MULTI-AREA ESTIMATES OF ACOUSTIC TRANSMISSION LOSS IN COASTAL WATERS

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ABSTRACT

World transmission loss data have been assembled and grouped to identify the influencing parameters. First tests indicate the importance of frequency and season.

The requirement for sonar systems to work in many areas presents a particular difficulty when specifying systems for coastal waters, whose acoustic variability is well known. To determine whether shallow water exhibits characteristic features irrespective of geographical location a computer data bank was devised to group and average transmission loss or reverberation data according to five fundamental factors (Fig. 1). 53 samples of transmission loss vs range from 17 areas, including North Atlantic, Arctic, Mediterranean and Pacific areas, were obtained from [1] and other sources.

FUNDAMENTAL FACTOR	CONDITION
SEASON	WINTER (ISOVELOCITY) SUMMER (NEG. GRADIENT)
BOTTOM TYPE	ABSORBING REFLECTING
FREQUENCY	LOW (< 1000 Hz) HIGH (≥ 1000 Hz)
WATER DEPTH	SHALLOW (≤ 300 ft) DEEP (> 300 ft)
SURFACE (SEA STATE)	CALM < 3 ROUGH ≥ 3

Fig. 1 Fundamental factors likely to influence transmission loss

The factors were quantized into 10 conditions (Fig. 1) considered the minimum desirable number to give a reasonable number of samples for each. Factors and conditions were set out in a selection tree (of which Fig. 2 shows the branches for low frequency). The tree represents a rank order of importance (initially assumed) for the factors, and allocates the greatest number of samples, indicated by the numbers at each branch, to the factors most likely to be influential, i.e. those at the left-hand side. The data are stored as transmission loss at 2, 5, 10, 20 and 50 kyd, and the basic presentation is of mean and standard deviation for each branch, or grouping. These means are compared within columns by computing the significance of their differences in terms of a confidence level, using Students t-test.

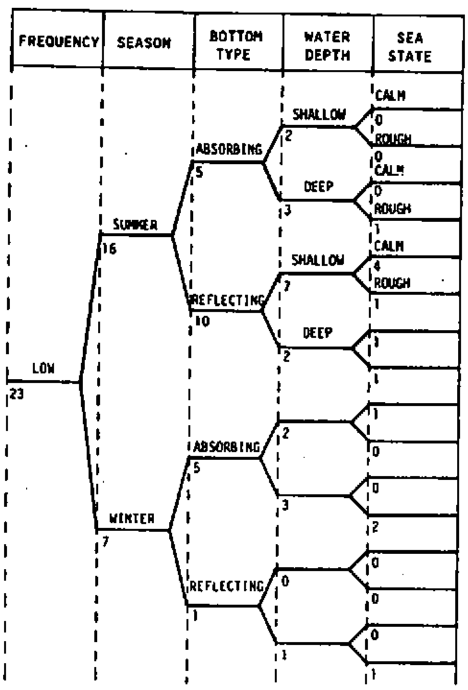

Fig. 2 Selection tree for significance tests

When the factors of frequency, season, bottom type, and water depth were tried in the first column, only frequency was convincingly influential,

(Fig. 3) with confidence levels exceeding 90% at 20 kyd and beyond, though in all cases the standard deviation was reduced, compared with all data. After allocating frequency to the first column, the best candidate for the second column was clearly season (Fig. 4), with similar confidence levels to those for frequency. Bottom type was then tried in the third column, but in no case did the confidence level exceed 80%, nor were standard deviations decreased: however, the samples for these third column tests (2-5) were probably too few for a conclusive rejection of bottom type as an influential factor. Sea state was too sparsely reported to be tested, while other likely factors (e.g. bottom slope, biological activity) were not reported at all. The two-column analysis thus appears to represent the limit of what is possible with the present data, though further refinement may be possible by manipulating the data groupings.

1ST COLUMN TEST	δ	RANGE kyd 2	5	10	20	50
1. SUMMER 2. WINTER	8.7-17.9 11.1-18.4	17%	35%	51%	69%	73%
1. 0-1000 Hz 2. 1000-3200 Hz	7.1-11.5 10.6-18.1	31%	75%	89%	93%	97%
1. REFLECTING 2. ABSORBING	6.6-19.0 12.2-19.6	59%	33%	11%	3%	7%
1. SHALLOW 2. DEEP	9.8-14.5 8.9-21.7	65%	65%	57%	45%	29%

Fig. 3 Significance levels for 1st column tests

	2ND COLUMN TEST	δ	RANGE kyd 2	5	10	20	50
0-1000Hz	1. REF. BOTTOM 2. ABS. BOTTOM	3.4-13.1 9.3- 8.3	45%	19%	55%	69%	69%
	1. SUMMER 2. WINTER	6.7-11.3 7.8- 5.1	49%	67%	83%	93%	97%
1000-3200Hz	1. REF. BOTTOM 2. ABS. BOTTOM	9.4-24.6 13.7-17.6	1%	3%	3%	1%	13%
	1. SUMMER 2. WINTER	11.4-16.2 11.0- 8.0	31%	49%	61%	75%	89%

Fig. 4 Significance levels for 2nd column tests

The mean curves of Fig. 5 have been used as gross models for performance prediction. Both mean loss and spread are lowest in winter and at low frequencies, and highest in summer and at high frequencies. Consequently the most satisfactory model is winter low-frequency, with a standard deviation generally less than 5 dB, and the least satisfactory is summer high-frequency, with a standard deviation about 20 dB. The results for winter high-frequency and summer low-frequency do not differ significantly. It is concluded that fundamental factors can influence shallow-water transmission loss to the extent that when their effect is allowed for, reasonable multi-area estimates can be made. Multi-area analysis would greatly benefit from more data, especially on the temporal variability of transmission loss, to substantiate the assumption of stationarity on which it rests.

REFERENCE

1. URICK, R.J. and BRADLEY, D.L. Comparison of various prediction models with a random selection of field observations of sound transmission in shallow water, NOLTR 69-709. White Oak, Md., U.S. Naval Ordnance Laboratory, 1969.