Ocean Waves definitions

Wind waves – “waves generated locally.” Their growth depends on the distance they travel in the generation (the *fetch* region), the duration of the wind, and the depth of the water. Deep water potentially allows the waves to reach their maximum growth for a given wind speed (given time). Shallow water restricts wave growth, but may temporarily grow larger (a process called shoaling) as the wave slows down. Tend to have irregular distances between wave crests and different heights. Looks somewhat chaotic.

Swell waves – “waves that have traveled out of their generation area.” Because of their different wave lengths and wave speeds, waves move outward from the windy areas where they formed, and separate into groups of waves with distinct wave periods. They take on a more typical sine wave pattern with generally equally rounded crests and troughs with about the same height.

Sea waves – combination of wind waves and swells, with a spectrum of periods and heights.

Fetch – “an area of the sea surface over which wind is constant in direction and speed.” Often used to mean the length of the region upwind of the point of interest. For parametric models, one tries to identify a rectangular area matching this description.

Duration - The time over which a more-or-less steady wind has blown

Period (T) - The time for one complete cycle e.g., time between wave crests at a point.

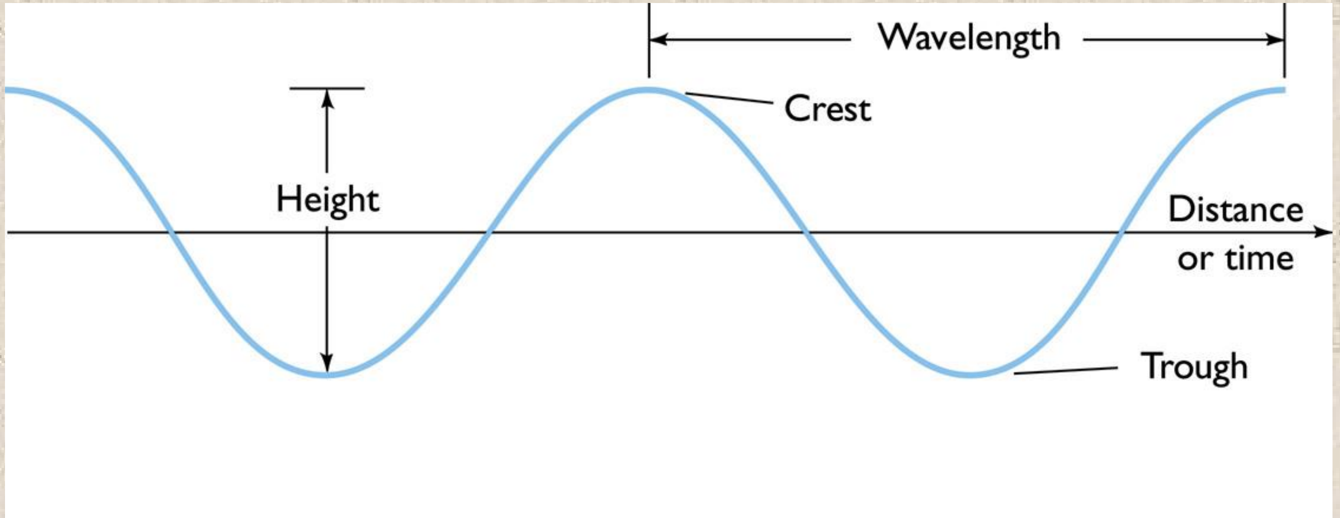
Frequency (f) - The reciprocal of the period, $f = 1/T$.

Wavelength (L) - The distance between successive crests or troughs.

Wave Height (H) - The vertical distance between crest and trough. Not the same as wave amplitude, which is the distance from the mean water level to crest or trough.

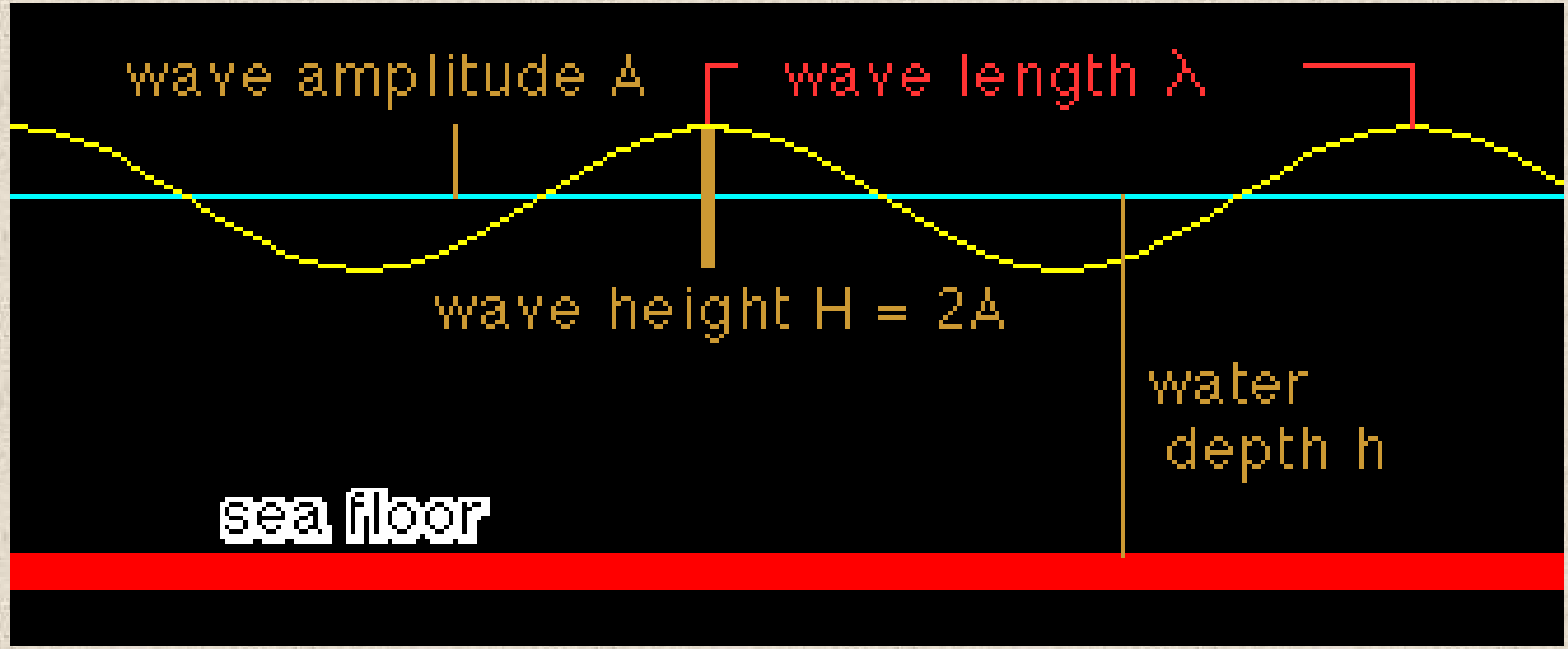
Waves are the undulatory motion of a water surface.

- **Parts of a wave are, Wave crest,Wave trough, Wave height (H), Wave Amplitude, Wave length (L),and Wave period (T).**
- **Wave period provides a basis for the wave classifications: Capillary waves, Chop, Swell, Tsunamis, Seiches.**



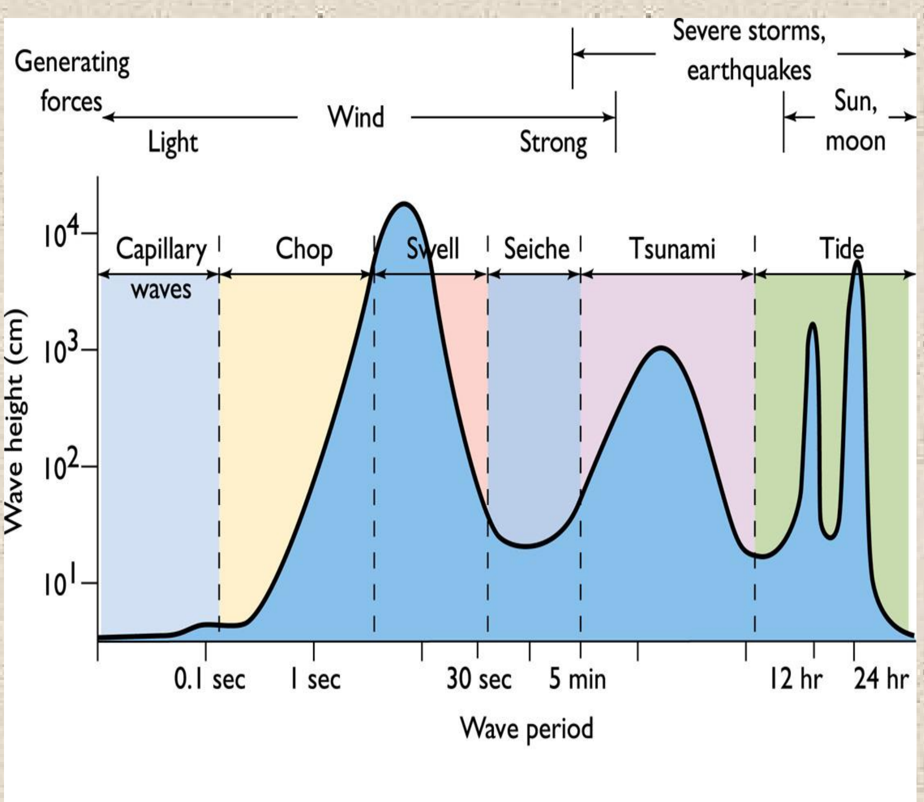
(a) WAVE PARAMETERS

Sketch of a harmonic or ideal (sinosoidal) wave. *H* is exaggerated against l for clarity. The narrow vertical bar gives the wave amplitude *A* (the distance between mean water level and wave crest); the heavy vertical bar gives the wave height *H* (the difference between wave trough and wave crest, or twice the wave amplitude).

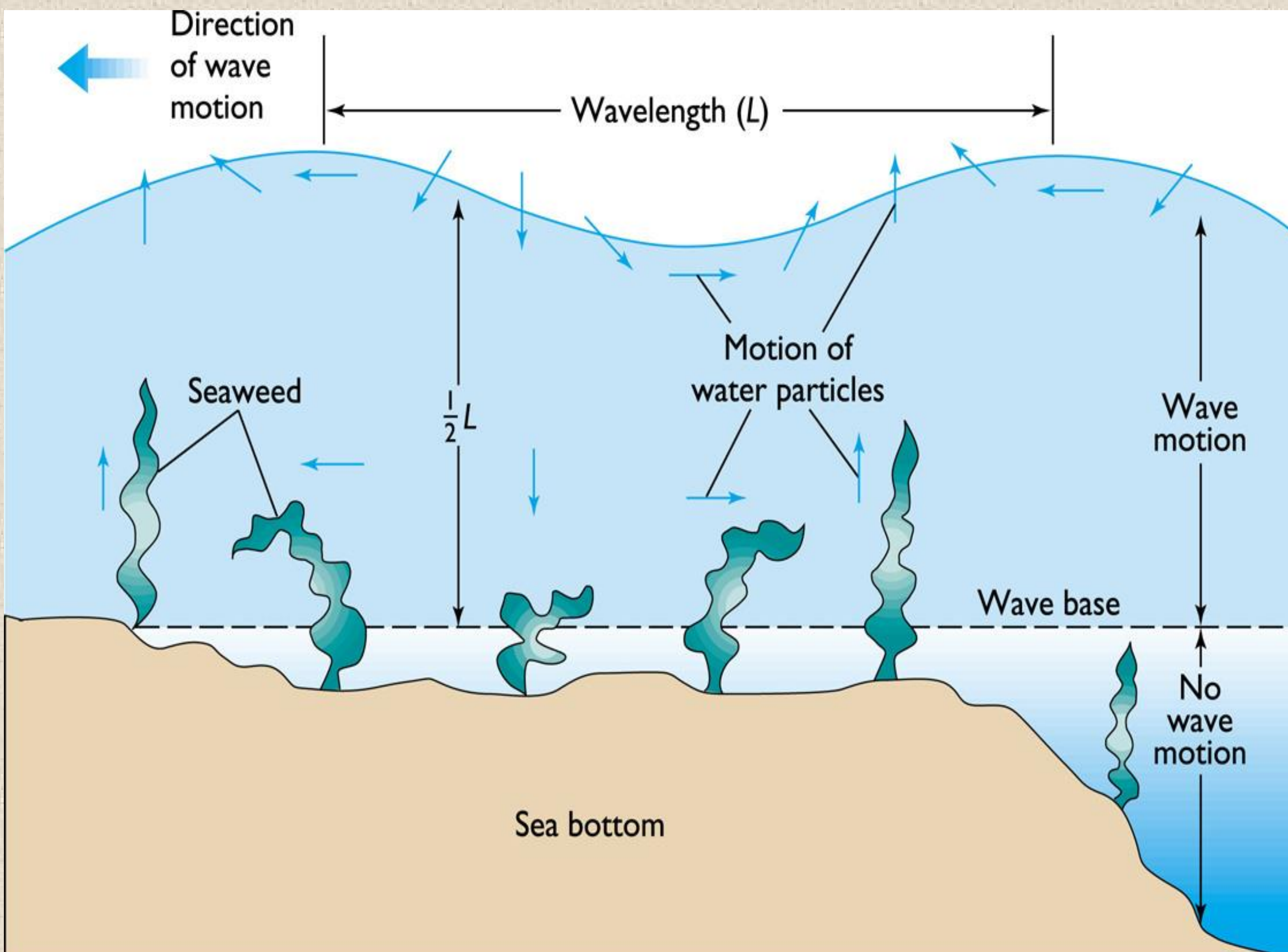


Most of the waves present on the ocean's surface are wind-generated waves.

- **Size and type of wind-generated waves are controlled by: Wind velocity, Wind duration, Fetch, and Original state of sea surface.**
- **As wind velocity increases wave length, period and height increase, but only if wind duration and fetch are sufficient.**
- **Fully developed sea is when the waves generated by the wind are as large as they can be under current conditions of wind velocity and fetch.**
- **Significant wave height is the average wave height of the highest 1/3 of the waves. This odd definition was chosen because visually mariners see the highest aves. However, it is also a good indicator of potential damage to vessels by waves.**



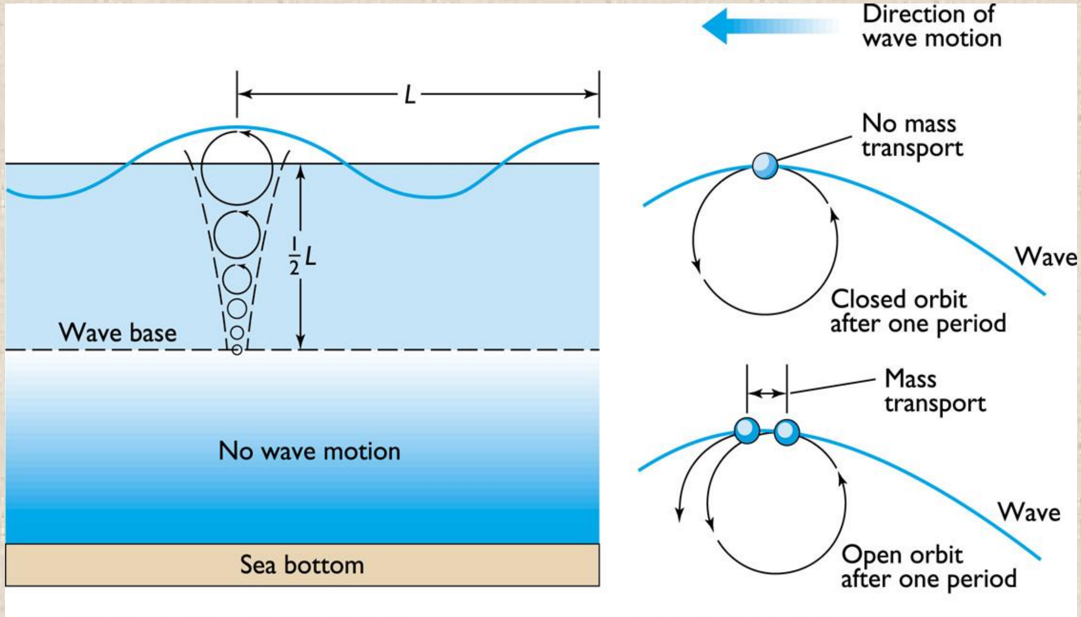
(b) IDEALIZED WAVE SPECTRUM



(a) WAVE MOTION WITH DEPTH

Progressive waves are waves that move forward across the surface.

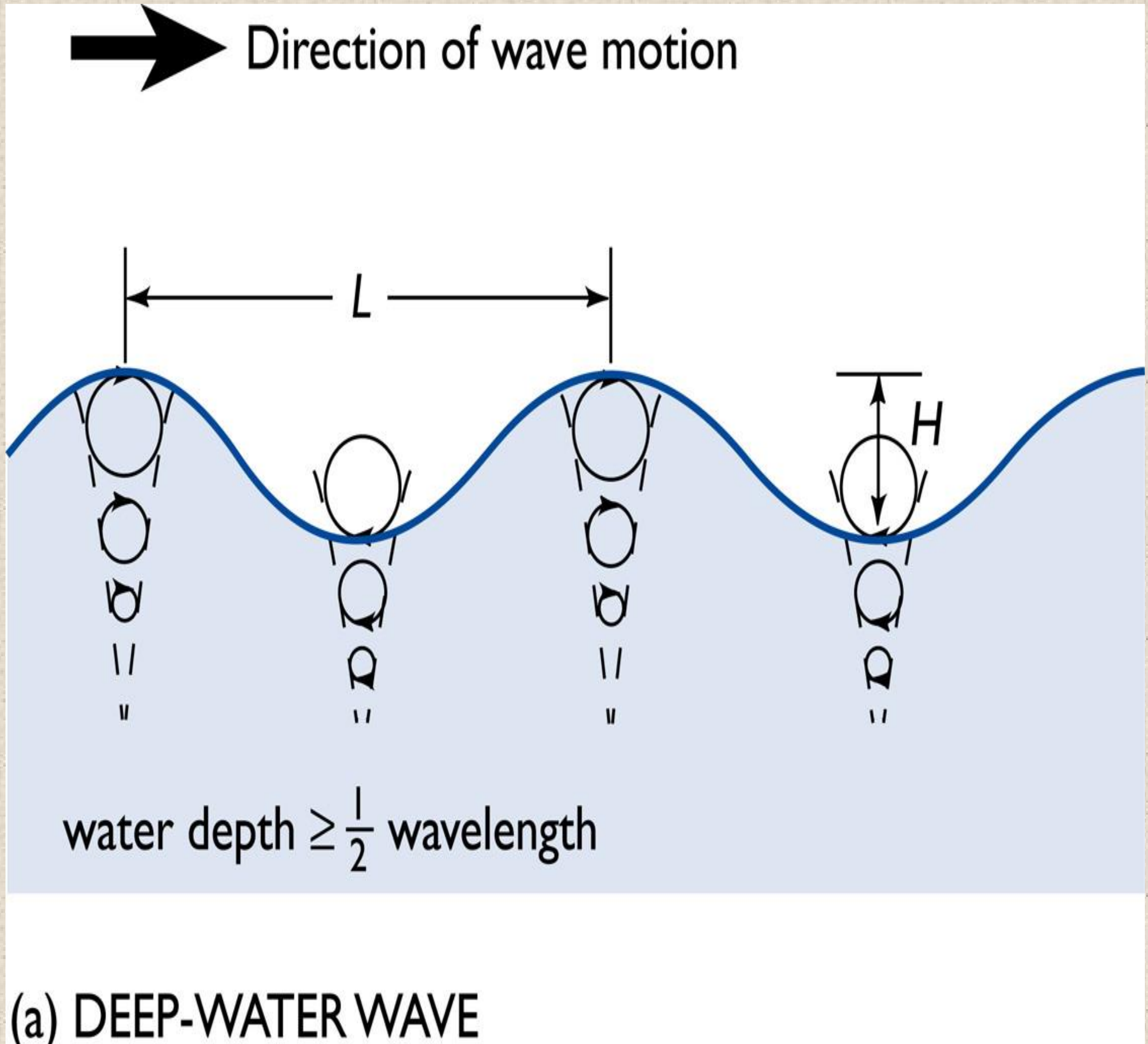
- **As waves pass, wave form and wave energy move rapidly forward, not the water.**
- **Water molecules move in an orbital motion as the wave passes.**
- **Diameter of orbit increases with increasing wave size and decreases with decreasing water depth.**
- **Wave base is the depth to which a wave can move water.**
- **If the water is deeper than wave base, orbits are circular and there is no interaction between the bottom and the wave, but if the water is shallower than wave base, orbits are elliptical and become increasingly flattened towards the bottom.**

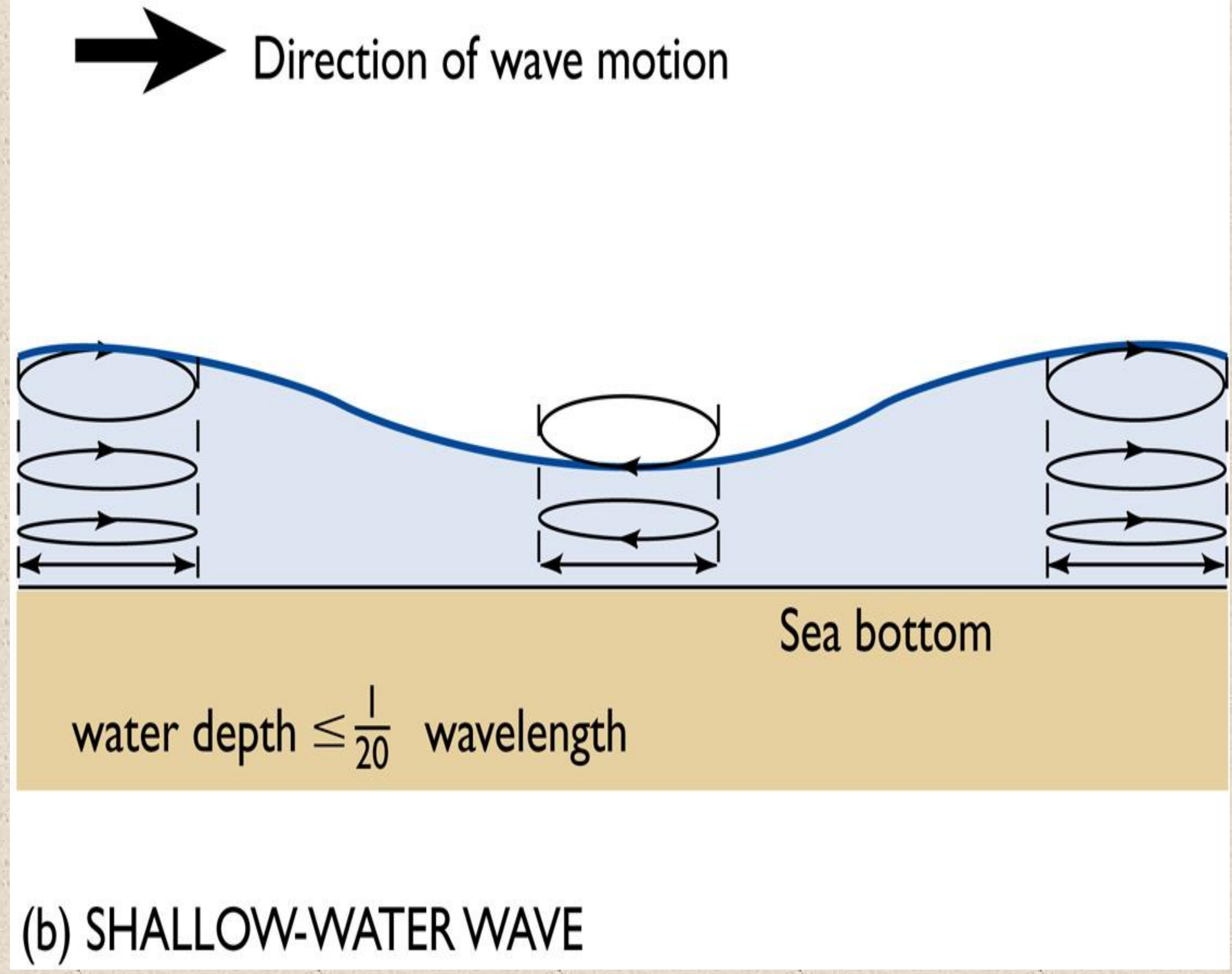


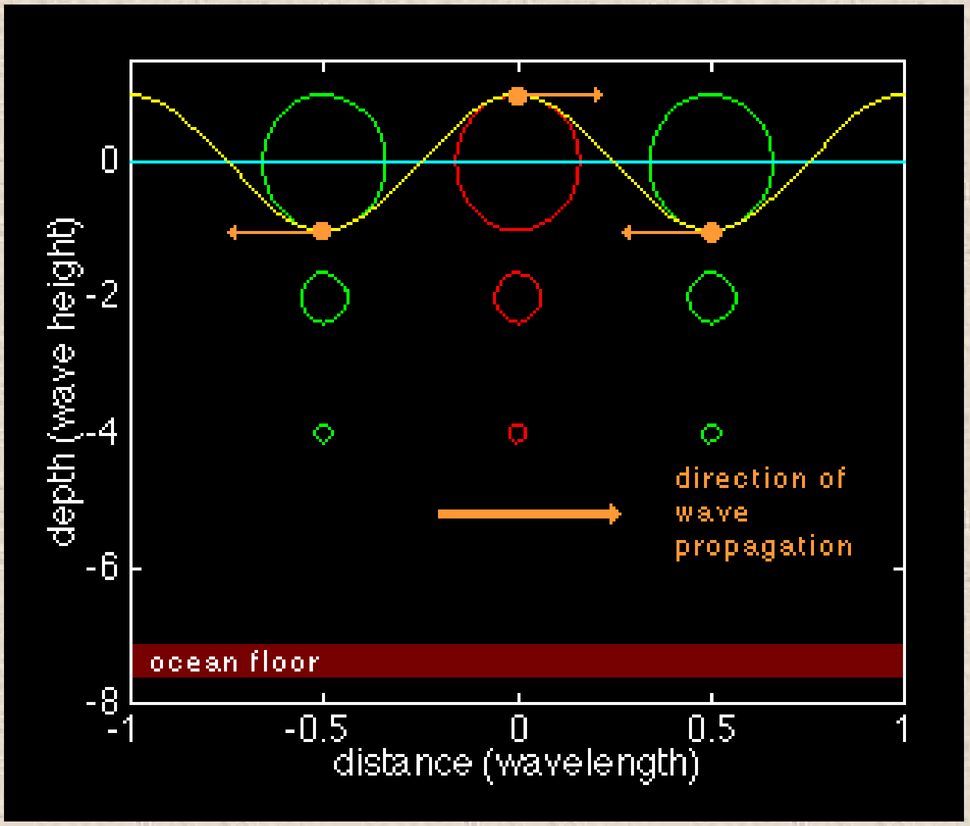
(b) ORBITS OF WATER PARTICLES (c) STOKES DRIFT

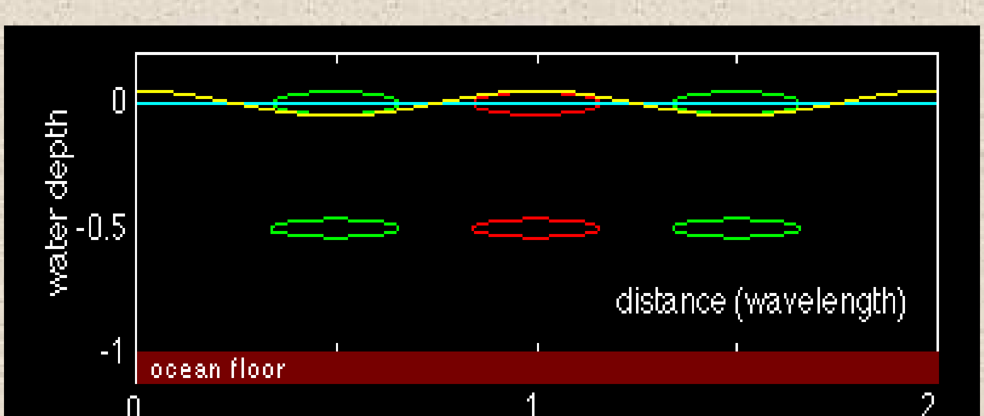
7-2 Wave Motions

- **There are three types of waves defined by water depth: Deep-water wave, Intermediate-water wave, and Shallow-water wave.**
- **Celerity (speed) is the velocity of the wave form, not the water, C= L/T.**


Direction of wave motion
L
H
water depth ≥ 1/2 wavelength
(a) DEEP-WATER WAVE


Direction of wave motion
Sea bottom
water depth $\leq \frac{1}{20}$ wavelength
(b) SHALLOW-WATER WAVE





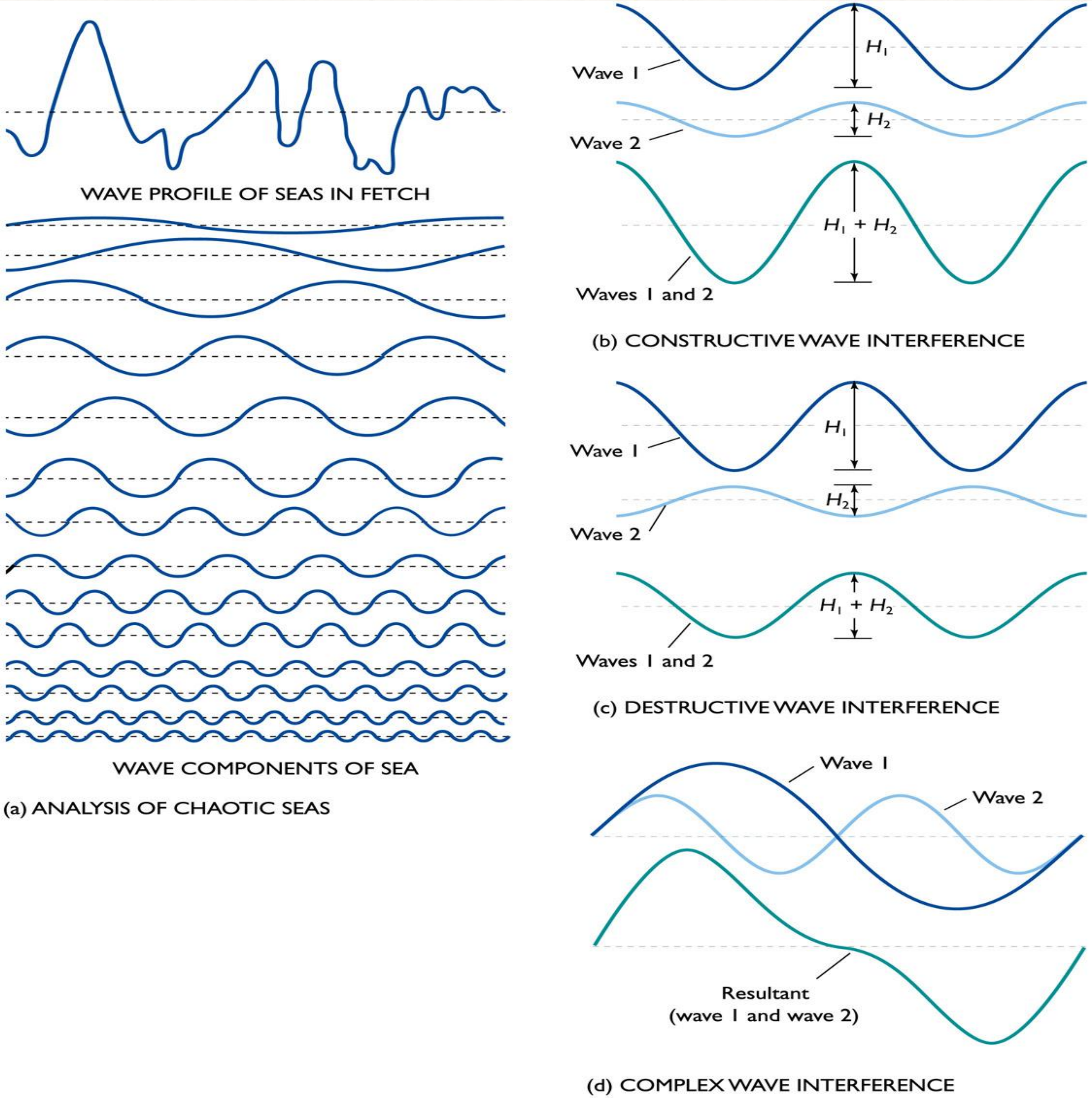
Particle movement in deep and shallow water waves

The diagrams use vertical exaggeration for clarity. First diagram: deep water waves. Second diagram: shallow water waves.

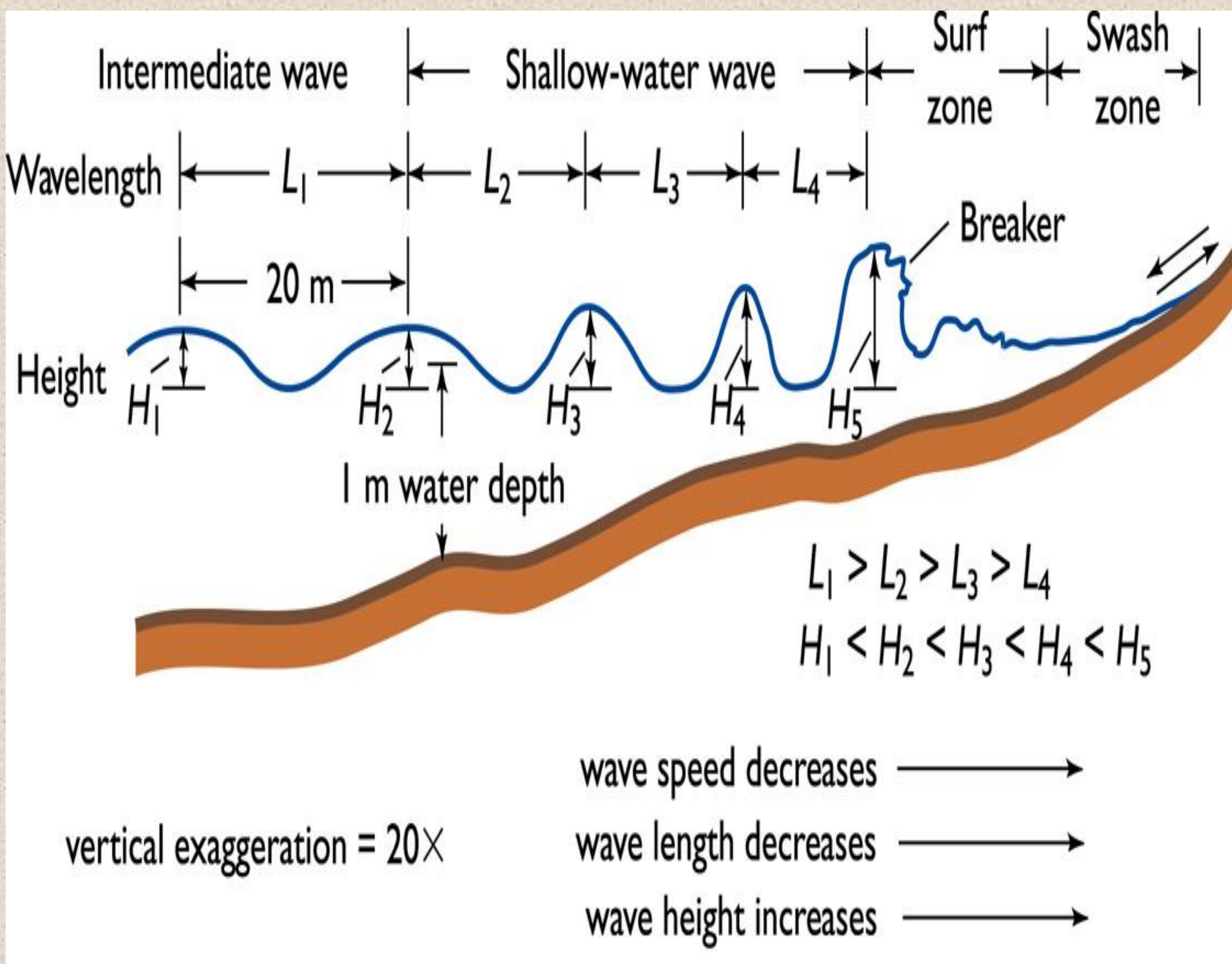
In deep water waves particles move on circles, in shallow water waves particles move on very flat ellipses.

Particle movement decreases rapidly (exponentially) with depth in deep water waves but remains essentially the same over the entire water depth in shallow water waves.

In both cases, particles under wave crests move in the direction of wave propagation; particles under wave troughs move against the direction of wave propagation.



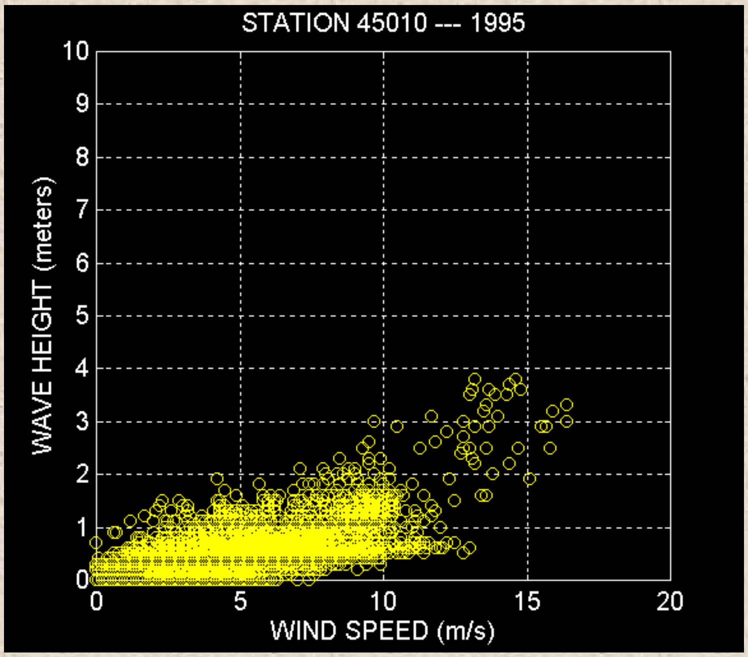
WAVE PROFILE OF SEAS IN FETCH
WAVE COMPONENTS OF SEA
(a) ANALYSIS OF CHAOTIC SEAS
Wave 1
Wave 2
Waves 1 and 2
H_1
H_2
$H_1 + H_2$
(b) CONSTRUCTIVE WAVE INTERFERENCE
Wave 1
Wave 2
Waves 1 and 2
H_1
H_2
$H_1 + H_2$
(c) DESTRUCTIVE WAVE INTERFERENCE
Wave 1
Wave 2
Resultant
(wave 1 and wave 2)
(d) COMPLEX WAVE INTERFERENCE



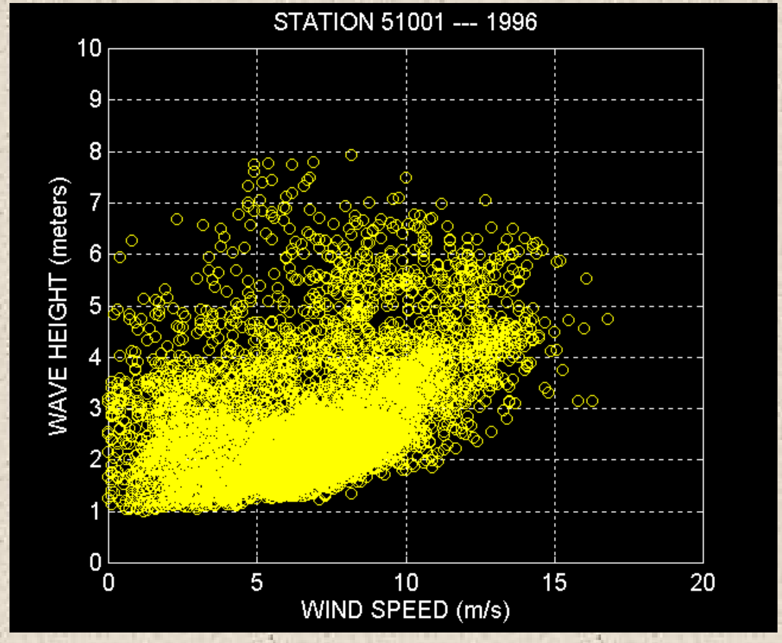
(b) SHALLOW-WATER WAVES IN PROFILE

Life History of Ocean Waves

- **Initial Wavelets – Ripples form over calm water with an initial breeze. Small eddies generate pressure fluctuations on the water to form these ripples a few millimeters in height, and are small and slow-moving.**
- **Growth of Waves - The differential push of the wind on the windward versus leeward side of the wave increases the height and wavelength of the waves, as long as the wind is faster than the velocity of the waves.**
- **Smaller waves form on the larger waves by local eddies, and can contribute to growth by nonlinear interactions.**
- **Spectrum of Waves - As waves grow, increasing amounts of wave energy are at longer periods and wavelengths. Thus, the growth by wind starts with small, high frequency waves and develops towards larger, lower frequency waves.**
- **As the sea develops, the longer wavelength waves move faster than the shorter waves. Recall that celerity is proportional to wavelength. Hence, wavelength is wind-dependent.**
- **Fully-developed Waves - Rate of energy supplied by the wind equals that dissipated by ocean turbulent dissipation. It’s a function of wind duration, wind speed, and fetch size.**

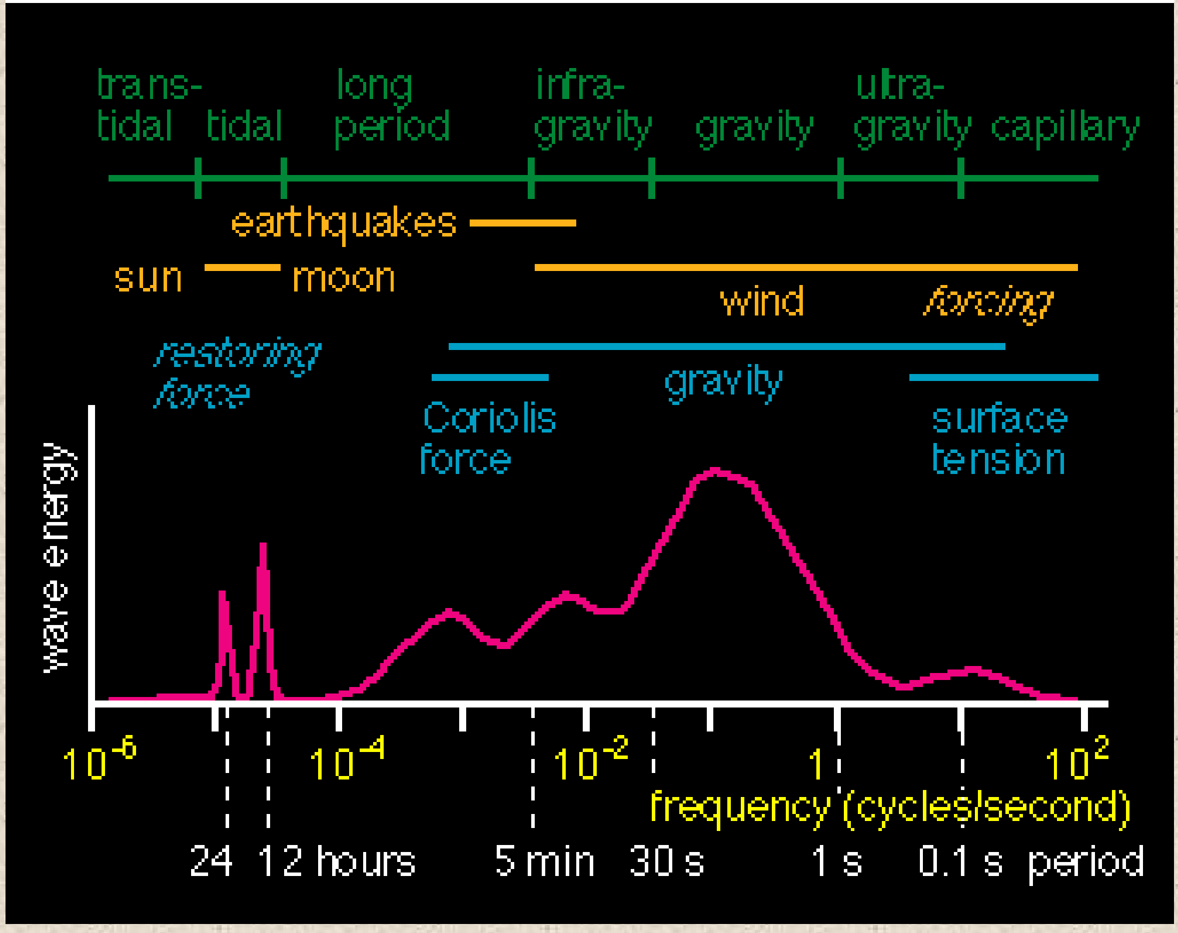


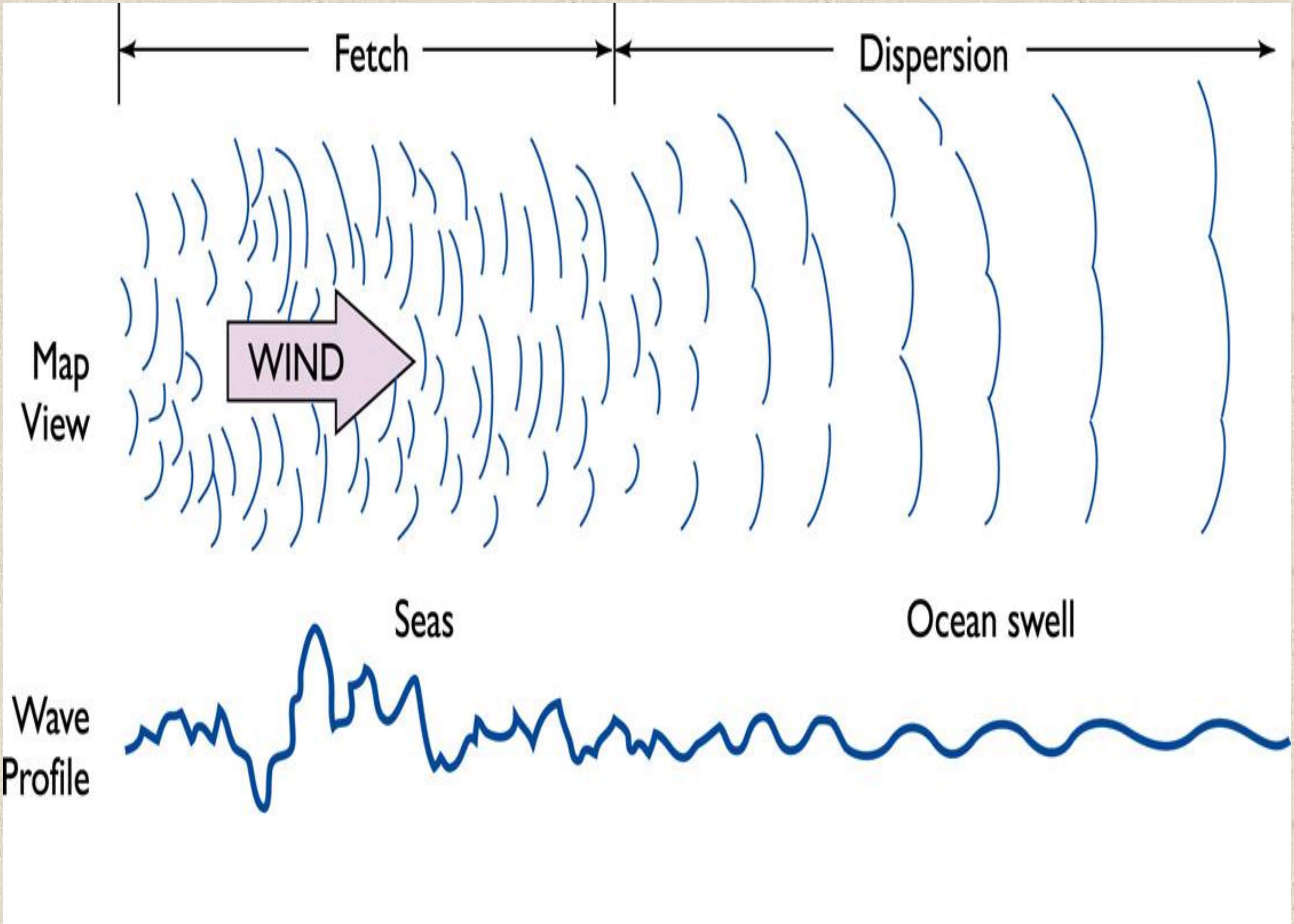
Great Lakes



Open Ocean

Sketch of the relative amounts of energy as a function of wave frequency in ocean waves. The top line (green) gives the classification based on period, the line below (gold) the classification based on the wave-generating force, and the bottom line (blue) the classification based on the restoring force.





(a) DEEP-WATER WAVE TRANSFORMATIONS

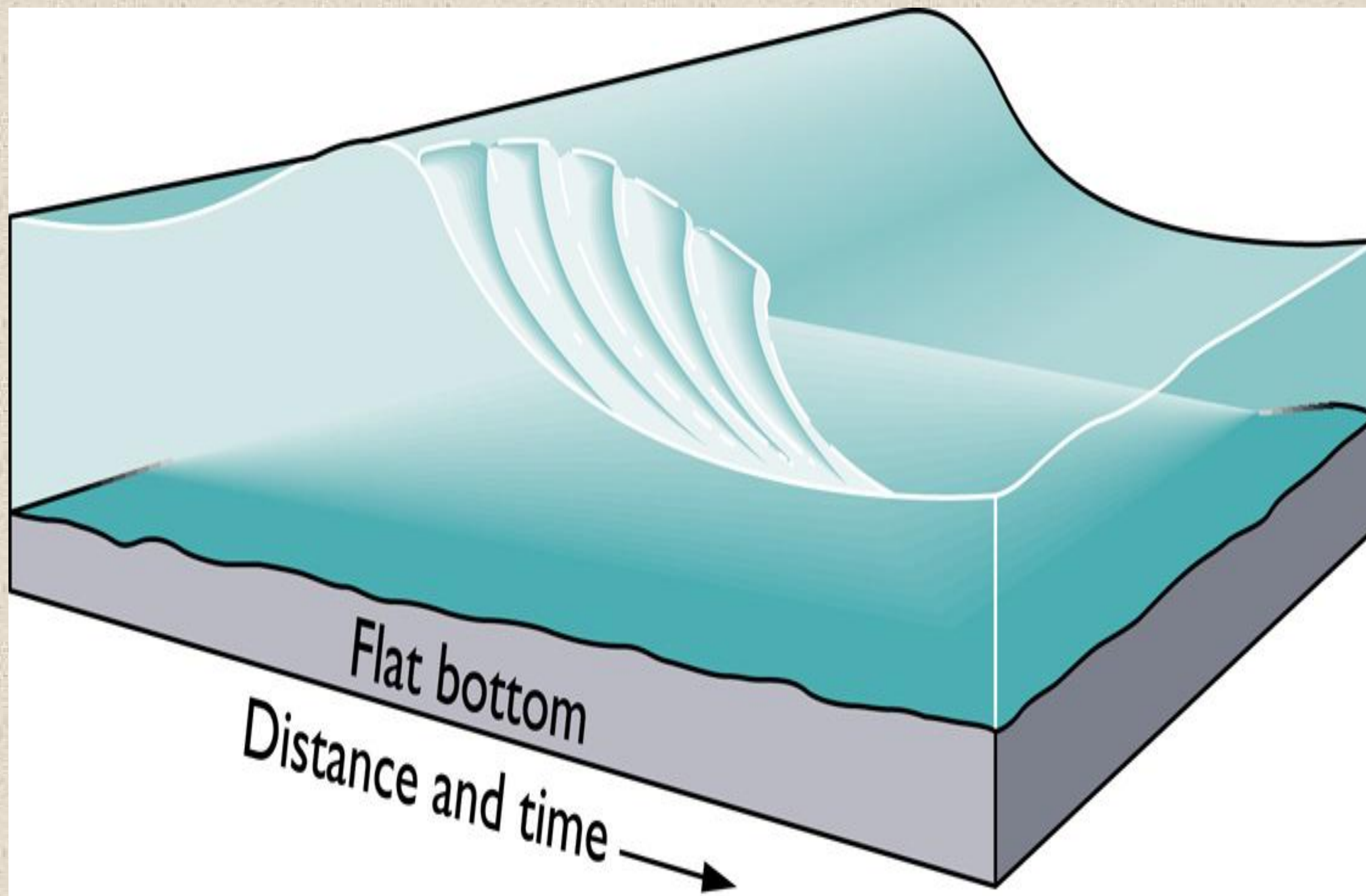
7-3 Life History of Ocean Waves

The shallower the water, the greater the interaction between the wave and the bottom alters the wave properties, eventually causing the wave to collapse.

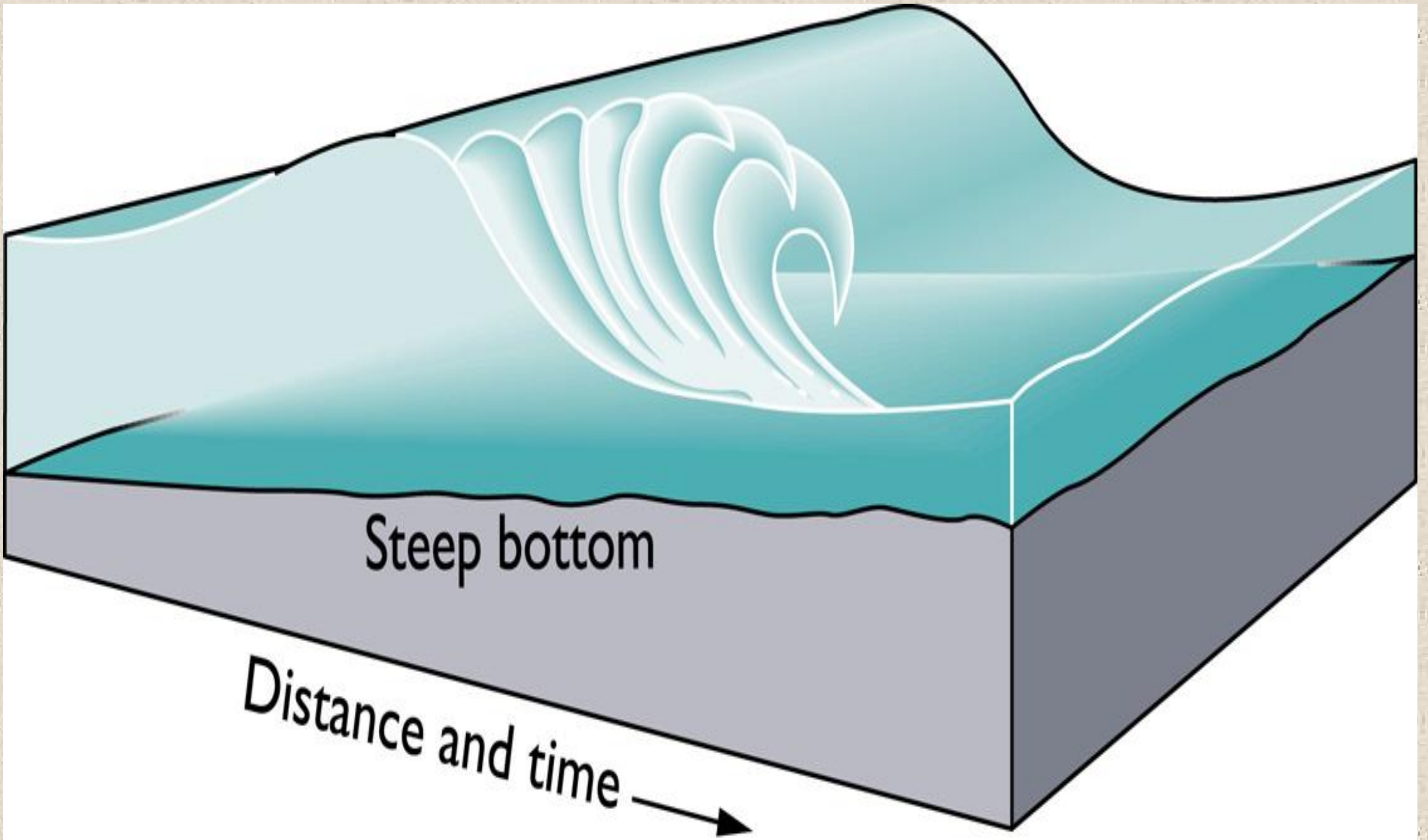
- **Celerity decreases as depth decreases.**
- **Wave length decreases as depth decreases.**
- **Wave height increases as depth decreases.**
- **Troughs become flattened and wave profile becomes extremely asymmetrical.**
- **Period remains unchanged. Period is a fundamental property of a wave**
- **Refraction is the bending of a wave into an area where it travels more slowly.**

Wave steepness (stability) is a ratio of wave height divided by wave length (= H/L).

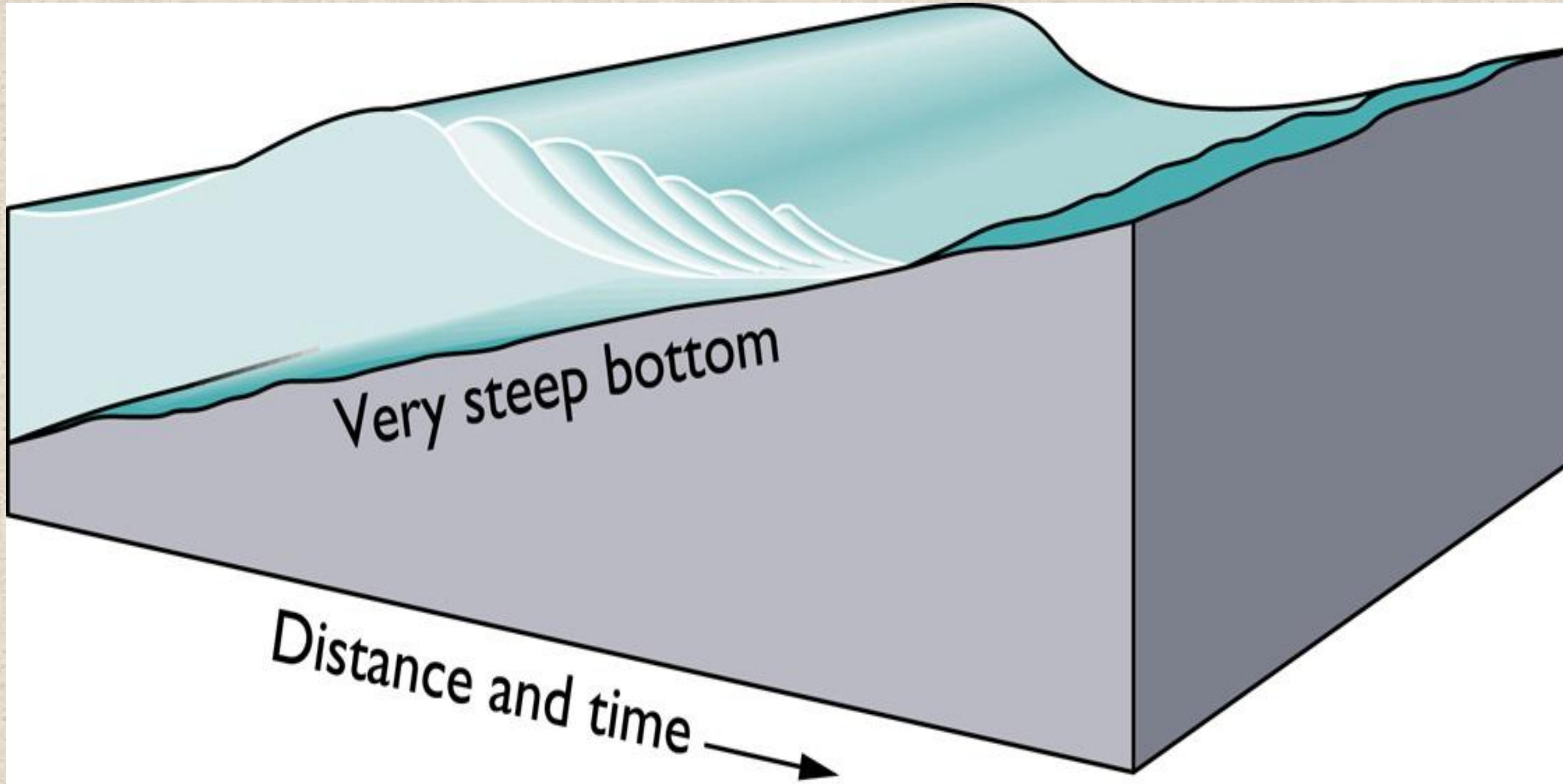
- **In shallow water, wave height increases and wave length decreases.**
- **When H/L is larger than or equals 1/7 ($H/L \geq 1/7$), the wave becomes unstable.**
- **There are three types of breakers:, Spilling breakers, Plunging breakers, and Surging breakers.**



(a) SPILLING BREAKER



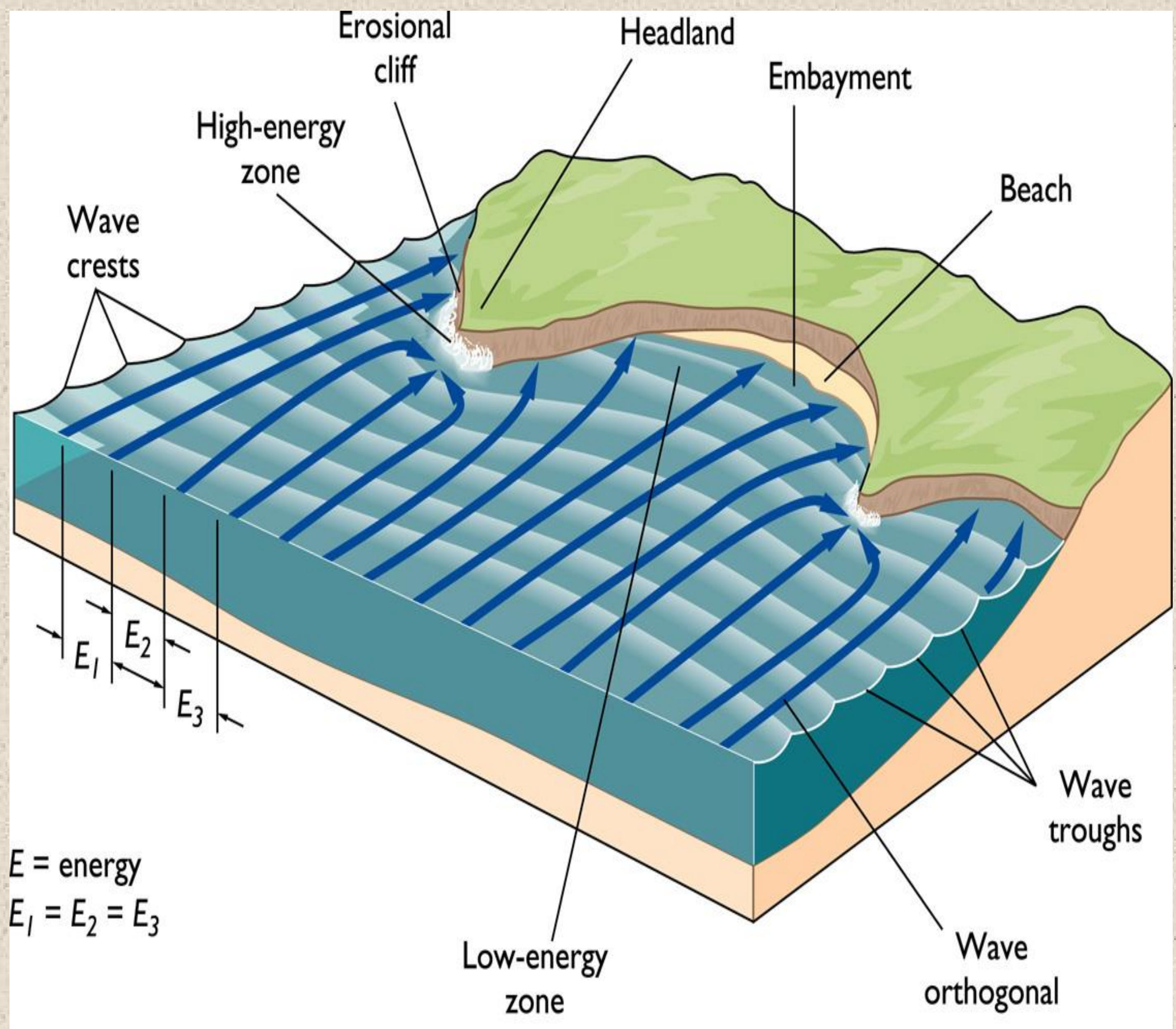
(b) PLUNGING BREAKER



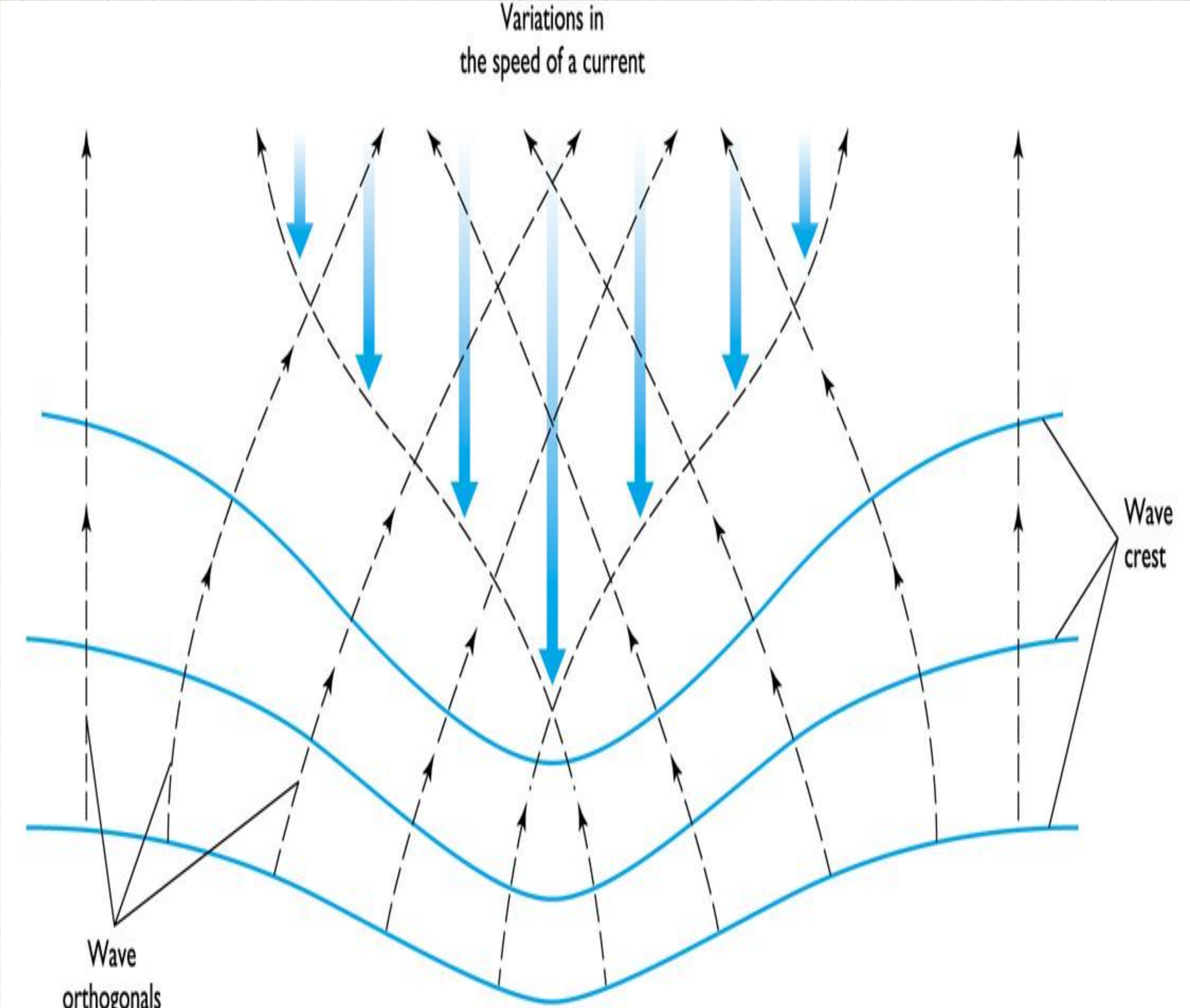
(c) SURGING BREAKER


photo: Al Shaben

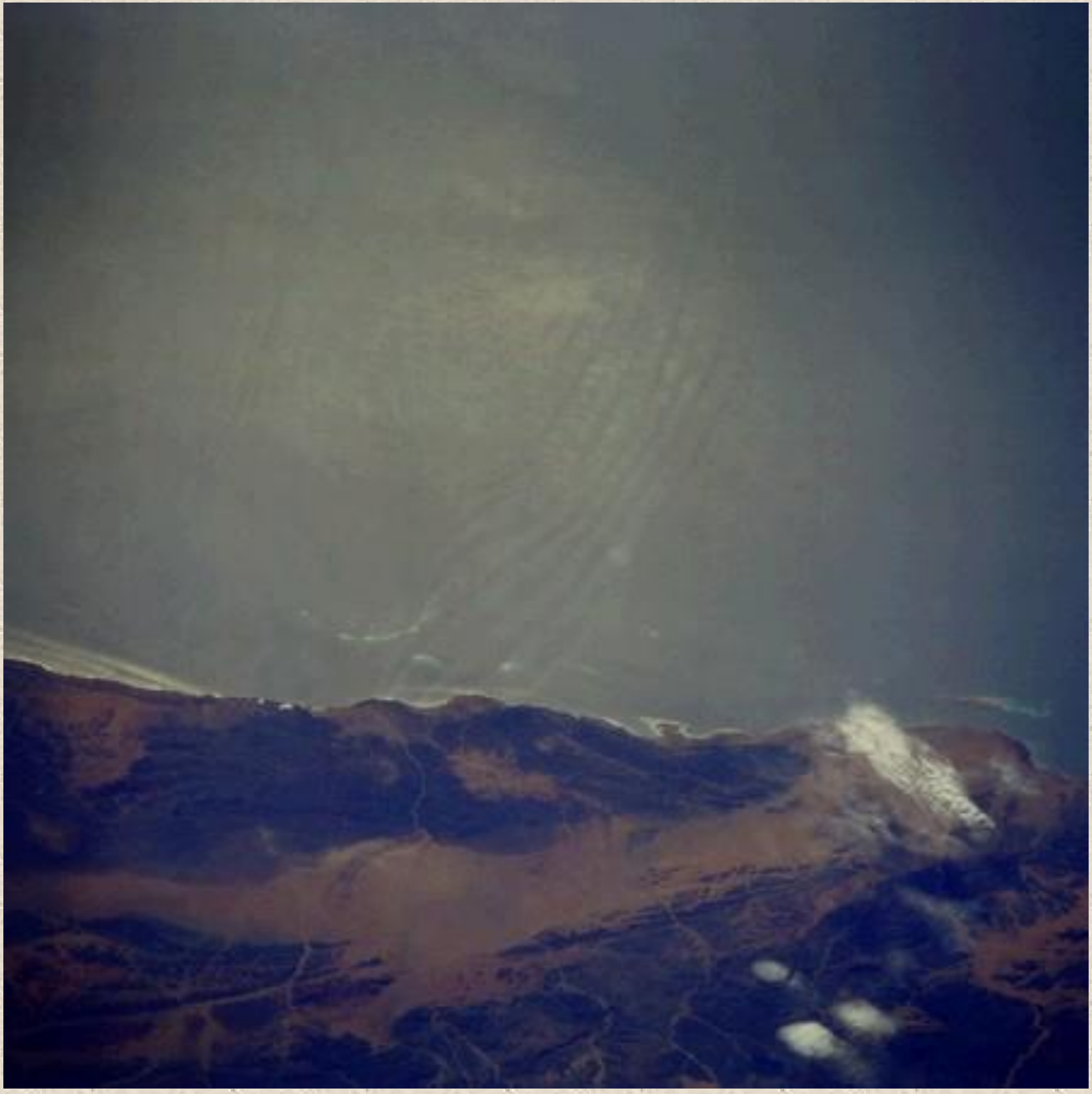

photo: Al Shaben



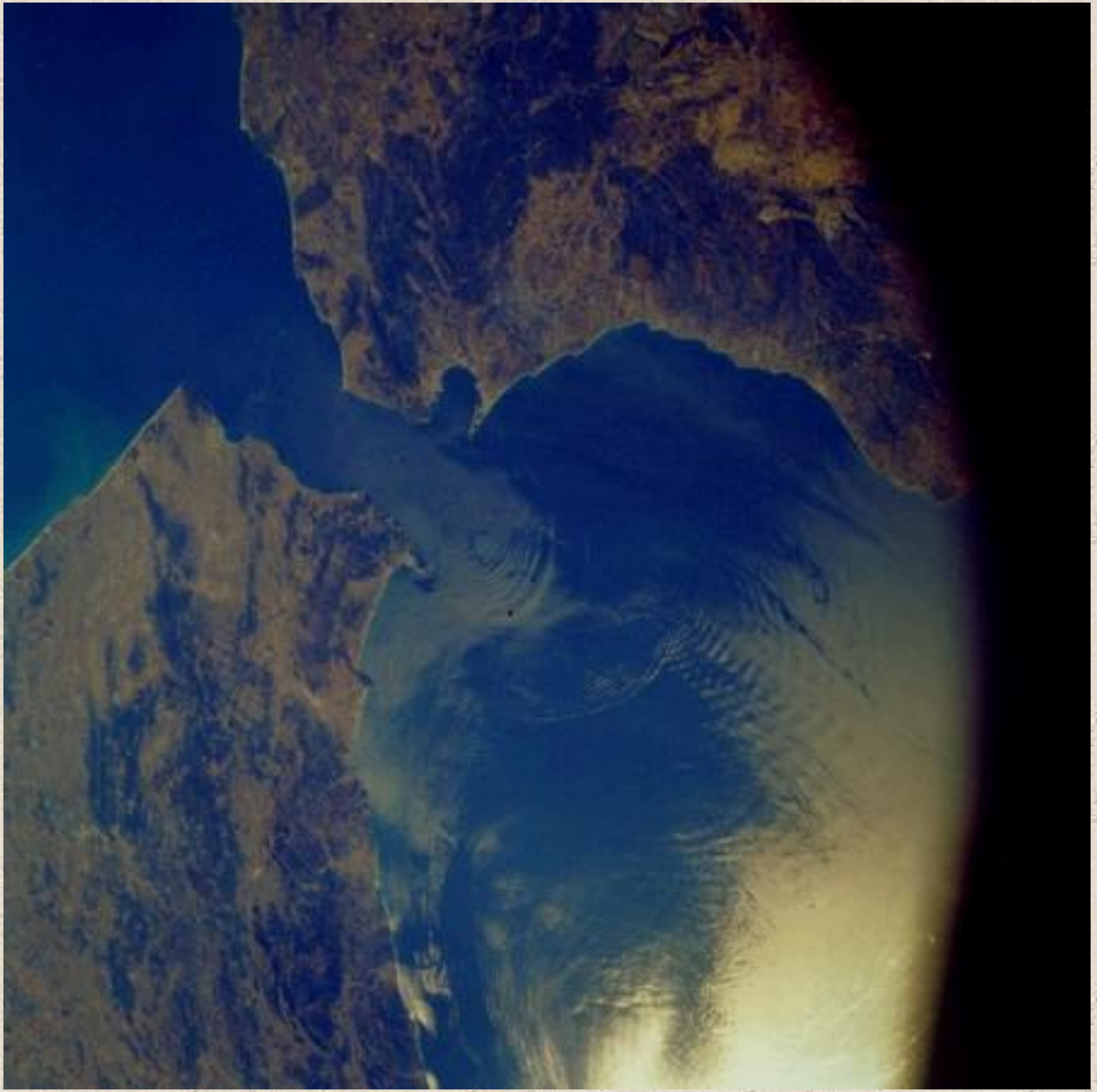
(a) WAVE REFRACTION

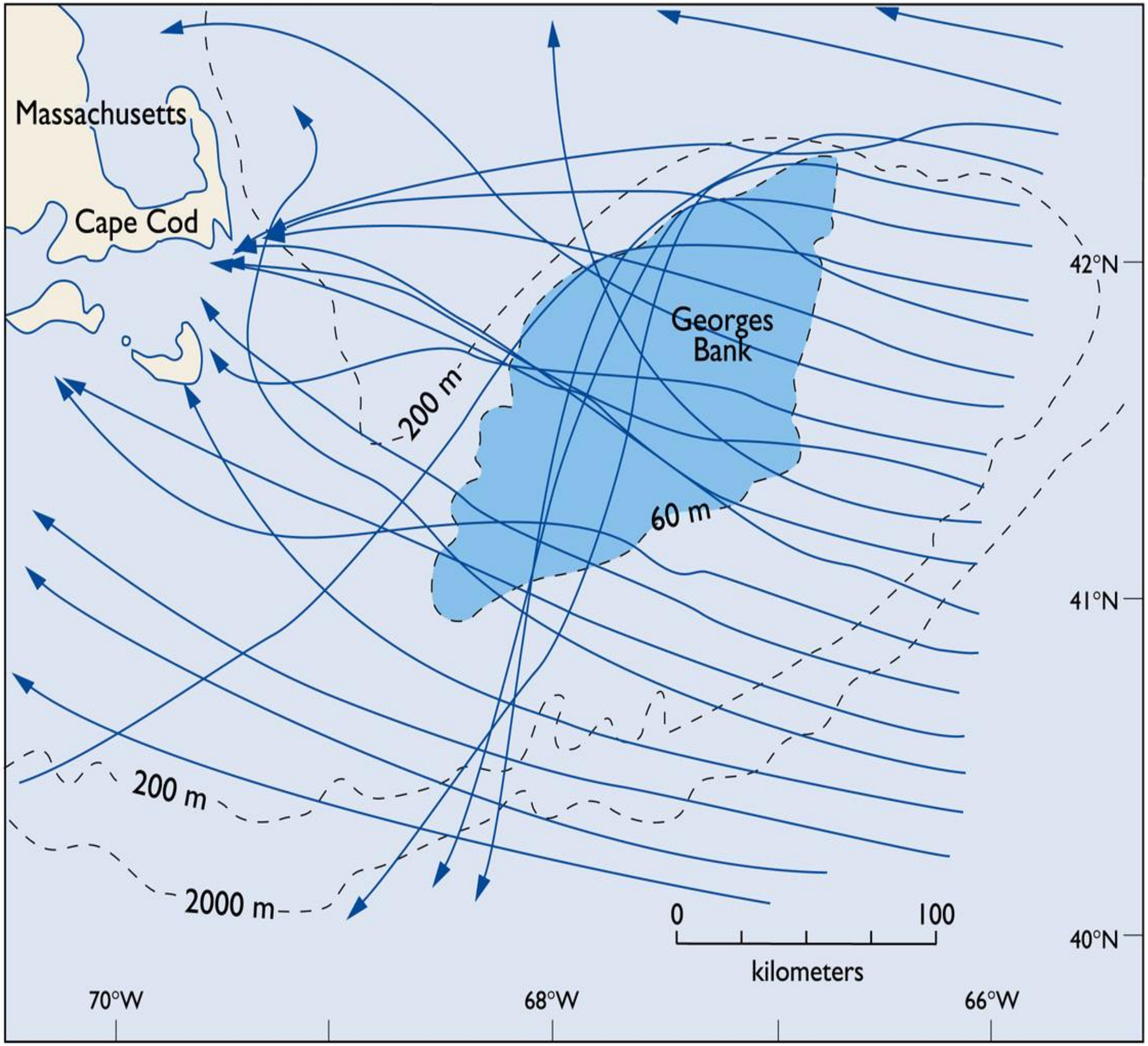

Variations in
the speed of a current
Wave
crest
Wave
orthogonals

Refraction along California

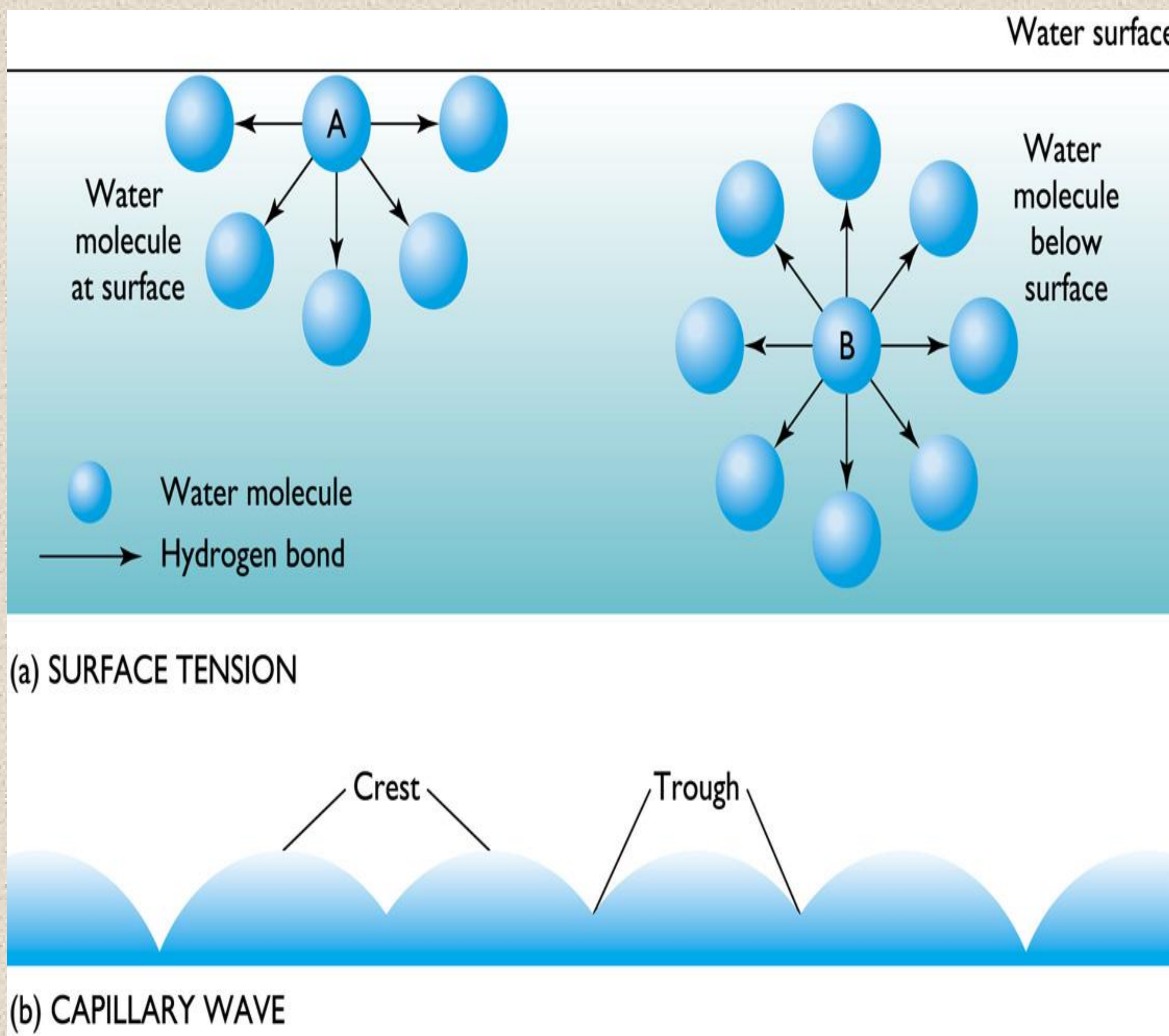


Gibraltar





(b) WAVE REFRACTION OFF CAPE COD


Water surface
A
Water molecule at surface
B
Water molecule below surface
Water molecule
Hydrogen bond
(a) SURFACE TENSION
Crest
Trough
(b) CAPILLARY WAVE

Deadly 100' Rogue Waves Destroy World's Giant Ships Scientists Baffled by Giant Walls Of Water

What Is a Rogue Wave?

A "rogue wave" is typically used to describe a wave that is significantly larger than other waves during a given time, at a given location. Several factors can create rogue waves. Multiple waves can intersect to create a much larger wave- up to the sum of the heights of the waves that combine. Additionally, currents can contribute to the formation of rogue waves. And rogue waves can result as a normal part of the wave spectrum. In other words, waves are not created individually but rather, in large groups. And a wave(s) within this group can be significantly larger than the rest.

Rogue waves have been witnessed all around the world. The North Sea, Gulf of Alaska, S. African coasts are infamous for producing rogue waves- some that have approached 100 feet in height.

Rogue Wave in the Agulas Current