
بسم الله الرحمن الرحيم

GEO 435

Oceanography

Dr. Sattam Abdulkareem Almadani

Waves & Water Dynamics:

- What causes ocean waves?
- How do waves move?
- What characteristics do waves possess?
- How do wind-generated waves develop?
- How do waves change in the surf zone?
- How are tsunami created?
- Can power from waves be harnessed as a source of energy?

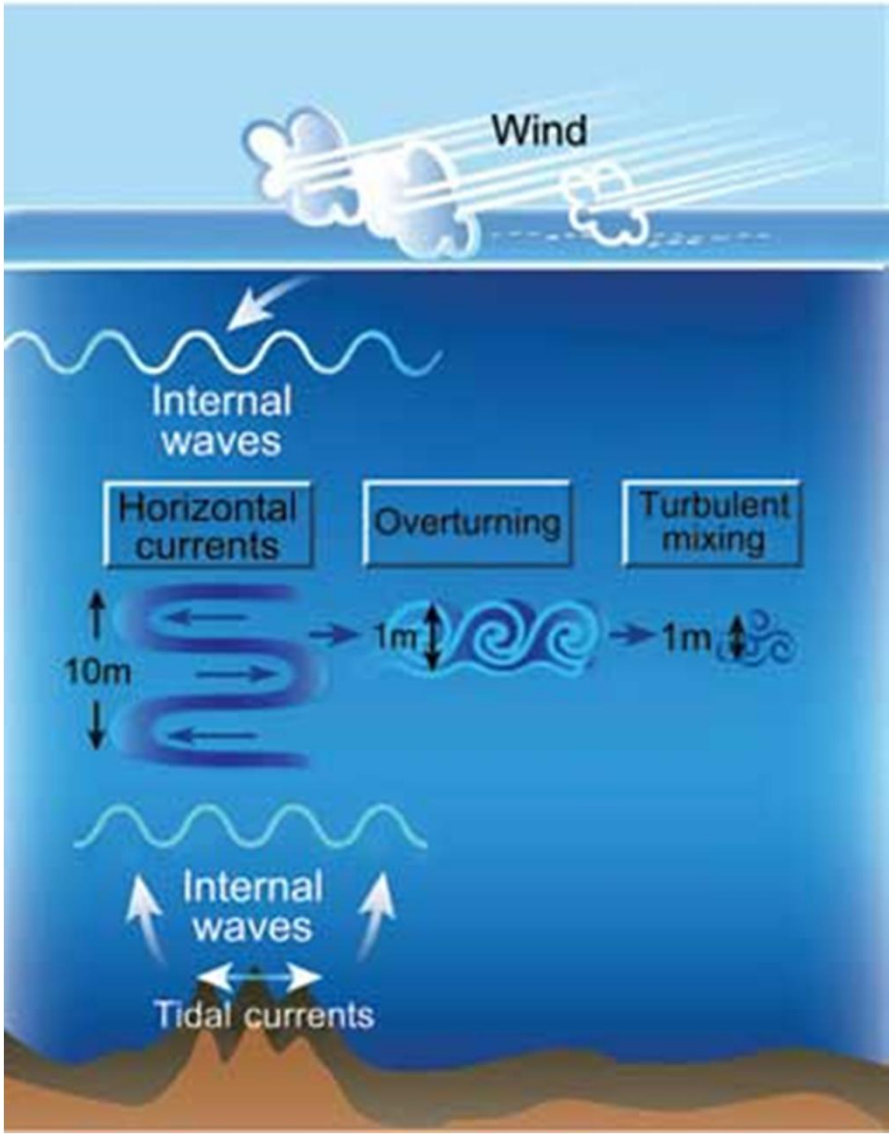
Q. What causes ocean waves?

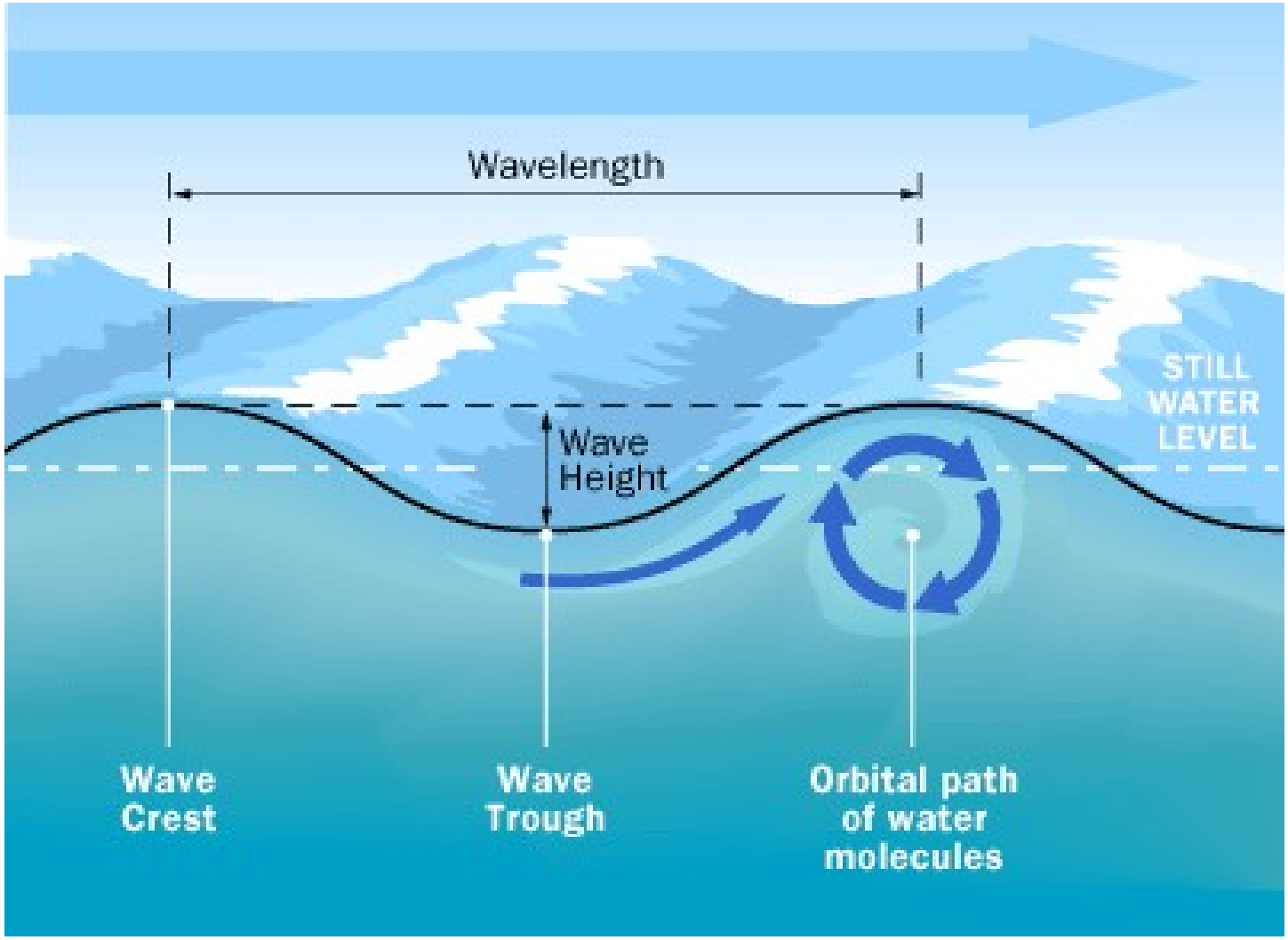
Most ocean waves are caused by:

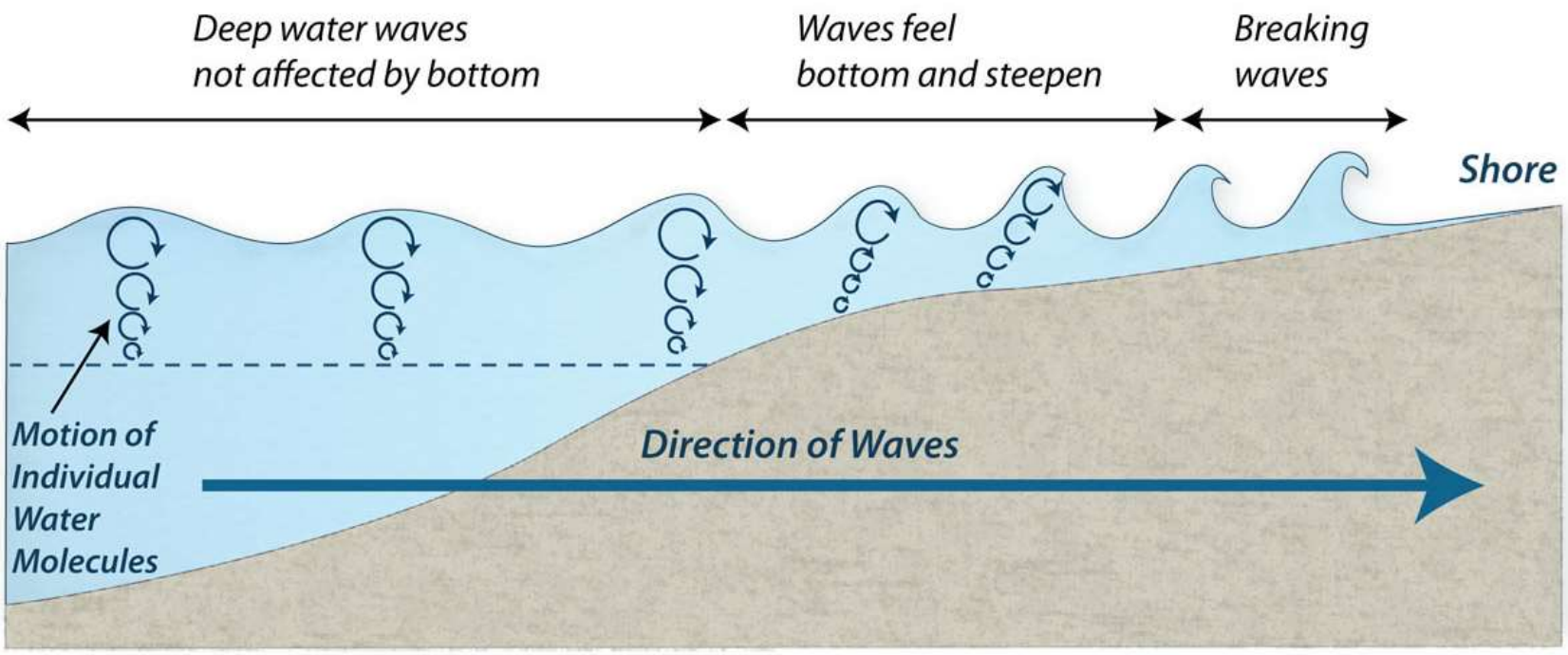
1. Wind.

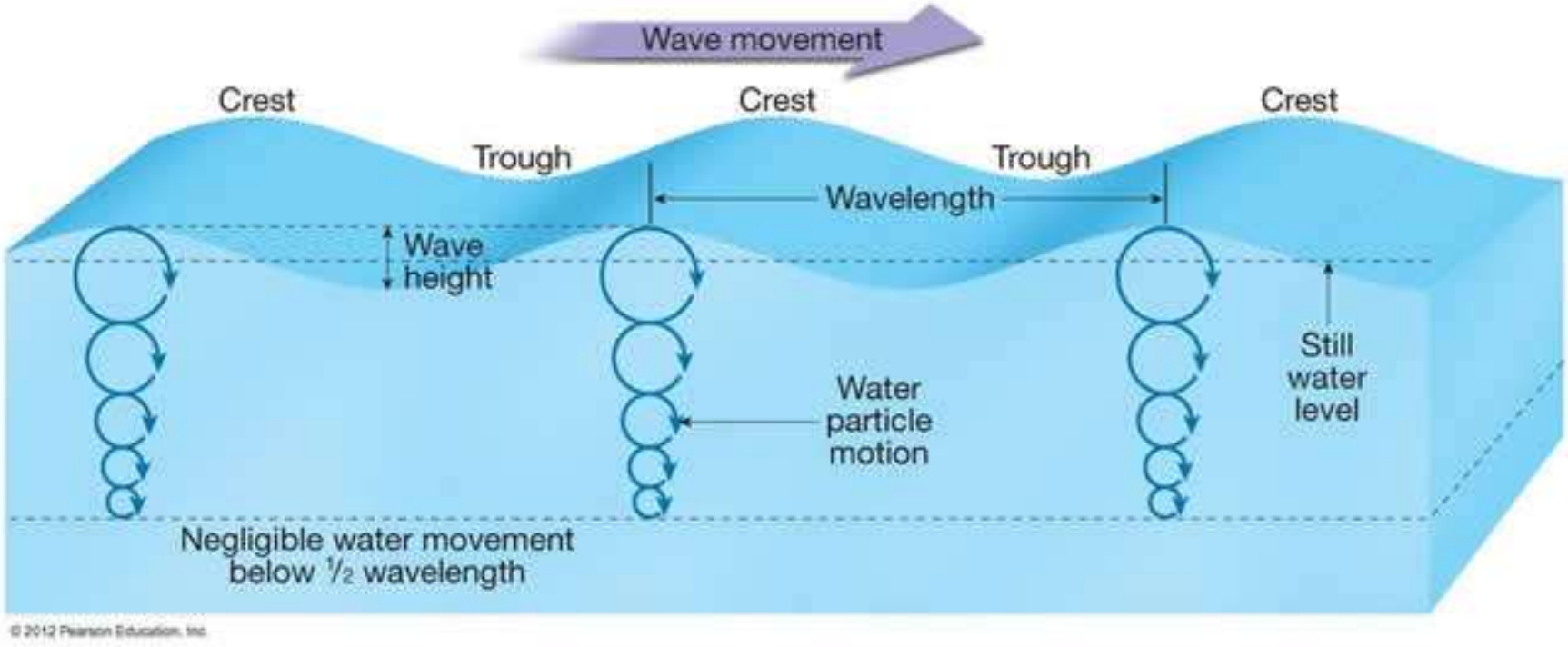
2. Atmospheric waves.

3. Internal waves.


Wind
Internal waves
Horizontal currents
Overturning
Turbulent mixing
10m
1m
1m
Internal waves
Tidal currents


Wavelength
STILL WATER LEVEL
Wave Height
Wave Crest
Wave Trough
Orbital path of water molecules


Deep water waves
not affected by bottom
Waves feel
bottom and steepen
Breaking
waves
Shore
Motion of
Individual
Water
Molecules
Direction of Waves


Wave movement
Crest
Crest
Crest
Trough
Trough
Wavelength
Wave height
Still water level
Water particle motion
Negligible water movement below ½ wavelength
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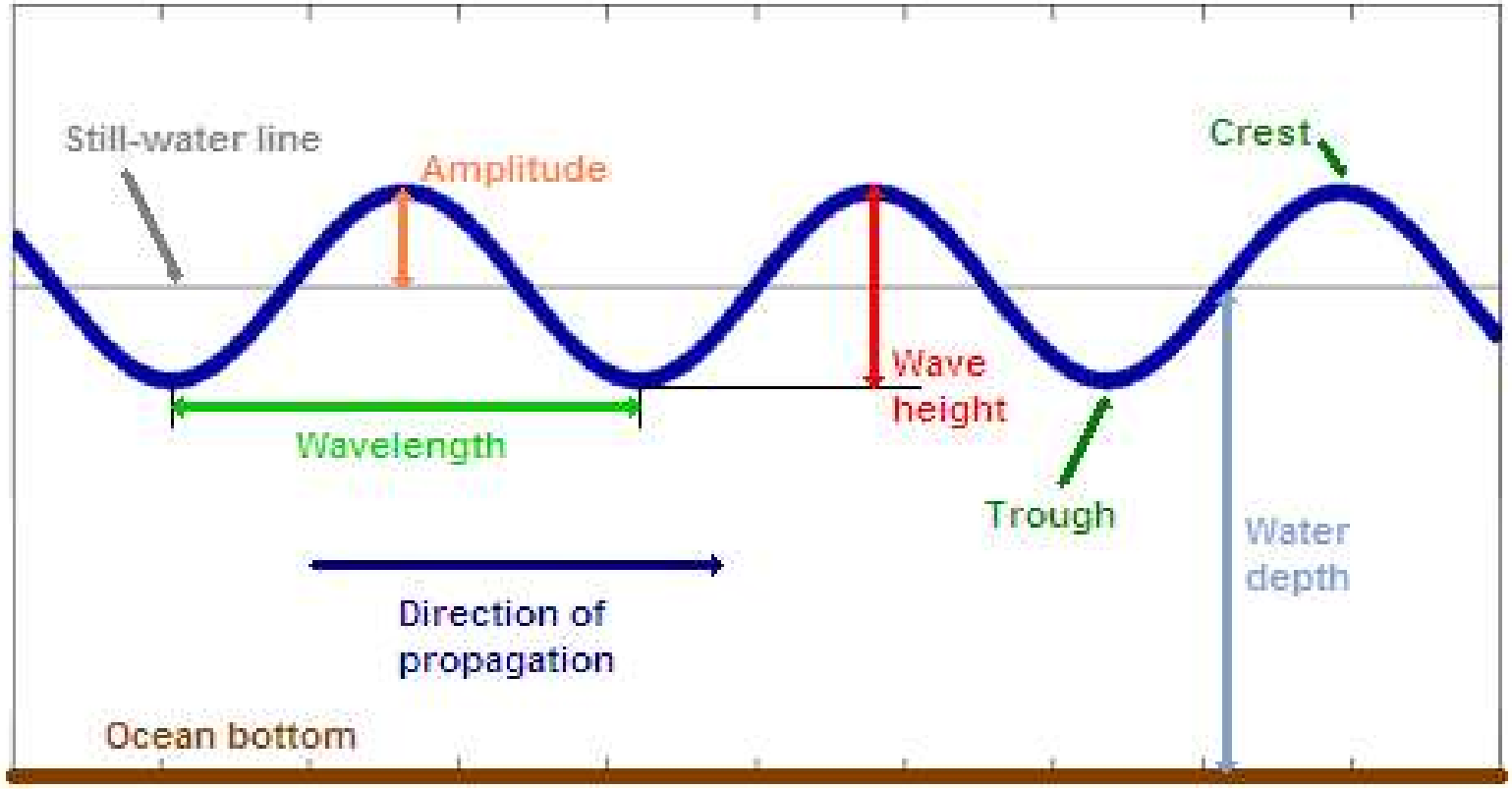
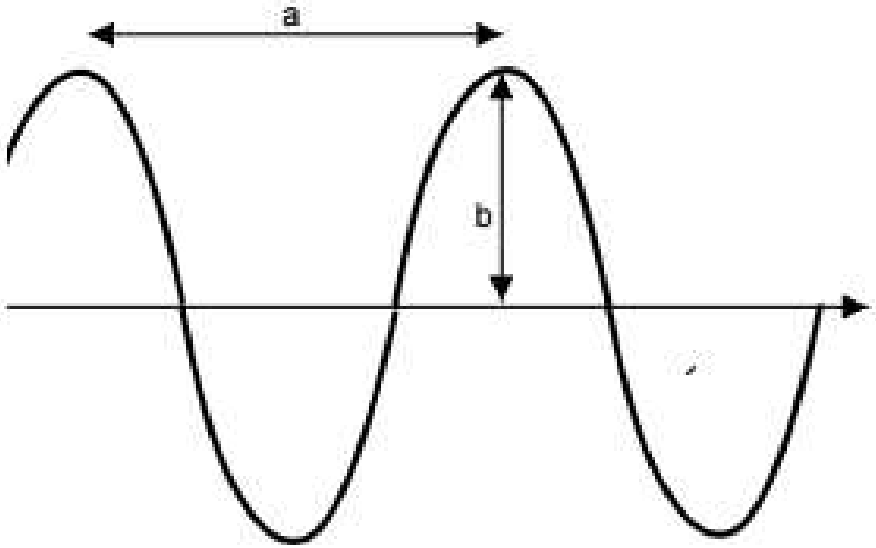
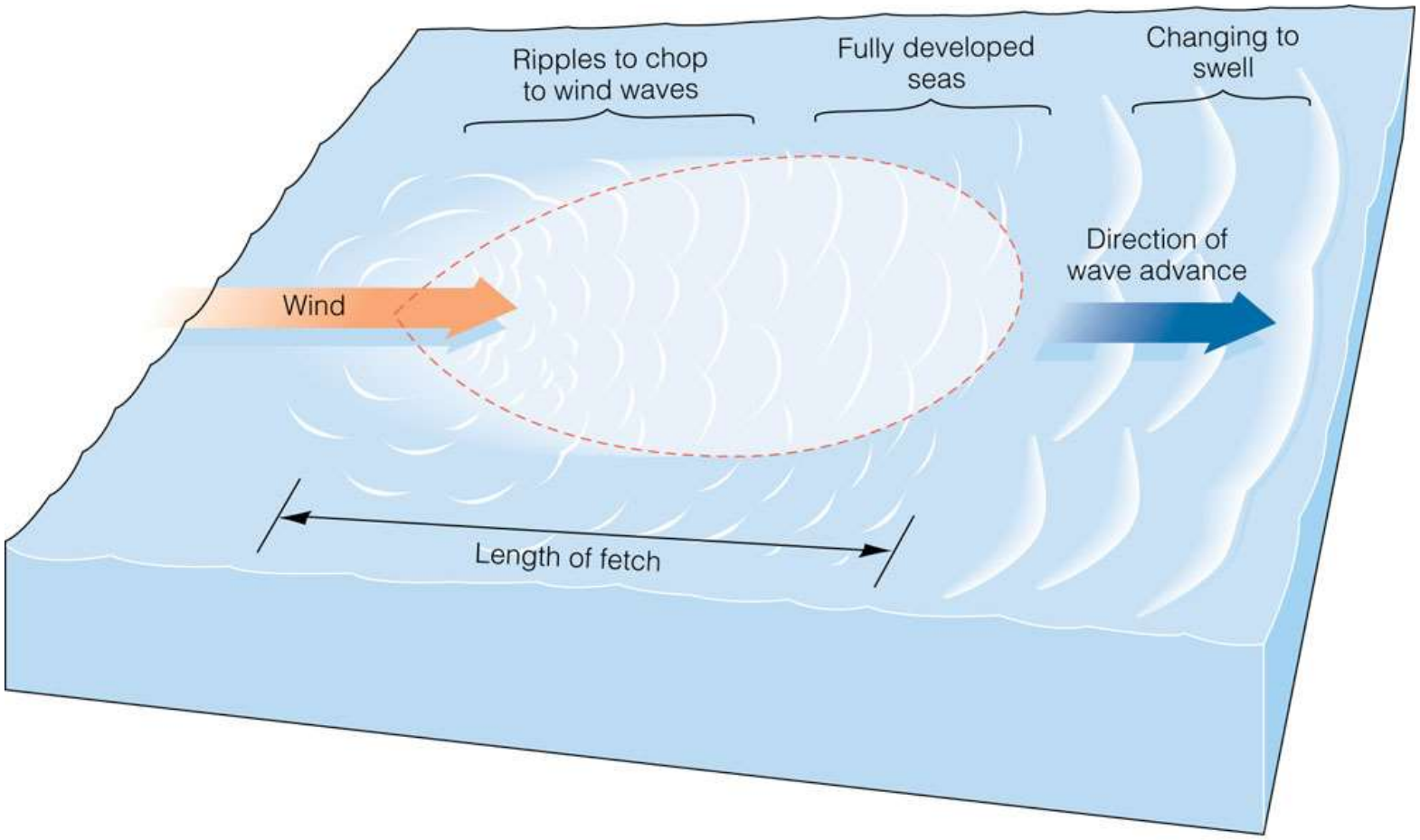

Still-water line
Amplitude
Crest
Wave height
Wavelength
Trough
Water depth
Direction of propagation
Ocean bottom

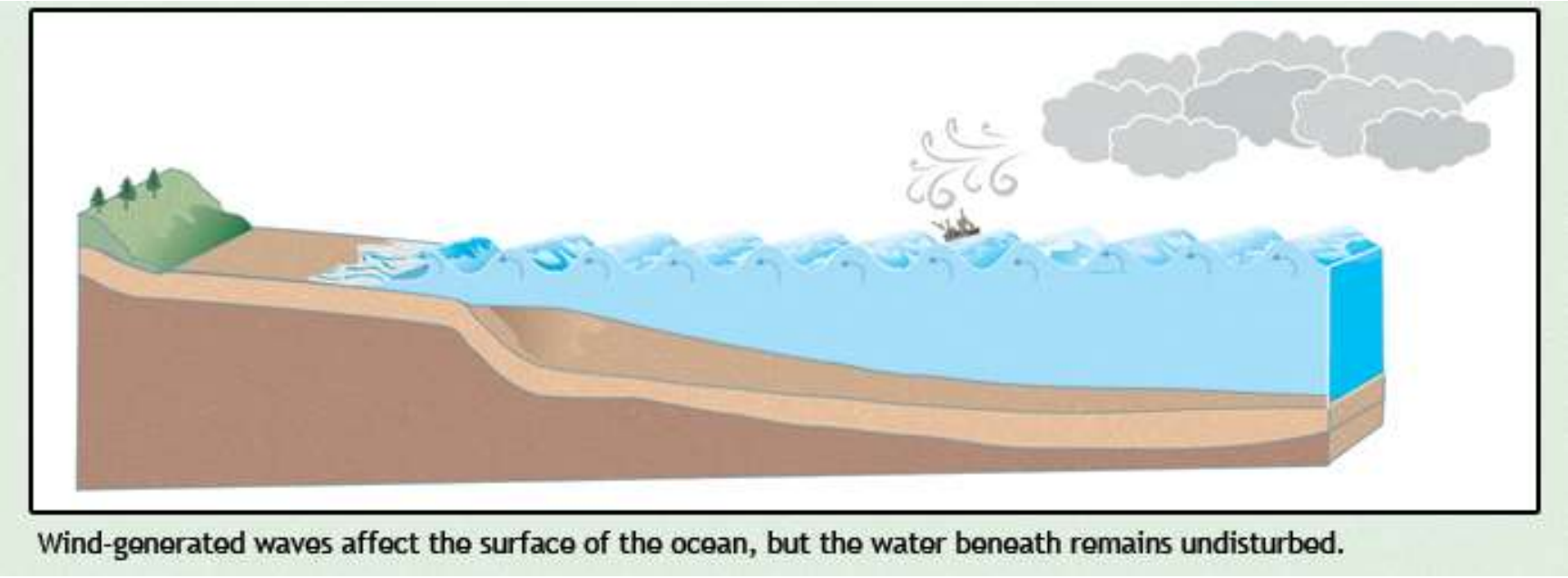


Generalities on the waves

b = amplitude
a = length of wave,
v= Velocity of propagation
λ = Wave length
f= frequency (hertz)
k= number of waves/ km
T = period = time for one cycle
K = wave number
T = 1 / frequency = wavelength / velocity
Wave length = velocity / frequency
Velocity = frequency * wavelength
Wave number = 1 / Wavelength

Frequency = 1/ period
f/ k = apparent velocity
T = period = length of a cycle
The seismic waves are elastic distortion waves, which propagate some various velocities into the rocks or along some layers limits.





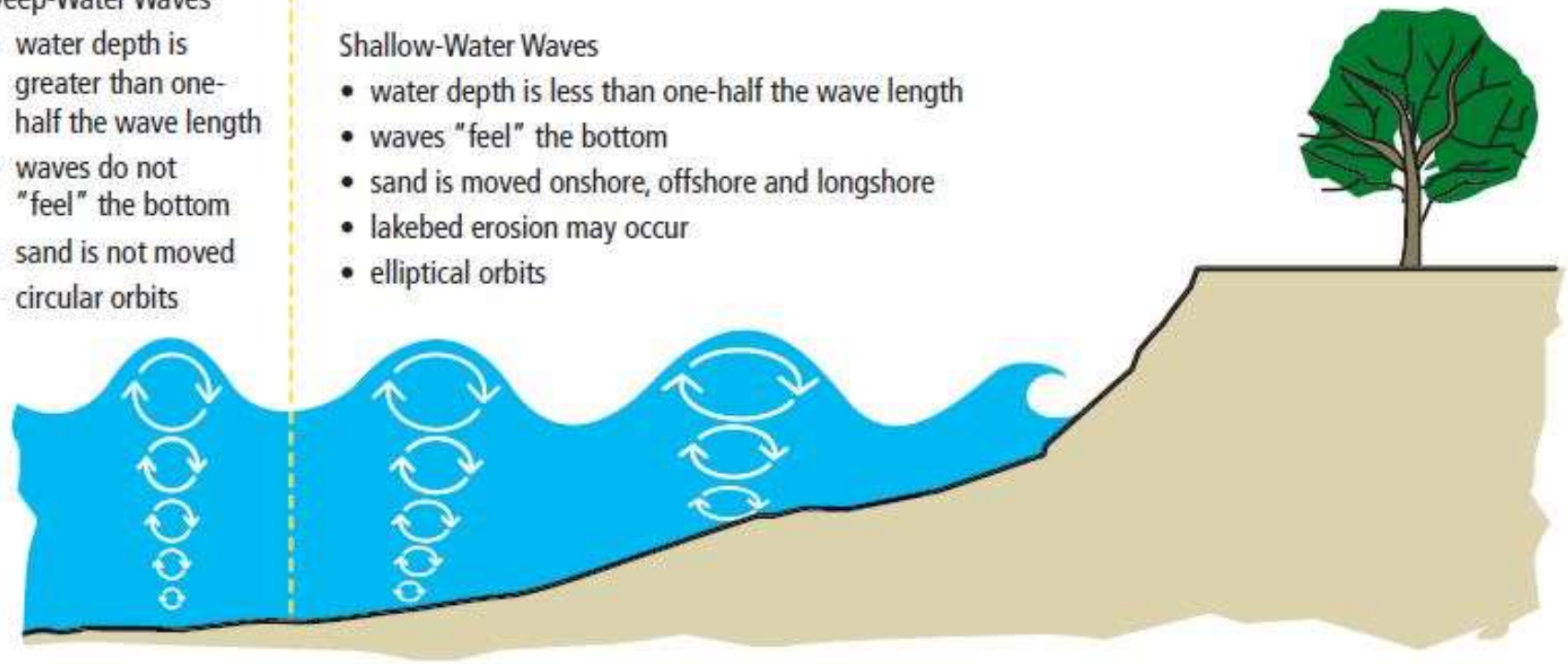
Wind-generated waves affect the surface of the ocean, but the water beneath remains undisturbed.

Deep-Water Waves

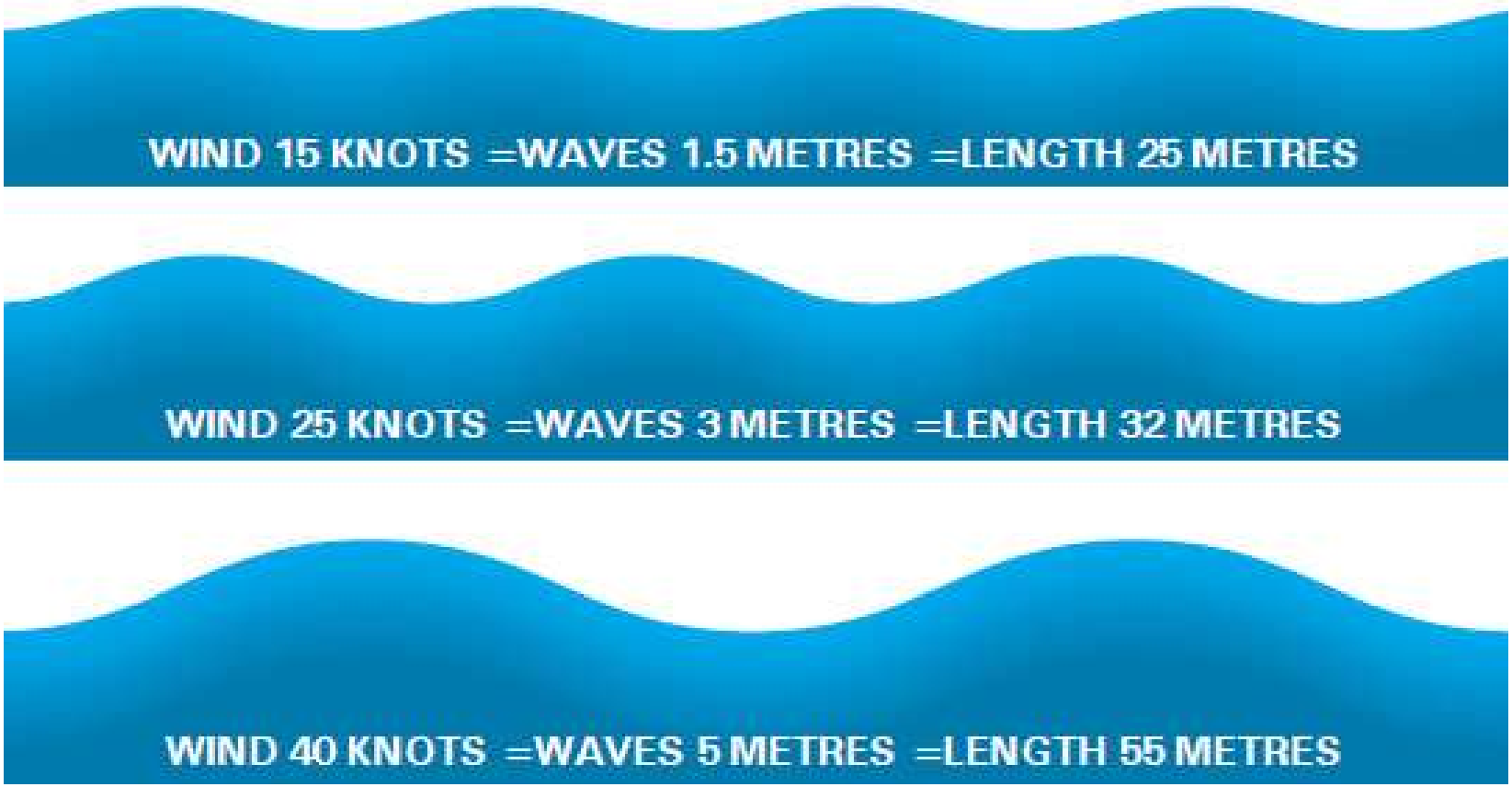
- water depth is greater than one-half the wave length
- waves do not "feel" the bottom
- sand is not moved
- circular orbits

Shallow-Water Waves

- water depth is less than one-half the wave length
- waves "feel" the bottom
- sand is moved onshore, offshore and longshore
- lakebed erosion may occur
- elliptical orbits

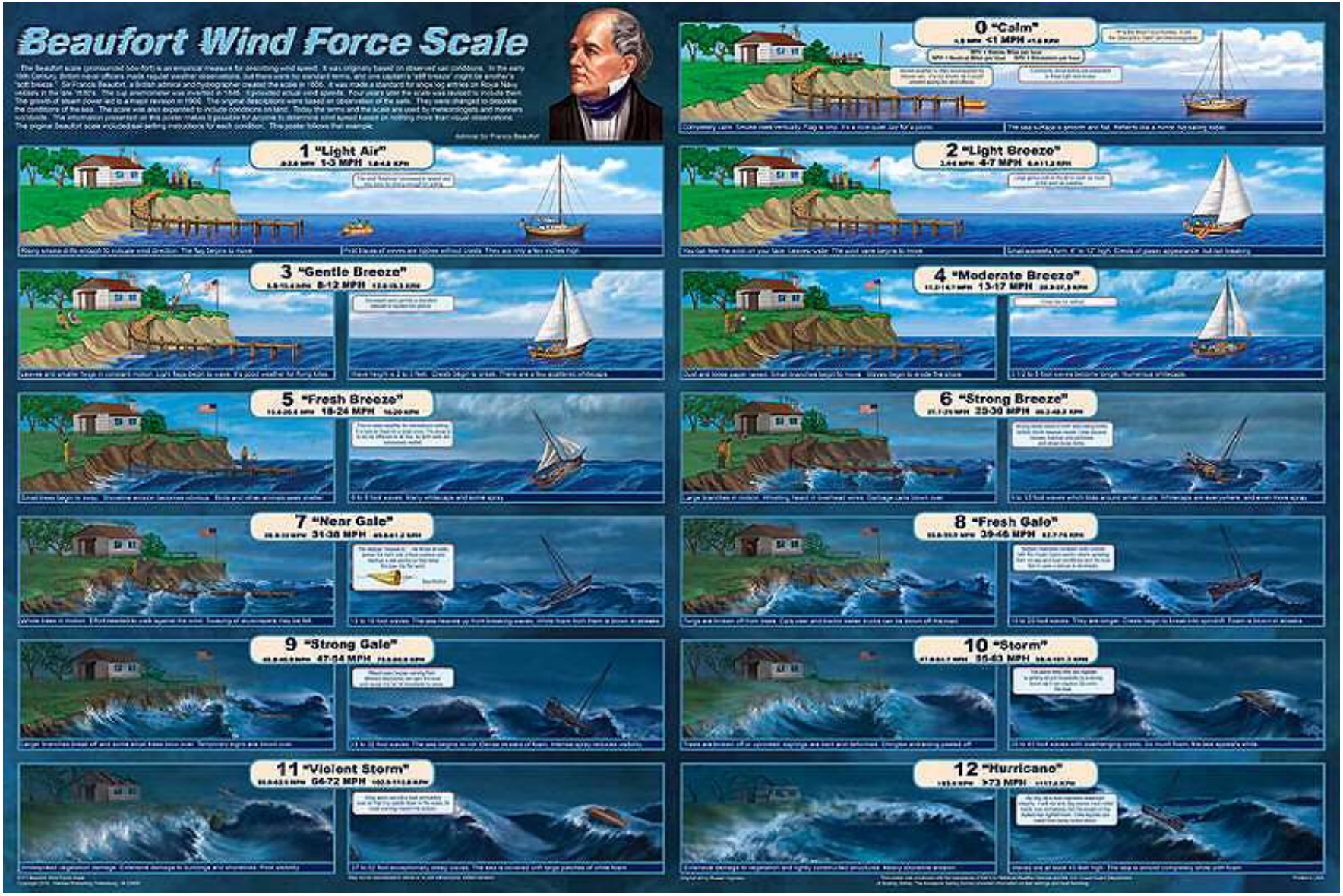


Waves Feeling the Lake Bottom

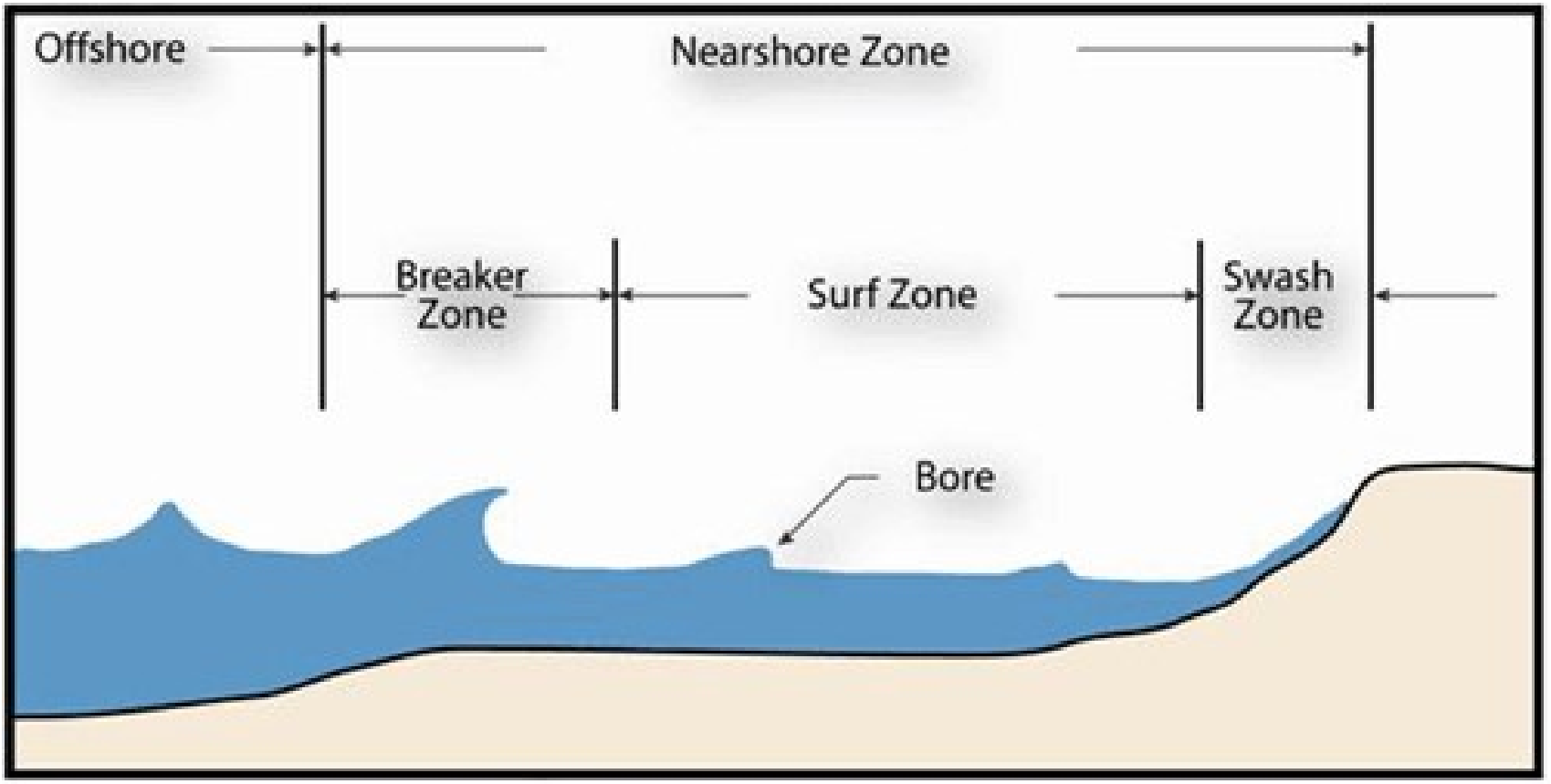

WIND 15 KNOTS =WAVES 1.5 METRES =LENGTH 25 METRES
WIND 25 KNOTS =WAVES 3 METRES =LENGTH 32 METRES
WIND 40 KNOTS =WAVES 5 METRES =LENGTH 55 METRES

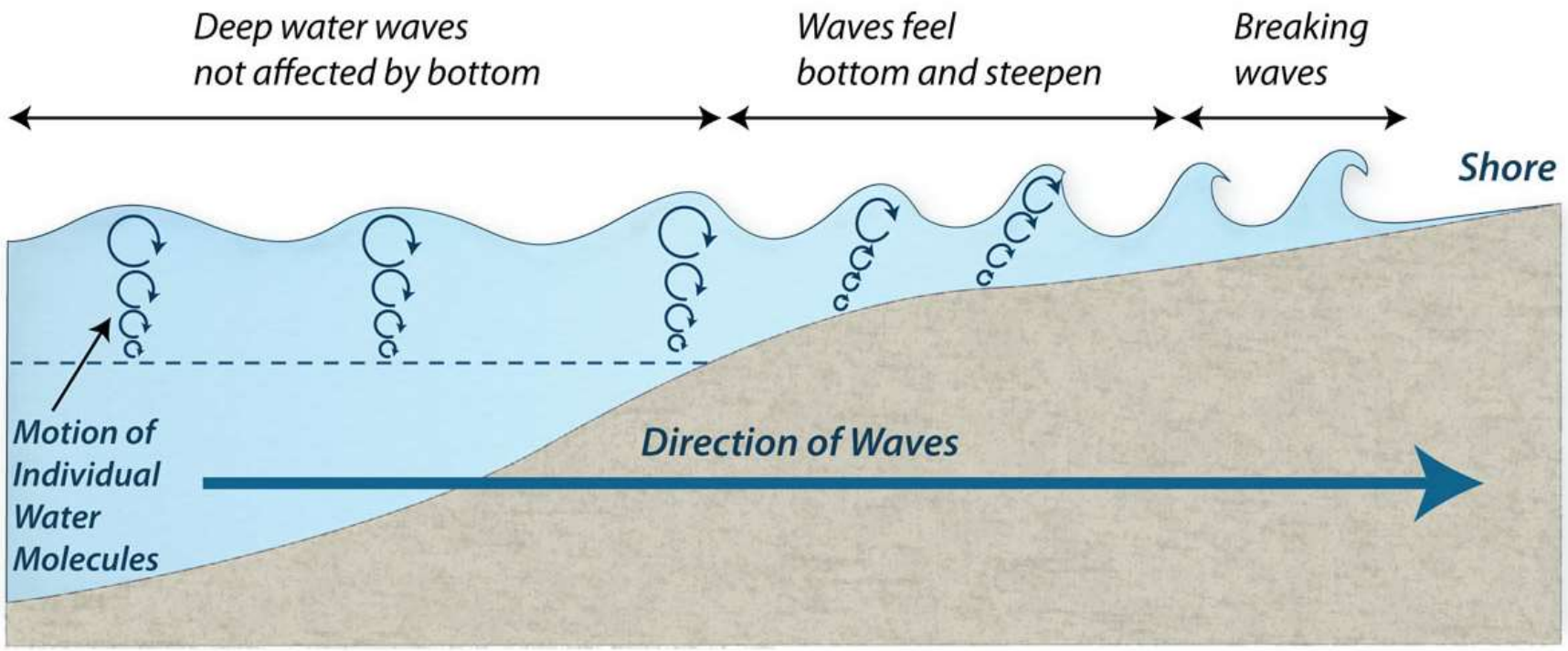
Beaufort Scale

Beaufort number	Wind Speed (mph)	Seaman's term		Effects on Land
0	Under 1	Calm		Calm; smoke rises vertically.
1	1-3	Light Air		Smoke drift indicates wind direction; vanes do not move.
2	4-7	Light Breeze		Wind felt on face; leaves rustle; vanes begin to move.
3	8-12	Gentle Breeze		Leaves, small twigs in constant motion; light flags extended.
4	13-18	Moderate Breeze		Dust, leaves and loose paper raised up; small branches move.
5	19-24	Fresh Breeze		Small trees begin to sway.
6	25-31	Strong Breeze		Large branches of trees in motion; whistling heard in wires.
7	32-38	Moderate Gale		Whole trees in motion; resistance felt in walking against the wind.
8	39-46	Fresh Gale		Twigs and small branches broken off trees.
9	47-54	Strong Gale		Slight structural damage occurs; slate blown from roofs.
10	55-63	Whole Gale		Seldom experienced on land; trees broken; structural damage occurs.
11	64-72	Storm		Very rarely experienced on land; usually with widespread damage.
12	73 or higher	Hurricane Force		Violence and destruction.


Beaufort Wind Force Scale
0 "Calm"
<1 MPH
1 "Light Air"
1-3 MPH
2 "Light Breeze"
4-7 MPH
3 "Gentle Breeze"
8-12 MPH
4 "Moderate Breeze"
13-17 MPH
5 "Fresh Breeze"
18-24 MPH
6 "Strong Breeze"
25-30 MPH
7 "Near Gale"
31-38 MPH
8 "Fresh Gale"
39-46 MPH
9 "Strong Gale"
47-54 MPH
10 "Storm"
55-63 MPH
11 "Violent Storm"
64-72 MPH
12 "Hurricane"
>73 MPH

Q. How do waves change in the surf zone?


Offshore
Nearshore Zone
Breaker Zone
Surf Zone
Swash Zone
Bore


Deep water waves
not affected by bottom
Waves feel
bottom and steepen
Breaking
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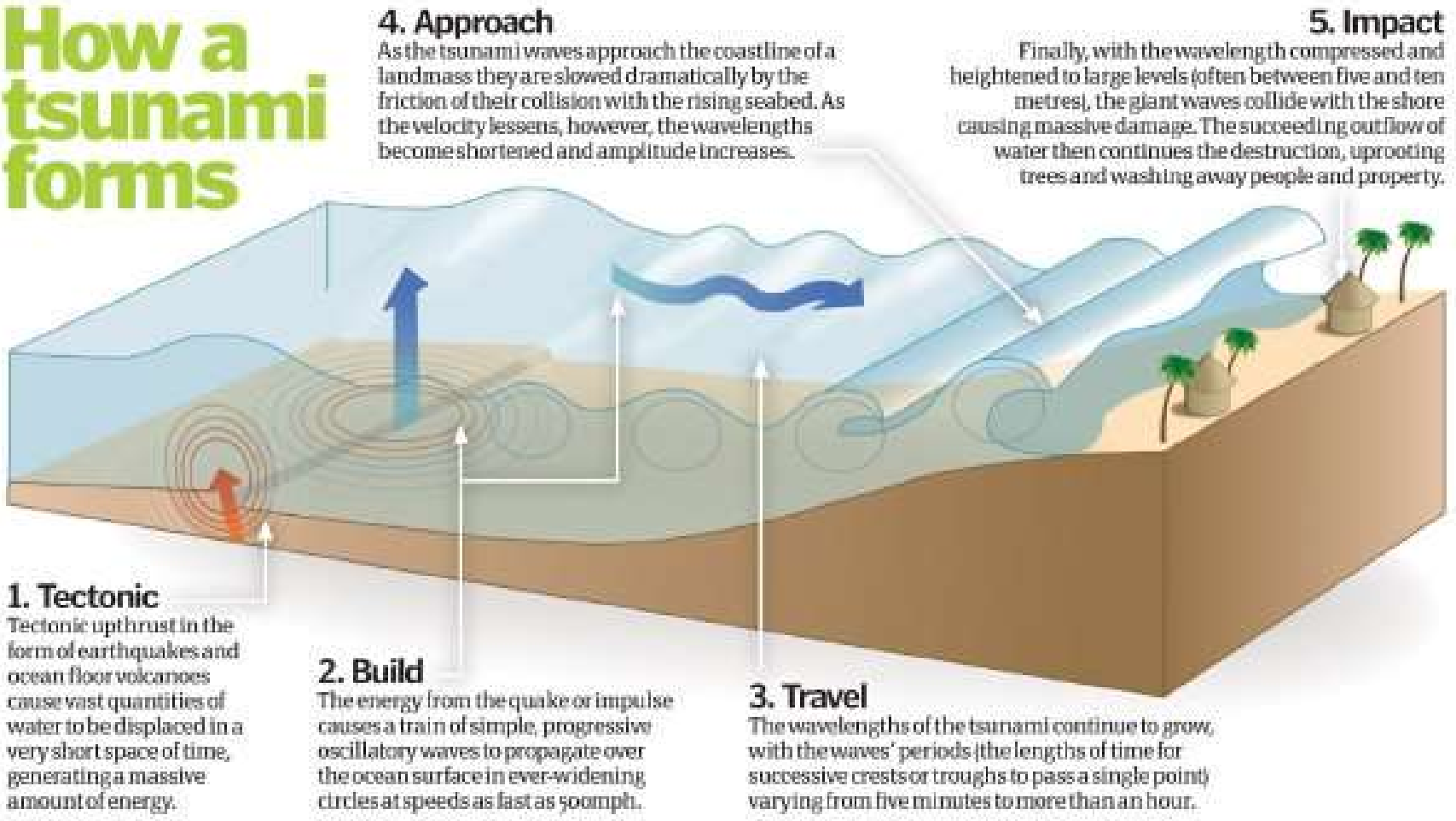
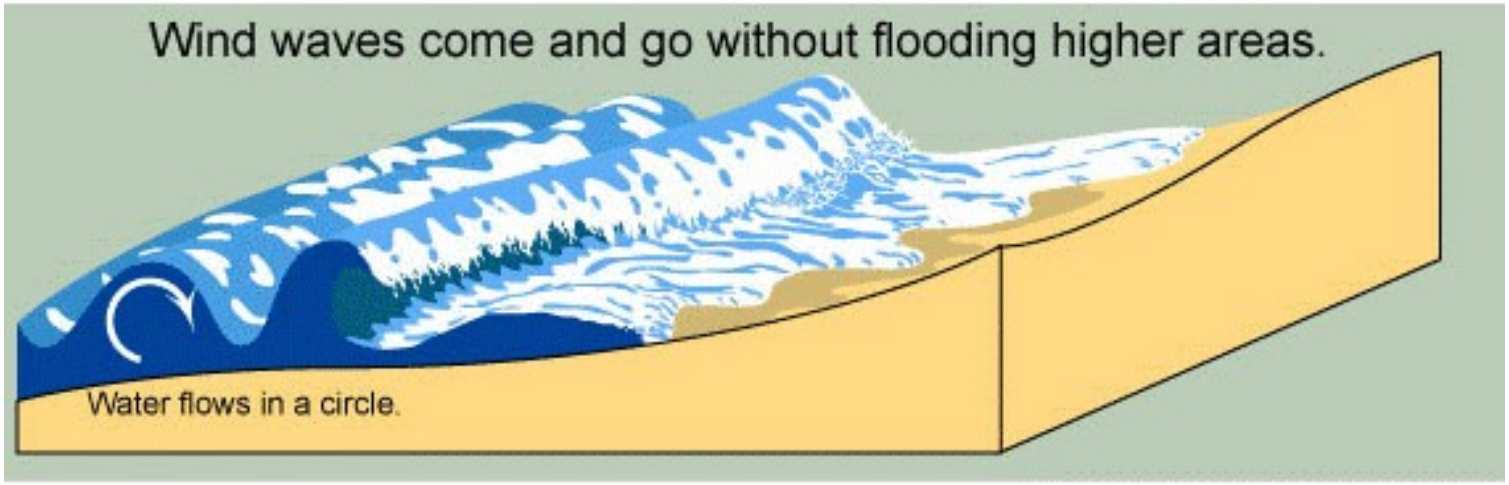
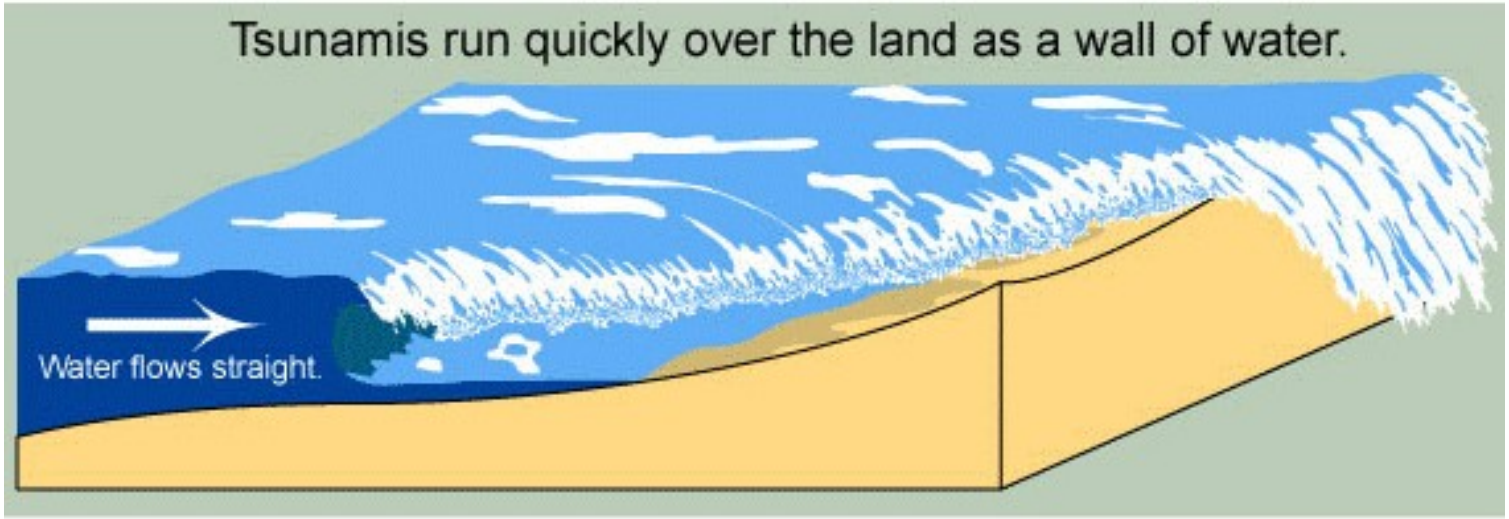
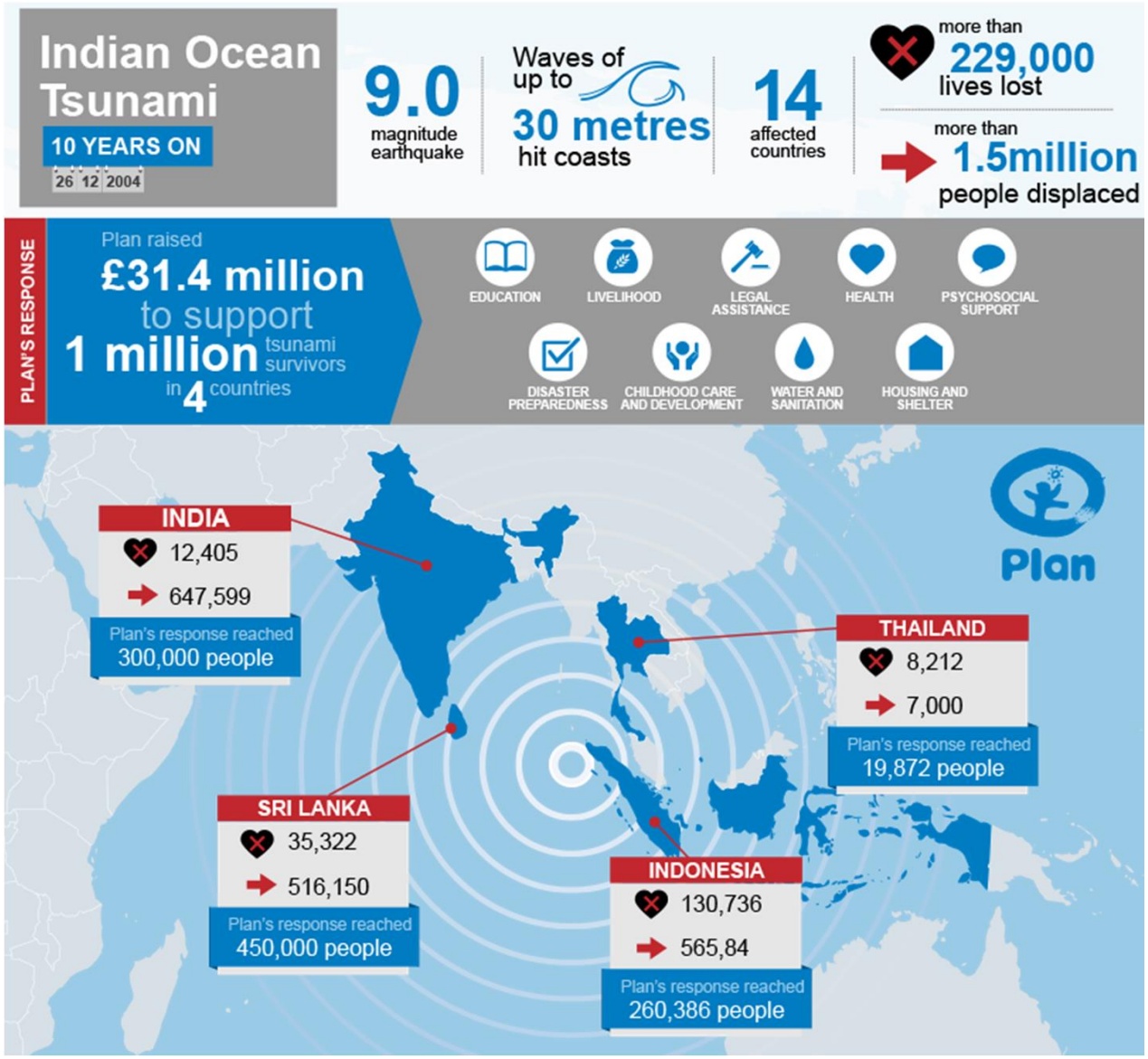
Shore
Motion of
Individual
Water
Molecules
Direction of Waves

Q. How are tsunami created?


How a tsunami forms
4. Approach
As the tsunami waves approach the coastline of a landmass they are slowed dramatically by the friction of their collision with the rising seabed. As the velocity lessens, however, the wavelengths become shortened and amplitude increases.
5. Impact
Finally, with the wavelength compressed and heightened to large levels (often between five and ten metres), the giant waves collide with the shore causing massive damage. The succeeding outflow of water then continues the destruction, uprooting trees and washing away people and property.
1. Tectonic
Tectonic upthrust in the form of earthquakes and ocean floor volcanoes cause vast quantities of water to be displaced in a very short space of time, generating a massive amount of energy.
2. Build
The energy from the quake or impulse causes a train of simple, progressive oscillatory waves to propagate over the ocean surface in ever-widening circles at speeds as fast as 500mph.
3. Travel
The wavelengths of the tsunami continue to grow, with the waves' periods (the lengths of time for successive crests or troughs to pass a single point) varying from five minutes to more than an hour.


Wind waves come and go without flooding higher areas.
Water flows in a circle.


Tsunamis run quickly over the land as a wall of water.
Water flows straight.


Indian Ocean Tsunami
10 YEARS ON
26 12 2004
9.0
magnitude earthquake
Waves of up to
30 metres
hit coasts
14
affected countries
more than
229,000
lives lost
more than
1.5million
people displaced
PLAN'S RESPONSE
Plan raised
£31.4 million
to support
1 million
tsunami survivors
in
4
countries
EDUCATION
LIVELIHOOD
LEGAL ASSISTANCE
HEALTH
PSYCHOSOCIAL SUPPORT
DISASTER PREPAREDNESS
CHILDHOOD CARE AND DEVELOPMENT
WATER AND SANITATION
HOUSING AND SHELTER
Plan
INDIA
12,405
647,599
Plan's response reached
300,000 people
THAILAND
8,212
7,000
Plan's response reached
19,872 people
SRI LANKA
35,322
516,150
Plan's response reached
450,000 people
INDONESIA
130,736
565,84
Plan's response reached
260,386 people