OCEAN WAVES

by

Fred Dobson

Rules of Thumb (Meteorological-N Hemisphere)

- Looking at the wind, the low is on your right (Buys Ballot's Law)
- If the wind direction doesn't change as the pressure drops, the storm is coming straight at you
- If the wind veers (CW variation) the storm is passing west of you
- If the wind backs (CCW variation) the storm is passing east of you

Facts about Water

- One cubic metre weighs one metric ton
- Because of its low compressibility, water acts like a solid when it strikes a solid surface at high speed

Rules of Thumb (Ocean Waves)

The governing equation, the dispersion relation for gravity waves, is $\omega^2 = g\kappa \tanh \kappa D$ where $\omega = 2\pi f$ is the radian frequency, the period T (units of seconds) is 1/f, $\kappa = 2\pi / L$ is the wavenumber, L is the wavelength (units of metres), and D is the water depth. For deep-water waves the tanh is 1, so $\omega^2 = g\kappa$. From this we derive $C = \omega / \kappa = g / \omega$ where C is the wave phase speed or travel speed of the disturbance (the group speed – the speed the wave energy travels at – is C/2). So $C = gT/2\pi$ and $L = gT^2/2\pi$ as below. For resonant wave growth, a storm carries along the waves it generates at their group speed. Waves with periods of about 10 seconds are common at sea; their wavelength is 156 m and they travel at 15.6 metres/sec (or 31 knots) with a group speed of 15.5 knots. The longest wind waves we see in the North Atlantic have periods of about 20 sec, leading to wavelengths of 624 m and phase speeds of 32 m/sec.

- Wave speed (and speed of generating wind) in knots is about 3 (actually g/Pi) times their period (time between crests) in seconds
- Wave length (crest to crest) in metres is about 1.6 (actually g/2Pi) times the square of their period in sec.
- Yes, every seventh wave is higher:- waves travel in groups

Facts (Ocean Waves)

- As a wave passes, the water moves in a vertical circle, with surface speeds of about a tenth of the travel speed
- When a wave breaks, the water surface speed at its crest approaches its travel speed
- Waves begin to "feel the bottom", slow down and get higher and steeper when the depth is less than one-quarter of their length
- As waves approach a beach, their period doesn't change (height, speed and wavelength do)

Facts (Winds and Waves)

- In storms, the air-sea boundary becomes indistinct: spray fills the air, bubbles fill the water
- Wave steepness (height/wavelength) is limited by breaking, so the highest waves have the longest wavelengths (and periods) and the highest speeds
- The fastest-moving and "tightest" lows produce the highest waves
- E Coast storms generate the longest, highest waves in their SE quadrant – there, the waves move with the storm as they grow with the local winds

Facts (Ocean Waves)

- Waves of all wavelengths and travelling in all directions are generated by a storm. As they leave the storm area they disperse, the longest wavelengths travelling the fastest
- A "rogue wave" is an unexpected one – often the result of the superposition of two wave trains travelling in different directions
- All numerical models fail to predict the very highest waves in intense storms