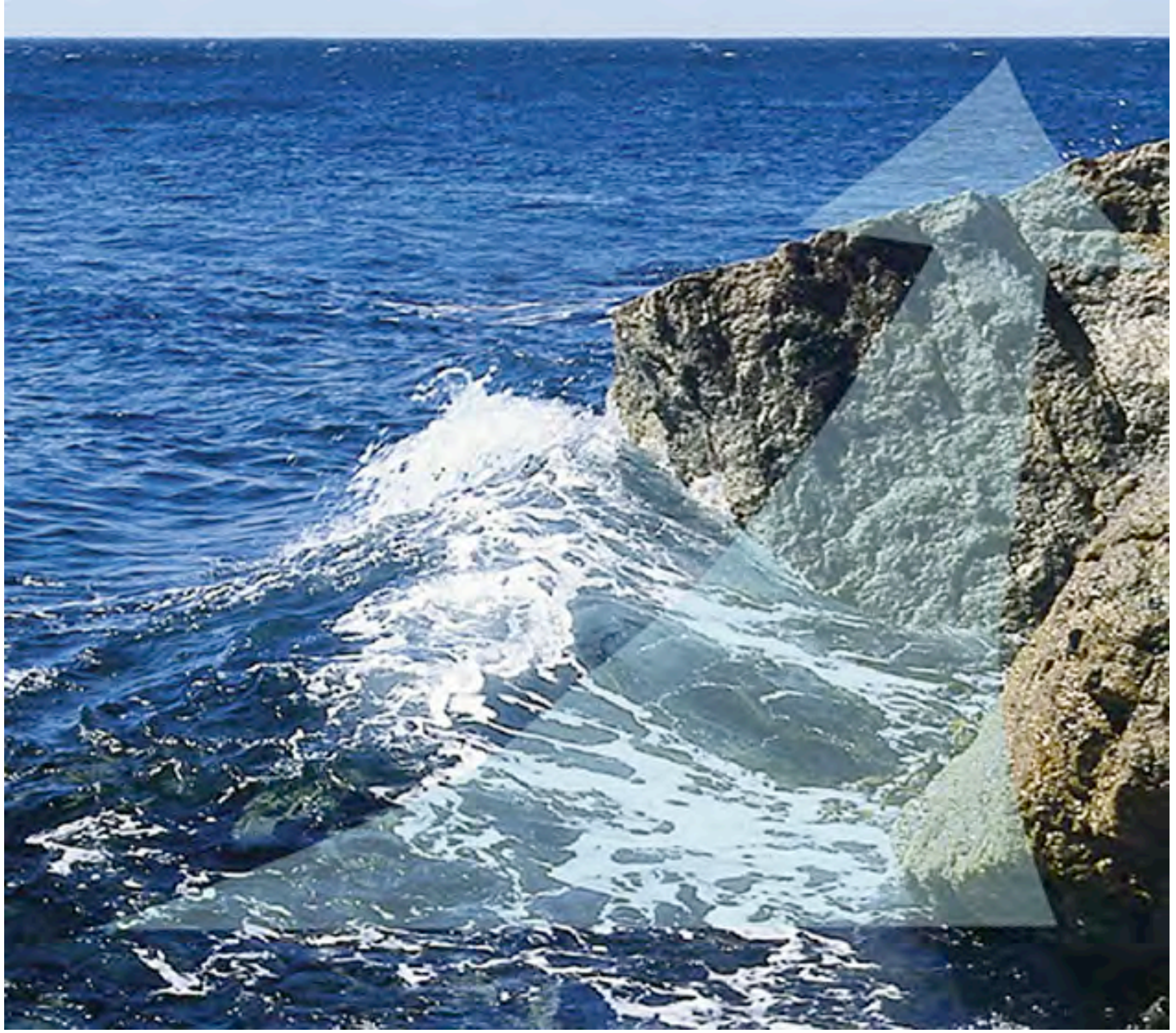
Photo View finder

These waves carry a great amount of energy and are dangerous for the inexperienced surfer (capable of spearing the surfer into the sand or reef below the shallow water).

Plunging wave
Photo Dick Hoole

Surging waves never break as they approach the shore, and are mostly associated with rocky headlands.

As surging waves carry enormous
power, rock fishermen need to take extreme care when fishing from rocky outcrop



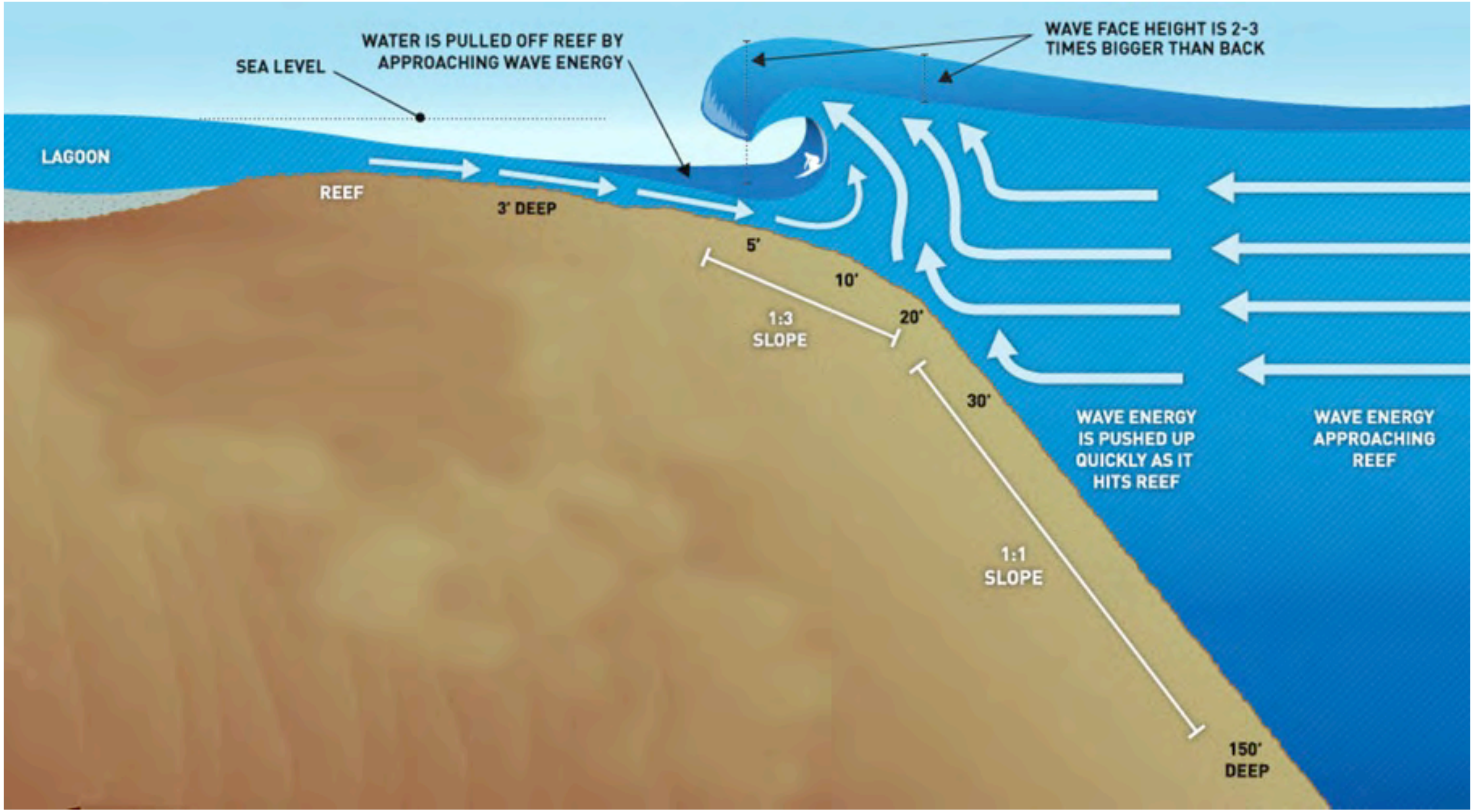
Surging wave
Photo Bob Moffatt

Wave height to water depth relationships can be useful in describing some famous surf breaks. For example Teahupo reef break in Tahiti.

“Choooww poo”

Kite surfing Teahupoo

Here the coral reef juts up from 45 metres changing rapidly from a 1:1 slope to a 1:3 slope



Teahupo wave mechanics

http://www.surfline.com/surf-news/teahupoo-surf-mechanics_58392/

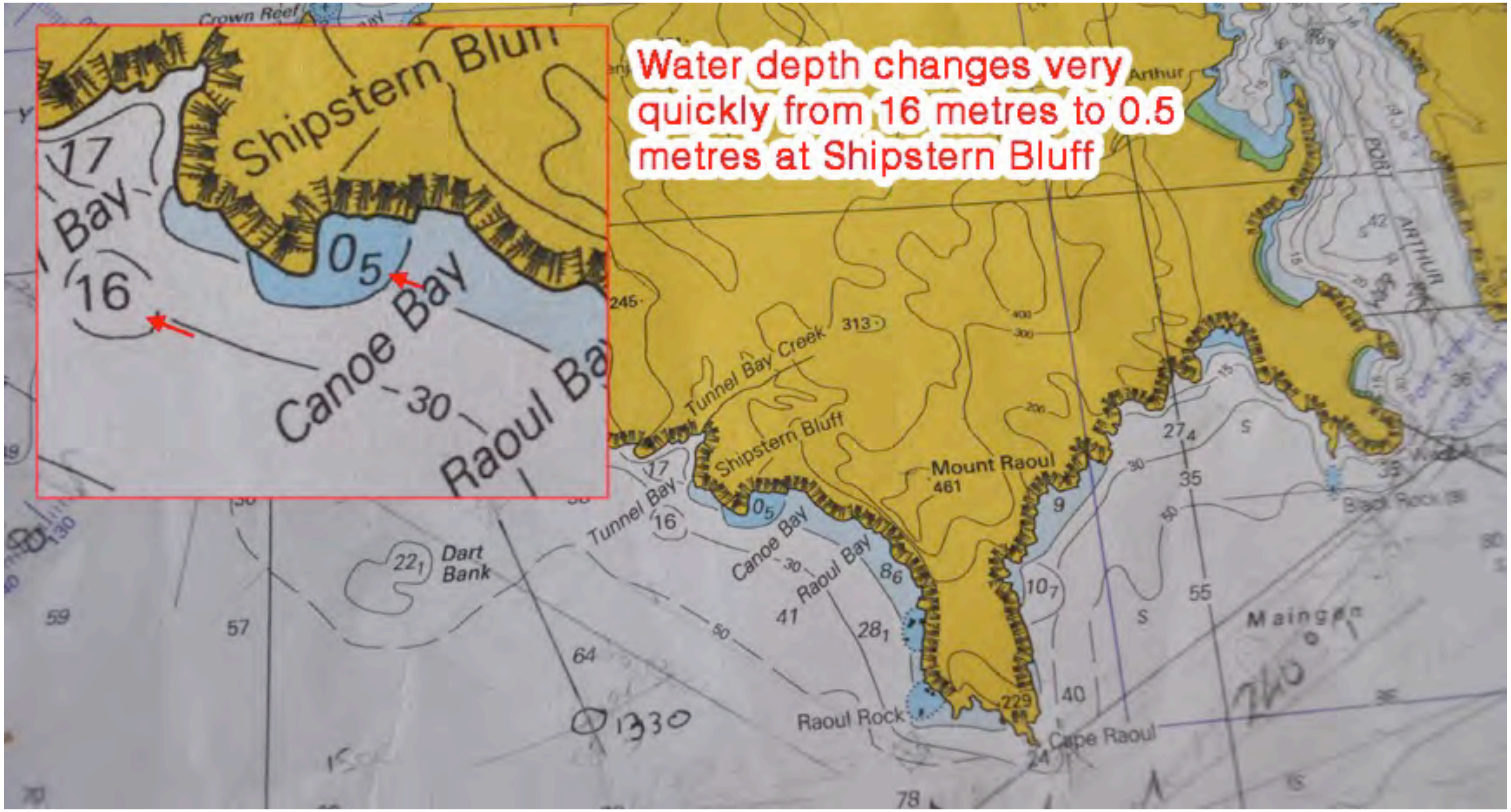
In Australia, a famous surf break at Shipstern Bluff in Tasmania.

Shipstern Bluff

Photo Jones

https://www.adventuresportsnetwork.com/sport/surf/top-ten-deadly-waves-of-the-world/

The seafloor at Shipstern is a slab of granite that takes the brunt of huge swells traveling from deep water and expounding all their force onto this ledge.



Shipstern Bluff water depth changes

Photo Bob Moffatt

Wave celerity, wave period and sets

The time taken for two successive crests (or troughs) to pass a fixed point is known as the wave period (T).

Time between two waves at a point

Photo Bob Moffatt

Wave period is also shown in weather apps

Swell height and period on an app

https://www.willyweather.com.au/

The wave celerity (C) or speed is calculated by dividing the wavelength by the wave period (C = L/T).

If the wave period at a point is 10 seconds and length estimated 30 metres, the speed of the wave is 3 m/sec

or

10.8 km/hr

Wave celerity at a point break

Photo Bob Moffatt

Wave sets are waves that come in groups.

Wave sets
Photo Bob Moffatt

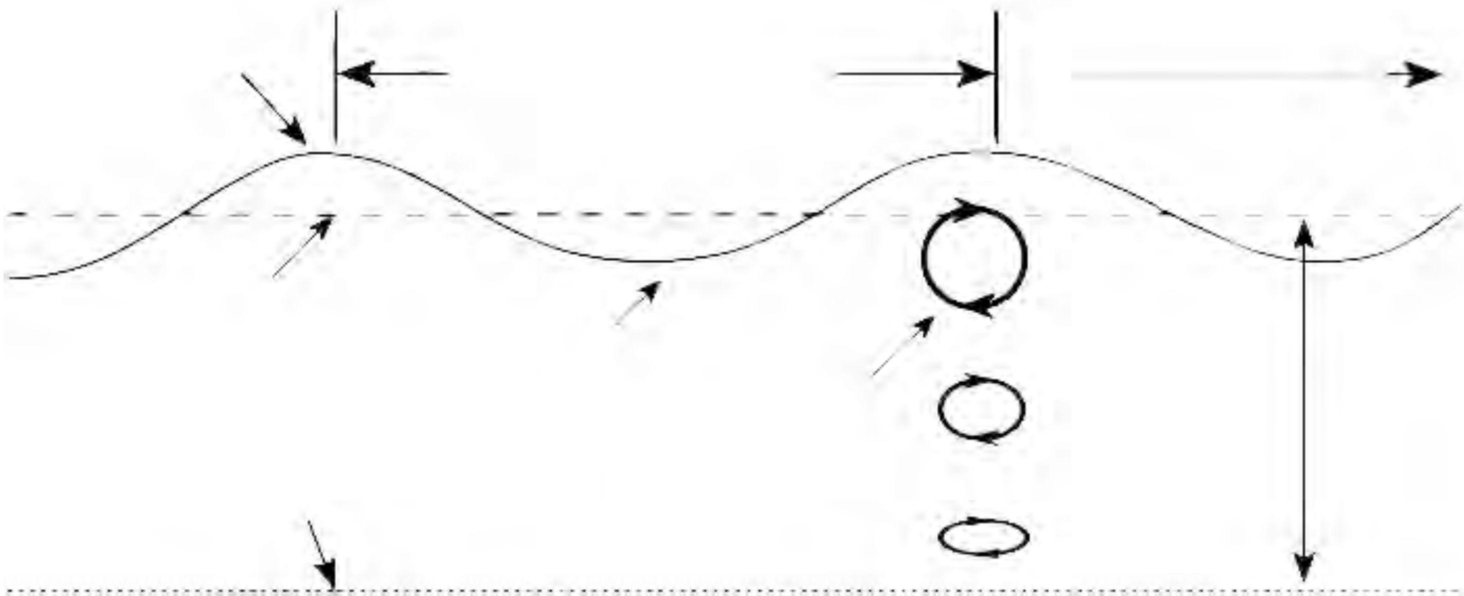
Question

Write a sentence to show you know the meaning of the following wave terms.

Draw diagrams to illustrate your answer from your local beach.

A. Fetch, wave crest, trough, length, height, orbit field, lip, whitewater and face
B. Wave height to water depth relationships
C. Wave speed, wave period

Eg.



Experiment

Calculate wave velocity (celerity) in a lab carry tray. Make sure the tray bottom is flat and not warped or it won't work. You might want to build a new one out of acrylic with a flat bottom.

Wave length	15 cm	30 cm
Frequency		
Velocity $v = \lambda f$	v = 15 x ______ / 15 = ______ cm/sec	v = 30 x ______ / 15 = ______ cm/sec

Figure 4.3 Velocity of waves

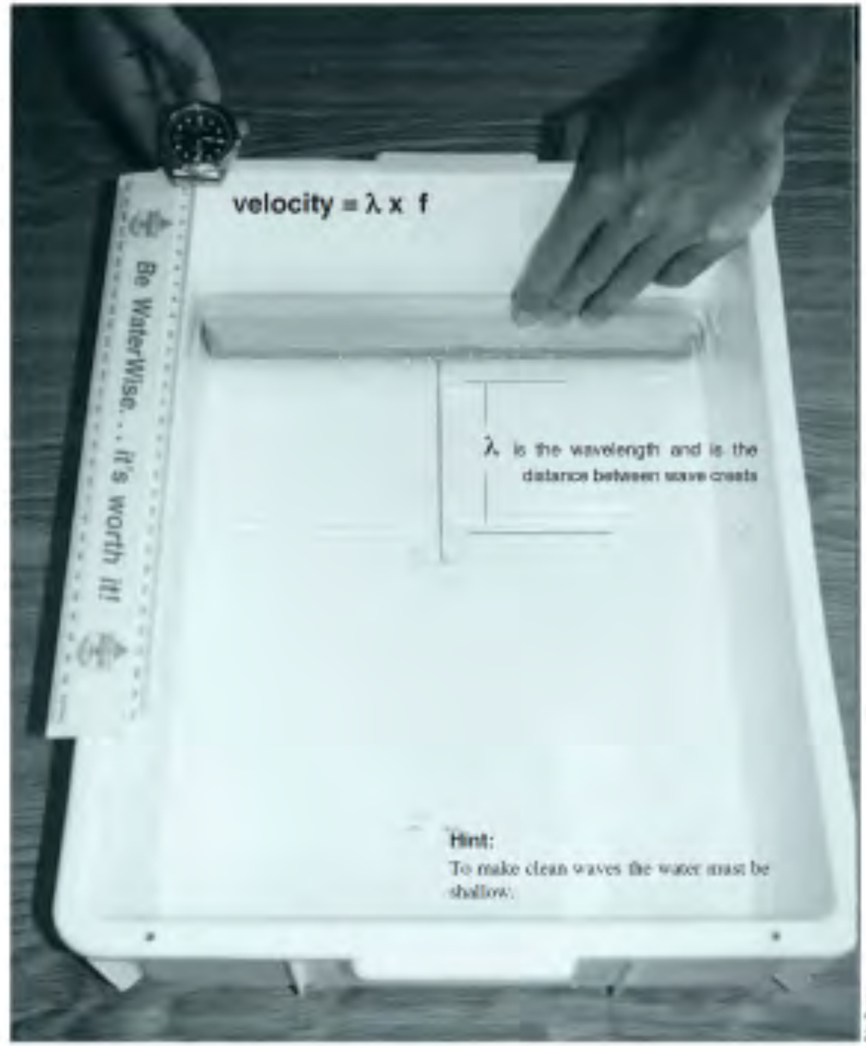
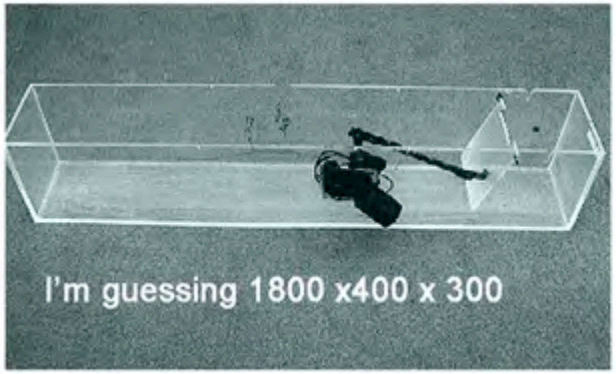
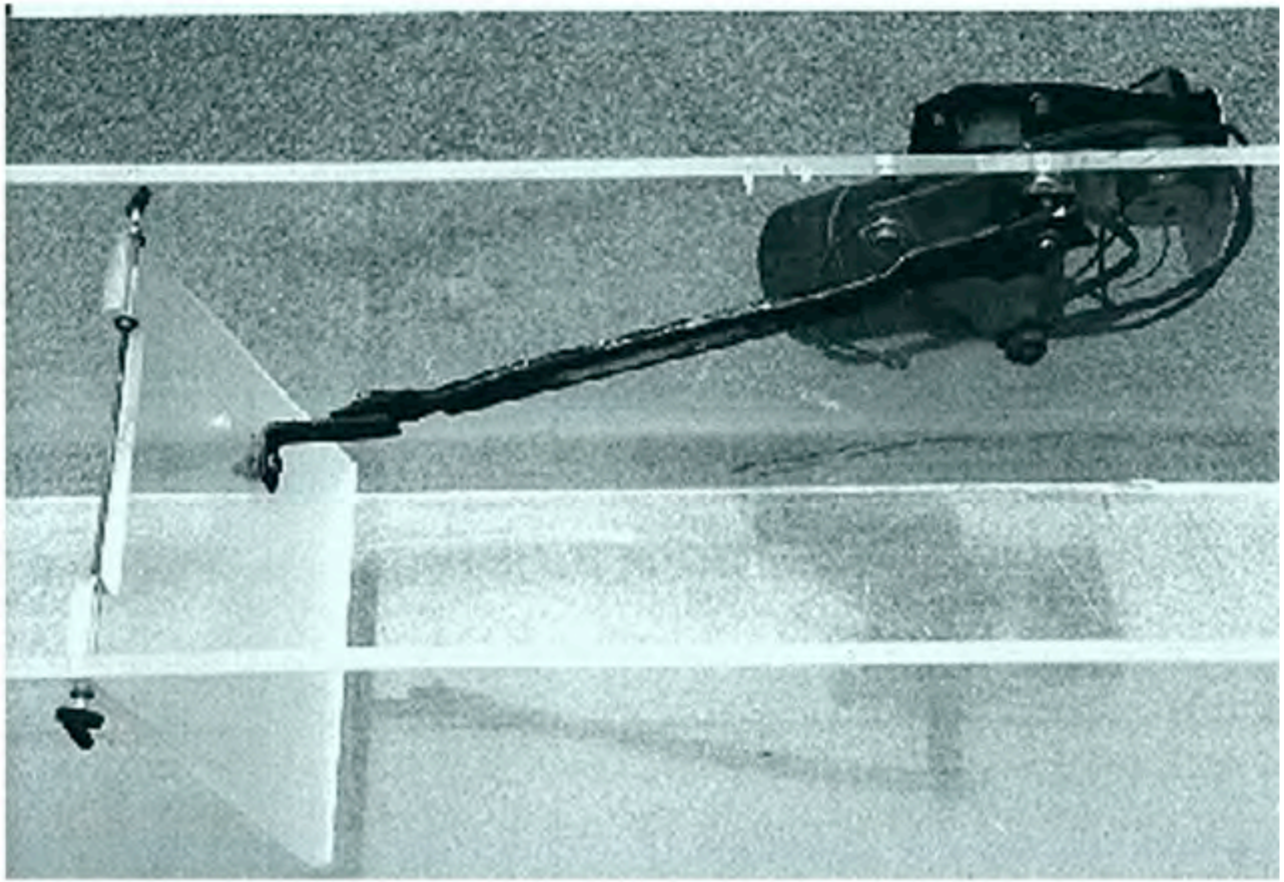


Figure 4.2 How to calculate the velocity of waves

Bob Moffatt

Demonstrations





Bob Moffatt

Wave tank construction details

Brad Spring
St Andrews Anglican College

I have a wave tank made about 10 years ago and still going of 6mm acrylic for about $150.

If you connect to the wiper motor $15 with a standard science power pack you can alter the speed by choosing 2,4,6,8, 12 volts.

The long section is one piece bent into a U 2450mm x 1250mm (U = 410mm x 420mm 410mm).

Ends are 420mm x 410mm glued with 120mm x 25mm triangular prism brackets glued into the top corners of each side for reinforcing.

I have 2 x 240mm x 450mm x 240mm U shaped movable brackets made out of 50mm x 10mm acrylic strips that sit on top to hold in sides as they can flex.

Any plastics company can make it to specs with the reinforcing required if you tell them how it will be used.

The length is good for modelling offshore bar formation that will move towards the beach on 2-4 volts left overnight and away from the beach on 6-12 volts.

Videoing or photographs with laptop or phone work really well with reference points ie rulers taped vertically and horizontally to the tank.

Worksheet we use (see over)

Investigating Waves

Aim: to measure wavelength and investigate the relationship between wavelength and water depth for waves.

- To investigate the relationship between wavelength and frequency.

Apparatus:

- Wave tank (in G4)
- Digital camera/computer/mobile phone
- 1 metre ruler
- Stop watch
- Whiteboard Marker
- Piece of measuring tape from broken tape

Methods:

Measuring wavelength

1. Assemble the wave Tank by moving the sand to the far end of the tank opposite the generator and drawing a waterline with a white board marker at the level with the generator stationary (this will be used later to determine wave height).
2. Turn on the wave generator, and set to a low setting.
3. Place the ruler along the front of the tank as a scale.
4. Take a digital photograph of the tank.
5. Analyse the photograph and determine the wavelength using the ruler in the photograph.
6. Compare the wavelength between the crests at the deep end and the shallow end of the tank.

Measuring frequency and speed

1. Count number of waves passing a given point in 10 seconds
2. Divide the number of waves by 10 to get the frequency (waves/second)
3. Repeat this at the shallow end water.

Breaking waves

1. Take a digital photograph of a breaking wave.
2. Analyse the photograph to determine the wavelength, the wave height and the depth of water.
3. Repeat with different generator speeds.

Results

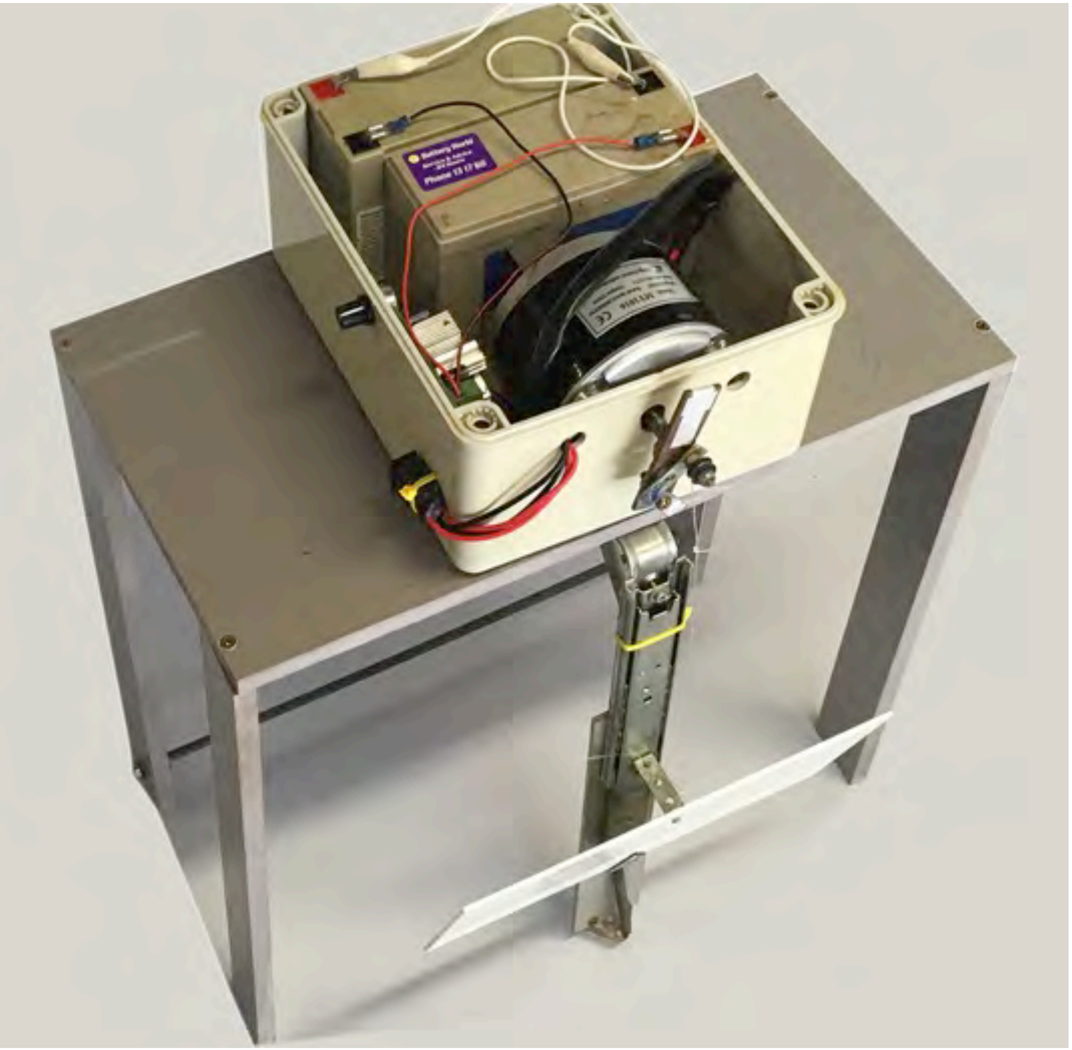
Generator speed	Depth	Wavelength	Frequency	Speed = wavelength x frequency
4	Deep =			
	Shallow =			
8	Deep=			
	Shallow=			
12	Deep=			
	Shallow=			

Discussion:

1. Describe the motion of water particles in a wave.
2. Describe the relationship between wavelength and depth.
3. Describe the mathematical relationship between wavelength and frequency.
4. What happens to swell when it enters shallow waters?
5. Is there any relationship between wavelength and depth for a breaking wave?
6. Is there any relationship between wave height and depth for a breaking wave?
7. **Justification:** Do the measurements for different generator speeds support your findings?
8. Can you recognize any features of the beach profile that have changed while running the generator?
   a) a storm bar developing
   b) rip developing
   c) erosion scarp
   d) movement of beach sand seaward or shoreward
   e) microridges on the beach

Conclusions

Griffith University wave generator



Maggie Muurmans
Griffith Uni Centre for Coastal Management