

Physics of Surfing Waves - part 2 David T. Sandwell (http://topex.ucsd.edu/ps)



- · Physics of waves
- Characteristics of waves
- · Generation of waves by storms
- · Wave speed shallow vs. deep ocean
- Sets dispersion
- · Refraction of waves Why is Black's so good?

wave characteristics







Airy solution

$$c(d) = \left[\frac{gL}{2\pi} \tanh\left(\frac{2\pi d}{L}\right)\right]^{1/2} \qquad L \text{ - wavelength} \\ g \text{ - acc. gravity} \\ d \text{ - ocean depth} \end{cases}$$

deep water waves d >> L/2 $c_d = \sqrt{\frac{gL}{2\pi}}$

shallow water waves

d << L/2

$$c_s = \sqrt{gd}$$

What causes "sets"?









Waves arrive in San Diego at the same time t_1 .

Suppose the waves were generated at the same time t_o .

$t_1 - t_o = 2R/c_1$	$c = \frac{gT}{2\pi}$	deep water dispersion
$t_1 - t_0 = 2(R + D)/c_2$		
$c_2 = c_1 \left(\frac{R+D}{R}\right)$	$T_2 = T_1 \left(\frac{R+D}{R}\right)$	

"sets"













shallow water waves

$$c_s = \sqrt{gd}$$







Munk, W. H. and M. A. Traylor, Refraction of Ocean Waves, J. Geology, v. LV, No. 1, 1947







Analysis Time - 21 DEC 2005 : 1123 PST

Swell Height (ft) – Southern California Bight



Stn 073: 9	Ban	dEner	gy	Units: metric 🛟 Timezone: UTC 🛟						update			
Date/Time	Hs	Тр		ENERGY (cm^2) - by period band (sec)									
(UTC)	(m)	(s)	22+	22-18	18-16	16-14	14-12	12-10	10-8	8-6	6-		
12-21-2005 19:45	1.64	9	129	26	121	292	227	176	311	203	199		
12-21-2005 18:45	1.49	15	116	21	134	233	215	172	161	167	172		
12-21-2005 17:45	1.51	15	87	27	209	240	153	106	209	170	231		
12-21-2005 16:45	1.52	17	121	38	287	201	137	98	184	160	219		
12-21-2005 15:45	1.46	9	114	37	120	195	155	122	239	176	182		
12-21-2005 14:45	1.35	13	89	49	150	116	203	105	112	159	151		
12-21-2005 13:45	1.09	9	48	24	66	49	121	94	126	104	108		
12-21-2005 12:45	1.05	9	48	22	34	44	93	107	159	82	95		
12-21-2005 11:45	1.05	9	41	20	22	37	104	87	143	122	119		
12-21-2005 10:45	1.10	9	31	10	9	53	130	132	177	96	117		
12-21-2005 09:45	1.12	9	27	8	7	51	121	102	229	107	133		
12-21-2005 08:45	1.00	9	26	7	5	33	71	107	160	104	117		
12-21-2005 07:45	1.01	9	26	4	5	35	82	104	151	92	137		
12-21-2005 06:45	0.94	9	17	2	3	44	53	95	127	104	102		
12-21-2005 05:45	0.86	4	13	1	3	21	45	76	107	84	115		
12-21-2005 04:45	0.90	4	12	2	4	17	75	98	105	83	112		
12-21-2005 03:45	0.85	9	9	1	3	19	60	77	104	75	99		
12-21-2005 02:45	0.92	4	11	1	5	12	75	105	108	103	111		
12-21-2005 01:45	0.97	9	11	1	6	21	48	122	170	107	108		
12-21-2005 00:45	1.03	11	12	2	6	16	73	153	126	136	140		
12-20-2005 23:45	1.05	9	14	2	3	16	77	165	168	112	139		
12-20-2005 22:45	1.09	9	25	2	4	14	78	158	171	135	152		
12-20-2005 21:45	1.12	9	21	3	3	14	134	133	211	122	150		
12-20-2005 20:45	1.10	9	24	3	4	12	143	122	189	108	151		



Conclusions

- Ocean waves: force of acceleration is balanced by the force of gravity.
- Wind speed >= wave speed. 17-s period waves require wind speed of 27 m/s = 60 mph.
- Wave speed: d >> L/2 waves are dispersive; d << L/2 speed depends on depth.
- Refraction is important when d < 10L.

Lab 1. Wave period (Due October 18)

This lab should be performed when the wind speed is low so the swell is apparent. Morning before 10 AM is the best time. This can be done at SIO or the Blacks overlook (UCSD Property).

- A. Describe the setup of the experiment. Where are you? Where is the surf? How are you measuring the waves?
- B. Perform experiment(s). Record the time as the crest of each wave passes a particular pier piling (> 50 waves).
- D. Make a histogram of the time interval between wave crests.
- E. Calculate the median and mean period of the swell.
- F. How does this compare with the values on the web site (<u>http://cdip.ucsd.edu</u>). (Go to models and then Southern California. Note the site saves the data from earlier that day.) Do the results agree? If they don't agree, what are some possible reasons for the disagreement?

The lab writeup should be neat, clear, and concise.



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CDIP recent observed 073 pm
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10/11/2006 04:08 PM
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Ture-cu.i					CDBW	USACE
	Recent	Historic	Documents	Station ID	÷	search
news I contact us I home			obse	erved nowcast mod	els forec	cast models

Station 073 - info SCRIPPS PIER,	Stn 073: Paramete	ers	Units: metric + Timezone: UTC + update					
SCRIPPS PIER, LA JOLLA CA Data Tables Parameter 9-band energy Daily & Weekly Plots Waves - 1 day Waves - 1 week Wind Temperature Monthly Plots Compendium plot Mountain plot Temperature plot Wind/Pressure plot Latest Data Run Spectral plot Spectral file	Stn 073: Parameter Date/Time (UTC) 10-11-2006 21:45 (10-11-2006 21:45 (10-11-2006 19:45 (10-11-2006 19:45 (10-11-2006 18:45 (10-11-2006 10:53 (10-11-2006 09:45 (10-11-2006 09:45 (10-11-2006 05:45 (10-11-2006 05:45 (10-11-2006 03:45 (10-11-200	ers Hs (m) 0.30 0.34 0.31 0.33 0.31 0.33 0.31 0.39 0.42 0.48 0.52 0.49 0.54 0.50 0.54 0.50 0.48 0.50	Units: U Tp (s) 8.26 8.83 9.48 8.83 9.14 9.48 3.88 3.82 3.88 3.82 3.82 3.51 3.08 3.32	metric 3 Ta (s) 6.32 6.38 6.66 6.58 6.28 5.78 4.97 4.65 4.67 4.49 4.47 4.33 4.23 4.13 4.39	Tim Depth (m) 6.88 7.15 7.32 7.32 7.32 7.31 7.14 6.52 6.60 6.65 6.63 6.51 6.33 6.09 5.88 5.72	ezone: Wind sp (m/s) 2.0 3.1 2.5 2.2 1.5 3.1 2.2 1.7 1.6 0.8 2.6 3.2 4.8 2.7 4.2	UTC : Wind dir (deg) 292.0 313.0 309.0 317.0 358.0 354.0 27.0 354.0 27.0 354.0 27.0 354.0 27.0 354.0 27.0 354.0 27.0 354.0 27.0 355.0 354.0 27.0 355.0 354.0 27.0 355.0 354.0 27.0 355.0 354.0 27.0 355.0 354.0 27.0 355.0 354.0 27.0 355.0 305.0	update Air temp (C) 20.6 20.1 20.4 19.9 20.8 18.2 16.7 17.1 17.2 17.3 17.4 17.4 17.4 17.4 17.2 17.4
Descriptions/Help Historic & Metadata Station: 073 +	10-11-2006 01:45 0 10-11-2006 00:45 0 10-10-2006 23:45 0	0.39 0.35 0.33	8.53 8.83 9.14	4.76 5.17 5.78	5.66 5.71 5.91	4.4 5.1 4.4	324.0 330.0 321.0	17.7 18.1 19.8

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