Characterizing and describing waves

"...at the present day, understanding of the mechanism of wave formation and the way that waves travel across the ocean is by no means complete."

- models of idealized fluids
- complexity of real ocean waves
Characterizing and describing waves

- Basic terminology

  - $T =$ period = time interval between two peaks passing a fixed point
  - $f = (1/T) =$ number of peaks passing a fixed point per second.
  - $L =$ wavelength
  - $H =$ wave height

Characterizing and describing waves

- What are waves?
  - Transfer a disturbance (energy) through material
  - Material remains essentially stationary
  - The wave form is relatively stable
  - The disturbance moves at approximately a constant speed

- Wave types – surface waves
  - Ocean-atmosphere interaction
  - Surface tension

Characterizing and describing waves

- Wind Waves
  - Wind $\rightarrow$ Frictional Stress $\rightarrow$ Energy

  - Wave generation reaches maximum at wavelength ($L$) corresponding to a speed $1/3$ that of wind speed. After that point transfer continues at decreasing rate.

  - Fully developed sea: equilibrium state
    - size and character of waves stop changing
    - reality $>>$ wave field
Characterizing and describing waves

Wave field

Wave theory, propagation, and dispersion

Motion of water particles
- Surface: orbital diameter = wave height
- Diameter decrease exponentially with depth
- Zero displacement at depth = L/2
- With depth < L/2, orbital pattern is flattened

Wave theory, propagation, and dispersion

Wave speed, \( c \)
- \( c = \frac{L}{T} \)

- \( c = \sqrt{\frac{gL}{2\pi \tanh \left( \frac{2\pi d}{L} \right)}} \) (variable depth)

- \( c = \frac{gL}{2\pi} = \sqrt{\frac{gL}{2\pi}} \) (deep water)

- \( g = 9.8 \text{ m s}^{-2} \)

Wave theory, propagation, and dispersion

Wave dispersion and sets
- “Those deep-water waves that have the greatest wavelengths and longest periods travel fastest, and thus are first to arrive in regions distant from the storm which generated them.”
- Dispersion = waves separate based on differing speeds, \( c \)

- \( c_g = \frac{c}{2} \) if \( c_1 = c_2 \).

- two wave trains in “phase” are a “set” or “group”
Swells (energy dispersion)

- Local waves and wind have little influence on the size and progress of swell waves.
- 90% of sea surface energy radiates out within 30-45 degree angle of wind direction.
- Spreading loss: wave energy over wide dispersion front
- Farther from the storm, more organized the wave energy