Week Six Oceanography Notes
October 15th and October 17th (Exam on October 19th)
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October 15th
Wave Basics THIS MATERIAL ON EXAM 2

"You cannot stop the waves, but you can learn to surf." -Jon Kabat Zinn

- Waves are moving **energy**, not water. The water basically stays in the same spot.
- Most waves are wind-driven, water waves are moving energy along an ocean-air interface
    - Wind is main distributing force
    - Boundary between and within fluids of different density
- **Air/ Ocean Interface:** ocean waves
- **Air/ Air Interface:** atmospheric waves, seen in clouds
- **Water/Water Interface:** Internal waves. Low density surface wave separated by internal wave from high density bottom
- Splash waves, like from coastal landslides, occur when you add something to water
- Seismic sea waves or tsunamis occur due to sea floor movement
- Wake- wave caused by ships, outboard engines
- Tides- gravitational attraction among moon, sun, and earth
- Waves are mostly wind-driven **but not all of them are**
- Wave Anatomy
    - Crest: Highest point of wave above still water level
    - Trough: Lowest point of wave below still water level
    - Still water level: The flat level of water if there had been no disturbance
    - Wavelength: Distance crest to crest
    - Wave height: Distance crest to trough
    - Wave Period: measured by **T**, time it takes for one full wave (crest to crest) to pass a fixed position. Typically ranges between 6 and 16 seconds
    - Wave frequency, measured in **f,** is the inverse of period, 1/T. It is the number of waves passing a fixed location per unit time. Wave period seriously varies, but most waves are between 1 and 30 seconds.
        - Waves of a longer period are more closely related to tides
        - Waves from earthquakes/ seismic ocean have a medium/intermediate period
- Water doesn't move, only the wave form. It is the transfer of energy across a settled body. Think of what may happen if a wind were to pass through a field of wheat, or trees. Would either of those move?
- Wave motion
    - Transmitting energy
    - Waves move in a cyclical motion
    - Up and Down and Back and Forth: **Circular**

    - Waves follow an orbital path
- Body Waves
    - Longitudinal Waves
        - Back and Forth, Compression and Decompression, think of a **slinky**
    - Transverse Waves
        - Side to side, moving at right angles
        - Vibration
        - Think of how a rope might move if you've ever seen someone work out with one
- Surface Wave combines Longitudinal and Transverse waves
- Orbital Wave is a surface wave
- Circular orbits of an object floating on the water's surface when a wave passes are equal to the wave height. Think of a bird floating over a passing wave
- **Wave Base**
    - Equal to ½ of the wavelength or L/2
    - Length of disturbance through the water column
    - Energy transmitted the most at the top of the wave, least at the bottom
    - Wavelength **only** controls depth of wave base. Longer wavelength = stronger wave base
- Waves based on Depth
    - **Deep Water Waves (≥ ½ L)**
        - Water depth is greater than the wave base
        - All wind generated waves in the open ocean are deep water waves
    - **Shallow Water Waves (≤ 1/20 L)**
        - In order for a wave to be a shallow water wave, the wave must interact with the bottom where **friction will change the wave's shape.**
        - The water depth must be **less than or equal to 1/20 of the wavelength**
    - **Transitional Waves**
        - Both deep and shallow characteristics
        - Depth of water is greater than one twentieth of the wavelength but is less than one half of it
        - Still a wave base, but the bottom will come first
- Speed
    - S = Wavelength/period (L/T)
    - Celerity is a more accurate word to describe waves instead of speed because celerity is used only in relation to circumstances in which there is **no mass in motion**
- When Waves Meet
    - In Phase: Constructive Interference. Building bigger waves with two waves of similar shape
    - Out of Phase: Destructive Interference. Waves do not line up in shape, and thus cancel one another out, making a calmer sea

    - Mixed Interference: Waves are mixed in and out of phase, making a messy, choppy sea, waves could be coming from different directions here
- How do you build a big wave?
    - Wind, energy, Seismic activity (sometimes)
    - **Big, wind driven waves have three factors that build them:**
        - **Wind Speed**
        - **Wind duration (the longer the wind blows, the more energy)**
        - **Fetch (distance the wind blows in one direction with no interference like an island or continent)**
- Some more wave vocab
    - Capillary Waves: small surface waves
    - Gravity Waves: Waves that grow bigger and bigger with more energy, swells
- When will a wave break?
    - Waves break when steepness exceeds 1/7 wave height to wavelength. This is called the 1/7 rule.
    - Steepness is calculated in wave height/ length
    - So, if a wave is 7m crest to crest, it may only be 1m high before it breaks
    - If you've seen white caps, you've seen when the 1/7 rule is broken
- South Pole is known as big spot for big waves, there is no landmass around the globe south of Australia and South America, which can make for long fetch and duration, big waves.

October 17, 2018
Wave Basics II START OF EXAM 3 MATERIAL!

- Rogue and Freak Waves and how we get them
    - Review: S. Hemisphere has big waves because no landmass to interfere with wind. Often called the Roaring 40s, Furious 50s, and Screaming 60s by seafarers sailing in those latitudes
    - Review: A wave will break when the steepness exceeds 1/7
- Why do we care about wave steepness?
    - Knowing the maximum wave height
    - A wave 7m long can only be 1m high before it breaks
- Review: Wave development is a product of wind speed, duration and fetch
- Wave Energy
    - Fully Developed Sea
        - For a given wind speed, fetch, and duration, the amount of energy transferred will reach a peak and a point where it cannot increase anymore
            - This can happen anywhere
            - Particularly pretty messy or violent seas
            - Equilibrium conditions
    - Swell

        - Uniform, symmetrical waves that travel outward from a storm area. Surfers love them
        - Long creats
    - Beaufort Wind Scale
        - Measure of the force of wind and the state of Sea
        - Scale of 0 to 11, sometimes 12
        - As wind speed increases, force increases, sea gets messier
        - Whitecaps will appear at around 25 knots
- How big can a wind-generated wave be?
    - The US Navy has a 60ft, 18.3m rule
    - USS Ramapo was in a typhoon in the Pacific Ocean, 108 km wind, 70 mph, experiences 112 ft wave
- Freak Waves
    - Walls of water, literally walls of water, moving at 10km/hr
    - Three Sisters: groups of three waves
    - Single, giant storm wave: 4x the size of the storm's wave height, collapses after a few seconds (Constructive Interference in action)
- Draupner Wave
    - Out of nowhere, enormous waves, 60ft, Jan 1 1995
- In the Open Ocean:
    - 1 in 23 Waves will be 2x as high as the surrounding sea state
    - 1 in 1100 will be 3x as high as the surrounding sea state
    - 1 in 300k will be 4x as high
    - 1 in several billion will be truly big, nearly unfathomable
- In 1995, The Queen Elizabeth II Cruise Ship experiences a 95ft wave
- Us Navy has measured a 91 ft wave
- How many ships are disappearing?
    - Rogue waves can bring ship disappearance, swallowing them whole
    - Someone hypothesized that 2 large ships disappear on average every week in the ocean. They check this with Lloyds of London, big maritime insurance
    - Based on numbers, it's decided that about 2 large ships a **month** disappear without a trace because of sea state/ waves
- Ground Swell
    - Deep ocean, Storm Wave
- Wind Swell
    - Didn't catch this part of the slide in class, need to find def.
- As a wave approaches shore:
    - Wind speed decreases
    - Wavelength increases
    - Wave height increases
    - Wave steepness increases (1/7)
    - Waves will break
- Breakers in the surf zone

    - Top of the wave topples over the base
    - Wave form not sustained
    - Depends on geography of seafloor (rocky? smooth?) and local conditions
- Spilling Breaker
    - Occurs on a gently sloping seafloor
    - Water slides down front of wave as though on a slope
    - Energy expended over a long distance
- Plunging Breaker
    - Moderately deep sea floor
    - Curling crest
    - Wave energy expended over shorter distance
    - Best for Board Surfers
- Surging Breaker
    - Breakers on Shore
    - Energy dissipated quickly
    - Shortest Distance
- West Coast better for waves? Why?
    - Continental Shelf
    - Fetch- Pacific Ocean big
    - Bigger, more steep beach slope
    - Wind blows toward the shore instead of away from it
- **Tsunamis and Seismic Sea Waves**
    - Geological event
    - Change in seafloor, earthquake, landslide, eruption
    - Long wavelength
    - Moving extremely fast
    - Shallow water waves
    - Sea level can rise up to 40m (131 ft) when a tsunami reaches shore
- Tsunamis are **rapid energy propagation**
- Most of them occur in the Pacific Ocean
- Damaging to Coastal area, catastrophic
- Anatomy of a Tsunami
    - Approximately 300 mile wavelength
    - Speed of a tsunami is the square root of gravity multiplied by depth of the ocean
    - Over 800km per hour, somewhere around 540 mph (as fast as some jets move, this is faster than the speed at which a commercial jet will descend and land)
- The Scotch Cap Lighthouse in the Aleutian Islands is decimated by 100ft wave
- A Tsunami is not just one wave, depending on the strength it can be multiple waves
- Sucking water away from shore because it is so strong, creating an immediate low tide
- The maximum vertical height of a tsunami is called the runup height
- Tsunamis can travel thousands of miles in hours

- If you are on a ship in the deep ocean, a tsunami will not affect you and you may not even be able to feel it because a tsunami is an interaction with the seafloor and the energy is pushed upward
- Approaching the shore, however, tsunamis will slow and their amplitude will build, making them catastrophic
- The world's warning system for tsunamis is not awesome
    - How do you tell someone?
    - Monitoring geological activity
    - Early Warning systems