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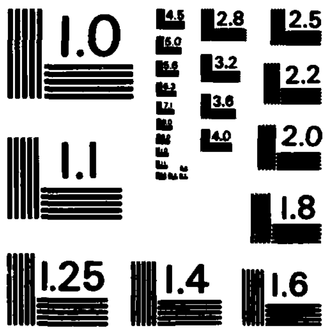

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RANRL TECHNICAL MEMORANDUM (EXTERNAL) No. 5/85

An investigation into the effect of the correlation between sea-surface roughness and duct-thickness on the distribution of acoustic propagation loss.

By

Marshall Hall and Robert T. Sandy

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ABSTRACT

Data were obtained and substituted into a model to test whether the distribution of the acoustic variable, propagation loss, is affected by the correlation between the two oceanographic parameters, sea surface roughness and mixed-layer thickness. It was found that the correlation coefficient is only 0.1 and that the distribution of propagation loss is not affected by this correlation.

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CONTENTS

1. INTRODUCTION

This report describes some work on the effects of correlation between environmental parameters on the distribution of acoustic propagation loss in the ocean surface-duct. It was prepared while the second author was visiting RANRL during a vacation from his courses at the University of New South Wales.

An isothermal mixed layer that is generally found near the surface of the sea has a positive sound-speed gradient (with respect to depth) and is therefore an acoustic duct. There are four main parameters in determining the propagation loss from a source:

a. Horizontal range

b. Frequency [In this paper, two frequencies will be examined: a medium frequency (1 kHz) at long range (50 km); and a high frequency (20 kHz) at a short range (4 km)];

c. Sea surface roughness; and

d. Duct thickness.

2. EXPERIMENTAL METHOD AND RESULTS

A. The first steps involved with this investigation were to select the Tasman Sea as the area of interest and then to obtain some data. With this in mind, we obtained reports of eight CSIRO Oceanographic cruises (refs 1-8) which passed through the rectangle of consideration, which was defined as latitudes from 32°S to 36°S, and longitudes from 151°E to 160°E. The data obtained from these reports are shown in part (a) of Table 1, in the form of joint distributions of wind-speed and duct-thickness obtained by analysing 153 observations of temperature profiles. The results are described by 10 intervals of wind-speed (the "Beaufort Scale") and by 12 intervals of duct-thickness.

The computer program that produces these data works in the following way:

1. It initializes all variables and files that are used.
2. It then checks whether the latitudes and longitudes are within the rectangle of consideration, and whether the sonic water depth is greater than 3000m.
3. The sound speed is checked to determine at what depth the sound speed is a maximum. Successive values for depth, temperature, and salinity are fed into the computer until it determines that the calculated sound speed is less than the previous sound speed.
4. Wind speed (Beaufort Scale), and depth at which sound speed was greatest, are used to determine which element in the distribution matrix corresponds to a given temperature profile.

The above process was repeated until the eight available reports were completed. After this was done, a small computer program was written which read the data and produced the matrices shown in Table 1.

For wind-speed, the level on the Beaufort Scale is defined as follows:

Beaufort level	Wind-speed (kt)	Beaufort level	Wind-speed (kt)
0	0	5	17 - 21
1	1 - 3	6	22 - 27
2	4 - 6	7	28 - 33
3	7 - 10	8	34 - 40
4	11 - 16	9	41 - 47

To convert from wind-speed to surface wave-height, we chose Neumann's expression for the mean square roughness (ref.9):

$$\overline{h^2} = 3 \times 3.05 \times (\pi/2)^{3/2} (U/2g)^5 \qquad (1)$$

or

$$A = \sqrt{(\overline{h^2})} = 2.5 \times 10^{-3} U^{2.5} \qquad (2)$$

where U is wind-speed in m/s. If W is the wind-speed in knots, then

$$U = 0.515 W \qquad (3)$$

and eq. 2 becomes

$$A = 0.475 \times 10^{-3} W^{2.5} \qquad (4)$$

Since there is a spread of windspeed within each level of the Beaufort scale, the average value of A was estimated by calculating the value of waveheight for the average wind-speed of each Beaufort level. The resulting RMS waveheights are as follows:

Beaufort level	$\overline{A}$ (m)	Beaufort level	$\overline{A}$ (m)
0	0.000	5	0.75
1	0.003	6	1.41
2	0.027	7	2.44
3	0.10	8	3.96
4	0.32	9	6.10

The next phase of the task was to obtain another set of data for analysing. The Hydrographic Office at North Sydney has a large collection of XBT's (Expendable Bathythermograms). An XBT provides a graphical illustration of the temperature profile in the ocean. With each XBT there is a "log" which contains other information such as wind speed (in knots), air temperature, etc. The task of looking at hundreds of XBT's was done manually because computer tapes with the digitized information were not yet available. Again the criterion for determining the duct-depth was maximum sound-speed. The depth at which the maximum sound-speed occurred was determined by laying a transparent plastic template (over the temperature/depth curve) on which were drawn contours of constant sound-speed. The template was moved horizontally until the temperature-depth curve touched the nearest contour in a tangential manner (from the left). The depth at which the two curves were tangential was taken as the depth of maximum sound-speed. (Salinity was neglected). The results for the joint distributions of wind-speed and duct-thickness obtained from 544 observations can be seen in part (b) of Table 1.

The basic statistical parameters of the data obtained are the means and standard deviations of RMS waveheight (in metres) and duct-depth (in metres), and the correlation coefficients between these variables. The results for these parameters can be found in Table 2, where we note for example that the (product-moment) correlation coefficients † between waveheight and duct-thickness are only 0.1 in both cases.

Propagation losses were calculated from the following formulae, which are adapted from ref. 10.

$$PL = 60 + 20 \log R + (C + D + E) R , \text{ if } R < 0.633 B^{1/2} \quad (5)$$

or

$$53.5 + 10 \log R + 5 \log B + (C + D + E) R, \text{ if } R > 0.633 B^{1/2}$$

---

† The correlation coefficient, whose maximum value is unity, is a measure

where

R is the horizontal range in km;

B is the duct thickness in m;

C is the coefficient of absorption (due to magnesium sulphate and boric acid in the ocean);

D is the coefficient of leakage from the duct due to diffraction (D is large if the frequency is below the "cut-off" frequency of the duct); and

E is the coefficient of leakage from the duct that is related to surface roughness.

(The units of C, D, and E are dB/km).

The only term that includes the surface waveheight is E, for which the following expression (adapted from ref. 11) has been chosen:

$$E = 7.1 \left[A/(B\lambda) \right]^{1/2} \quad \text{dB/km} \tag{6}$$

where A is the RMS waveheight (m);

B is the duct-thickness (m); and

λ is the acoustic wavelength (m).

The coefficient of absorption (C) is primarily a function of frequency. At 1 kHz, the absorption is dominated by boric acid and is sensitive to the pH of the ocean. In the Tasman Sea the surface pH varies between 8.1 and 8.2 (ref. 12); we select the more common value of 8.1. For a (summer) water temperature of 23°C, the "relaxation frequency" (f_r) of boric acid is 1.5 kHz (ref.13). Substitution of these values into the expression (ref. 13):

$$C\text{ (boron)} = 0.11 \times 10^{pH-8} f^2 f_r/(f_r^2 + f^2) \quad , \qquad (7)$$

where f is the frequency in kHz,

yields

$$C(\text{boron, 1 kHz}) = 0.064 \text{ dB/km.}$$

At the same temperature, the contribution of magnesium sulphate to the absorption at 1 kHz is only 0.004 dB/km (ref. 14). The total absorption coefficient at 1 kHz is therefore

$$C(\text{1kHz}) = 0.068 \text{ dB/km}$$

At 20 kHz, absorption is dominated by magnesium sulphate and is sensitive to water temperature. For a temperature of 23°C the coefficient is 1.8 dB/km (ref.14).

The contribution of boron is, from eq 7,

$$C(\text{boron, 20 kHz}) = 0.2 \text{ dB/km}$$

The total absorption coefficient at 20 kHz is therefore

$$C(\text{20kHz}) = 2.0 \text{ dB/km}$$

Evaluation of the diffraction coefficient (D) is described in ref.15. Basically, D decreases as the ratio of frequency to the duct's "cut-off" frequency (f_{co}) increases ($f_{co} \propto B^{-3/2}$, and $f_{co} = 200$ Hz when B = 100 m).

At the cut-off frequency, $D_{co} \propto f_{co}^{1/3}$, and $D_{co} = 0.7$ dB/km when $f_{co} = 200$ Hz.

Since the required parameters have now all been prescribed, the values of the propagation loss (in dB) for 1 kHz at 50 km Range, and for 20 kHz at 4 km range, were calculated on a computer for each combination of waveheight and duct-thickness. The results are shown in Table 3.

As well as calculating the propagation losses, the computer program also calculated the cumulative probability distributions of propagation loss for the cases of duct-thickness and waveheight being both dependent and independent. The resulting cumulative distributions are presented in fig. 1. It can be seen from fig. 1 that the differences between the "actual" and "independent" cumulative distributions are negligible. In view of the small correlations between these two parameters, this result was to be expected.

3. DISCUSSION

The main objective of this section is to compare our results with those presented by Hall (ref.15). In that paper, the surface roughness was divided into the following three intervals of wind-speed (as measured on the Beaufort scale): 0 - 2; 3 and 4; and 5 and above. (The average values of RMS waveheight for these intervals were estimated to be 0.05, 0.3, and 1.5 metres respectively). The duct-thickness was divided into the following four intervals: 0 - 25m; 25 - 35 m; 35 - 45 m; and greater than 45 m. The average values for each of these intervals were estimated to be 10, 30, 40, and 60 m, respectively. Hall presented a joint distribution (roughness and duct-thickness) for each of 10 ocean areas around Australia. Of these, Area #3 corresponds closely with the region selected for this report.

(a) Distributions of Duct-thickness and Sea-State

An interesting fact that can be seen in ref. 15 is that for a "rough" sea (which corresponds to a wind-speed of at least 5 on the Beaufort scale), B = 40 m never occurred in any of the ten areas which were presented. Also to emerge was that for "slight" seas (corresponding to wind-speeds of up to 2 on the Beaufort scale) B = 30 m never occurs (in the ten areas). Within the CSIRO results, a duct thickness (B) of 35 m $\pm$5 m never occurred. In the HYDRO Results, the combination of B = 40 m and small wind speed has a very low frequency of occurrence. The combination of B = 30 m and small wind speed has a frequency of occurrence that is consistent with that of the ten areas presented in ref. 15.

Table 1 also shows the marginal probabilities for the CSIRO and HYDRO Results. The likelihood of slight seas is 42% in the CSIRO Results, and 18% in the HYDRO Results. The latter results are comparable with those presented by Hall, where the likelihood of slight seas in Area #3 was 22%. The prevalence of "rough" seas is 21% in the CSIRO Results and 35% in the HYDRO Results. Again, these results are comparable with those of Hall, where the likelihood of rough seas in Area #3 is shown as 34%.

The mean and standard deviation for both sets of data are comparable with the results presented in ref.15. The correlation coefficient between waveheight and duct-thickness is 0.10 for the CSIRO Results and 0.09 for the HYDRO Results. These coefficients are about one half of that presented by Hall, where the correlation coefficient in Area #3 is shown as 0.24.

(b) Distributions of Acoustic Propagation Loss

The distribution of propagation loss (PL) for the 1 kHz and 50 km range problem is approximately the same as in ref. 15. Very large values for PL occur for small duct-thickness and large waveheight, which is as would be expected.

The cumulative probability distributions (CPD) derived in the present study differ from those presented in ref.15. For the case of 20-kHz frequency and 4-km range, for example, Hall's CPD's had standard deviations of several decibels, whereas the standard deviations in the present study are much larger. Given that the variations in the environmental parameters are comparable, and that the same acoustic model has been used, the cause of this difference should be that we have used

10 or 12 values to represent the environmental parameters, whereas Hall used only 3 or 4. This hypothesis was checked by re-presenting the data in Table 1 in the same manner as in ref.15, followed by a re-calculation of the probability distributions of propagation loss. The resulting (simplified) joint distributions of the wind-speed and duct thickness are shown in Table 4 (together with the distribution for Area #3 from ref.15). Neither of these distributions is similar to the distribution for Area #3 in ref.15 (although the distribution of surface-roughness for the Hydrographic Office data is similar to that for Area #3). A comparison of the resulting cumulative probabilities of PL (at 1-kHz frequency and 50-km range) as calculated using (a) 3 x 4 and (b) 10 x 12 values of surface-roughness and duct-thickness is shown in fig. 3. In this example we see that, for both the "Hydro" and the CSIRO data, and for most values of PL, the "coarse" method yields significantly lower cumulative probabilities than does the "fine" method. For example, for the "Hydro" data, the second decile occurs at PL = 97 dB for the fine method, whereas the coarse method predicts that it occurs at PL = 104 dB. A similar comparison of the predicted results of the coarse and fine methods for the example of 20-kHz frequency and 4-km range is shown in fig. 4. The differences are again significant, but in this example both positive and negative values for the difference between the predictions of the two methods, occur. For the Hydro data, the second decile occurs at PL = 82 dB for the fine method, whereas the coarse method predicts that it occurs at PL = 86 dB. (For the 9'th decile, however, the corresponding values of PL are 105 and 100 dB respectively).

4. CONCLUSIONS

Surface-roughness and duct-thickness are not quite independent, since they are observed to have a correlation coefficient of 0.1. This correlation is sufficiently small, however, that it has no effect on cumulative probability distributions of functions (such as acoustic propagation loss) of these two parameters.

Division of environmental parameters into only 3 or 4 levels causes significant errors in the predicted probability distribution of dependent parameters such as propagation loss.

ACKNOWLEDGMENTS

This research was conducted while the second Author held a vacation employment position at RANRL, from January to March 1985. He gratefully acknowledges the guidance of his supervisor (the first author) for his time and assistance. The assistance of Mr Ian Halls of the RAN Hydrographic Office in giving us access to their XBT data is also appreciated.

REFERENCES

1. CSIRO Aust. Oceanogr. Cruise Rep. No. 6 (1963)
2. CSIRO Aust. Oceanogr. Cruise Rep. No. 19 (1967)
3. CSIRO Aust. Oceanogr. Cruise Rep. No. 29 (1967)
4. CSIRO Aust. Oceanogr. Cruise Rep. No. 31 (1967)
5. CSIRO Aust. Oceanogr. Cruise Rep. No. 32 (1967)
6. CSIRO Aust. Oceanogr. Cruise Rep. No. 35 (1967)
7. CSIRO Aust. Oceanogr. Cruise Rep. No. 39 (1967)
8. CSIRO Aust. Oceanogr. Cruise Rep. No. 42 (1968)
9. B. Kinsman, "Wind-waves, their Generation and Propagation on the Ocean Surface "(Prentice Hall, Englewood Cliffs, NJ, 1965); p. 390.
10. W.F. Baker, "New formula for calculating acoustic propagation loss in a surface duct in the sea." J.Acoust. Soc. Am. 57, 1198-1200 (1975).
11. M. Schulkin, "Surface-coupled losses in surface sound channels." J Acoust. Soc. Am. 44, 1152-1154 (1968)
12. S.G. Gorshkov (Ed.) "World Ocean Atlas : Volume 1, Pacific Ocean" (Pergamon Press, Oxford, 1974) p.234.
13. R.H. Mellen and D.G. Browning, "Variability of low-frequency sound absorption in the ocean : pH dependence." J.Acoust. Soc. Am. 61, 704-706 (1977)
14. M. Schulkin and H.W. Marsh, "Absorption of sound in Sea-Water." J. Brit. I.R.E. 25, 493-500 (1963)
15. M. Hall "Some effects of correlation between environmental parameters on the distribution of acoustic propagation loss in the ocean surface-duct," Bulletin Aust. Acoust. Soc. 12, 47-50 (1984)

(a) CSIRO data

Duct-Thickness(m) \ Wind-speed (Beaufort Scale)	0	1	2	3	4	5	6	7	8	9	MARGINAL TOTALS
0 - 9	1	10	20	10	5	4	3	2	0	0	55
10 - 19	0	0	0	0	1	0	0	0	0	0	1
20 - 29	1	11	6	9	7	9	1	2	1	0	47
30 - 39	0	0	0	0	0	0	0	0	0	0	0
40 - 49	0	0	2	3	2	0	2	0	0	0	9
50 - 74	0	2	1	3	2	1	0	1	0	0	10
74 - 99	0	0	2	2	3	3	0	0	0	0	10
100 - 124	1	1	1	1	2	0	0	0	0	0	6
125 - 149	0	0	0	2	0	0	0	1	0	1	4
150 - 199	0	1	1	2	0	0	0	0	0	0	4
200 - 249	0	1	1	2	0	0	0	0	0	0	4
250 - 350	0	0	2	0	0	0	0	1	0	0	3
MARGINAL TOTALS	3	26	36	34	22	17	6	7	1	1	153

(b) Hydrographic Office data

Duct-Thickness(m) \ Wind-speed (Beaufort Scale)	0	1	2	3	4	5	6	7	8	MARGINAL TOTALS
0 - 9	1	5	7	10	11	4	6	0	0	44
10 - 19	0	4	6	15	15	10	1	1	1	53
20 - 29	1	6	8	11	13	6	7	2	3	57
30 - 39	1	3	9	20	22	10	11	6	0	82
40 - 49	2	1	4	15	23	6	5	0	3	59
50 - 74	1	5	12	17	24	14	13	5	5	96
75 - 99	0	2	3	7	5	4	3	2	0	26
100 - 124	0	0	4	3	6	6	3	0	2	24
125 - 149	1	2	3	2	5	4	3	6	0	26
150 - 199	0	0	1	13	2	6	11	3	1	37
200 - 249	0	0	6	8	8	14	0	4	0	40
MARGINAL TOTALS	7	28	63	121	134	84	63	29	15	544

Table 1: Numbers of joint occurrences of wind-speed and duct-thickness as obtained from (a) CSIRO oceanographic data, and (b) RAN Hydrographic Office XBT data.

(a) CSIRO STATISTICS

(A) RMS waveheight:	$\overline{A}$ = 0.37 m
	σ_A = 0.77 m
(B) Duct-thickness:	$\overline{B}$ = 46.41 m
	σ_B = 61.72 m
	ρ_{AB} = 0.10

(b) HYDROGRAPHIC OFFICE STATISTICS

(A) RMS waveheight:	$\overline{A}$ = 0.59 m
	σ_A = 0.82 m
(B) Duct-thickness:	$\overline{B}$ = 69.94 m
	σ_B = 62.79 m
	ρ_{AB} = 0.09

Table 2: Summary of the statistics of waveheight and duct-thickness.

(i) Frequency 1 kHz, Range 50 km

Wave-height (m) / Duct-Thickness (m)	0.000	0.003	0.027	0.10	0.32	0.75	1.41	2.44	3.96	6.10
5	1992	2003	2015	2038	2064	2088	2140	2189	2247	2310
15	758	764	771	784	799	813	843	871	905	941
25	255	260	265	275	287	298	321	343	369	397
35	132	136	141	149	159	168	188	206	228	252
45	93	97	101	109	117	125	142	159	178	199
63	82	85	88	95	102	109	124	137	154	172
87	83	85	88	94	100	106	118	130	144	159
113	83	86	88	93	98	104	114	125	137	150
138	84	86	88	92	97	102	112	121	132	144
175	84	86	88	92	96	100	109	117	127	130
225	85	86	88	92	96	99	107	114	123	132
300	85	87	88	91	95	98	104	111	118	126

(ii) Frequency 20 kHz, Range 4km

Wave-height (m) / Duct-Thickness (m)	0.000	0.003	0.027	0.10	0.32	0.75	1.41	2.44	3.96	6.10
5	225	229	233	241	251	260	278	295	316	339
15	73	75	78	82	88	93	103	114	126	139
25	74	76	78	81	86	89	98	105	115	125
35	75	76	78	81	85	88	95	101	109	118
45	80	81	82	85	88	91	97	103	110	117
63	80	81	82	84	87	89	94	99	105	112
87	80	80	82	83	86	88	92	96	101	107
113	80	80	81	83	85	87	91	94	99	103
138	80	80	81	83	84	86	90	93	97	101
175	80	80	81	82	84	85	88	91	95	99
225	80	80	81	82	83	85	87	90	93	96
300	80	80	81	82	83	84	86	89	91	94

Table 3: Propagation loss for each of the 120 combinations of duct-thickness and RMS waveheight based on a theoretical model.

B(m) \ A(m)	0.05	0.3	1.5	β
CSIRO				
10	20	11	6	37
30	12	11	9	32
40	1	3	1	5
60	9	12	5	26
α	42	37	21	100
HYDRO				
10	4	9	4	17
30	4	8	6	18
40	3	11	5	19
60	7	19	20	46
α	18	47	35	100
AREA #3				
10	11	19	6	36
30	0	1	8	9
40	4	8	0	12
60	7	16	20	43
α	22	44	34	100

Table 4: Joint probability distribution (%) of surface-roughness and duct-thickness when described by 3 and 4 values of the parameters (respectively).

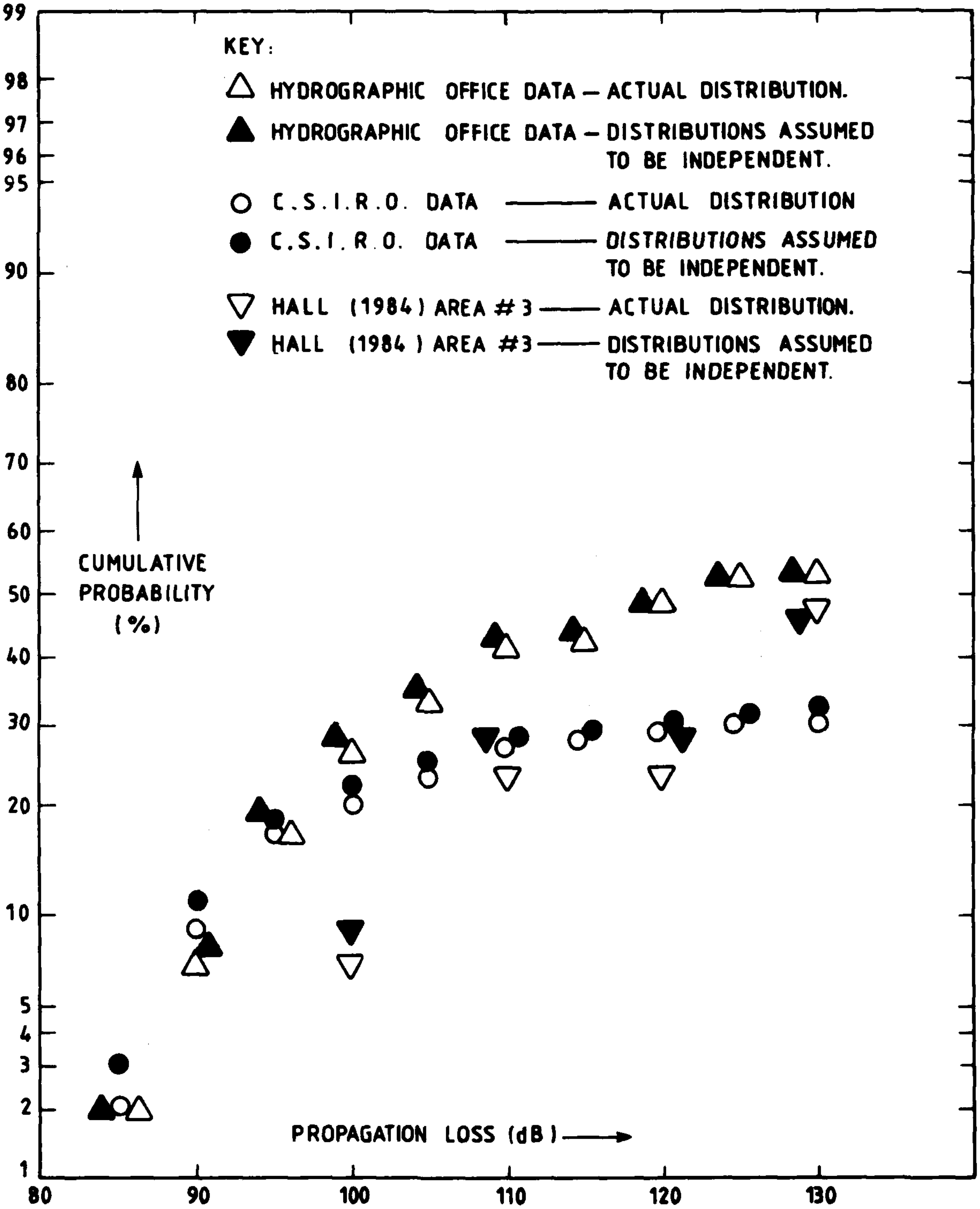

Fig. 1. Predicted cumulative probability distributions of surface-duct propagation loss in the Tasman Sea for a frequency of 1 kHz and a range of 50 km.

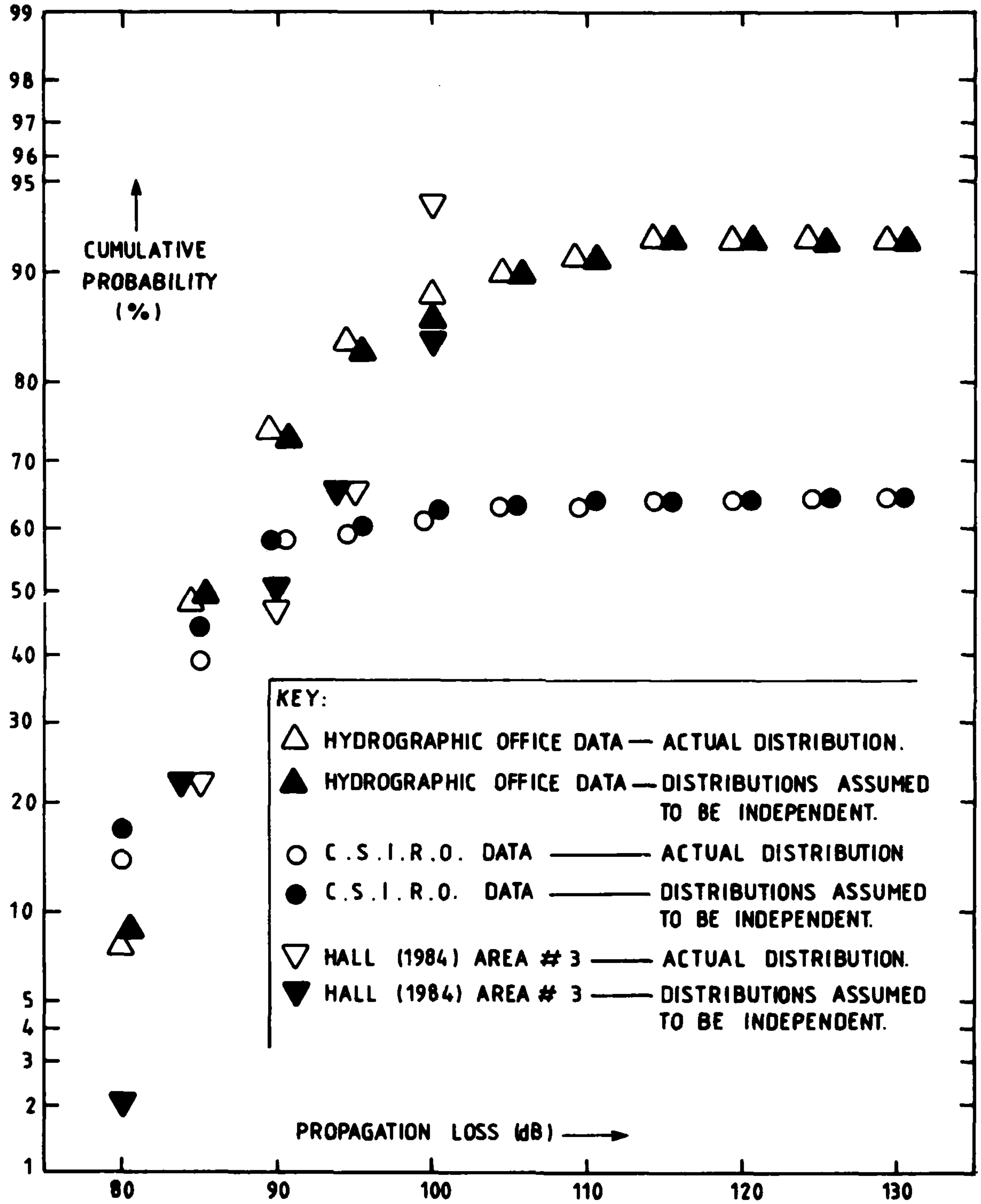

Fig 2. Predicted cumulative probability distributions of surface-duct propagation loss in the Tasman Sea for a frequency of 20 kHz and a range of 4 km.

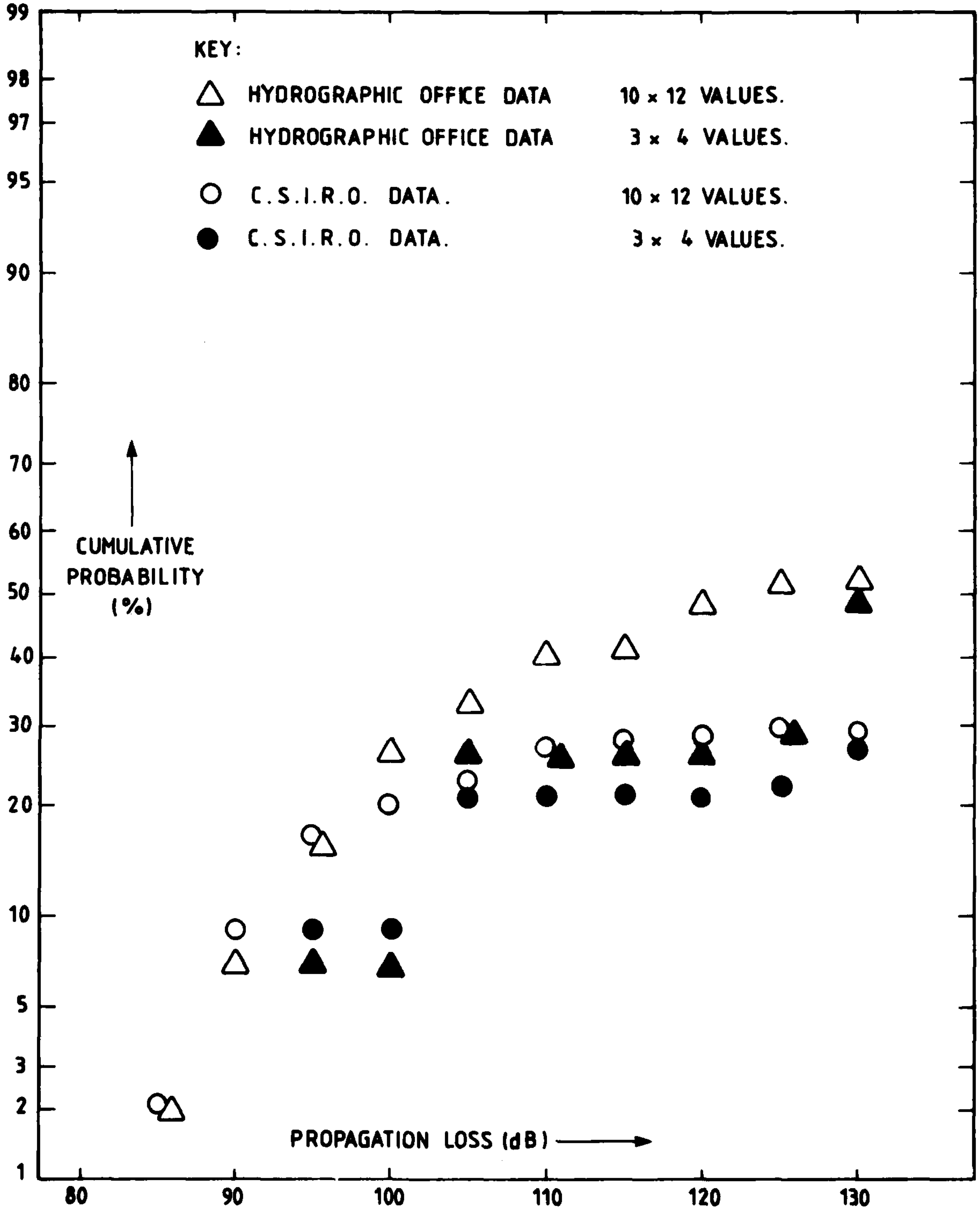

Fig. 3. Comparison of the probability distributions of propagation loss obtained with (a) 3 × 4 and (b) 10 × 12 values of the parameters surface-roughness and duct-thickness, for the case of 1 kHz frequency and 50 km range.

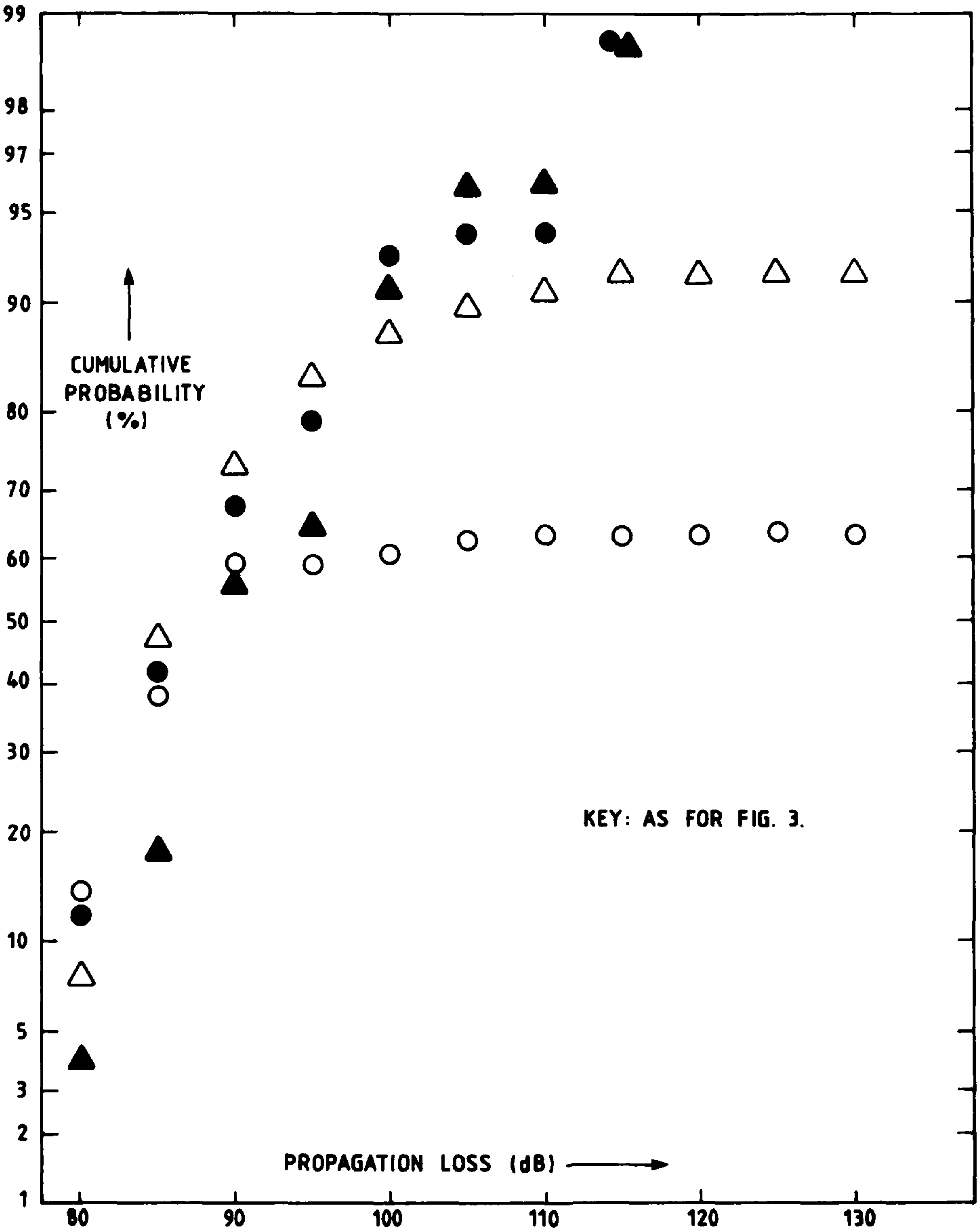

Fig. 4. Comparison of the probability distributions of propagation loss obtained with (a) 3 × 4 and (b) 10 × 12 values of the parameters surface-roughness and duct-thickness, for the case of 20 kHz frequency and 4 km range.

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16. Abstract

DATA WAS OBTAINED AND SUBSTITUTED INTO A MODEL TO TEST WHETHER THE DISTRIBUTION OF THE ACOUSTIC VARIABLE, PROPAGATION LOSS, IS AFFECTED BY THE CORRELATION BETWEEN THE TWO OCEANOGRAPHIC PARAMETERS, SEA SURFACE ROUGHNESS AND MIXED-LAYER THICKNESS. IT WAS FOUND THAT THE CORRELATION COEFFICIENT IS ONLY 0.1 AND THAT THE DISTRIBUTION OF PROPAGATION LOSS IS NOT AFFECTED BY THIS CORRELATION.

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16. Abstract *(Contd)*		
17. Imprint		
18. Document Series and Number	19, Cost Code	20. Type of Report and Period Covered
21. Computer Programs Used		
22. Establishment File Ref(s)		

END

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