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Ocean Waves Around the Coastlines of Australia

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SUMMARY Monthly averages of wind and waves available in oceanographic charts of the various oceans have been summed to provide figures for seasonal and annual conditions. These apply for each of 35 squares of 5° latitude - longitude dimension. Cyclonicity data are also included to supply information on arrival directions of high storm waves, the characteristics of which are noted. Sealevel changes due to tides and storm surge are also itemised for each 5° square since the application of wave heights in design of maritime structures involves their maximum reach above the existing still water level.

1 INTRODUCTION

Wave conditions at the coast can be divided into two main categories, namely storm waves and swell. The former are still being generated when they arrive at a structure or shoreline, whilst the latter have spread out from distant fetches. Knowledge of their duration and direction of approach are as important to a coastal engineer as their major characteristics of height and period.

Long term averages of such oceanographical phenomena are available in charts produced by a number of countries through their oceanographic or other marine institutes. These generally contain roses of percentage occurrence within squares of ocean 5° each direction for eight compass directions. Each atlas covers one oceanic area and averages are provided for each month of the year.

The purpose of this paper is to integrate values into seasonal and annual percentages, covering the complete coastal margin of Australia. Figures should thus represent conditions for a 5° length of shoreline or approximately 300 nautical miles (NM's) (1 NM = 6080 ft, 1.85 kms). As can be seen in Figure 1 the 10,000 odd NM's of Australian coastline requires 35 squares to present the data. The numbers designated therein will be used in the tables.

The squares in Figure 1 are numbered clockwise commencing and ending at the northern border of New South Wales. It is immediately recognised that squares numbered 1 to 18 refer to extra-tropical regions, whilst 19 to 35 apply to tropical condit-

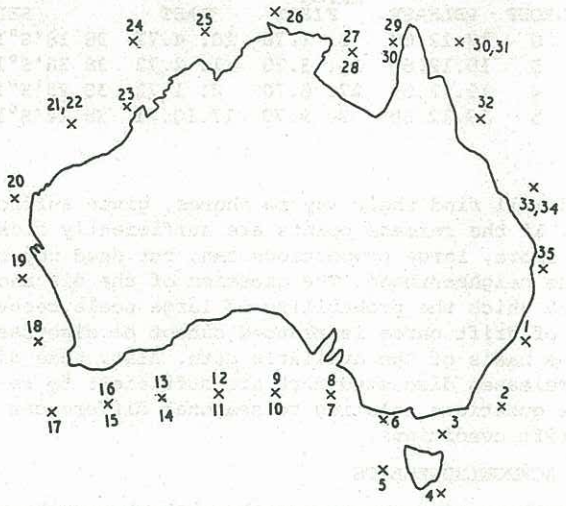

Figure 2 Location of 26 wind roses (1)(2) with related square numbers from Figure 1

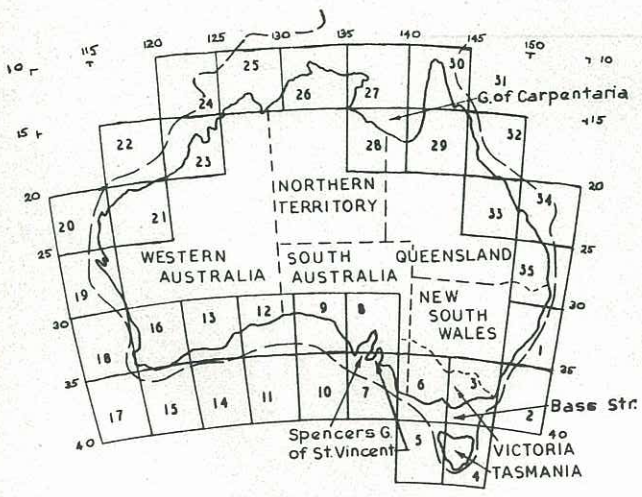

Figure 1 Five degree squares of ocean used in data collation

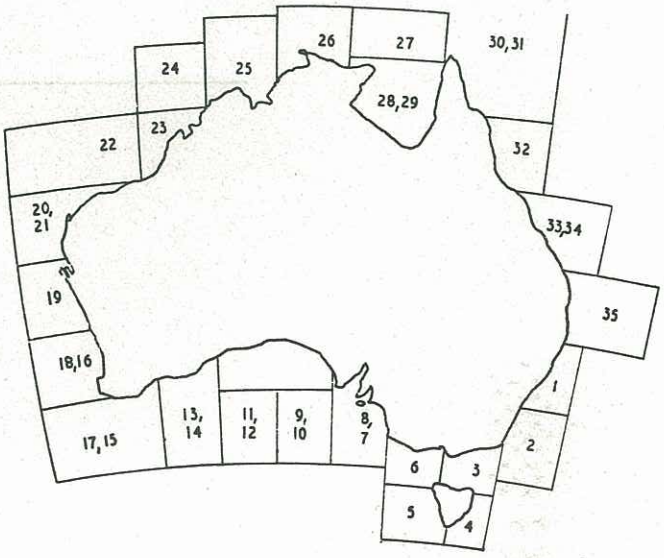

Figure 3 Sea areas covered by sea and swell roses

TABLE I

AVERAGE NUMBER OF EXTRA-TROPICAL CYCLONE CENTRES WITHIN 5° SQUARES OVER 15 YEARS (5)

Season	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Summer	47	42	26	69	63	45	55	22	48	41	21	60	53	44	35	43	9	22
Autum	29	41	20	57	58	28	40	13	29	42	45	26	20	51	63	35	49	34
Winter	33	46	18	71	88	36	62	15	30	65	61	28	19	66	93	18	82	42
Spring	51	55	39	85	90	33	76	46	87	60	38	86	63	49	53	35	25	22
Total	160	184	103	282	299	162	233	96	194	208	165	200	155	210	244	131	165	120
Annual	10.7	12.3	6.9	18.8	19.9	10.8	15.5	6.4	12.9	13.9	11.0	13.3	10.3	14.0	16.3	8.7	11.0	8.0

ions. Some squares partly cover or almost fully cover land areas. The actual location of the wind roses available (1)(2) is noted in Figure 2, with the relevant square numbers associated with them. Similarly, Figure 3 shows the areas covered by sea and swell roses (3)(4)

2 WINDS

Because waves are generated locally by winds adjacent to the coast the occurrence of moderate and extreme wind velocities should be examined. The detailed wind structure within cyclones will not be discussed here due to shortage of space.

Karelsky (5) has provided cyclonicity data around the complete coastline, based upon records from 1946 to 1960 inclusive. From these are extracted in Table I the average number of cyclones entering any square over the period and thus the annual average. The monthly values provided have been added into seasonal and annual values. The seasons in all cases are three monthly periods commencing with summer from December to February.

In Table I it is clear that Tasmania has the highest incidence of low-pressure centres, where Karelsky (5) notes they are generally more intense. He also states that extra-tropical cyclones remain on average 10 hours in any 5° square, implying a centre speed of 30 knots or greater.

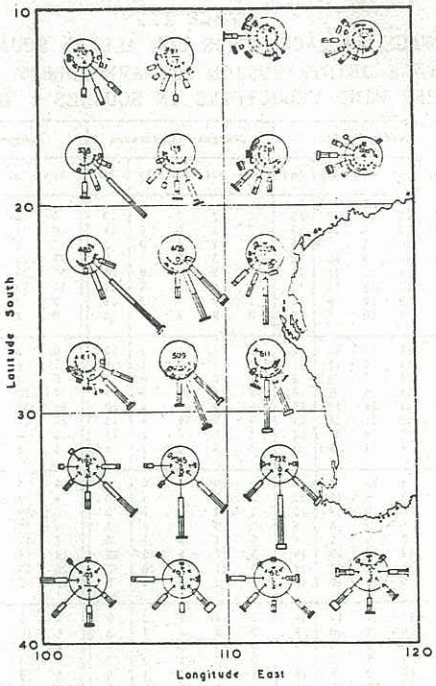

Figure 4 Extract of wind data from references (1)

The centres of tropical cyclones are better defined than extra-tropical sequences, and hence their direction of travel can be determined more readily. Coleman (6) has compiled data covering 50 to 60 years, portions of which are summarised in Table II. These are percentages of all cyclones moving in the specified direction. The migration of centres away from the equator should be noted. Coleman (6) also records that velocities in the region average 10 knots. Also included in Table II are the number of cyclones over 60 years from which an annual average can be determined. The remaining data in the table will be discussed later.

TABLE II

PERCENTAGES OF TROPICAL CYCLONES TRAVELLING IN SPECIFIED DIRECTION WITH 5° SQUARES AND OPTIMUM WAVE CHARACTERISTICS

Direction of Travel	Square Numbers																	Total	
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	No.	%
N	-	-	-	-	-	-	6	3	2	-	-	2	-	3	4	2	-	22	1.3
NE	-	-	-	2	2	2	4	3	7	5	1	5	2	4	7	3	3	50	3.1
E	-	-	6	3	7	8	9	9	9	10	16	20	10	14	14	15	8	158	9.7
SE	13	17	28	8	11	6	10	14	16	24	22	20	13	24	29	26	33	314	19.3
S	67	32	38	20	20	16	10	10	12	16	17	2	11	18	13	24	23	349	21.4
SW	10	32	20	40	30	33	33	24	18	22	15	20	18	17	14	11	23	380	23.3
W	4	10	5	26	19	32	26	34	23	14	23	27	31	12	8	5	-	299	18.4
NW	-	3	2	1	3	-	2	2	12	3	2	5	8	3	4	2	4	56	3.5
Number of Cyclones over 60 years	21	63	59	124	111	45	69	70	73	68	95	52	81	170	63	121	95		
H(m) typical	5.0	5.5	5.5	5.0	5.0	5.0	5.5	5.0	5.0	5.0	5.0	5.0	4.5	5.0	5.0	5.0	5.0		
H(m) extreme	7.5	9.0	9.0	9.0	8.0	10.0	10.0	10.0	8.5	7.5	8.0	9.5	7.5	10.0	7.5	9.0	7.5		
T(sec) typ.	9.0	9.5	9.5	9.0	9.0	9.0	9.5	9.5	9.0	9.0	9.0	9.0	8.5	9.0	9.0	9.0	9.0		
T(sec) extr.	11.0	12.0	12.0	12.0	11.5	12.5	12.5	12.5	11.5	11.0	11.5	12.0	11.0	12.5	11.0	12.0	11.0		
Dir. typical	S	S	S	SW	SW	SW	SW	W	W	SE	W/SE	W	W	SE	SE	SE	SE		
Dir. extreme	E	E	SE	SE	SE	SE	S	S	S/W	SW	E	W	SW	SW	SW	SW	W		

TABLE III

PERCENTAGE AVERAGE WINDS FOR ALL 35 SQUARES AND PERCENTAGE DEISTRIBUTION OF WAVE ENERGY ($=U^4$) FOR HIGHER WIND VELOCITIES IN SQUARES 1 TO 18

Sq. No.	Direction	Average Winds					Cyclonic Conditions					Average Winds					Sq. No.
		Sum	Aut	Win	Spr	Ann	Sum	Aut	Win	Spr	Ann	Sum	Aut	Win	Spr	Ann	
1.	N	12	12	11	19	13	2	2	1	8	13	0	2	3	0	1	19.
	NE	18	13	6	16	13	7	1	0	3	11	0	5	6	1	3	
	E	12	10	5	7	9	1	1	1	0	3	2	9	12	2	6	
	SE	13	14	8	10	11	3	3	2	1	9	27	24	20	25	24	
	S	15	18	15	17	16	4	9	6	10	28	50	26	18	40	34	
	SW	11	12	19	11	13	4	4	11	4	22	14	13	18	21	17	
	W	6	9	19	9	11	1	2	7	2	12	2	7	10	8	7	
	NW	5	8	10	7	8	0	0	1	1	2	0	2	3	2	2	
2.	N	14	15	14	17	15	2	3	1	3	10	0	3	3	1	2	20.
	NE	15	11	5	12	11	2	1	0	1	5	1	6	6	1	3	
	E	9	6	3	5	6	1	0	0	0	1	0	7	10	1	5	
	SE	8	11	6	8	8	0	1	1	1	3	7	20	23	16	18	
	S	15	16	14	17	15	4	5	7	4	20	45	32	25	46	37	
	SW	18	16	21	16	18	4	9	19	9	41	27	17	10	28	20	
	W	8	12	18	11	12	1	5	7	4	17	6	4	5	6	5	
	NW	6	7	15	8	9	0	0	3	1	4	3	3	2	2	3	
3.	N	5	8	13	8	8	0	0	1	0	2	6	5	2	3	4	21.
	NE	15	12	8	12	12	2	0	0	1	3	6	6	8	4	5	22.
	E	16	9	5	9	10	1	0	0	1	2	5	19	21	5	13	
	SE	7	8	3	6	6	0	0	0	2	3	4	18	21	6	12	
	S	7	8	3	6	7	0	1	1	1	2	5	12	10	15	11	
	SW	20	19	17	20	19	5	7	6	10	28	19	16	13	17	19	
	W	18	21	22	23	21	10	11	12	20	52	26	13	6	28	19	
	NW	4	9	19	10	10	0	2	4	2	8	18	3	2	10	10	
4.	N	12	14	17	14	14	2	2	2	3	9	6	5	2	6	5	23.
	NE	8	10	9	10	9	0	0	1	1	3	4	10	4	1	5	
	E	5	5	3	4	4	0	0	0	0	0	4	19	15	2	10	
	SE	13	5	5	5	7	0	0	1	0	2	7	23	30	5	16	
	S	13	10	8	8	10	1	2	2	1	6	5	8	15	11	10	
	SW	10	17	18	16	15	3	11	9	10	32	18	9	11	26	16	
	W	11	18	19	20	17	2	5	11	11	29	28	7	4	26	16	
	NW	18	16	17	19	17	1	3	7	7	19	18	6	1	15	10	
5.	N	15	15	21	15	17	2	5	7	4	18	4	5	3	3	4	24.
	NE	9	5	12	5	8	1	0	2	1	4	2	10	8	4	6	
	E	6	6	5	3	5	0	1	0	0	1	5	26	34	12	19	
	SE	8	6	4	4	5	0	0	1	0	2	7	20	29	20	19	
	S	9	9	7	7	8	1	6	1	1	8	7	3	9	16	10	
	SW	15	14	8	13	13	4	4	1	4	13	21	5	4	21	13	
	W	14	19	16	27	19	3	5	7	16	30	26	6	3	12	12	
	NW	16	20	20	21	19	2	5	9	6	23	14	6	3	5	7	
6.	N	3	11	17	9	10	0	1	6	2	9	6	4	5	6	5	25.
	NE	7	10	9	7	8	0	1	1	1	2	6	9	8	8	8	
	E	13	11	6	7	9	2	1	0	0	4	7	24	19	8	15	
	SE	14	10	5	9	9	1	1	0	0	3	5	25	18	6	14	
	S	16	14	10	10	13	2	4	1	1	8	6	8	8	5	7	
	SW	18	16	13	16	16	4	7	5	5	21	13	6	9	16	11	
	W	15	14	17	22	17	6	5	12	16	38	27	6	9	25	17	
	NW	3	10	13	13	11	0	2	7	5	14	15	2	7	13	9	
7. 8.	N	4	11	16	8	10	0	2	5	1	8	11	5	4	13	8	26.
	NE	5	10	10	7	8	0	1	1	1	2	6	8	9	13	9	
	E	14	9	7	8	9	2	0	0	1	3	5	25	24	18	18	
	SE	22	14	7	8	13	9	1	1	1	12	1	32	32	9	19	
	S	20	16	11	11	15	4	3	2	1	11	3	5	6	3	4	
	SW	17	15	14	22	17	5	5	4	13	27	4	4	4	5	4	
	W	9	12	16	20	14	1	3	6	13	24	30	4	3	12	12	
	NW	2	9	15	12	10	0	2	6	5	12	30	8	3	12	13	
9. 10.	N	5	14	18	13	12	0	3	7	3	13	9	2	0	1	3	27. 28.
	NE	8	10	8	8	8	0	1	1	1	3	11	2	1	10	6	
	E	14	11	6	7	9	2	0	0	0	3	11	25	26	49	28	
	SE	14	14	5	5	9	2	1	0	1	5	7	39	56	20	30	
	S	17	11	10	9	12	4	1	1	2	8	1	8	12	3	6	
	SW	19	11	12	17	15	8	2	4	9	24	3	3	1	1	2	
	W	12	12	17	21	16	4	4	9	14	31	20	5	0	3	7	
	NW	4	9	17	14	11	0	1	7	5	14	30	9	0	4	11	
11. 12.	N	8	16	19	16	15	1	3	10	6	19	4	2	1	1	2	29.
	NE	14	13	7	10	11	3	1	2	1	7	7	3	0	6	4	
	E	15	8	4	5	8	1	0	0	0	2	14	23	30	40	27	
	SE	9	7	1	4	5	0	0	0	0	1	9	47	52	31	35	
	S	13	10	10	8	10	1	1	2	1	5	1	4	5	2	3	
	SW	18	18	14	17	17	7	5	7	12	32	3	3	1	1	2	
	W	12	14	19	21	16	2	5	12	9	27	21	3	0	1	6	
	NW	5	8	18	11	11	1	1	5	1	8	23	6	0	3	8	
13. 14.	N	7	10	15	13	11	0	1	4	4	10	7	1	0	2	3	30. 31.
	NE	18	13	8	10	12	4	2	1	1	8	7	2	4	8	5	
	E	15	9	2	7	8	2	1	0	1	3	17	23	21	29	22	
	SE	9	7	2	5	5	1	0	0	0	1	24	59	58	40	45	
	S	11	10	11	12	11	0	1	3	1	5	3	7	9	9	7	
	SW	17	16	18	18	17	3	4	10	8	25	2	2	1	0	1	
	W	14	13	23	20	17	4	3	23	17	46	7	2	0	0	2	
	NW	5	9	17	10	10	0	0	0	0	0	16	2	0	1	5	
15.	N	3	8	12	5	7	0	0	2	0	3	11	4	2	6	6	32.
	NE	8	12	7	6	8	1	1	0	0	2	3	4	1	2	3	
	E	18	11	3	7	10	3	1	0	1	5	19	15	10	18	16	
	SE	14	9	2	7	8	1	1	0	0	2	35	45	43	32	39	
	S	16	10	5	11	11	1	1	1	1	3	9	13	20	10	13	
	SW	21	17	19	21	19	3	4	9	7	23	2	4	4	2	3	
	W	14	16	24	26	20	3	4	27	16	50	2	2	2	0	2	
	NW	5	11	18	10	11	0	2	8	2	12	6	3	1	2	3	
16.	N	1	4	8	3	4	0	0	1	0	2	10	3	3	13	7	33. 34.
	NE	1	5	7	1	3	0	0	0	0	1	14	5	4	12	9	
	E	4	9	6	4	6	0	1	0	0	1	24	17	10	21	18	
	SE	24	20	7	12	16	11	5	0	2	18	33	35	35	21	31	
	S	34	20	9	21	21	15	5	1	5	25	6	12	21	3	11	
	SW	22	16	19	24	20	5	3	9	6	22	1	5	7	2	4	
	W	7	13	22	19	15	1	3	13	7	24	1	2	2	2	2	
	NW	2	7	15	10	8	0	1	5	2	8	5	4	4	9	6	
17.	N	4	8	14	5	8	0	1	5	0	7	16	7	7	19	12	35.
	NE	3	3	8	2	4	0	0	2	0	2	13	8	4	13	9	
	E	12	9	6	3	7	2	2	1	0	5	16	14	5	13	12	
	SE	17	15	2	8	10	3	3	0	0	7	22	23	10	18	19	
	S	17	12	12	13	14	2	3	4	2	12	13	18	16	11	14	
	SW	16	16	18	15	16	2	3	13	7	25	4	11	15	5	9	
	W	16	15	23	21	19	3	3	11	11	28	1	6	11	2	5	
	NW	6	16	17	20	15	0	4	4	8	16	5	4	11	10	7	
18.	N	1	4	8	3	4	0	0	1	0	2						
	NE	1	5	7	1	3	0	0	0	0	1						
	E	4	9	6	4	6	0	1	0	0	1						
	SE	24	20	7	12	16	11	5	0	2	18						
	S	34	20	9	21	21	15	5	1	5	25						
	SW	22	16	19	24	20	5	3	9	6	22						
	W	7	13	22	19	15	1	3	13	7	24						
	NW	2	7	15	10	8	0	1	5	2	8						

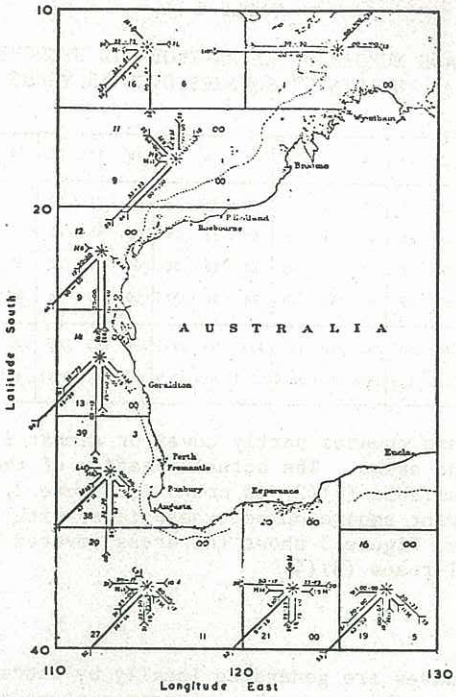

Figure 5 Section of sea and swell charts from Reference (3)

Average wind conditions are recorded for both extra-tropical cyclones (Squares 1-18) and tropical cyclones (Squares 19-35) in Table III. These percentages are for all wind velocities, gleaned from distributions for various velocity increments.

Because wave data are not generally available for storm conditions (ships masters want to avoid them) and because fetches and durations cannot be defined in averages, storm waves for extra-tropical cyclones will not be computed. However, the directional wave energy has been computed for the higher wind velocities on the basis of energy per unit area of ocean equalling wave height squared (H^2) and wave height varying with wind velocity squared (U^2). Thus the directional distribution of U^4 is noted in Table III for Squares 1 to 18 only, as gleaned from wind roses as in Figure 3.

3 WAVES

Sea and swell heights (3)(4) have been classified as low, medium and high from roses depicted in Figure 5, the legend for which the reader is referred to the original publication. Wave period is not specified since there is no correlation between it and wave height. Swell from any given storm varies continuously in height and period and hence period averages are not meaningful. For coastal studies waves recorded from landward directions in 5° squares serve little purpose and hence in Table IV have been omitted.

As noted already, average storm waves in extra-tropical cyclones cannot be assessed and therefore directional wave energy (varying as U^4) has been listed in Table III. Where annual percentages exceed 20% it could be expected that winds in excess of 30 knots could blow for sufficiently long to produce a fully arisen sea. Assuming such conditions Silvester (7) has shown that the significant wave height ($H^1/_3$) is 6 metres and significant period ($T^1/_3$) is 11 seconds. Such deep-water values should be used for all extra-tropical zones (Squares 1 to 18) unless worse wind conditions are known to be possible. A

TABLE V

MAXIMUM TIDAL RANGES AND STORM SURGES (IN METRES) FOR ALL COASTAL MARGINS

5° Sq No.	Max Tide	Storm Surge		5° Sq No.	Max Tide	Storm Surge	
		Ave	Extr.			Ave	Extr.
1	1.8	0.1	0.3	19	1.4	0.3	0.75
2	1.7	0.1	0.4	20	2.0	0.7	1.9
3	0.6	0.1	0.3	21	4.7	0.6	2.1
4	2.2	0.4	0.5	23	8.4	0.85	3.1
5	1.1	0.2	0.55	25	5.4	1.0	4.3
6	1.4	0.15	0.45	26	5.1	0.9	4.0
7	1.2	0.15	0.5	27	3.2	1.0	5.0
8	2.4	1.0	2.5	28	2.5	1.0	5.0
9	2.0	0.15	0.6	29	3.2	1.0	5.0
12	1.7	0.15	0.5	30	3.1	0.7	3.2
13	1.1	0.1	0.4	32	2.8	0.5	2.0
15	1.0	0.15	0.4	33	3.8	0.7	2.2
16	0.8	0.1	0.35	34	4.9	0.9	5.5
18	0.65	0.15	0.45	35	2.2	0.6	1.5

maximum wave height (H_{max}) (once in 1000 waves) can be computed from

$$H_{max} = 1.86\ H^{1}/_{3}.$$

Waves generated by tropical cyclones can be computed without references to the wind structure, by the method proposed by Bretschneider (8). The wave heights and periods vary throughout the area of the cyclone, the maxima occur near the edge of the eye (where the highest wind velocities exist) and move in the direction of travel of the centre. These maxima (H and T) are noted at the base of Table II, together with directions of travel for both typical and extreme cyclones. The modifications necessary to derive characteristics of waves issuing from other parts of the cyclone are detailed elsewhere (7).

4 SEA-LEVEL CHANGE

Since the use of wave data for design purposes is closely associated with the transient level of the sea at the location, it is worthwhile summarising information on tidal range and storm surge. Tidal variations around Australia have been examined by Mitchell (9) but are not yet in publishable form. Storm surges have also been compiled by Mitchell (9) but have been published in abreviated form elsewhere (10).

Tidal records for many points around the Australian coastline have provided maximum ranges, besides other averages, which can thus be computed from a knowledge of deep-water oscillation at the edge of the shelf (11). Values can be derived which are representative of each 5° square around the Australian coastline (12). More definitive values can be obtained by using more specific input data. The optimum tidal ranges are listed in Table V.

Optimum storm surge values computed for typical or extreme cyclones are also listed in Table V (9). Where the tide is exceptionally high the extra inshore depth will tend to attenuate the effect of wind drag on the sea surface. Thus for these sites the tide and surge need

TABLE IV

AVERAGE SEA AND SWELL FOR ALL 35 SQUARES

Sq No.	Height Group	Direction	Average Sea					Swell					Direction	Average Sea					Swell					Sq No.
			Sum	Aut	Win	Spr	Ann	Sum	Aut	Win	Spr	Ann		Sum	Aut	Win	Spr	Ann	Sum	Aut	Win	Spr	Ann	
1.	Low	N		13		5	5						S	8	5	7	14	9	15	3		7	6	19.
		NE	7	8		4	5	7			6	3	SW	13	4	8	4	7	11	26	16	14	17	
		E				8	2	12	14		7	8	W		5		3	2		2	16		5	
		SE	9				2	7	8	5		20	NW			8		2						
		S		5	6	5	6	7	7	5	4	6	N											
	Medium	N	10			11	5	7			10	4	S	42	33	7	25	27	15	11	3	25	14	
		NE	18	6		11	9	7	10		8	6	SW	7	12	15	9	11	19	24	17	17	19	
		E	10	19			7						W		5	5		3	5		8	3	4	
		SE	9	13	7	10	10	6	11	8		6	NW			15		4			3		1	
		S	10	14	12	14	13	12	11	21	20	16	N			2		1						
	High	N				1	0						S	13			19	8	16	12		6	9	
		NE	3	1		1	1	1			8	2	SW		3	5	7	4	5	18	25	28	19	
		E											W											
		SE						3	9	3	13	7	NW			5		1						
		S		4	2	1	2	2	7	13	8	8	N											
2.	Low	NE	16	6			2	12	7			5	S	4	18	12	17	13	20	10	12	8	13	20.
		E								13	14	7	SW	3	7	7	8	6	16	24	22	15	19	
		SE		11	11	7	8	2		8		3	W											
		S	7		6	4	4		16	3	5	6	NW			4		1		3			1	
		SW	2		6	4	3	5	3		8	4	N		2			1						
	Medium	NE	5	8			3		13			3	S	47	19	3	28	24	18	5	6	21	13	
		E			11		3						SW	12	13	11	14	13	14	11	7	12	11	
		SE	12	8			5	10		5		4	W											
		S	9	8	9	11	9	8	7	18	14	12	NW			2		1						
		SW	14	11	11	18	14	15	18	10	11	15	N											
	High	NE		9			2						S	17	8		3	7	14	15		15	11	
		E											SW	3			7	4	3	5	18	13	10	
		SE						5		2		2	W	3				1						
		S	2		3		1	8	3	10	5	7	NW											
		SW	5	6	8	2	5	6	4			3	N											
3.	Low	E	5	13			5				19	5	SW	26		5	5	9	36	11	11	27	21	21. 22.
		SE			14	8	6		7	4		3	W	9	3			4						
		S	10				3			8		2	NW									3	1	
		SW	12			14	7	6	7	4	19	9	N					2						
		W	13		7	6	7	9			9	5	NE											
	Medium	E	10		11	8	7		12	12		6	SW	26	3		8	9	22	6	4	10	10	
		SE		10			3						W						6				2	
		S			7		2	14	19		13	12	NW	13				3						
		SW	15	13	7	6	10	15	11	12	3	10	N	5				1						
		W	5	10	7	8	8			12	6	5	NE		9			2						
	High	E											SW	9				2			4		1	
		SE								12		3	W	5				1						
		S											NW						11				3	
		SW	5		11		4	6	4			3	N						11				3	
		W	2		4	8	4				6	2	NE	9				2						
4.	Low	NW											SW	12				3				30	8	23.
		W											W				7	2						
		NW											NW				33	8				10	3	
		NE											N				13	3						
		E								34		11	NE											
		SE																						
	Medium	NW											SW				13	3	11			20	8	
		N											W	12				3	22				6	
		NE		33			11		33			11	NW	12				3						
		E											N	12				3						
		SE								34		11	NE		11			3						
	High	NW											SW								11		3	
		N											W											
		NE											NW						12				3	
		E											N						22				6	
		SE											NE	37				9						
5.	Low	S											SW				12	3		25		21	12	24.
		SW	40			14	18		17			6	W	11			12	6				22	6	
		W				14	5	25	17			14	NW						9			7	4	
		NW						25			17	14	N		11		12	6						
		N											NE		8	7		4			11		3	
	Medium	S											SW	11			6	4	11				3	
		SW		12			4		17			6	W	11				3	22			7	7	
		W	20			14	11						NW											
		NW	40			14	18		17			6	N											
		N		12			4						NE	11			8	5						
	High	S											SW								11		3	
		SW						50			17	22	W						11				3	
		W		25			8						NW						12				3	
		NW		12			4				17	6	N						22				5	
		N				14	3						NE		4			1						
6.	Low	E		8			2						W				15	5				50	17	25.
		SE		8	8	11	7						NW				15	5						
		S	9		3		3	10				3	N											
		SW	5	8	8	5	7	13	9	18	21	15	NE											
		W	7	5		5	4	5	11		7	6	E				43	14						
	Medium	E	7	8			4		9			2	W				15	5						
		SE	14	8			7		9			2	NW											
		S	9		8		4			13		3	N											
		SW	7		10	15	8	20	9	8	15	13	NE											
		W	9	16	10	6	10	10	8		2	5	E											
	High	E					1	13				3	W											
		SE		3			2						NW									17	6	
		S	3		5		3						N											
		SW	9			2	3	13	12	13	19	14	NE											
		W	5	11	13	9	10		12	13	15	10	E				19	6						
7. &	Low	SE				11	3		9			2	W	29				7	17				4	26.
		S		12	14	8	9	7		11		5	NW	43				11						
		SW	4	8		6	5	20	13	11	12	14	N						17				4	
		W	7	12	4	6	7		4	7	7	5	NE											
		NW	7	7	2		4						E		11	20	50	20		7		22	7	
	Medium	SE	13	8			3						W											
		S	7				2	5				1	NW	14				4						
		SW	15	12		15	11	22	15	4	12	13	N											
		W	11		10	16	9		6	4	8	5	NE											
		NW		24	14	7	11						E									7	2	
	High	SE											W									7	2	
		S						3				1	NW									7	2	
		SW	6	2		8	4	17	17	9	29	18	N											
		W	2		10	3	4	13	7	9	9	10	NE											
		NW		24	8		8			9		2	E				10	3						

TABLE IV

(continued)

Sq No.	Height Group	Direction	Average Sea Sum	Aut	Win	Spr	Ann	Swell Sum	Aut	Win	Spr	Ann	Direction	Average Sea Sum	Aut	Win	Spr	Ann	Swell Sum	Aut	Win	Spr	Ann	Sq No.
9. 10.	Low	E		7			2						NW	11				3	22				6	27.
		SE	7				2						N											
		S	11		7	10	7						NE											
		SW	13	9	10	4	9	20	9	8	20	14	E	11	11		41	16			9	23	8	
		W	15	12	4	4	6	1	12	6	1	5	SE	45	13	30	21	27		12	14	11	9	
	Medium	E	13	12			6			8		2	NW	11				3						
		SE	11		7		5		9			2	N											
		S			12		3						NE											
		SW			8		2	17	23	6	17	16	E		6	10	17	8				4	1	
		W		7	6	15	7	10	9	10	10	10	SE		50	35	3	22						
	High	E											NW	11				3						
		SE											N											
		S											NE											
		SW		2	8	9	5	20	16	16	20	24	E											
		W	3	5	6	2	4	12	9	14	12	12	SE			19	3	6				23	6	
11. 12.	Low	E				10	3						W											28. 29.
		SE						9	10			5	NW	7				4	9				5	
		S						9			8	4	N						18				9	
		SW	4		14	3	5	13	12	3	5	8	NE											
		W		9	5	3	4		1	5	2	2	E			10		5						
	Medium	E		10			3						W											
		SE	13				3						NW	50				25						
		S	11	9		8	7						N	7				4						
		SW	13	14	3	15	11	18	15	14	21	17	NE											
		W	11	11	11	14	12	6	5	28	7	12	E											
	High	E	8				2						W											
		SE											NW	7				4						
		S											N											
		SW	11		11	5	7	21	25	20	24	23	NE											
		W		6	5	5	4	10	18	1	18	12	E											
13. 14.	Low	E		11			3						W		11			3						30. 31.
		SE											NW											
		S	5				1						N	12				3						
		SW	4		11	9	6	14	9		8	8	NE	12			11	6						
		W	7	9	5		5		3	2	2	2	E	25	22	10	29	22	25		10	9	11	
	Medium	E	13				3						W											
		SE											NW											
		S	10		8	8	7	12				3	N											
		SW	16	14	9	14	13	15	20	12	14	15	NE											
		W	11	9	14	12	12		5	13	15	6	E											
	High	E											W											
		SE											NW											
		S	2							11			N											
		SW	2			2	1	29	23	17	32	25	NE											
		W	4	9	5	12	8	13	18	15	23	17	E											
15.	Low	E	1	9		4	4		12			3	NW	8			7	4						32.
		SE	8	9		4	5		2			1	N				7	2						
		S	8	2		6	4	1	5			2	NE	8				2				12	3	
		SW	4	10	5	12	8	7	26	4	1	10	E	17		11	13	10				12	3	
		W	4	10	5	3	6	2	3	5	2	3	SE	34		22	19	19	33			6	10	
	Medium	E	8	7		6	5	4	6		2	3	NW											
		SE	6			3	2	5				1	N											
		S	4	3	4	7	5	12			4	4	NE								23		6	
		SW	17	5	3	8	8	19	18	11	28	19	E				7	2						
		W	14	2	11	8	12	6	8	10	4	7	SE	34	100	22	13	42	7	17	25	6	14	
	High	E		2		5	2						NW											
		SE	1										N											
		S	3			1	1		2	8		3	NE											
		SW	4	4	7	7	6	22	10	13	29	19	E											
		W	3	8	14	9	9	8	13	28	14	16	SE			11	13	6			25	13	10	
16.	Low	S	11	7	3	14	9	7	5		7	5	NW	24				6		7			2	33. 34.
		SW	1	2	8	8	5	9	17	7	11	11	N				10	3	13				3	
		W	13	6	5	4	7		7	8	3	5	NE	12				3				13	3	
		NW		2	4		2			1			E	18		15	30	16	25		19	13	14	
		N											SE	6	6	10	10	8	14		10	17	10	
	Medium	S	22	12		13	12	16	8	3	3	9	NW											
		SW	16	14	11	14	14	21	19	10	13	16	N											
		W		6	14	10	8	3	7	25	7	11	NE											
		NW			11	4	4			1			E	6		15	10	8	8	7	10	7	8	
		N			4		1						SE	12	68	35	10	31		33	15	20	17	
	High	S	6	2		3	3	29	4		10	11	NW											
		SW	1		2	6	2	12	12	19	24	17	N											
		W		1	5	4	3	3	5	24	11	11	NE				15	4						
		NW		3	2		1			3		1	E											
		N											SE	12	6			5	14	33		6	13	
17.	Low	E	1	9		4	4		12			3	N											35.
		SE	8	9		4	5		2			1	NE	6			10	4	10				3	
		S	8	2		6	4	1	5			2	E	10	6		10	7	10	6			4	
		SW	4	10	5	12	8	7	26	4	1	10	SE	8	10	4	8	8	12	9	4	7	8	
		W	4	10	5	3	6	2	3	5	2	3	S		6	6	4	4	7	5	6	8	7	
	Medium	E	8	7		6	5	4	6		2	3	N	10			11	5						
		SE	6			3	2	5				1	NE	8				2						
		S	4	3	4	7	5	12			4	4	E	6	12			5						
		SW	17	5	3	8	8	19	18	11	28	19	SE	19	20	15	14	17	12	22	13	15	17	
		W	14	2	11	8	12	6	8	10	4	7	S	11	15	9	15	13	6	11	14	15	12	
	High	E		2		5	2						N											
		SE	1										NE	1										
		S	3			1	1		2	8		3	E		1				3	5			2	
		SW	4	4	7	7	6	22	10	13	29	19	SE	2	6	3	1	3	2	12	4	4	6	
		W	3	8	14	9	9	8	13	28	14	16	S		5	4	2	3	3	3	12	48	17	
18.	Low	S	11	7	3	14	9	7	5		7	5												
		SW	1	2	8	8	5	9	17	7	11	11												
		W	13	6	5	4	7		7	8	3	5												
		NW		2	4		2			1														
		N																						
	Medium	S	22	12		13	12	16	8	3	3	9												
		SW	16	14	11	14	14	21	19	10	13	16												
		W		6	14	10	8	3	7	25	7	11												
		NW			11	4	4			1														
		N			4		1																	
	High	S	6	2		3	3	29	4		10	11												
		SW	1		2	6	2	12	12	19	24	17												
		W		1	5	4	3	3	5	24	11	11												
		NW		3	2		1			3		1												
		N																						

not necessarily be added. Comparisons should continually be made between recorded sealevels during storms with computed storm surge and expected astronomical tides. Extrapolation procedures are outlined elsewhere (7)(9).

It is relevant to point out that tide and surge levels as quoted for the shoreline are not applicable to greater depths, which are closer to the seaward edge of the continental shelf. The height distribution of tidal range and the wind stress component of the storm surge is attenuated seawards by proportions that are dependent upon the shelf profile. More research is required on this topic.

5 CONCLUSIONS

The wind and wave data presented herein must perforce be succinct. It has been reduced from monthly values and other variables. It does, however, provide an initial insight into wave conditions around the coastlines of Australia. Space does not permit of comparisons with other workers although the work of Nelson (13) for the tropical regions is worthy of note.

6 REFERENCES

1. Monthly Meteorological Charts, Indian Ocean Met. Office, Great Britain 1949.
2. Monthly Meteorological Charts, Western Pacific Ocean Met. Office. Great Britain 1956.
3. Atlas of Sea and Swell Charts. Indian Ocean Naval U.S. Oceanographic Office, Washington, 1944.
4. Atlas of Sea and Swell Charts, South Western Pacific Ocean U.S. Naval Oceanographic Office, Washington, 1949.
5. Karelsky S. "Monthly and Seasonal anticyclonicity and cyclonicity in the Australian Region - 15 years (1946-1950) averages" Met. Study No.13, Bureau of Met., Comm. of Aust. 1961.
6. Coleman F."Frequencies tracks & intensities of tropical cyclones in the Australian region Nov. 1909 to June 1969" Bur. of Met. Comm. of Aust. 1971.
7. Silvester R. Coastal Engineering Vol I Elsevier Publ. Co., Amsterdam, 1974.
8. Bretschneider C.L. "Revisions to hurricane design wave practices" Proc. 13th Conf. Coastal Eng. Vol. I, 1972 167-195.
9. Mitchell H.L. "Oceanographic phenomena around the coastlines of Australia" Dept. of Civil Eng. Report, Uni. of Western Australia (In Press).
10. Silvester R and H.L. Mitchell "Storm surges around Australian Coastlines "Proc. 3rd Aust. Conf. Coastal Eng. 1977, 49-57.
11. Easton A.K. "The tides of the continent of Australia" Res. Pap. No. 37, Horace Lamb Centre, Flinders University, 1970.
12. Admiralty Tide Tables Vol. 3 Admiralty Hydrographic Dept., Royal Navy, Annual.
13. Nelson R.C. "Design wave characteristics for tropical cyclones in the Australian region." Trans. Instn. Engrs. Aust. CE14(1), 1972, 37-41.