LIGHT PENETRATION IN THE TASMAN SEA

DIVISION OF FISHERIES AND OCEANOGRAPHY TECHNICAL PAPER NO. 6

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION, AUSTRALIA 1959

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Division of Fisheries and Oceanography
Technical Paper No. 6

Commonwealth Scientific and Industrial
Research Organization, Australia

Melbourne 1959

Printed by C.S.I.R.O., Melbourne

MEASUREMENTS OF LIGHT PENETRATION IN THE TASMAN SEA, 1955–57

By H. R. Jitts *

[*Manuscript received July 18, 1958*]

Summary

Measurements of the depth of penetration of 1 per cent. of surface light in the Tasman Sea during 1955–57 were made with a selenium photocell submarine photometer. At two onshore stations near Sydney an annual cyclic trend of from 120 m in summer to 40 m in winter was found in the depth of penetration during 1955–56. In the Northern Tasman Sea, in November–December 1955, the depth of penetration varied from 224 m off Noumea to 102 m off Sydney. From April to November 1957 measurements made on lines of stations east of Sydney showed that in waters more than 50 miles off the coast the depth varied from 60 m to 120 m.

A diurnal variation of the depth of penetration of light was found in oceanic waters, which could be accounted for by the effect of solar altitude. However, in onshore waters the diurnal variation was much greater, and also irregular, making it evident that other factors had a greater influence than solar altitude.

I. Introduction

Since 1955, measurements of submarine light penetration have been made at numerous stations in the Tasman Sea during various cruises of the F.R.V. *Derwent Hunter* and from small boats at two onshore stations off Port Hacking, near Sydney. These studies were made to obtain information on the depth of the euphotic zone at the stations and also to explore the possibility of using transparency as an identifying characteristic of water masses. In addition, at the two onshore stations at Port Hacking, a study was made of the annual variation of light penetration. The results obtained in these studies are presented in this paper.

The methods used were similar to those of Jerlov (1951) and Steemann Nielsen and Jensen (1957), though not as detailed or accurate. The depth of the euphotic zone was measured by estimating the depth to which 1 per cent. of the surface light penetrates. This method of measurement of the depth of the euphotic zone has been used in productivity studies by Steemann Nielsen (1952) and by Jitts and Rotschi (1957).

During 1951 the Danish research vessel *Galathea* carried out measurements of light penetration at several stations in the Tasman Sea (Steemann Nielsen and Jensen 1957). Only three of these stations were in waters adjacent to Australia. Apart from these, no other light measurements in the Tasman Sea have been reported.

II. Methods

(*a*) *Submarine Photometer*

The submarine photometer used in this work was designed by the Division of Physics, C.S.I.R.O. It consisted of a selenium photocell housed in a watertight

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brass casing with a $\frac{1}{4}$-in. plate glass circular window. An opal glass diffuser bowl, 8 in. in diameter, covered the window of the photometer (see Fig. 1). A plastic-covered, armoured, two-core cable entered the brass casing through a watertight gland, and transmitted the electrical output of the photocell to the metering system on deck.

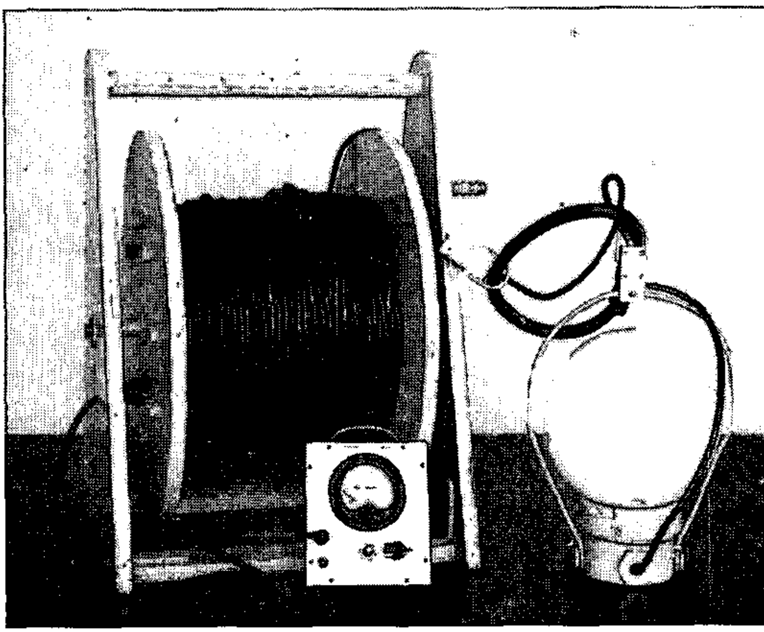

Fig. 1.—Submarine photometer with its cable and shunted microammeter.

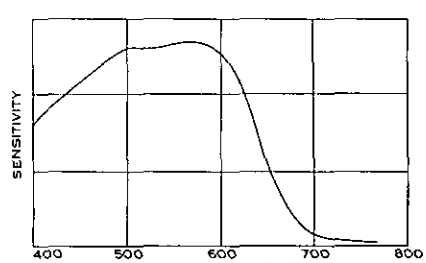

Fig. 2.—Spectral sensitivity of the Megatron Photocell, type B. (With acknowledgments to Megatron Ltd.).

The photocell used was a Megatron Type B, 45 mm in diameter. The maker's specifications (see Fig. 2) showed a fairly uniform spectral response for this type between wavelengths of 440 mμ and 630 mμ. No filters were used. The metering system consisted of a microammeter (120 Ω resistance, 100 μA full scale) with a universal shunt which gave five ranges of sensitivity with a constant input resistance of 80 Ω. No attempt was made to calibrate the photometer, as the meter readings were used directly to determine only the relation of light intensities at various depths to that at the surface.

(*b*) *Measurement of Light Penetration*

Photometer readings were taken just below the surface of the water and then at 10 m intervals (determined by the length of cable paid out) down to 50 m at the onshore stations. At offshore stations readings were sometimes taken down to 60, 80, and occasionally 100 m. At most stations, readings were repeated at the same depth intervals while raising the photometer. The readings thus obtained were then converted to percentages of that obtained at the surface at each station, and are

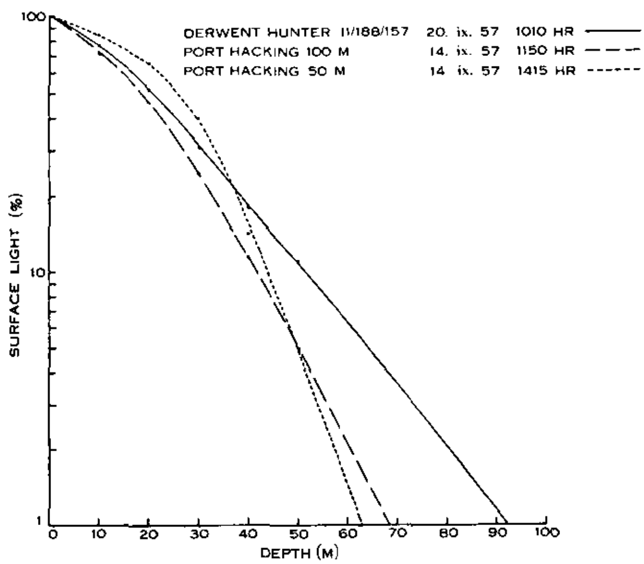

Fig. 3.—Typical examples of extrapolations to obtain the depth of penetration of 1 per cent. of surface light.

presented as such in this report. Corrections for variations in light intensity at the surface were made in a similar way to that of Steemann Nielsen and Jensen (1957), taking simultaneous readings of deck light intensity with a separate photometer.

(*c*) *Estimation of the Depth of Penetration of* 1 *per cent. of Surface Light*

The percentage of surface light found at each depth interval was plotted on a logarithmic scale against depths. The curve of best fit joining these points was selected by inspection and extrapolated to the intersection with the line of 1 per cent. of surface light. The depth indicated at this point of intersection was taken as that to which 1 per cent. of the surface light penetrated.

The curves obtained in the above manner showed a similar decrease in transparency with depth as found by Jerlov (1951), though this decrease was by no means constant and in fact varied during the day. Some typical examples of this are shown in Figure 3. The decreases in transparency were usually found to be greater than those found by Jerlov. This was probably due to the fact that no filters were used; thus the narrowing of the spectral band width with penetration into the water would have given an added apparent decrease in transparency.

The inaccuracies of the depth measurements and instrumental errors, as well as the uncertainty of the extrapolation of the curve, made the accuracy of the estimation of the depth of penetration of light probably of the order of ± 5 per cent.

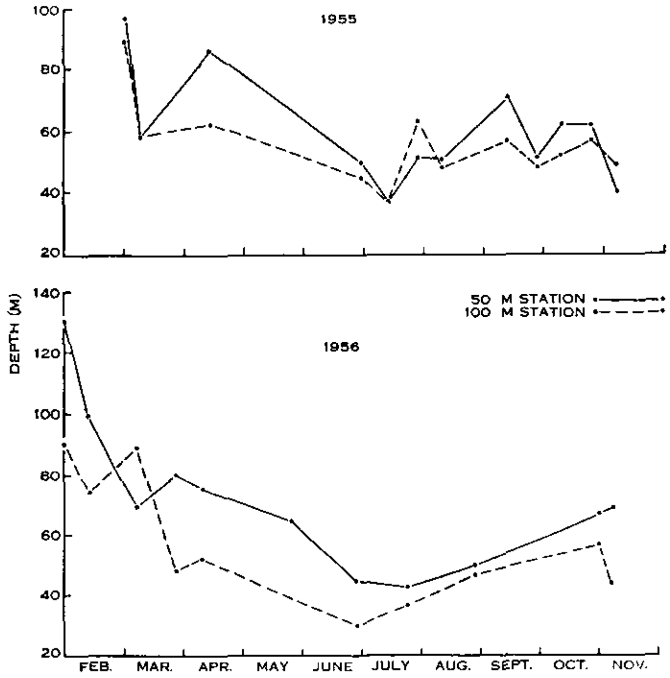

Fig. 4.—Annual variations of the depth of penetration of 1 per cent. surface light at the Port Hacking 50 m and 100 m stations during 1955 and 1956.

III. Results

The details of light penetration measurements made in the Tasman Sea during 1955–56–57 are given in the Appendix. Estimates of the depth of penetration are presented below.

(a) *Port Hacking Onshore Stations*

Measurements were made during 1955–56–57 at two onshore stations on the continental shelf off Port Hacking. At the first, the Port Hacking 50 m station, about 3 miles off the coast with a sounding depth of approximately 60 m, measurements were made on 22 occasions during 1955–56 at roughly monthly intervals, and on two occasions during 1957. At the second station, the Port Hacking 100 m station, about 7 miles off the coast with a sounding depth of 120 m, measurements were made on 23 occasions during 1955–56 at roughly monthly intervals, and on ten occasions during 1957.

Although there was a considerable fluctuation between successive measurements, the depth of 1 per cent. surface light at these two stations showed a marked annual cyclic trend (Fig. 4) during 1955 and 1956. Results during 1957 were too fragmentary to show this variation. The annual cycle showed a summer maximum of about 120 m in January and a winter minimum of about 40 m in July.

On 22 occasions during 1955–56, measurements were made at both stations on the same day. It was found that the depth of penetration at the 100 m station was

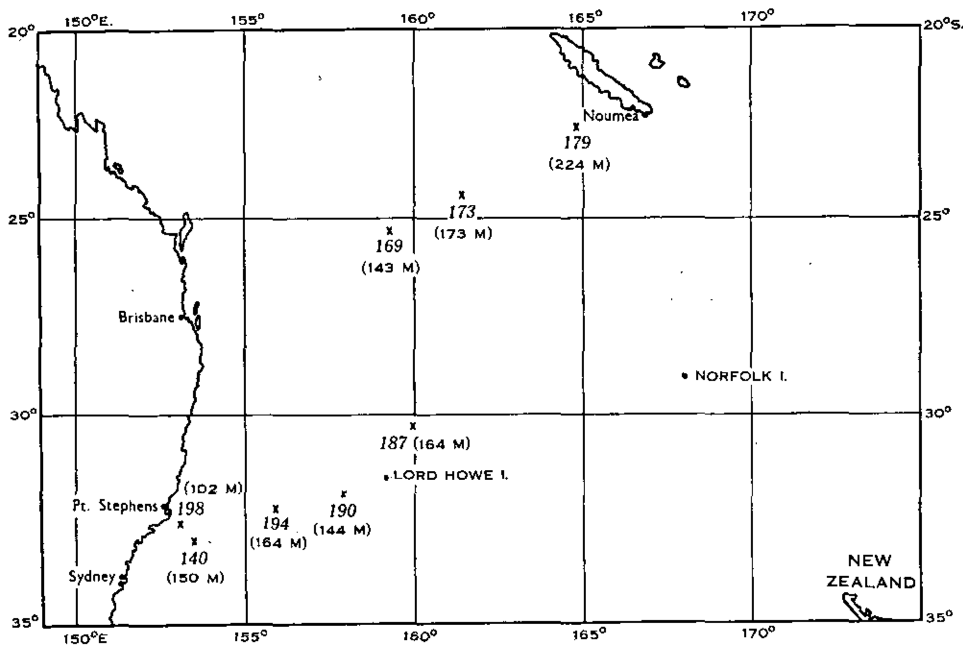

Fig. 5.—Light penetration in the Northern Tasman Sea during November–December 1955. Station positions marked ×, station numbers in *italic* numerals, depth of 1 per cent. surface light in parentheses.

greater than that at the 50 m station on all but four of these days. The average depth of penetration at the 100 m station for the 22 measurements was 66 m. An average of 56 m was found at the 50 m station.

(b) *Tasman Sea Oceanic Stations*

During the November-December 1955 cruise of the F.R.V. *Derwent Hunter* in the Northern Tasman Sea, measurements of light penetration were made at three stations between Brisbane and Noumea, and at five stations between Lord Howe Island and Sydney (Fig. 5). The depth of penetration of 1 per cent. of surface light was found to vary from 143 m to 224 m in the waters between Brisbane and Noumea Between Lord Howe Island and Sydney it was found to vary from 102 m to 164 m.

From April to November 1957 light measurements were made during four cruises of the F.R.V. *Derwent Hunter* (cruises DH3/57, DH6/57, DH11/57, and DH15/57) on lines of stations east of Port Hacking. The depths of penetration of

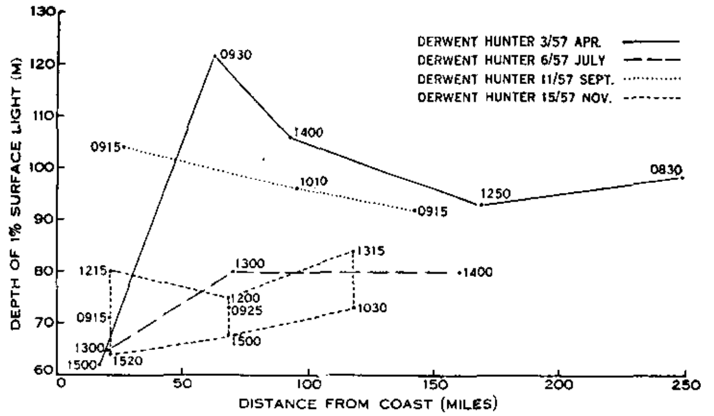

Fig. 6.—Light penetration measurements made on cruises east of Sydney by F.R.V. *Derwent Hunter* in April–November 1957. Numerals indicate the time of measurement.

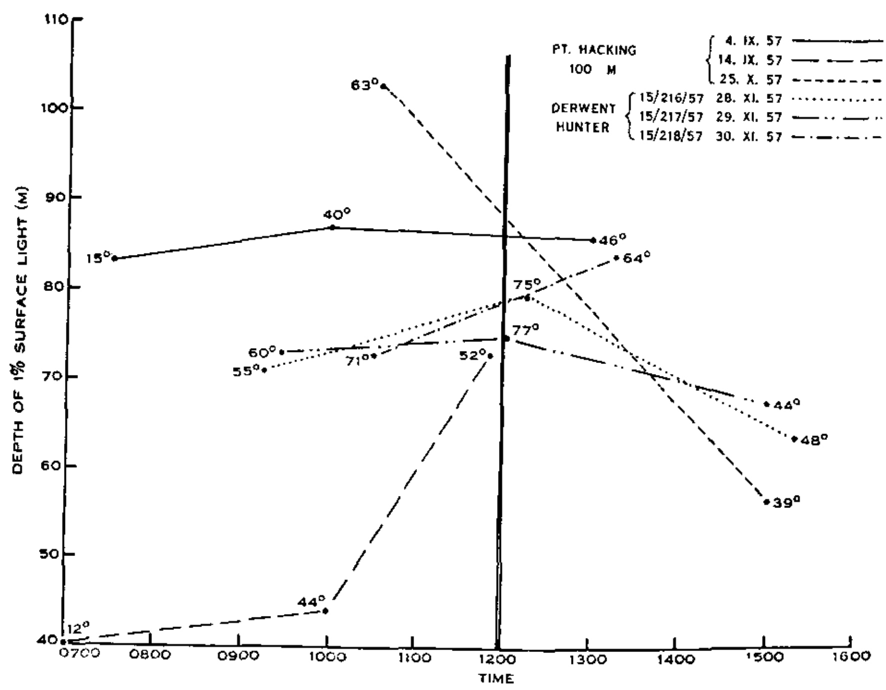

Fig. 7.—Diurnal variations of light penetration on several occasions during 1957. Numerals indicate solar altitude.

1 per cent. surface light at these stations are given in Figure 6. Apart from the September cruise DH11/57, these results showed that stations less than 25 miles from the coast had a depth of penetration significantly less than stations more than 50 miles from the coast. The results also suggested that the waters between 50 and 100 miles east of Sydney were characterized by a depth of penetration of between 90 m and 120 m in April and again in November, while in July and September their depth of penetration was between 60 m and 80 m.

(c) *Diurnal Variations*

On three days in 1957, light penetration was measured on several occasions during the course of the same day at the Port Hacking 100 m station. This procedure was also followed at three stations during Cruise DH15/57 of the F.R.V. *Derwent Hunter* in November 1957. The results are given in Figure 7.

At the Port Hacking 100 m station, on September 4, 1957, very little variation was found in the depth of penetration of 1 per cent. surface light between 0730 hr and 1300 hr, the variation between 83 m and 87 m being within the order of accuracy of the estimation. However, on September 14, 1957, the depth of penetration rose from 40 m at 0700 hr to 73 m at 1150 hr. Again on October 25, 1957, a large variation was found, the depth falling from 103 m at 1030 hr to 57 m at 1500 hr.

At the three oceanic stations in November a significant diurnal variation was found (e.g. 80 m at 1220 hr to 64 m at 1520 hr, station DH15/216/57), but the magnitude was not as great as found at the Port Hacking onshore station.

IV. Discussion

The greater depth of penetration of light at the oceanic stations more than 50 miles off the coast gave evidence that the land mass influenced light penetration off Sydney to a distance of at least 25 miles. That this was a land mass effect was supported by the evidence that the depth of penetration at the Port Hacking 50 m station was significantly lower than at the 100 m station.

Whilst the data were too fragmentary to permit conclusions, the magnitude found for the diurnal variation of the depth of penetration of light made it obvious that the subject requires further extensive study. Although Sverdrup, Johnson, and Fleming (1942, p. 86) state that solar altitude within wide limits does not affect extinction coefficient measurements, the evidence of Jerlov (1951) suggests that it could have a marked effect. The diurnal variations found at the oceanic stations in the Tasman Sea are of a similar order to those given by Jerlov, and could thus be accounted for by solar altitude and inaccuracies in the measurements. This is not the case in the onshore stations at Port Hacking. The irregular nature of the variations and their magnitude make it evident that other factors have a greater influence than solar altitude. The same argument applies to the annual cycle found for the depth of penetration of light at Port Hacking, though not necessarily owing to the same factors.

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APPENDIX I

RESULTS OF LIGHT PENETRATION MEASUREMENTS, PORT HACKING

TABLE 1

PORT HACKING, 1955

50 Metre Station (34° 5′ S., 151° 14′ E.)						100 Metre Station (34° 5′ S., 151° 17′ E.)					
Day and Time (hr)	Depth (m)	% S.L.* Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude	Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
1. iii.55 1000	0	100	100	89	51°	1. iii.55 1045	0	100		96	58°
	10	32	50				10	27			
	20	35	23				20	39			
	30	23	20				30	25			
	40	13	11				40	16			
	50	9·3	8·4				50	7·9			
8. iii.55 1045	0	100	100	58	55°	8. iii.55 1000	0	100	100	100	49°
	10	40	47				10	55	33		
	20	13	25				20	27	13		
	30	8·7	6·7				30	13	5·6		
	40	2·9	3·7				40	6·4	2·6		
	50	1·6	2·1				50	3·4	1·6		
13. iv.55 1245	0	100	100	61	45°	13. iv.55 1120	0	100	100	86	46°
	10	64	40				10	66	61		
	20	21	17				20	42	41		
	30	10	8·0				30	26	22		
	40	6·2	4·0				40	13	11		
	50	3·9	3·2				50	6·6	5·4		
29. vi.55 1255	0	100	100	45	31°	29. vi.55 1210	0	100	100	50	32°
	10	30	50				10	39	39		
	20	10	14				20	16	16		
	30	3·8	5·7				30	8·1	6·9		
	40	1·3	2·1				40	2·4	2·9		
	50	0·5	0·8				50	1·0	1·0		

* S.L. = surface light.

TABLE 1 (*Continued*)

50 Metre Station (34° 5′ S., 151° 14′ E.)						100 Metre Station (34° 5′ S., 151° 17′ E.)					
Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude	Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
11. vii.55 1050	0	100	100	37	32°	11. vii.55 1115	0	100	100	37	33°
	10	32	33				10	33	54		
	20	8·0	9·4				20	8·9	15		
	30	1·9	2·3				30	2·4	3·9		
	40	0·6	0·7				40	0·8	1·1		
	50	0·2	0·2				50	0·3	0·4		
26. vii.55 1025	0	100	100	63	32°	26. vii.55 0905	0	100	100	51	22°
	10	42	45				10	30	40		
	20	20	21				20	15	17		
	30	8·3	9·3				30	6·4	7·0		
	40	4·0	4·3				40	2·8	3·2		
	50	1·6	1·7				50	1·3	1·3		
11.viii.55 1115	0	100	100	48	39°	11.viii.55 1015	0	100	100	51	35°
	10	36	41				10	43	39		
	20	12	17				20	17	15		
	30	4·8	5·3				30	6·8	6·8		
	40	1·8	2·1				40	3·4	3·2		
	50	0·8	0·9				50	1·1	1·1		
13. ix.55 1200	0	100	100	57	44°	13. ix.55 1025	0	100	100	71	47°
	10	33	42				10	48	46		
	20	12	19				20	27	26		
	30	5·4	9·2				30	14	14		
	40	3·3	4·9				40	6·8	7·1		
	50	1·9	2·7				50	3·5	4·0		

TABLE 1 (*Continued*)

50 Metre Station (34° 5′ S., 151° 14′ E.)						100 Metre Station (34° 5′ S., 151° 17′ E.)					
Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude	Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
28. ix.55 *c.*1100	0	100	100	48	57°	28. ix.55 1000	0	100	100	51	67°
	10	50	45				10	60	46		
	20	16	16				20	24	19		
	30	5·8	5·6				30	6·4	5·6		
	40	2·0	1·7				40	2·8	2·2		
	50	1·0	1·0				50	1·4	1·1		
10. x.55 1115	0	100	100	52	58°	10. x.55 1010	0	100	100	62	55°
	10	37	38				10	48	48		
	20	13	15				20	24	22		
	30	6·0	7·0				30	9·2	9·7		
	40	3·3	4·2				40	4·9	4·9		
	50	1·6	2·0				50	2·9	2·8		
24. x.55 1115	0	100	100	57	67°	24. x.55 0950	0	100	100	64	56°
	10	37	44				10	68	68		
	20	17	21				20	30	27		
	30	7·8	10				30	17	13		
	40	3·7	5·4				40	6·6	4·8		
	50	2·0	2·3				50	3·0	2·1		
7. xi.55 1135	0	100	100	50	72°	7. xi.55 1010	0	100	100	40	63°
	10	25	21				10	42	36		
	20	11	6·8				20	11	9·2		
	30	6·0	4·1				30	2·9	2·9		
	40	3·3	2·7				40	1·0	1·7		
	50	1·5	1·4				50	0·6	0·5		

TABLE 2

PORT HACKING, 1956

50 Metre Station (34° 5′ S., 151° 14′ E.)						100 Metre Station (34° 5′ S., 151° 17′ E.)					
Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude	Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
31. i.56	0	100	100	90	73°	31. i.56	0	100	100	130	66°
1225	10	63	65			1050	10	57	68		
	20	40	39				20	48	42		
	30	25	26				30	35	37		
	40	15	14				40	23	26		
	50	8·3	8·4				50	12	13		
13. ii.56	0	100	100	74	68°	13. ii.56	0	100	100	99	58°
1140	10	39	25			1020	10	70	56		
	20	17	26				20	60	40		
	30	14	11				30	37	30		
	40	7·2	6·3				40	22	16		
	50	3·6	3·0				50	11	7·3		
5. iii.56	0	100	100	89	62°	5. iii.56	0	100	100	69	58°
1140	10	41	34			1055	10	35	24		
	20	20	21				20	18	16		
	30	7·7	10				30	11	8·3		
	40	6·2	10				40	5·6	4·4		
	50	3·2	8·0				50	3·6	3·5		
26. iii.56	0	100	100	48	53°	26. iii.56	0	100	100	80	48°
c.1130	10	25	20			1030	10	20	15		
	20	7·5	7·6				20	15	11		
	30	3·7	3·3				30	7·1	5·7		
	40	2·4	2·1				40	5·1	4·2		
	50	2·0	1·8				50	4·5	3·6		

TABLE 2 (*Continued*)

50 Metre Station (34° 5′ S., 151° 14′ E.)						100 Metre Station (34° 5′ S., 151° 17′ E.)					
Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude	Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
9. iv.56	0	100	100	52	48°	9. iv.56	0	100	100	75	41°
1130	10	25	22			1010	10	58	58		
	20	7·9	7·5				20	39	36		
	30	3·8	3·6				30	21	19		
	40	2·6	2·4				40	10	9·4		
	50	2·0	1·9				50	4·6	4·6		
						23. v.56	0	100	100	65	36°
						1000	10	79	41		
							20	40	25		
							30	20	10		
							40	7·8	4·0		
							50	3·9	2·0		
27. vi.56	0	100	100	30	32°	27. vi.56	0	100	100	45	26°
1115	10	13	12			0955	10	32	33		
	20	3·5	3·4				20	10	11		
	30	1·2	1·0				30	3·9	4·2		
	40	0·4	0·3				40	1·6	1·7		
	50	0·1	0·1				50	0·7	0·8		
23. vii.56	0	100	100	37	35°	23. vii.56	0	100	100	43	29°
1120	10	29	30			1000	10	36	34		
	20	10	10				20	10	10		
	30	3·5	3·2				30	2·8	2·9		
	40	1·5	1·3				40	0·8	0·9		
	50	0·6	0·5				50	0·3	0·3		

TABLE 2 (*Continued*)

50 Metre Station (34° 5′ S., 151° 14′ E.)						100 Metre Station (34° 5′ S., 151° 17′ E.)					
Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude	Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
27.viii.56	0	100	100	47		27.viii.56	0	100	100	50	
c.0900	10	135	32			*c*.1000	10	45	60		
	20	18	12				20	22	100		
	30	6·2	4·4				30	3·3	61		
	40	2·3	1·6				40	1·5	29		
	50	0·0	0·0				50	3·5	14		
30. x.56	0	100	100	57	57°	30. x.56	0	100	100	67	66°
0945	10	71	68			1045	10	74	76		
	20	26	29				20	35	35		
	30	8·2	9·4				30	17	16		
	40	3·5	3·8				40	7·4	7·2		
	50	1·8	1·8				50	4·0	3·6		
7. xi.56	0	100	100	44	66°	7. xi.56	0	100	100	69	55°
1030	10	20	20			1930	10	49	56		
	20	12	12				20	22	30		
	30	4·8	4·8				30	13	18		
	40	1·5	1·5				40	5·6	10		
	50	0·5	0·5				50	2·6	2·9		

TABLE 3

PORT HACKING, 1957

50 Metre Station (34° 5′ S., 151° 14′ E.)						100 Metre Station (34° 5′ S., 151° 17′ E.)					
Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude	Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
25. ii.57 c.1100	0	100		62		25. ii.57 c.1000	0	100		63	
	10	80					10	92			
	20	56					20	71			
	30	16					30	36			
	40	6·0					40	13			
	50	3·0					50	3·9			
						29. iv.57 c.1000	0	100	100	65	
							10	54	52		
							20	26	26		
							30	12	13		
							40	7·7	8·4		
							50	6·3	6·3		
						4. ix.57 0730	0	100	100	83	15°
							10	145	132		
							20	65	50		
							30	27	22		
							40	13	10		
							50	8·0	5·8		
							60	5·1	3·7		
						4. ix.57 1000	0	100	100	87	40°
							10	74	71		
							20	53	52		
							30	31	30		
							40	16	16		
							50	8·7	8·5		
							60	5·3	5·0		

TABLE 3 (*Continued*)

50 Metre Station (34° 5′ S., 151° 14′ E.)						100 Metre Station (34° 5′ S., 151° 17′ E.)					
Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude	Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
						4. ix.57 1300	0	100	100	86	46°
							10	77	72		
							20	55	51		
							30	31	29		
							40	16	16		
							50	8·3	8·1		
							60	5·0	4·7		
14. ix.57 1415	0	100	100	63	39°	14. ix.57 0700	0	100	100	40	12°
	10	81	87				10	21	23		
	20	60	71				20	7·1	7·1		
	30	28	50				30	2·6	2·6		
	40	11	18				40	1·1	1·0		
	50	5·0	4·5				50	0·4	0·4		
						14. ix.57 1000	0	100	100	44	44°
							10	45	47		
							20	12	12		
							30	3·5	3·9		
							40	1·6	1·8		
							50	0·8	0·8		

TABLE 3 (*Continued*)

50 Metre Station (34° 5′ S., 151° 14′ E.)						100 Metre Station (34° 5′ S., 151° 17′ E.)					
Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude	Day and Time (hr)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
						14. ix.57 1150	0	100	100	68	52°
							10	70	72		
							20	45	48		
							30	24	25		
							40	11	12		
							50	5·5	5·3		
						25. x.57 1035	0	100	100	104	63°
							10	81	82		
							20	66	65		
							30	50	55		
							40	31	42		
							50	16	25		
							60	12	11		
						25. x.57 1500	0	100	100	57	39°
							10	52	54		
							20	25	29		
							30	9·0	14		
							40	3·3	5·3		
							50	1·7	1·9		
							60	1·1	1·1		

APPENDIX II

RESULTS OF LIGHT PENETRATION MEASUREMENTS, F.R.V. DERWENT HUNTER

TABLE 4

F.R.V. DERWENT HUNTER, NORTHERN TASMAN CRUISE

November–December 1955

Station	Day and Time (hr)	Position	Depth (m)	% S.L.	Depth of 1% S.L. (m)	Solar Altitude
DH/140/55	17. xi.55	33° 3′ S.	0	100	150	74°
	1100	153° 28′ E.	10	60		
			20	45		
			30	39		
			40	27		
			50	19		
DH/169/55	29. xi.55	25° 6′ S.	0	100	143	26°
	0730	159° 18′ E.	10	71		
			20	44		
			30	42		
			40	30		
			50	20		
			100	9		
DH/173/55	30. xi.55	24° 23′ S.	0	100	173	87°
	1200	161° 29′ E.	10	70		
			20	60		
			30	48		
			40	38		
			50	25		
			100	6		
DH/179/55	2. xii.55	22° 36·5′ S.	0	100	224	65°
	1000	164° 56′ E.	10	90		
			20	74		
			30	46		
			40	45		
			50	33		
			100	12		
DH/187/55	11. xii.55	30° 12′ S.	0	100	164	47°
	0900	160° 0′ E.	10	90		
			20	83		
			30	40		
			40	47		
			50	18		
			100	6		
DH/190/55	12. xii.55	31° 52′ S.	0	100	144	59°
	1000	158° 2′ E.	10	97		
			20	42		
			30	34		
			40	28		
			50	14		
			100	9		

TABLE 4 (*Continued*)

Station	Day and Time (hr)	Position	Depth (m)	% S.L.	Depth of 1% S.L. (m)	Solar Altitude
DH/194/55	13. xii.55 0930	32° 18′ S. 155° 46′ E.	0	100	164	50°
			10	71		
			20	53		
			30	32		
			40	37		
			50	28		
			100	5		
DH/198/55	14. xii.55 0900	32° 40′ S. 153° 6′ E.	0	100	102	41°
			10	59		
			20	39		
			30	31		
			40	19		
			50	11		
			100	1		

TABLE 5
F.R.V. DERWENT HUNTER, CRUISE DH3/57
April 1957

Station No. Day and Time (hr)	Position	Distance from Coast (miles)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
DH3/46/57 18. iv.57 1500	34° 20′ S. 151° 32′ E.	17	0	100	100	62	27°
			10	60	57		
			20	33	31		
			30	11	10		
			40	5·9	4·6		
			50	2·7	2·9		
DH3/49/57 19. iv.57 0430	34° 54′ S. 152° 23′ E.	62	0	100		122	33°
			10	67			
			20	48			
			30	33			
			40	21			
			50	15			
DH3/50/57 19. iv.57 1400	35° 16′ S. 153° 2′ E.	92	0	100		106	34°
			10	62			
			20	40			
			30	27			
			40	18			
			50	12			
			60	7·6			
			70	4·4			
			80	3·1			

TABLE 5 (*Continued*)

Station No. Day and Time (hr)	Position	Distance from Coast (miles)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
DH3/52/57 20. iv.57 1250	34° 37′ S. 154° 44′ E.	169	0	100		93	40°
			10	58			
			20	46			
			30	27			
			40	14			
			50	9·3			
DH3/54/57 21. iv.57 0830	35° 30′ S. 156° 26′ E.	247	0	100	100	98	26°
			10	83	70		
			20	33	40		
			30	25	25		
			40	17	15		
			50	10	6·0		
DH3/55/57 21. iv.57 1315	35° 35′ S. 156° 46′ E.	275	0	100		113	
			10	64			
			20	49			
			30	32			
			40	20			
			50	14			
DH3/60/57 23. iv.57 0915	35° 1′ S. 157° 30′ E.	300	0	100	100	90	33°
			10	60	67		
			20	43	43		
			30	27	28		
			40	15	16		
			50	8·1	8·6		
			60	3·3	3·8		
			70	1·9	1·9		
			80	1·0	1·0		
DH3/63/57 25. iv.57 1230	33° 34′ S. 152° 49′ E.	60	0	100	100	98	42°
			10	69	72		
			20	50	50		
			30	32	33		
			40	20	20		
			50	11	12		
			60	7·1	6·9		
			70	4·0	4·3		
			80	2·4	2·4		

TABLE 6

F.R.V. DERWENT HUNTER, CRUISE DH6/57

July 1957

Station No. Day and Time (hr)	Position	Distance from Coast (miles)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
DH6/137/57 25. vii.57 1400	35° 3′ S. 154° 14′ E.	160	0 10 20 30 40 50 60	100 94 64 22 21 9·0 2·7		80	27°
DH6/138/57 26. vii.57 1300	34° 24′ S. 152° 33′ E.	70	0 10 20 30 40 50 60	100 57 35 15 8·2 6·1 2·8	100 80 39 22 9·3 4·4 2·8	80	34°
DH6/139/57 27. vii.57 1300	34° 1′ S. 151° 59′ E.	25	0 10 20 30 40 50 60	100 57 24 11 5·6 3·1 1·7	100 52 19 8·7 4·8 2·7 1·5	65	35°

TABLE 7

F.R.V. DERWENT HUNTER, CRUISE DH11/57

September 1957

Station No. Day and Time (hr)	Position	Distance from Coast (miles)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
DH11/187/57 19. ix.57 0915	35° 2′ S. 154° 1′ E.	142	0 10 20 30 40 50 60	100 72 42 20 12 6·9 4·7	100 69 31 28 20 10 4·7	92	40°
DH11/188/57 20. ix.57 1010	34° 3′ S. 153° 29′ E.	95	0 10 20 30 40 50 60	100 75 53 31 18 11 0·5	100 78 50	92	51°
DH11/189/57 21. ix.57 0915	34° 31′ S. 151° 33′ E.	26	0 10 20 30 40 50 60	100 77 58 42 27 17 11·3	100 67 56 44 26 17 9·2	104	40°

TABLE 8
F.R.V. DERWENT HUNTER, CRUISE DH15/57
November 1957

Station No. Day and Time (hr)	Position	Distance from Coast (miles)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
DH15/216/57 28. xi.57 0915	34° 13′ S. 151° 35′ E.	21	0	100	100	71	55°
			10	56	56		
			20	36	37		
			30	20	25		
			40	9·2	12		
			50	4·3	5·4		
			60	2·3	2·3		
1215	34° 13′ S. 151° 35′ E.		0	100	100	80	75°
			10	60	56		
			20	45	50		
			30	24	28		
			40	12	13		
			50	6·3	6·6		
			60	4·0	3·8		
1520	34° 13′ S. 151° 35′ E.		0	100	100	64	40°
			10	60	63		
			20	26	30		
			30	11	16		
			40	4·5	8·4		
			50	2·7	3·6		
			60	1·1	1·1		
DH15/217/57 29. xi.57 0925	34° 35′ S. 152° 29′ E.	68	0	100	100	73	44°
			10	75	78		
			20	59	65		
			30	40	49		
			40	22	28		
			50	10	14		
			60	4·4	4·4		
1200	34° 35′ S. 152° 29′ E.		0	100	100	75	71°
			10	80	77		
			20	65	66		
			30	44	46		
			40	23	24		
			50	11	11		
			60	4·7	4·4		

TABLE 8 (*Continued*)

Station No. Day and Time (hr)	Position	Distance from Coast (miles)	Depth (m)	% S.L. Down	% S.L. Up	Depth of 1% S.L. (m)	Solar Altitude
DH15/217/57 29. xi.57 1500	34° 35′ S. 152° 29′ E.		0	100	100	68	64°
			10	74	72		
			20	45	47		
			30	20	20		
			40	8·4	9·2		
			50	3·9	4·4		
			60	1·9	1·9		
DH15/218/57 30. xi.57 1030	34° 58′ S. 153° 30′ E.	118	0	100	100	73	71°
			10	74	77		
			20	50	66		
			30	28	49		
			40	18	27		
			50	13	9·2		
			60	3·9	3·8		
1315	34° 58′ S. 153° 30′ E.		0	100		84	64°
			10	73			
			20	61			
			30	39			
			40	21			
			50	10			
			60	4·8			