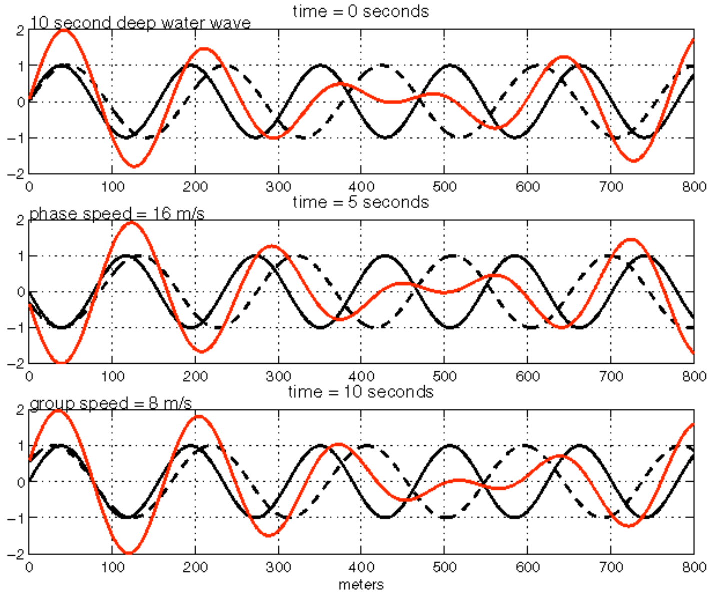
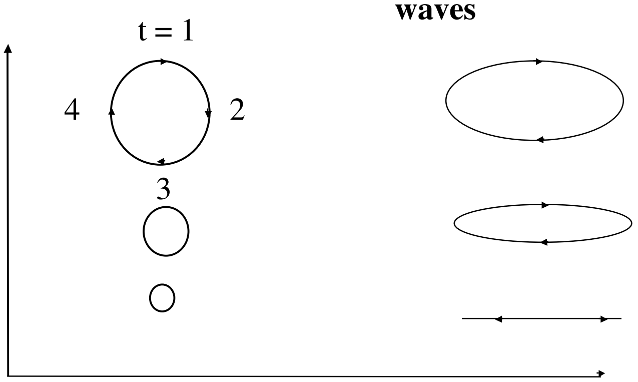


Deep water waves

Shallow water waves



direction of propagation

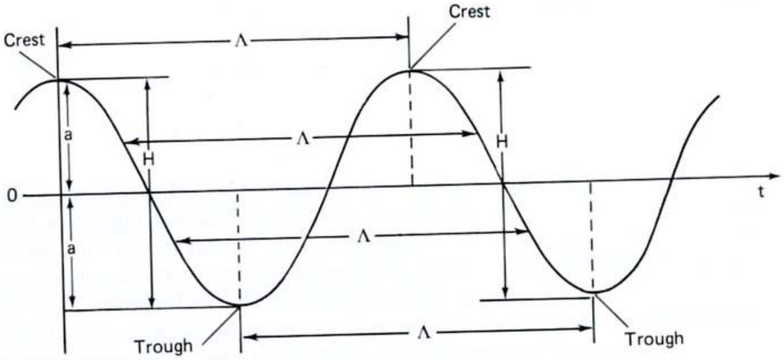


Figure 9.2 Parts of a simple sinusoidal wave. Note that the wave height is defined as twice the amplitude.

(Figure 9.8). The regions of maximum wave height in the envelope travel at a speed different from either of the individual wave trains. Thus the wave energy is propagated at a

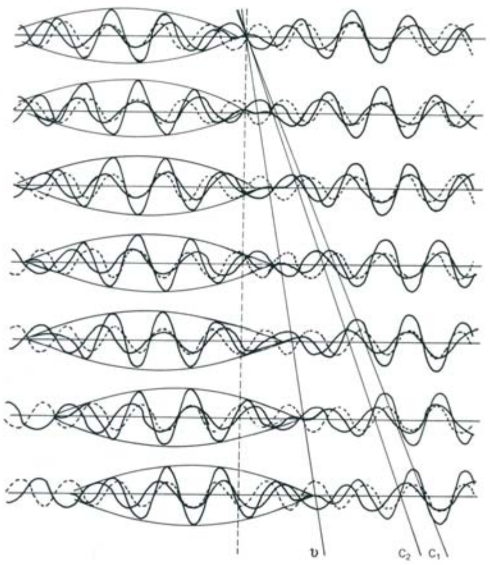


Figure 9.8 Two progressive wave trains of similar amplitude, but different wavelength and wave speeds, move in and out of phase. Individual wave nodal points can be tracked at wave speeds C_1 and C_2. The nodal point of the wave envelope progresses at the group velocity *(V)*, which is half the phase velocity.

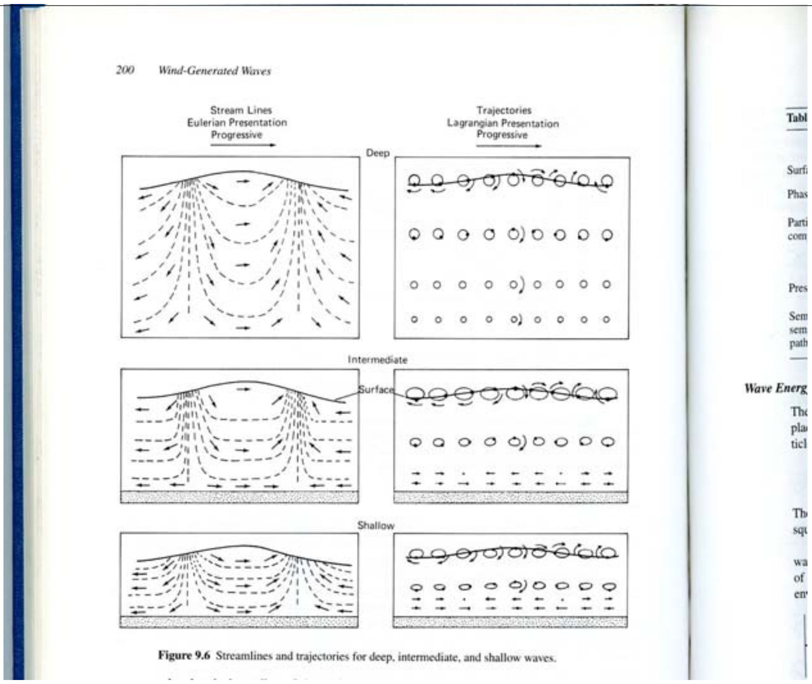


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Figure 9.6 Streamlines and trajectories for deep, intermediate, and shallow waves.

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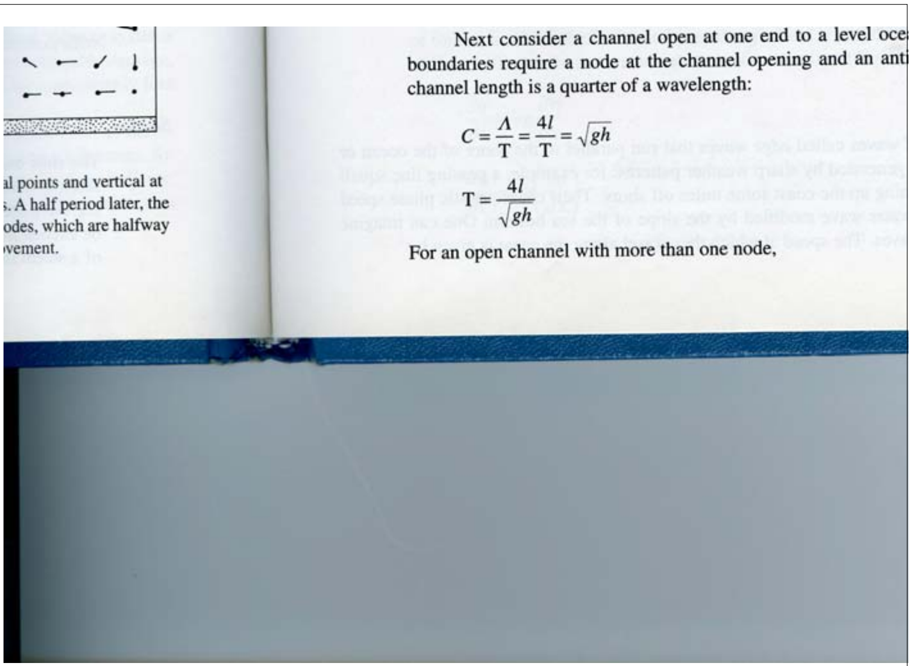


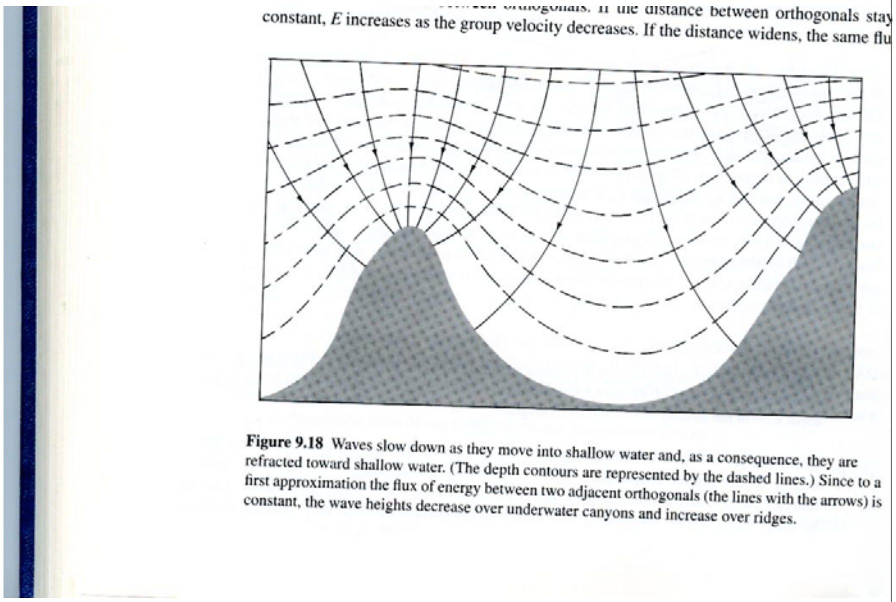
al points and vertical at
s. A half period later, the
odes, which are halfway
vement.

Next consider a channel open at one end to a level oce
boundaries require a node at the channel opening and an anti
channel length is a quarter of a wavelength:

$$C = \frac{\Lambda}{T} = \frac{4l}{T} = \sqrt{gh}$$

$$T = \frac{4l}{\sqrt{gh}}$$

For an open channel with more than one node,



between orthogonals. If the distance between orthogonals stay
constant, *E* increases as the group velocity decreases. If the distance widens, the same flu

Figure 9.18 Waves slow down as they move into shallow water and, as a consequence, they are refracted toward shallow water. (The depth contours are represented by the dashed lines.) Since to a first approximation the flux of energy between two adjacent orthogonals (the lines with the arrows) is constant, the wave heights decrease over underwater canyons and increase over ridges.

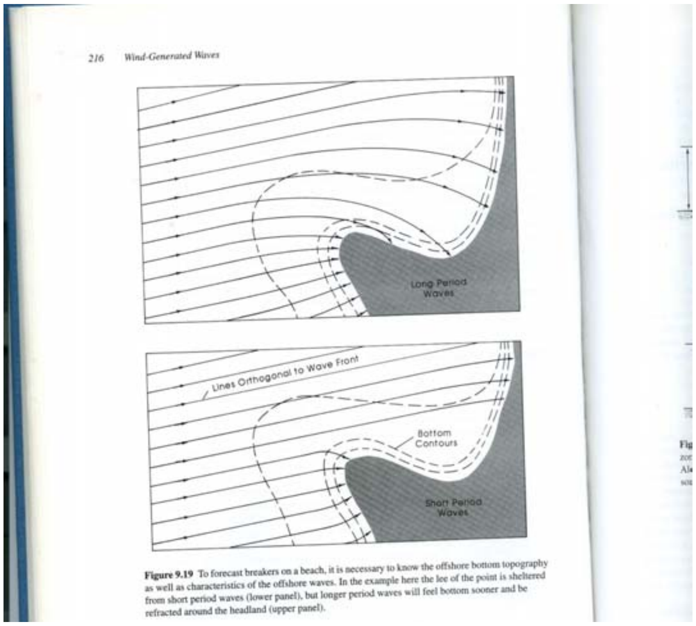


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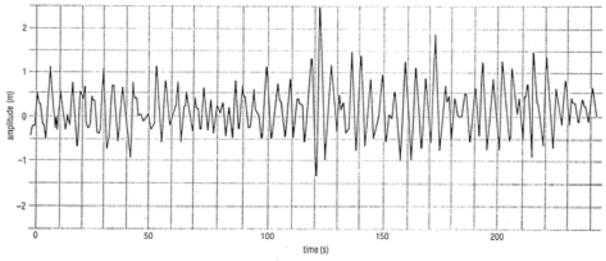
Figure 9.19 To forecast breakers on a beach, it is necessary to know the offshore bottom topography as well as characteristics of the offshore waves. In the example here the lee of the point is sheltered from short period waves (lower panel), but longer period waves will feel bottom sooner and be refracted around the headland (upper panel).

Figure 1.5 A typical wave record, i.e. a record of variation in water level with time at one position.



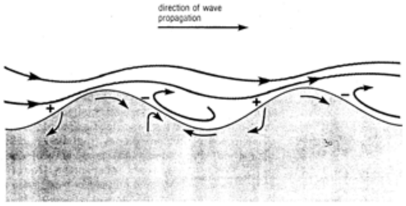


Figure 1.3 Jeffreys' 'sheltering' model of wave generation. Curved lines indicate air flow; short, straight arrows show water movement, which will be explained more fully in Section 1.2.1. The rear face of the wave against which the wind blows experiences a higher pressure than the front face, which is sheltered from the force of the wind. Air eddies are formed in front of each wave, leading to differences in air pressure. The excesses and deficiencies of pressure are shown by plus and minus signs respectively. The pressure difference pushes the wave along.

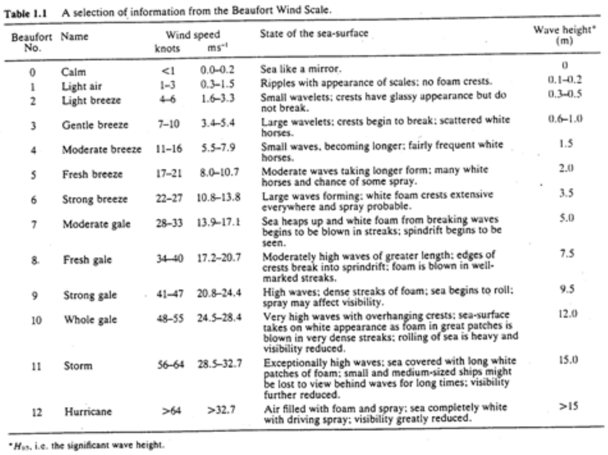


Table 1.1 A selection of information from the Beaufort Wind Scale.

Beaufort No.	Name	Wind speed knots	ms^{-1}	State of the sea-surface	Wave height* (m)
0	Calm	<1	0.0–0.2	Sea like a mirror.	0
1	Light air	1–3	0.3–1.5	Ripples with appearance of scales; no foam crests.	0.1–0.2
2	Light breeze	4–6	1.6–3.3	Small wavelets; crests have glassy appearance but do not break.	0.3–0.5
3	Gentle breeze	7–10	3.4–5.4	Large wavelets; crests begin to break; scattered white horses.	0.6–1.0
4	Moderate breeze	11–16	5.5–7.9	Small waves, becoming longer; fairly frequent white horses.	1.5
5	Fresh breeze	17–21	8.0–10.7	Moderate waves taking longer form; many white horses and chance of some spray.	2.0
6	Strong breeze	22–27	10.8–13.8	Large waves forming; white foam crests extensive everywhere and spray probable.	3.5
7	Moderate gale	28–33	13.9–17.1	Sea heaps up and white foam from breaking waves begins to be blown in streaks; spindrift begins to be seen.	5.0
8.	Fresh gale	34–40	17.2–20.7	Moderately high waves of greater length; edges of crests break into sprindrift; foam is blown in well-marked streaks.	7.5
9	Strong gale	41–47	20.8–24.4	High waves; dense streaks of foam; sea begins to roll; spray may affect visibility.	9.5
10	Whole gale	48–55	24.5–28.4	Very high waves with overhanging crests; sea-surface takes on white appearance as foam in great patches is blown in very dense streaks; rolling of sea is heavy and visibility reduced.	12.0
11	Storm	56–64	28.5–32.7	Exceptionally high waves; sea covered with long white patches of foam; small and medium-sized ships might be lost to view behind waves for long times; visibility further reduced.	15.0
12	Hurricane	>64	>32.7	Air filled with foam and spray; sea completely white with driving spray; visibility greatly reduced.	>15

*$H_{1/3}$, i.e. the significant wave height.

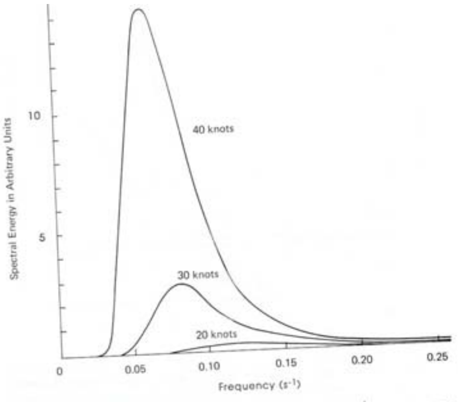


Figure 9.11 Idealized wave spectra for a fully developed sea for winds of 20, 30, and 40 knots.

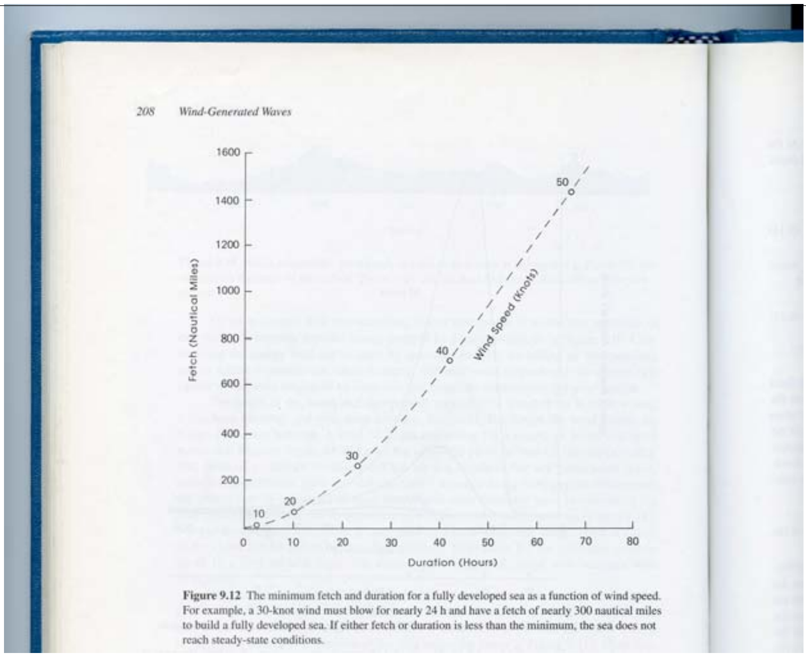

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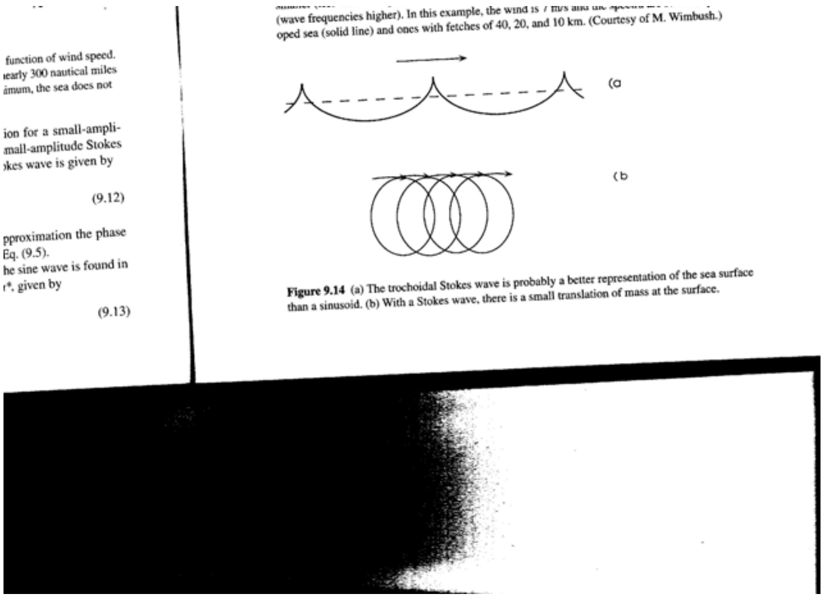
Figure 9.12 The minimum fetch and duration for a fully developed sea as a function of wind speed. For example, a 30-knot wind must blow for nearly 24 h and have a fetch of nearly 300 nautical miles to build a fully developed sea. If either fetch or duration is less than the minimum, the sea does not reach steady-state conditions.


function of wind speed.
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(9.12)

pproximation the phase
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he sine wave is found in
r*, given by

(9.13)

(wave frequencies higher). In this example, the wind is 7 m/s and the
oped sea (solid line) and ones with fetches of 40, 20, and 10 km. (Courtesy of M. Wimbush.)

Figure 9.14 (a) The trochoidal Stokes wave is probably a better representation of the sea surface than a sinusoid. (b) With a Stokes wave, there is a small translation of mass at the surface.

WAVE TYPE	**BASIC DYNAMICS**	**DISPERSION RELATION**	**FORM OF THE SOLUTION** **(MOVEMENT OF PARTICLES IN WAVE)**	**WHAT FORCES WAVES (RESTORING/ DISTURBING)**	**DISPERSIVE OR NONDISPERSIVE**	**λ wavelength**	**T period**
Capillary Waves		$\omega^2= k(g+(sk^2/\rho))$		Surface tension/ wind		Cm	0.1s
Shallow Water Gravity Waves	Small kH Samll H/λ $\lambda > 20H$	$\omega = \sqrt{(gH)}\ k$ $c = \sqrt{gh}$	Elliptical BOTH LOOSE STRENGTH	Gravity/ Wind	Dispersive	10-100m	3-30s
Deep Water Gravity Waves	Big kH $\lambda<2H$	$\omega=\sqrt{(gk)}$ $c=\sqrt{(g/k)}$	Orbital WITH DEPTH	Gravity/ Wind	NON-Dispersive	10-100m	3-30s
Internal Waves	$N^2= -\frac{g\,d\rho}{\rho\,dz}$	$\omega^2= N^2\cos^2\gamma$ γ= phi angle		Gravity/ Wind and Tides	NON-Dispersive		
Inertial/ Poincane Waves	$du/dt-fv=0$ acceleration coriolis force Moves CW in NH Particlesmove is circles	$\omega^2= f^2+ gHk^2$	High freq= elliptical Low freq= circular	Gravity/ Centrifical	For superinterial $\omega_{min}= f$ DISPERSIVE	100m-km	10min-hrs
Kelvin Waves	Decay offshore	$C= \sqrt{(gH)}$			NON-Dispersal		
Rossby Waves	Transverse waves	$\omega=$			NON-Dispersive		