Oceanography Chapter 10

Waves – disturbances caused by the movement of energy from a source through some medium.

Floating Gull- Figure 10.1 – water is not moving – only the energy is moving through the water.

Transfer of energy from water particle to water particle – circular path, an orbit

Orbital waves – a wave in which particles of the medium (water) move in closed circles as the wave passes.

- These types of waves occur between fluids of different densities as well as between air/water.

These waves are Progressive Waves – move forward through their medium.

Parts of the wave:
Wave Crest: highest Part of the wave

Wave Trough: valley between wave crests

Wave Period: time it takes for a wave to move a distance of one wave length.

Wave Length: horizontal distance between two successive crests (or troughs)

Wave Frequency: the number of waves that pass a fixed point per second

Motion of the wave is negligible after ½ wavelength in depth

Figure 10.3 indicates that water molecules in the crest of a passing wave move in the same direction as the wave, but molecules in the trough move in the opposite direction.

Stokes Drift- the small net amount of mass transport of water in the direction of a wave

<u>CLASSIFYING WAVES</u>
Ocean waves are classified by:
1. Disturbing force-creates them
2. Influence of Disturbing Force once the wave is formed
3. Restoring Force- tries to flatten waves
4. Wavelength

Disturbing Forces
1. Blowing wind for wind waves
2. Arrival of a storm surge, change in Pressure – seiche
3. Land slides, eruptions, faulting - Seismic Sea Waves
4. G on Earth –Tides

Forced Waves vs. Free Waves

$\Downarrow$ $\Downarrow$

maintained by its disturbing force | propagates after disturbing force

$\Downarrow$ $\Downarrow$

Tides | Seismic Sea Waves $\Downarrow$ Storm Waves

Restoring Force – dominant force that return the water surface to flatness after a wave has formed in it.

- Gravity for everything bigger than 1.77 cm wavelength
- Only capillary waves are restored by cohesion of the water molecules

Figure 10.5 – explains

Wave Length

- Important measure for size
- Biggest Wavelengths- Tides, Tsunanis, Seiches

WAVE ENERGY – Figure 10.5

DEEP WATER WAVES vs. SHALOW WATER WAVES

Remember wave depth = ½ L

Deep water waves – moving through water deeper than half of their wave length. (Oscillation waves)

Figure 10.6

Transitional waves – travel through water deeper than 1/20 their original wave length, but shallower than ½ their original wave length.

Shallow-Water Waves – waves in water shallower than 1/20 their original wave length (they are breaking)

Of our waves, only capillary and wind waves can be Deep Water.

$$\underset{\text{(speed)}}{C} = \frac{L}{T} \quad \frac{\text{(Wavelength)}}{\text{(Period)}} \quad \frac{m}{s}$$

Since C is always controlled by g: $C = (\underline{gL/2\pi})^{-2}$

$g = 9.8$ m/s

then $C = 1.25(L)^{-2}$

But Period is easier: $C = \frac{gT}{2\pi} = 1.56T$

Thus, if one characteristic can be measured, then the other two can be calculated.

	Wind Waves	vs. Seismic Sea Waves
Period	20 Seconds	20 minutes
Wavelegth	600 Meters (2000′) (extreme)	200 km (125 miles)
Speed	112 km/h (70 mi /hr)	760 km /hr (470 mi/hr)

Wind Waves

- Formed by the transfer of wind energy into water
- Most are less than 3m (10′) high
- Wavelengths from 60-150 m (200-500ft) are common
- Grow from capillary waves (Figure 10.8)
- The wave will continue to grow if it remains in deeper water.

Sea – irregular peaked waves in the area of wind wave formation.

Swell- Smooth undulation of ocean

- Produced by dispersion (wave separation)
- Bigger wavelngths wave move faster ($C = 1.25(L)^{-2}$)

Wave Trains – Progressing groups of swell with the same origin and wavelength

- Front one dissipates and new ones form behind as energy is left behind
- Train itself moves at half the speed of an individual wave (group velocity)

FACTORS THAT AFFECT WIND WAVE DEVELOPMENT

1. The wind must begin moving faster than the wave crests for energy transfer from air to sea to continue – Wind Strength
2. Wind Duration – the length of time the wind blows
3. Fetch – uninterrupted distance over which the wind blows without significant change in direction

Fully Developed Sea – max wave size theoretically possible for a wind of a specific strength, duration and fetch.
→ Table 10.2

Biggest waves can be found in the WWD.

Wind Wave Height – exhibit a max ratio of 1:7 of height to Wavelngth. 7m, 1m high → 70m, 10m high

The angle of their crest will not exceed 120°

If a wave gets lower than this, it will break.

Wave trains or waves meet – Interference

1. Destructive
   - cancelling

2. Constructive
   - addition of crests

Surf Beat- Interference and surfing
- ➢ Ride big ones, swim back out, ride some more
- ➢ No set ratio

Rogue wave- lots of constructive interference
- ➢ 3x height of max in a developed sea, or 4x
- ➢ can also form when high waves hit currents

<u>Waves Approaching the Shore – Figure 10.17</u>

Waves break on the shore:
1. Plunging Waves- form when waves approach a steeply sloping bottom.

2. Spilling wave – form when waves approach a gradual sloped bottom.

Slope alone does not determine how waves will break. If you've got stuff on the bottom, you can loose energy.
- ➢ Sometimes no waves.

Wave Refraction – wave approaches shoreline obliquely.
- ➢ Waves break parallel to the shore (Figure 10.20)

Wave Diffraction – propagation of a wave around an obstacle.
- ➢ Diffracted waves are much smaller.

Internal waves- waves that occur at a boundary between water layers
- ➢ Usually more slowly
- ➢ Generated by wind energy, tidal energy and ocean currents.

Importance – mix nutrients
- ➢ USS Thresher – 1963
- ➢ Oil platform rotated

"Tidal Waves" - not tidal
- Seismics, Seiches, Rogues

<u>Storm Surges (Storm Tides)</u>
- ➢ Abrupt bulge of water driven ashore by a tropical cyclone or frontal storm.

The low atmospheric pressure creates a bulge as much as a 1 meter (3 ft) higher than sea level

- The dome becomes large as the storm surge hits the shoreline
- Can add up to 9 m (30 ft) to coastal sea level (can be even higher in a bay or estuary)
- Short- lived (only a crest)

Biggest – 40 ft – Bangladesh in Nov. 1970 (300k)
1953- Dutch Coast – surge and high tide (drowned 1783 people)
1900 – Galveston, Texas – 6000 residents

Now build protective surge barriers – London, Providence

<u>Seiches</u>
Water moving at a specific resonant frequency
First studied in Switzerland (Lake Geneva)

- Noticed lake level going up and down

Node – water moves back and forth
Energy can be added rhythmically to seiches

Causes: storms, tides, surf beat

In large areas the wavelength may rival a tsunami's. Usually only cause harm if coupled with a tsunami or big wind waves

<u>Tsunami and Seismic Sea Waves</u>

Tsunami – shallow water progressive waves caused by the rapid displacement of ocean water
Tsu – harbor   Nami - wave

Seismic Sea Waves – caused by movement along faults

Tsunami can also be caused by land slides, icebergs falling, volcanic eruptions, and other direct displacements.

All SSW are Tsunami, but not all tsunami are SSW.

Origins
Underwater land slides or other displacements.

Tsunami Formation – Figure 10.30 – Aleutian Islands
X marks the spot of the lighthouse

- 472 mi/hr
- 5 hours to get to Hilo, HA

$$C = (gd)^{-2} = \{(9.8 \text{ m/s})\ (4600 \text{ m})\}^{-2} = 212 \text{ m/s}$$
$$= \{(32.2 \text{ ft})\ \ (15{,}000 \text{ ft})\}^{-2} = 470 \text{ mi/hr}$$

Encountering Tsunami:
It's steepness starts out low – makes it almost imperceptible at sea (along with a long period)

At first - 16 minute period – up for 8, down for 8 (about a foot)

When it approaches shore, the biggest one will achieve 50 feet in height – but not a plunging

150 killed in Hilo.

Tsunami in History

1960-Preu/Chile trench—killed 4000 in S.A, then another 180 when it reached Japan
→ Seiches in LA, SD

1992- Nicaragua—170 people killed

1993- sea of Japan-confined space—100 ft increase-239 people

Figure 10.36—tsunamis—New Guinea (ssw)

Lisbon Portugal—estuary lowered—pick up fish
→ next wave got 'em
→ 50K

Japan –1703—100K

Krakatoa-1883—huge eruption—115 ft, 36K

K/T-may have been 300 feet high.

Tsunami warning network
--data-pressure sensors, seismographs, computer modeling (long wavelength waves)

--crazies