OCE-3014L

Lab 7—Waves & Longshore Currents

- To understand the physics behind the limits of the height and velocity of deep-water wind waves
- To understand the characteristics of wind waves as they move from deep water to shallow water
- To discover what causes waves to peak and break as surf and how they generate longshore currents and dangerous rip currents
- To investigate the dynamics of sand, beach drifting, and beach erosion

Waves at Sea

Waves at sea are created by winds blowing across the water surface and transferring energy to the water by the impact of the air. Small ripples develop first, and frictional drag on their windward side causes them to grow larger, or to collapse and contribute part of their expended energy to larger waves. Consequently, large waves capture increasing amounts of energy and continue to develop as long as the wind maintains sufficient strength and a constant direction.

Generally, high winds of long duration produce large waves with long wavelengths and wave periods. As more and more energy is transferred to the water surface, waves become higher and longer, and travel with increasing wave velocities; 50-foot waves are not uncommon in the open ocean, and waves more than 100 feet high have been reported.

A. Deep-Water Waves

If the water depth (d) is greater then the wave base (equal to one-half the wavelength, or L/2), the waves are called deep-water waves. Deep-water waves have no interference with the ocean bottom, so they include all wind-generated waves in the open ocean. Submarines can avoid large ocean waves by submerging below the wave base.

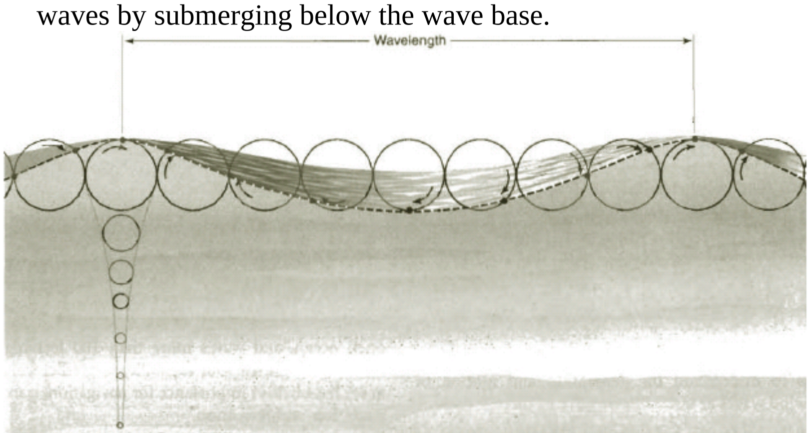


Figure 7a: Cross section of an ocean wave traveling from left to right; wavelength. The time it takes for two wave crest to pass a point is the wave period.

1. Wave Speed (S) = $\frac{\text{wavelength (L)}}{\text{wave period (T)}}$ $\frac{\text{meters}}{\text{seconds}}$

Wave Length (m)	Wave Period (s)*	Wave Speed (m/s)
100	8	
156	10	
200	11	
400	16	
* Typical wave periods range between 6 and 16 seconds		

The longer the wave <u>the longer</u> or <u>the shorter</u> the period? (CIRCLE)

Deep water wave speed depends only on wavelength: The longer the wave <u>the faster</u> <u>the slower</u> the speed? (CIRCLE)

2. **Wave Height:** Go to the website below and click on *Make Waves*
http://www.nationalgeographic.com/volvooceanrace/interactives/waves/index.html
Then Click *Make Waves*
Adjust wavelength and period to create the tallest waves.
What adjustments create the highest waves?

Energy imparted by the wind increases the height, length, and speed of a wave. When wave speed equals wind speed, neither wave length nor wave height can change because there is no net energy exchange and the wave has reached its maximum size, this is called a **fully developed sea.** Factors that determine the amount of energy in waves are 1) **wind speed**, 2) the **duration**—length of time wind blows in one direction, and 3) **fetch**—the distance over which the wind blows in one direction.
One knot/hour = 1.85 km/hr.

3.

The distance from San Pedro, California, to Avalon, on Santa Catalina Island, is about 25 nautical miles (nm). The island is almost due south (180°) from the Los Angeles Harbor at San Pedro.
What is the minimum wind speed that can set up a fully developed sea in this channel with a north wind? Refer to the table below and interpolate between fetch distances 10 nm and 70 nm (rounded to nearest whole number).

_________________ knots _____________________ km/hour

How long must the north wind blow for a fully developed sea to develop (interpolation required)?

_________________ hours

Minimum fetch and duration required for selected wind speeds to set up fully developed seas

Wind speed (knots)	Fetch (nautical miles)	Duration (hours)*
10	10	2
20	70	10
30	280	23
40	710	42
50	1420	69

4. A storm is raging in the North Atlantic 2000 nautical miles due east from Cocoa Beach, Florida. The fetch of the storm (the distance of the open ocean that its winds are whipping up) is *roughly* 1000 nautical miles. Low pressure winter weather conditions are such that the winds are from the east. Refer to the table above interpolating the fetch distance to determine the wind speed to set up a fully developed sea.

______________________________knots ________________________km/hour

How long must the east winds blow for a fully developed sea? __________________hours

B. Swells

The North Atlantic storm (above) was strong enough to whip up waves that slam into each other. If enough waves come together, their energy will create swell that can travel fast enough and far enough to survive a trip around the globe. Along the way, the less energetic, choppy elements of the wave will be lost and smooth glassy faced swell waves will arrive along Florida's east coast.

Swell: Waves that have traveled a long distance from the generating area and have been sorted out by travel into long waves of the same approximate period, which may range between 12 and 24 seconds (longer than that of typical waves).

The first swell arrives offshore encountering a water depth less than one-half its wavelength; it "feels bottom" encountering frictional drag along the bottom. The energy of the wave is compressed causing the crest of the wave to grow taller. It also slows down—the bottom of the wave slows down first, meaning the crest of the wave is traveling faster, overrunning the bottom part. The net result is the wave starts to peak increasing its steepness H/L. When wave steepness reaches a 1:7 ratio, the wave can no longer maintain its shape and spills out its energy in a few seconds by breaking on or near the beach.

5. Increases or Decreases? Choose the correct answer for the 4 blanks below.
As waves come into shallow water and feel bottom

Wavelength________________________ Wave Height_________________________

Wave Speed_________________________ Wave Steepness_______________________

6. Use the internet to access the following site:
http://facs.scripps.edu/surf/images/maps/ganimnep.gif

The image is an animation of the significant wave height for the Pacific Ocean over the next 120 hours (5 days), viewed in 6-hour intervals. Storm centers are shown as areas of high waves.

List today's date_______________ Are most storms located in the northern or southern hemisphere?

_____________________________What season is it in that hemisphere?______________________

Describe location of any storm centers (be specific)______________________________________

____

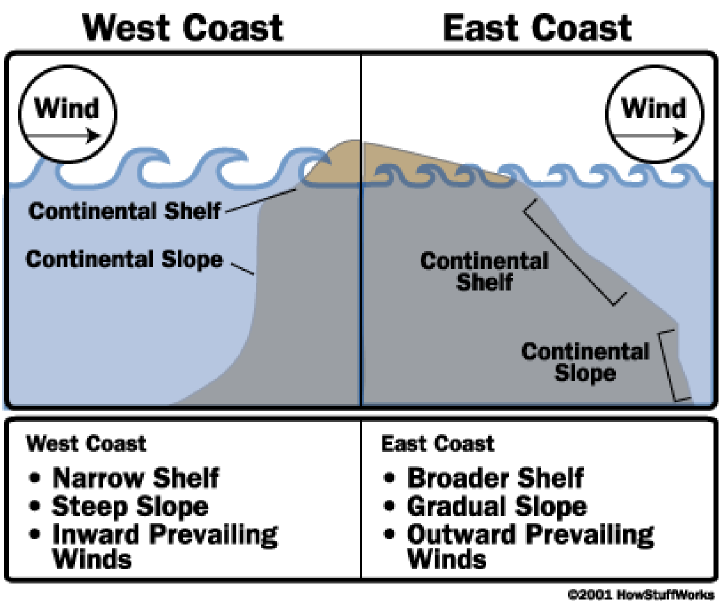
In which direction are they moving? ____
What is the height of the highest wave? ________Ft.

C. Surf Zone Breakers

6. Calculate the wavelength of breaking waves.

Wave Height * (Ft.)	Reference height: adult standing in surf zone*	Breaking Wave's Wavelength (Ft)
3	Waist	
5	Head	
7	Overhead	
10	Double Overhead	

* The measurements above are facing the breaking wave. In Hawaii waves are traditionally measured from the back (seaward) side.



1) Along the East Coast of the U.S. the prevailing Westerlies blow off shore, while along the West Coast Westerlies blow onshore enhancing waves.
2)The Pacific Ocean has a greater expanse than the Atlantic Ocean. This means that the **fetch** (the distance over which the wind blows) is greater on the West Coast than on the East Coast.
3) The West Coast's continental shelf is narrower than the broad gently sloping shelf along the East Coast which has a slowing effect on waves a much greater distance from land. On the West Coast, the shelf rises suddenly near the coast, so the waves are much larger when they crash into the coastline and feel bottom.

7. Hawaiian Waves—Powerful North Pacific winter storms send monster swells to crash on Oahu's north shore. Considering the conditions in the figure above and considering that the Hawaiian Islands are all oceanic volcanoes, what factors might contribute to thirty foot waves arriving on Hawaii's north coast?

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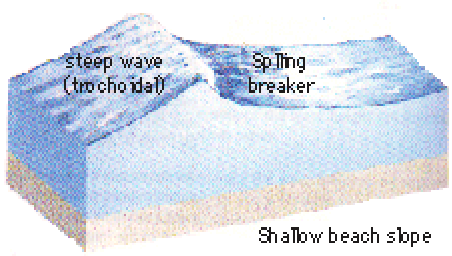
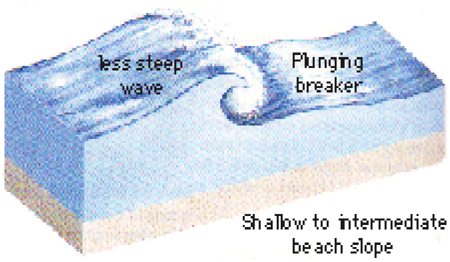
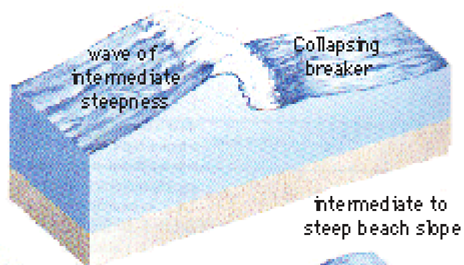
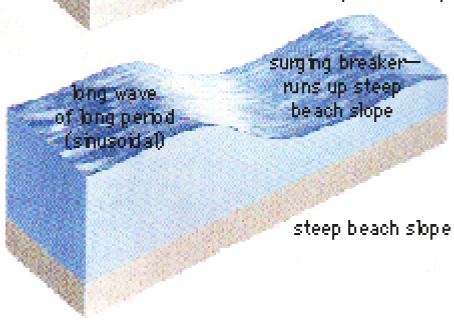
Wave types from a surfing perspective









a. Spilling Breakers, long life span give surfers a long, if unchallenging ride.

b. Plunging "pipeline" Breakers. Ultimate surfing challenge. Curling crest outruns the wave creating an air pocket tube.

c. Collapsing breakers- break irregularly offshore. Large waves can provide short rides where the skill is cutting-out backside before they crash rather than length of ride.

d. Surging breakers build up wall-like breaking almost on

8.. Sketch in ocean bottom slopes for each of the four wave types in the boxes above— Start your profile to where waves begin to feel bottom to shoreline.

8. The height of a breaker is approximately 0.78 of its depth; thus, a breaker 7.8 feet high would occur in water 10 feet deep. A sport fishing pier is planned for a resort on the west coast of Mexico with the intent of setting pilings in water 20 feet deep at mean high tide. Waves along this stretch of the Mexican Coast have reached heights just under 15 feet. How high would you recommend that the pier be engineered? If you want to get the contract you have to be the lowest bidder. Show work.

D. Longshore Currents & Littoral Drift

As a rule, waves approach the shoreline at an angle and are refracted**; however, refraction is incomplete. The swash is the water from the wave that travels on shore at the same angle as the wave approach, expending the last of the wave energy. The backwash is the water that flows back into the ocean; gravity alone powers the backwash, so there is a zigzag path between swash and backwash which establishes a weak longshore current that transports water parallel to the shoreline (Fig.10). The longshore is capable of moving sand along the beach, a process known as beach drift or longshore transport. The earth material transported along the beach is called littoral drift.

****Refraction**: waves bend to conform to the shape of coastline. This process begins as they begin to feel bottom and they bend to follow the contoured shape of the sea floor offshore.

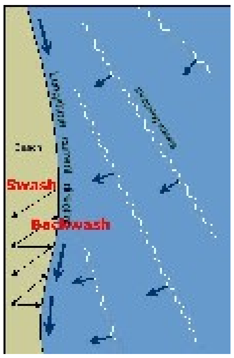


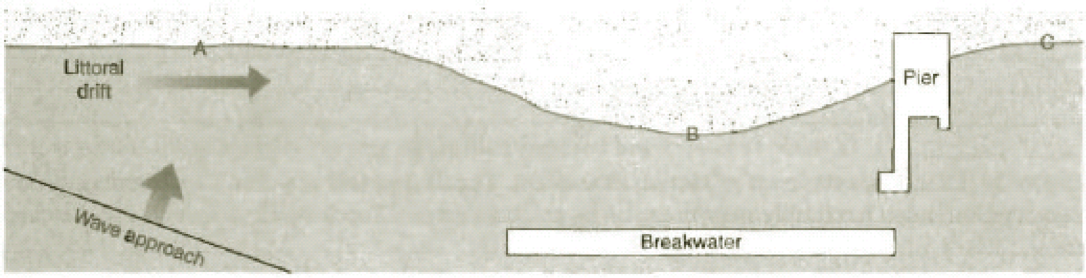
Figure 10

10. Coastal stabilization structures protect property from wave erosion and protect loss of sand from beaches. Such structures disrupt longshore transport. The littoral drift (sand) builds up on the upstream side of structures, eroding sand from the downstream side of structures (groins and jetties). In Figure 10 draw a groin in the middle of the beach; then sketch in where sand will build up and where the beach will begin to erode. Which side of the groin will you build your beach house?

North South

11. What is the direction of longshore transport of littoral drift below? Indicate with an arrow. How did you determine this?

12.
The figure below depicts the nearshore oceanographic conditions at Santa Monica Beach, California. It should be noted that the pier is on widely spaced wooden pilings and has little influence on wave energy.



a. Why has sand built out behind the breakwater?

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b. Indicate on the figure above the relative wave energy at points A through C. Use the terms *high*, *low*, and *nil*.

c. Based upon the presence of the breakwater and wave direction shown in the figure above, what condition of beach stability would you predict at point C: deposition, erosion, or no change? Explain why.