Physical Oceanography
waves, currents, circulation, evaporation

old sow vortex
toroidal vortices

Water Cycle
Carbon Cycle
Types of Waves
How Waves form
Anatomy of a wave
Currents
Coriolis
El Nino
Tides
Waves

- A disturbance which moves through or over the surface of a fluid
- Mostly caused by winds
  (Also earthquakes, volcanoes, grav. pull)
- Form of great energy
Parts of a wave:

- **Parts of a Wave**
  - **Crest** = high point
  - **Trough** = low point
  - **Height** = vertical distance from crest to trough
  - **Wavelength** = Horizontal distance between crest to crest or trough to trough

Wave period: time for 2 crests to pass fixed point (T) sec

Wave speed (C): \( C = \frac{\text{wavelength}}{T} \) (m/s)

Wave steepness: \( H / \text{wavelength} \)

When \( H / \text{wavelength} = 1/7 \) or angle at crest 120 or less = Breaker

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**Size of Wind Generated Waves**

- **Depends on 3 things:**
  - Wind Speed
  - Wind Duration (length of time wind blows)
  - “Fetch” Extent of open water across which the wind can blow

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**Wave movement**

- Water travels in vertical circular orbits
- Wave moves, particles don’t!
Importance of Waves

➢ Shaping Coastlines
  • Erode cliffs
  • Grind rock into sand

➢ Ecology
  • Returns O₂ to water
  • Stir up food for filter feeders

Types of Waves

CHOP – Short period (back bays)
SWELL – Long period (boat rolls; seasickness)
SWASH – Water up beach  BACKWASH – Back down

Spilling: break when wind pushes them (wave breaks apart)
Plunging: curl over and break (perfect wave)
Surging: never really curls just washes ashore
TSUNAMI  “TIDAL WAVE”

Caused by undersea quake or volcano
- Wavelength = ~150 mi.
- Wave height = 6” – 1’
  Can NOT perceive in boat
  Speed > 500 mph
  Slows down to ~25 mph at shore; water builds up to ~65+ ft

Tsunami Waves
Tides occur four times a day (most of the time). Two High tides and two low tides that are 50 minutes longer each time. (because it takes the moon 24 hours and 50 minutes to circle the Earth).

The moon is the main gravitational pull but the Sun also plays a role.

The heights and time of tides vary depending on where you are on Earth and what the geography of your location is like.

Tides

➢ The rhythmic rise and fall of the ocean’s water
   High tide = rising, incoming tide, flow
   Low tide = receding, outgoing tide, ebb
➢ Slack tide = vertical movement stops
➢ Produced by motions of Earth, sun, & moon
➢ Bulge on opposite side because centr. force > pull of moon
Tides are very long, slow waves:
- They have a wave period of 12 hours 25 min
- Tidal day is 24 hours 50 min
- MA has 2 high and 2 low tides daily

Interactive tide

Tidal bulge

Interactive tide

Tidal bulge

Produced by motions of Earth, sun, & moon

Bulge on opposite side because centr. force > pull of moon

Tides

Earth and moon rotating around each other

Figure 1

High highs
Low Lows

High Lows
Low Highs

High highs
Low Lows

High Lows
Low Highs
Importance of Tides

- Expose & submerge organisms
- Circulate water in bays & estuaries
- Circulates food, wastes, etc
- Trigger spawning (grunion, horseshoe crab)

Tidal Bores

a super cool event when the tide comes in all at one time. Happens in Anchorage, AK and The Bay of Fundy, Canada
Rogue, freak, or killer waves have been part of marine folklore for centuries, but have only been accepted as a real phenomenon by scientists over the past few decades.

Rogues, called 'extreme storm waves' by scientists, are those waves which are greater than twice the size of surrounding waves, are very unpredictable, and often come unexpectedly from directions other than prevailing wind and waves.

Most reports of extreme storm waves say they look like "walls of water." They are often steep-sided with unusually deep troughs.

Since these waves are uncommon, measurements and analysis of this phenomenon is extremely rare. Exactly how and when rogue waves form is still under investigation, but there are several known causes.