NUSC Technical Document 8805
24 January 1991

AD-A265 128

The Curtain Effect in a Multiple Convergence Zone Environment: Part 1 -- Implications for Ambient Noise

Presented at the 120th Meeting of the Acoustical Society of America, San Diego, California, 26-30 November 1990

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Preface

This document was prepared under Project No. A20022, principal investigator P. Herstein. It contains the oral and written presentation, "The Curtain Effect in a Multiple Convergence Zone Environment: Part 1 — Implications for Ambient Noise."

The authors wish to express their graditude to Peter D. Herstein (Code 33A) for his guidance and support.

Reviewed and Approved: 24 January 1991

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SUPPORT SYSTEMS DEPARTMENT

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)

2. REPORT DATE
24 January 1991

3. REPORT TYPE AND DATES COVERED
Presentation

4. TITLE AND SUBTITLE
THE CURTAIN EFFECT IN A MULTIPLE CONVERGENCE ZONE ENVIRONMENT: PART 1 -- IMPLICATIONS FOR AMBIENT NOISE

5. FUNDING NUMBERS
PR A20022

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Underwater Systems Center
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New London, CT 06320

8. PERFORMING ORGANIZATION REPORT NUMBER
TD 8805

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Presented at the 120th Meeting of the Acoustical Society of America, San Diego, California, 26-30 November 1990.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)
Over multiple convergence zone propagation ranges the relative spreading loss per zone, although initially high, decreases with range. The other major component of propagation loss, attenuation, remains unchanged and eventually becomes greater than the rate of spreading loss. The range at which this crossover occurs -- the curtain effect [Browning et al., J. Acoust. Soc. Am. Suppl. 1, vol. 80, S54 (1986] -- is highly frequency dependent. At low frequencies the curtain effect occurs at long ranges; this allows sources or scatterers in the second convergence zone or beyond to impact the received level since they suffer only a relatively small additional loss compared to the spreading loss to the first convergence zone. For a given distribution of noise source levels or scattering strengths it is estimated what would be the resulting background level and the relative importance of events, for example, a comparison between medium strength multiple events at medium ranges and a strong event at long range. This analysis is then extended to higher frequencies where the curtain effect occurs at a range of one convergence zone or less.

14. SUBJECT TERMS
Ambient Noise
Curtain Effect
Propagation Loss
Spreading Loss

15. NUMBER OF PAGES
14

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

THE CURTAIN EFFECT IN A MULTIPLE CONVERGENCE ZONE ENVIRONMENT:

PART 1, IMPLICATIONS FOR AMBIENT NOISE.

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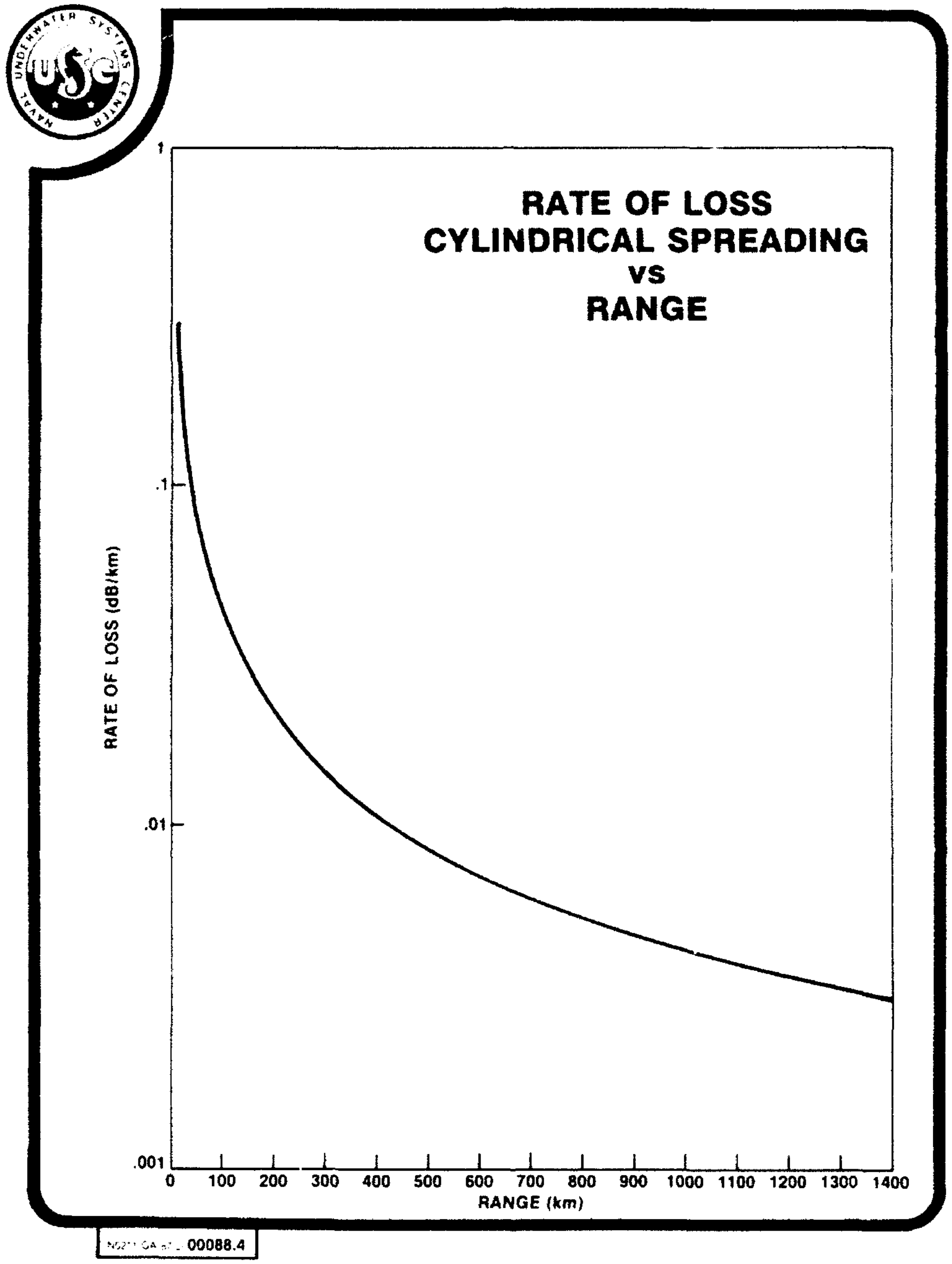
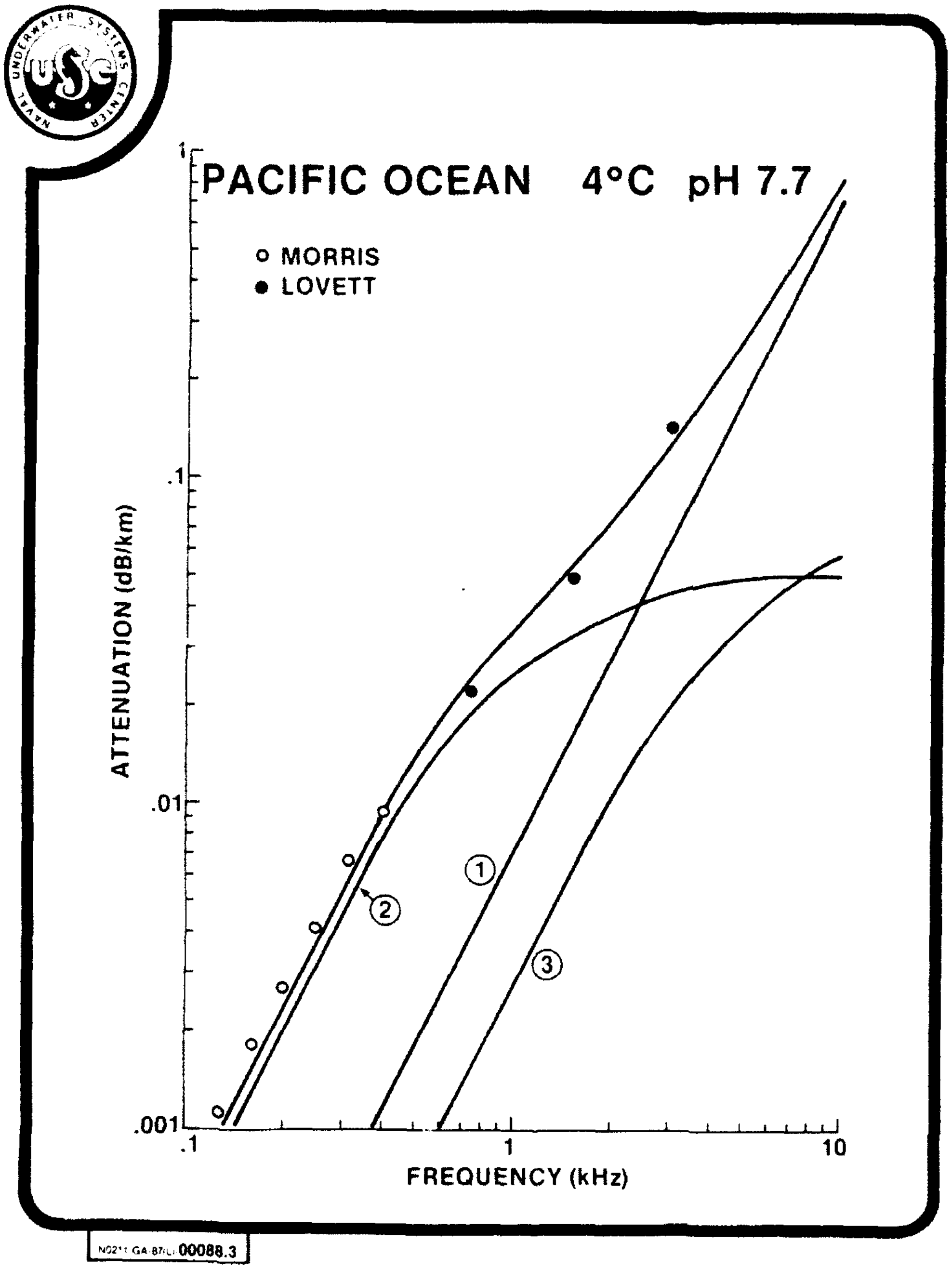
VIEWGRAPH 1

It would be highly desirable to receive broad spectrum acoustic signals over multiple convergence zone (CZ) ranges in the ocean. Unfortunately, such desires are constrained by the realities of spreading loss and sea water attenuation which result in what we have termed the "curtain effect" [1]. In this paper we describe the first part of our study of multiple CZ propagation; specifically one-way (passive) propagation loss and its impact on ambient noise levels.



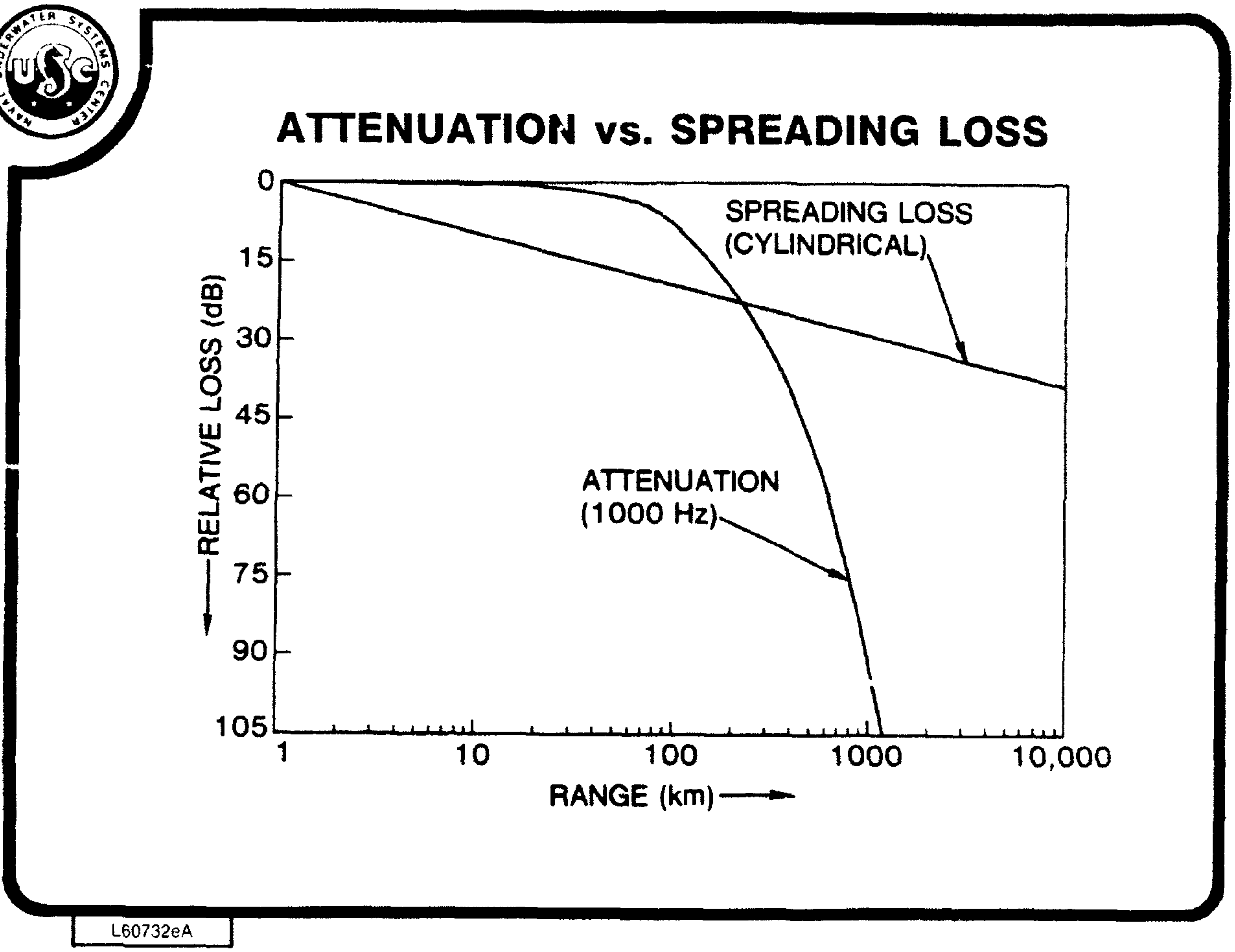
VIEWGRAPH 2. RATE OF SPREADING LOSS

The fundamental component of propagation loss is spreading loss whose most interesting aspect is that the rate of spreading loss decreases with range. This is especially important in multiple CZ propagation because, in a typical deep ocean case, by the time you reach the first CZ the rate of spreading loss has greatly decreased. Hence, further interzone spreading loss is significantly less than the initial loss to the first CZ.



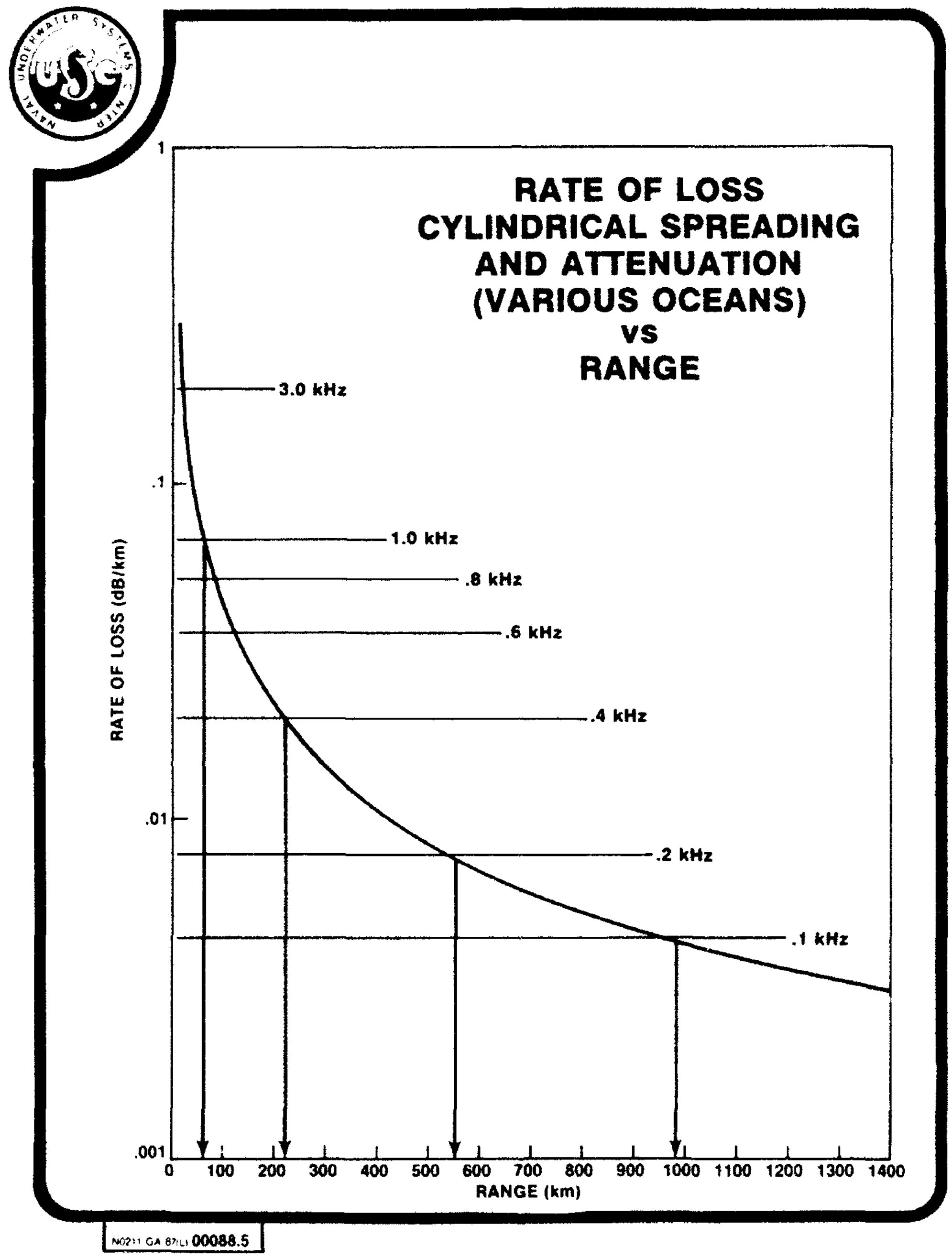
VIEWGRAPH 3. ATTENUATION LOSS

In contrast, attenuation (which is also a rate of loss) for a given frequency and barring any significant oceanographic changes is constant with range [2]. It is, however, highly frequency-dependent.



VIEWGRAPH 4. CURTAIN EFFECT

As the rate of spreading loss decreases with range, we sooner or later (depending on frequency) reach a range where attenuation is larger than the rate of spreading loss. This results in the "curtain effect" shown here for 1000 Hz, which, due to increasing loss, essentially limits any further increase in propagation range.



VIEWGRAPH 5. COMPARISON OF RATE OF LOSS

By comparing the rates of loss and determining the crossover ranges, we can obtain a feeling for how the attainable ranges depend on frequency. Simply stated, the ocean is divided into a greater than 200 Hz short range world and a less than 200 Hz long range world.

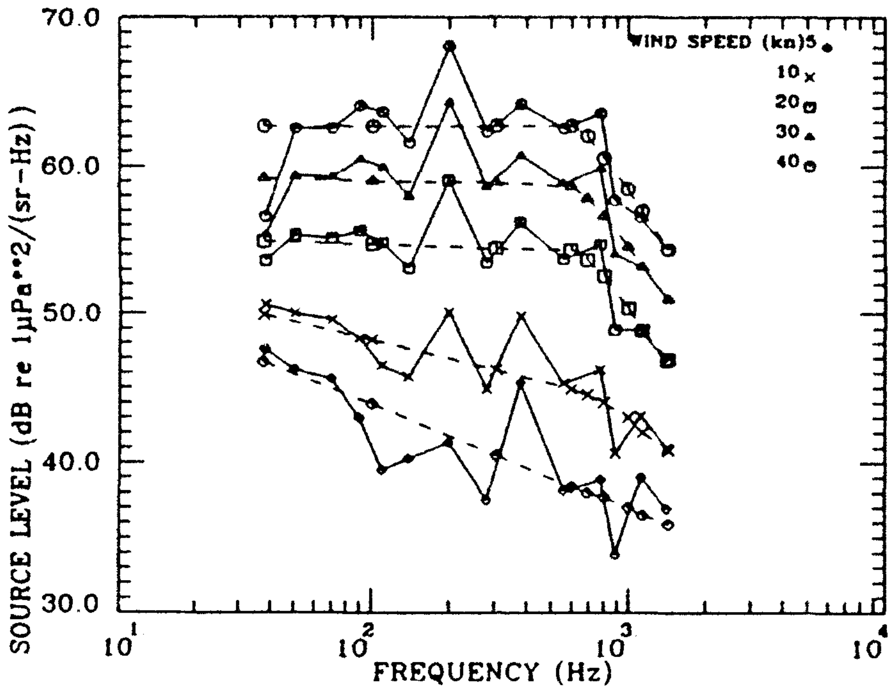
INTERZONE PROPAGATION LOSS (dB)

	CZ	SL	100Hz	1000Hz	10,000Hz
Initial Loss to Zone 1	0-1	80	.07	4.5	70
Interzone Losses	1-2	3	.07	4.5	70
	2-3	1.8	.07	4.5	70
	3-4	1.2	.07	4.5	70
	4-5	.9	.07	4.5	70
	5-6	.8	.07	4.5	70
	6-7	.7	.07	4.5	70
	7-8	.6	.07	4.5	70
	8-9	.5	.07	4.5	70
	9-10	.4	.07	4.5	70
			(.6)	(40.5)	(630)
Total Loss from Zone 1 out to Zone 10 →	1 - 10	10	10.6	50.5	640

70 KM CONVERGENCE ZONES, NORTH ATLANTIC

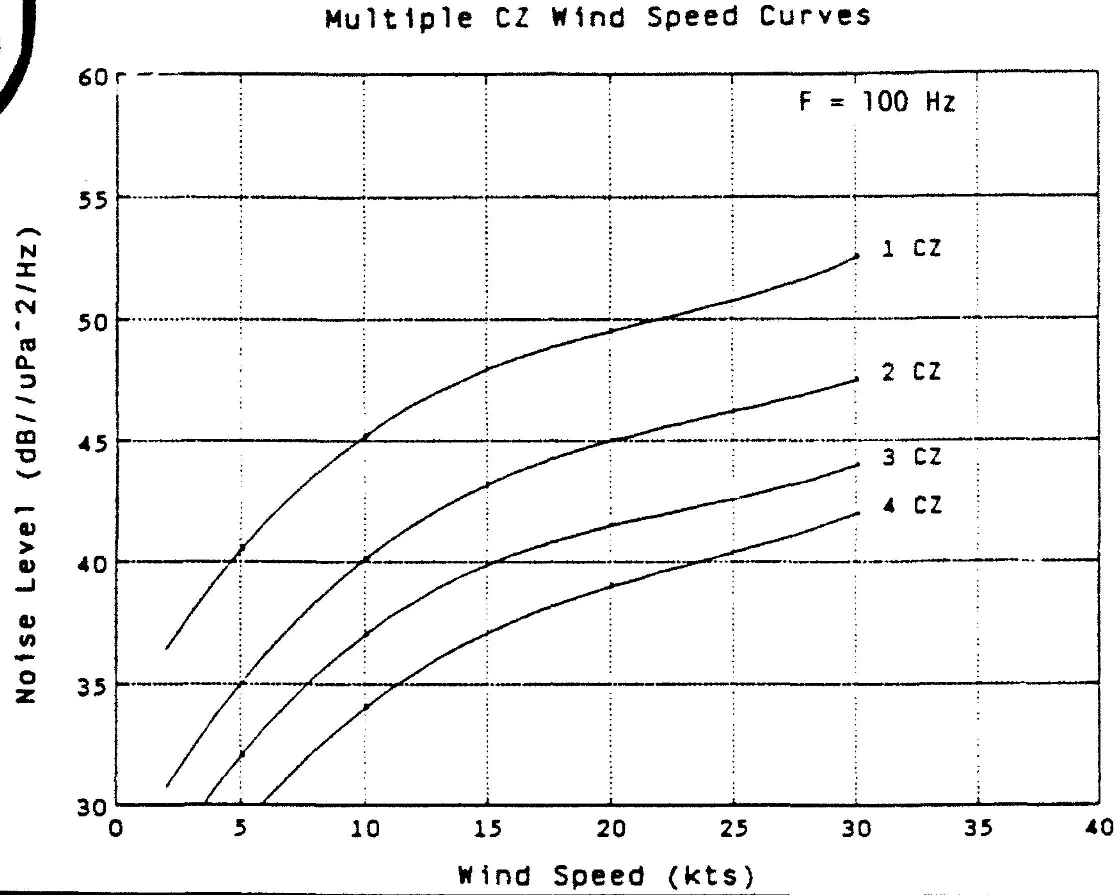
VIEWGRAPH 6. TABLE

To put this in the context of multiple CZ propagation, we have constructed this table. Interzone losses are listed for spreading loss in the first column. The next three columns presents attenuation at three different frequencies out to the tenth CZ. The total for both attenuation and spreading loss is shown on the bottom line. We have assumed typical north Atlantic deep water conditions. Compare the spreading loss encountered to get to the first CZ with what it takes to go all the way from the first to the tenth. At 100 Hz attenuation is not a significant factor, while at 10,000 Hz the problem becomes meaningless because you probably can't get to the first CZ. The important point is that in the low frequency world it does not take a large increase in source level to overcome interzone losses past the first CZ.



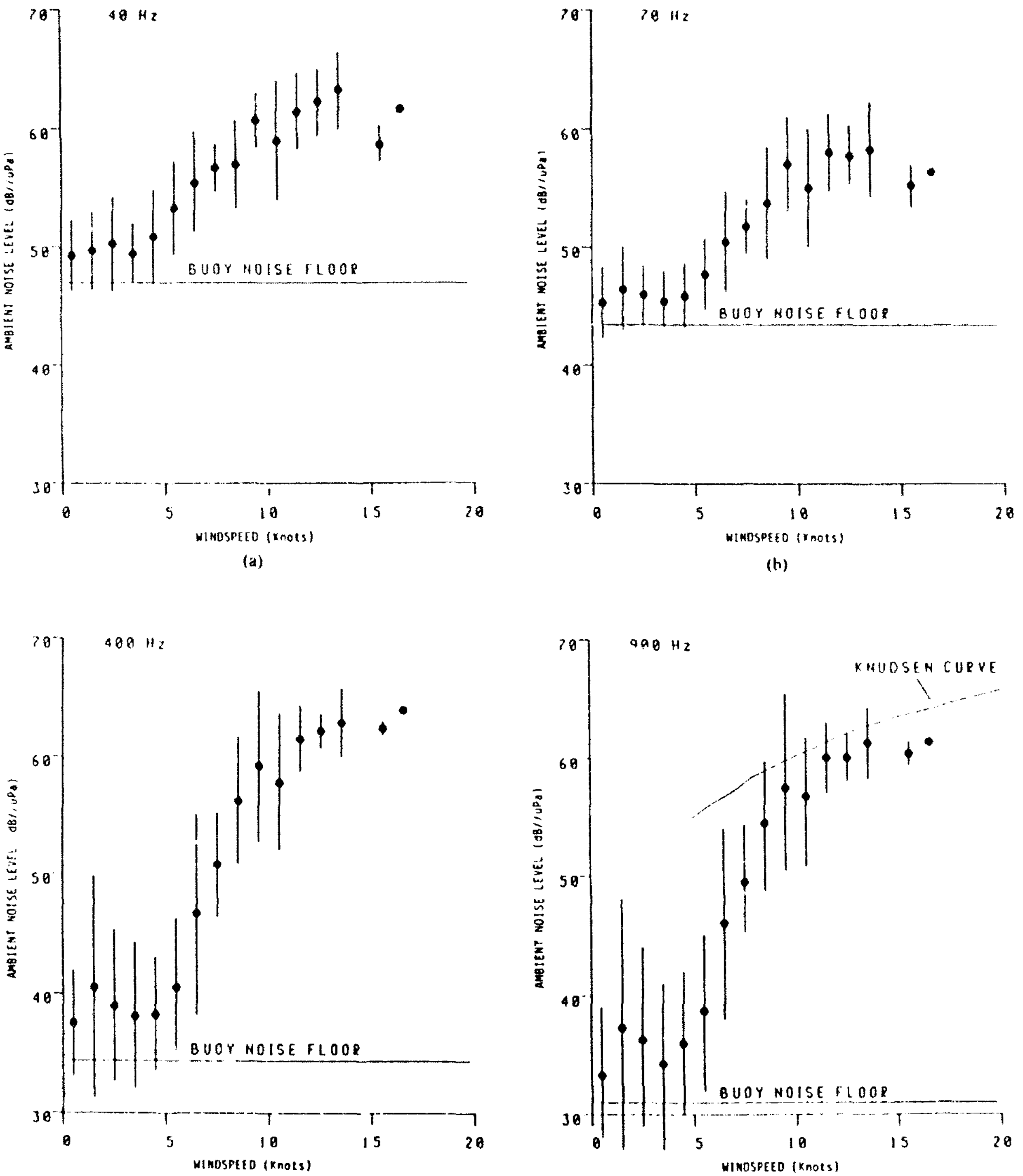
VIEWGRAPH 7. SOURCE LEVELS

To apply this, let us consider wind-generated ambient noise in a multiple CZ environment. Through the work of Kewley, Kuperman, Carey and others, we have reasonable estimates of wind generated ambient noise source levels [3]. Note that the change in levels over a reasonable range of windspeeds is greater than the low frequency interzone losses past the first CZ (see viewgraph 6). For example at 100 Hz, a shift from 5 to 20 knots in windspeed increases the source level by approximately 12 dB.



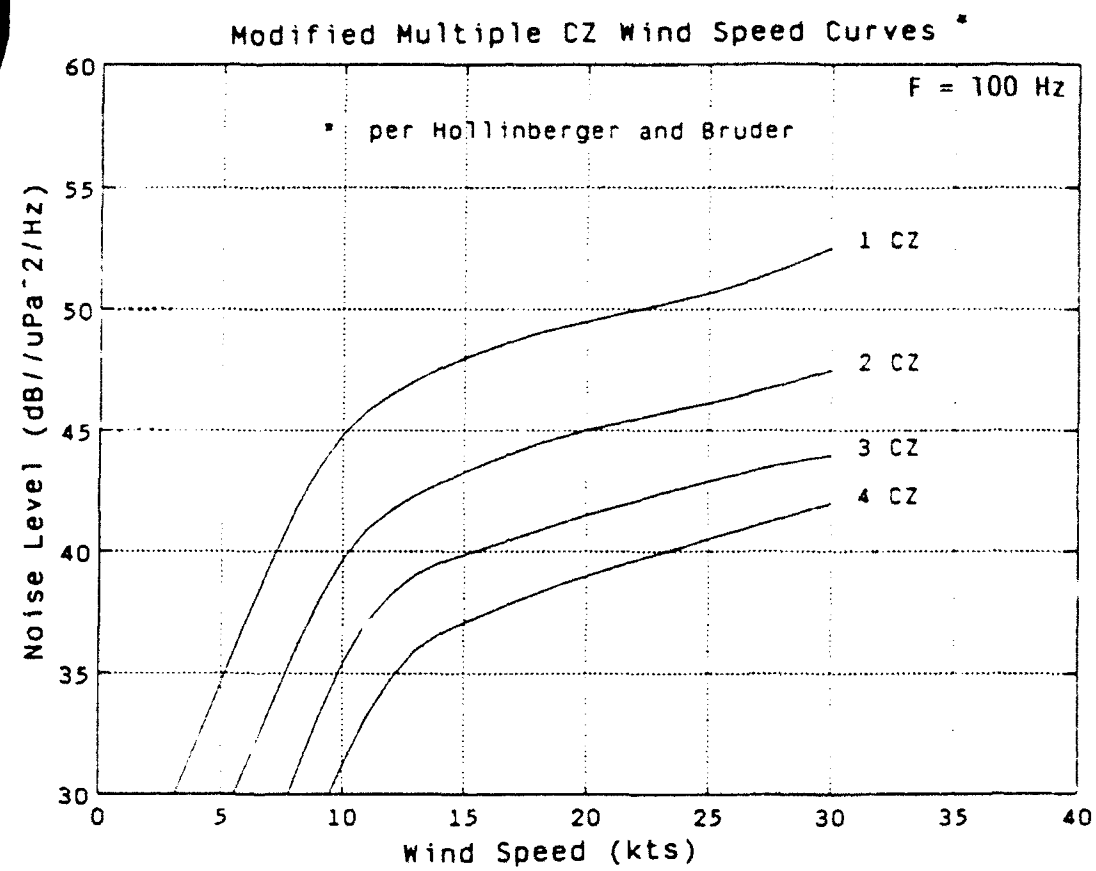
VIEWGRAPH 8. DUNES MODEL PREDICTIONS

Using the DUNES ambient noise prediction model [4] at 100 Hz, we can move a patch of wind-generated ambient noise from one CZ to another to obtain the corresponding levels from each zone back at the receiver. We are dealing with the contribution from each CZ and are not considering short range noise.



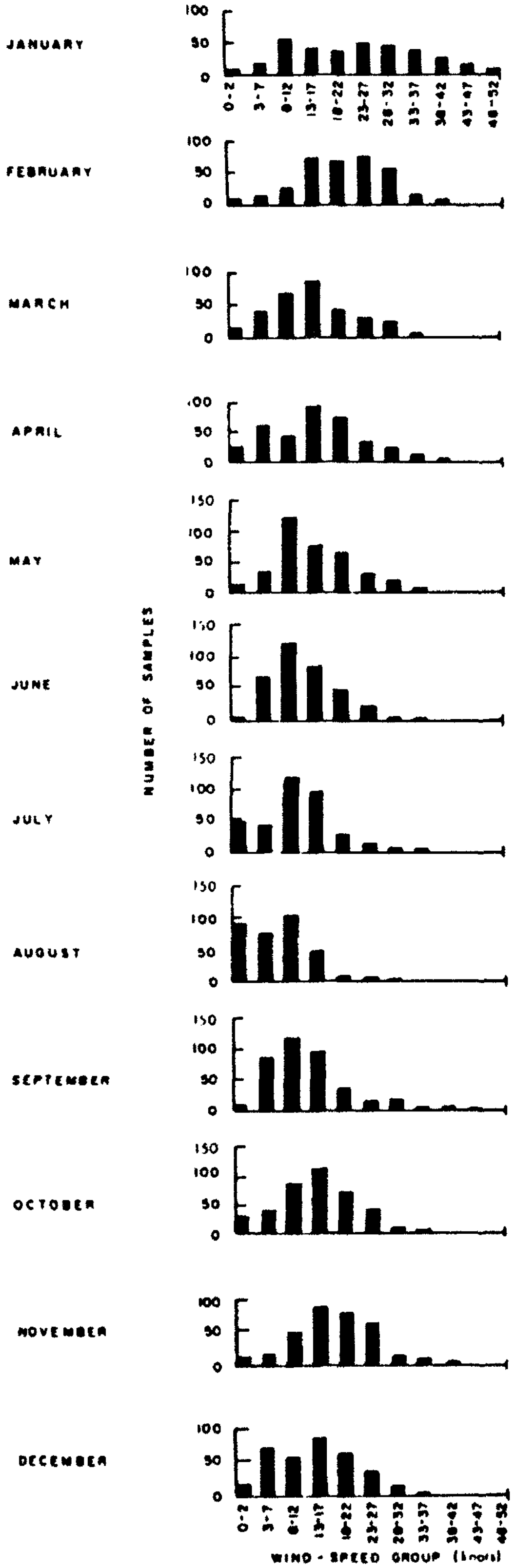
VIEWGRAPH 9. FJORD DATA (After Hollinberger and Bruder [5])

In the October issue of OCEANIC ENGINEERING, Hollinberger and Bruder [5] present noise levels obtained in an isolated fjord. Their windspeed-dependency is greater over the range 5 to 10 knots than are given by the source levels developed from open ocean measurements which were used in the DUNES Model. We have incorporated the Hollinberger and Bruder data into the DUNES predictions.



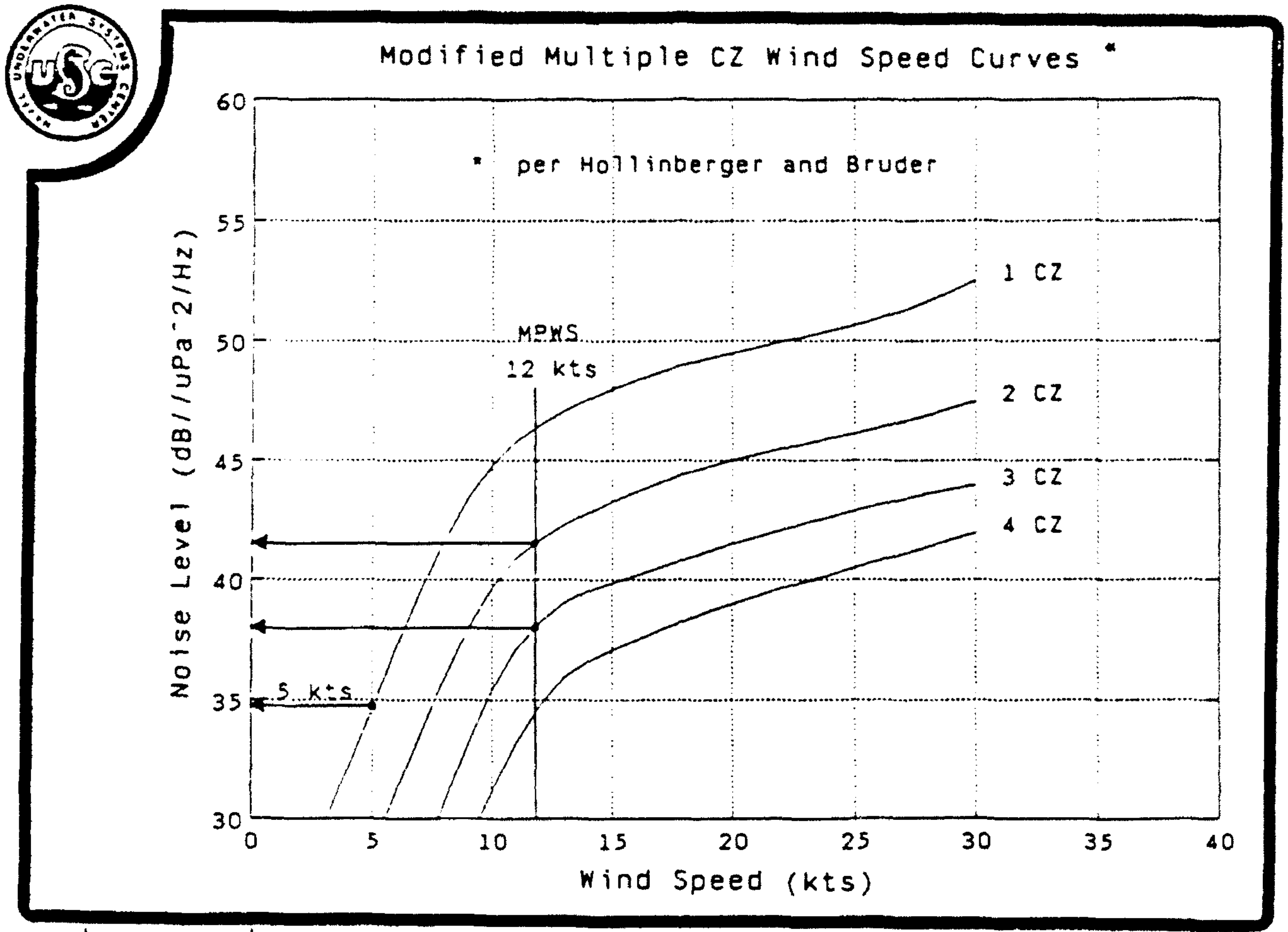
VIEWGRAPH 10. MODIFIED DUNES CURVES

These are the resulting modified DUNES predictions with the stronger roll-off at low windspeeds for various CZs at 100 Hz.



VIEWGRAPH 11. BERMUDA WINDSPEED DISTRIBUTION

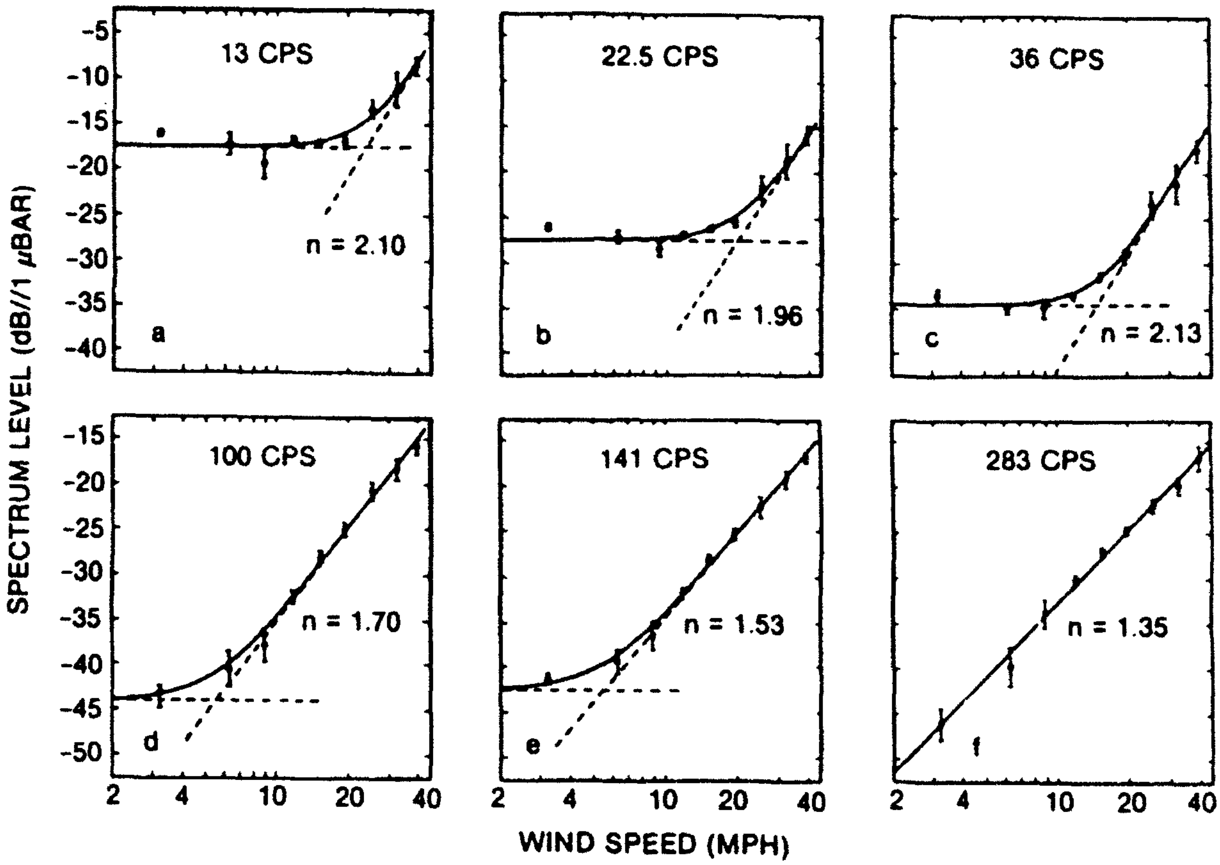
To develop what would be a meaningful scenario we examined the windspeed distribution for a typical North Atlantic site, i.e., Bermuda. Although there is certainly seasonal variability, we determined that the most probable windspeed would be 12 knots with a fairly rapid decrease in probability on either side. We therefore constructed the following scenario. Let us assume that the wind is blowing at the most probable windspeed at all the CZs except the first and let's vary the windspeed at the first CZ and see what the resulting ambient noise levels are.



VIEWGRAPH 12. MODIFIED DUNES FIRST CZ WIND 5 KNOTS

Here we have the result with the windspeed at the first CZ being 5 knots, the other CZs having the most probable windspeed (MPWS) of 12 knots. The ambient noise levels are for a frequency of 100 Hz. You can see that when the windspeed at the first CZ drops below the most probable windspeed, contribution from other CZs can dominate. The lower the local windspeed gets, the more contributions can come in from the outer CZs. This suggests that there will always be a threshold for low frequency noise which will be linked to the most probable windspeed throughout the region and this may be, at least in part, the cause of the "second mechanism" required to fit open ocean low frequency wind generated ambient noise data.

LOW FREQUENCY OCEAN AMBIENT NOISE: MEASUREMENTS AND THEORY
(After Piggott [6])



VIEWGRAPH 13. PIGGOTT'S RESULTS

It is interesting to go back and look at Piggott's results [6] with this idea in mind. A threshold level does seem to occur below 200 Hz, although it should be noted that we have only demonstrated such an effect could happen for CZ contributions. It may well be that other more local modes may interact in the same way. For example, perhaps if the direct path contribution was low, bottom reflected paths might dominate.

CONCLUSIONS

1. THE CURTAIN EFFECT LIMITS THE "FULL SPECTRUM" IN A MULTIPLE CONVERGENCE ZONE ENVIRONMENT.

2. AT LOW FREQUENCIES THE INTERZONE LOSSES ARE RELATIVELY SMALL AND CAN BE COMPENSATED BY NATURAL SOURCE LEVEL INCREASES.

3. BELOW 200 HERTZ EXPECT A WIND GENERATED NOISE THRESHOLD BASED ON THE MOST PROBABLE WINDSPEED FOR THE REGION.

VIEWGRAPH 14. CONCLUSIONS

We can summarize our results as follows:

1. The curtain effect limits the "full spectrum" in a multiple convergence zone environment.
2. At lower frequencies, the interzone losses are relatively small and can be compensated by natural source level increases.
3. Below 200 Hz, expect a wind-generated noise threshold based on the most probable windspeed for the region.

REFERENCES

1. D. G. Browning, J. J. Hanrahan, R. J. Christian, and R. H. Mellen, "Limitations of Sound Propagation: The Curtain Effect," NUSC Technical Document 7919, Naval Underwater Systems Center, New London, CT, 5 March 1987.

2. R. H. Mellen, P. M. Scheifele, and D. Browning, "Global Model for Sound Absorption in Sea Water," NUSC Technical Report 7923, Naval Underwater Systems Center, New London, CT, 1 October 1983.

3. D. J. Kewley, D. G. Browning, and W. M. Carey, "Low-Frequency Wind-Generated Ambient Noise Source Levels," Journal of the Acoustical Society of America, vol. 88, no. 4, October 1990, pp. 1894-1902.

4. R. W. Bannister, D. J. Kewley, and A. S. Burgess, "Directional Underwater Noise Estimates - The Dunes Model," Australia DSTO WSRL-TN-34/89 (AR-005-920), July 1989.

5. D. E. Hollinberger and D. W. Bruder, "Ambient Noise Data Logger Buoy," IEEE Journal of Oceanic Engineering, vol. 15, no. 4, October 1990, pp. 286-291.

6. C. L. Piggott, "Ambient Sea Noise at Low Frequencies in Shallow Water of the Scotian Shelf," Journal of the Acoustical Society of America, vol. 36, no. 11, November 1964, pp. 2152-2163.

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