

AD 721679

NUSC Report No. NL-3038

Acoustical Investigation of the Deep Scattering Layers at the Bermuda Ocean Acre Site In April and November 1969

ROBERT K. DULLEA
Ocean Sciences Division



10 December 1970

DDC
RECEIVED
APR 14 1971
C

NAVAL UNDERWATER SYSTEMS CENTER
New London Laboratory

This document has been approved for public release and sale;
its distribution is unlimited.

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
Springfield, Va. 22151

ACCESSION FOR	
DEPT	WHITE SECTION <input checked="" type="checkbox"/>
DDC	DIFF SECTION <input type="checkbox"/>
UNANNOUNCED <input type="checkbox"/>	
JUSTIFICATION	
BY	
DISTRIBUTION/ADMINISTRATIVE CODES	
DIST.	AVAIL. NO./or SYMBOL
A	

REVIEWED AND APPROVED: 10 December 1970

W. A. Von Winkle

W. A. Von Winkle
 Associate Technical Director
 for Research
 New London Laboratory

Correspondence concerning this report should be addressed as follows:

Officer in Charge
 New London Laboratory
 Naval Underwater Systems Center
 New London, Connecticut 06320

ABSTRACT

As a part of the Ocean Acre Program, experimental studies of volume reverberation were conducted near Bermuda during April and November of 1969. Downward looking transducers with CW pulse transmissions were used. The spring measurements were made at frequencies of 3.5, 13.5, and 15.5 kHz. The fall measurements were made at 12.0 kHz. The resultant data include frequency comparisons of peak scattering strength versus depth, as well as daily and seasonal comparisons of scattering strength. During the spring studies, daytime scattering at the upper frequencies was greater than that at 3.5 kHz. At nighttime, the reverberation at 3.5 kHz increased to a level comparable with that of the upper frequencies. Daily comparisons of the scattering strength profiles exhibited excellent structural repeatability. The fall reverberation measurements yielded generally greater peak scattering strengths when compared with the spring measurements.

ADMINISTRATIVE INFORMATION

The work was accomplished under New London Laboratory Project No. A-403-00-00, "Reverberation Research Studies" (U), Principal Investigators, N. P. Fisch and R. K. Dullea, Code 2211, and Navy Subproject and Task No. SF 11552 001-112-11284, Program Manager, J. Reeves, NAVSHIPS 00V1.

The author thanks D. M. Potter, N. P. Fisch, and G. F. Battista for their assistance in the various phases of the experiment.

The Technical Reviewer for this report was J. J. Hanrahan of the Systems Analysis Staff (Code 2042).

i/ii
REVERSE BLANK

2

TABLE OF CONTENTS

	Page
ABSTRACT	i
ADMINISTRATIVE INFORMATION	i
LIST OF ILLUSTRATIONS	v
INTRODUCTION	1
BACKGROUND	1
DATA ACQUISITION AND REDUCTION SYSTEM	1
THEORY	3
RESULTS	3
CONCLUSIONS	10
INITIAL DISTRIBUTION LIST Inside Back Cover

LIST OF ILLUSTRATIONS

Figure		Page
1	Block Diagram of Data Acquisition and Reduction System	2
2	Diurnal Variations of Volume Reverberation Profiles for Ocean Acre Site (28 April 1969)	5
3	Frequency Comparison of Volume Reverberation Profiles for Ocean Acre Site (28 April 1969)	6
4	Nighttime Comparison of Volume Reverberation Profiles for Ocean Acre Site (28 April 1969)	7
5	Noontime Comparison of Volume Reverberation Profiles for Ocean Acre Site (29 and 30 April 1969)	8
6	Diurnal Variation of Volume Reverberation Profile at 12 kHz for Ocean Acre Site (24 November 1969)	9
7	Nighttime Seasonal Comparison of Volume Reverberation Profiles for Ocean Acre Site	9

ACOUSTICAL INVESTIGATION OF THE DEEP SCATTERING
LAYERS AT THE BERMUDA OCEAN ACRE SITE
IN APRIL AND NOVEMBER 1969

INTRODUCTION

The results of the acoustical investigations of the deep scattering layers (DSL) at the Bermuda Ocean Acre Site¹ are presented for the spring of 1969, Ocean Acre Cruise 6, and the fall of 1969, Ocean Acre Cruise 8. The spring measurements were made by using a series of transducers operated at 3.5 kHz, 13.5 kHz, and 15.5 kHz. The UNIVAC 1230 computer installed on the USNS SANDS (AGOR-6) was employed in the experiment for at-sea processing of reverberation data. The fall measurements were made by using a 12.0-kHz transducer on the R/V TRIDENT. This report presents the analysis of the morning, noon, and nighttime variations of the volume scattering strength versus depth at the above frequencies, as well as daily and seasonal comparisons.

BACKGROUND

The primary objective of the Ocean Acre program² is to determine by concurrent studies over a 3- to 5-year period the acoustical and biological characteristics of the DSL at a selected oceanic site. The site chosen for this undertaking is a water column 60 nautical miles square by 4000 meters deep about 15 nautical miles southeast of Bermuda (32°N, 64°W). It is expected that this study will provide a greater insight into the acoustical resonant frequencies and associated scattering strengths, migrational habits, life histories, geographical distribution, and seasonal variations of the inhabitants of the DSL.

DATA ACQUISITION AND REDUCTION SYSTEM

A number of research ships are participating in the Ocean Acre program. During Cruise 6, the SANDS was the research vessel, and

¹"Ocean Acre," NUSL Pub. No. 1107, 2 April 1970.

²Ibid.

data were obtained at 13.5 kHz and 15.5 kHz from a modified hull-mounted AN/UQN echo sounder and at 3.5 kHz from a special hull-mounted projector and receiving array. Data at 12 kHz were obtained during Cruise 8 by using an AN/UQN mounted in an ORE towbody that was towed from TRIDENT.

In both studies, the data were recorded on analog tape and then processed on the UNIVAC 1230 computer system aboard the SANDS. The block diagram for the data acquisition and reduction system is shown in Fig. 1. A Giffit recorder generates a key pulse that triggers the transceiver, and the resultant reverberation is recorded on tape. During the tape playback, this same key pulse starts the input sampling program of the computer. After being filtered and envelope-detected, the reverberation signal is sampled at a rate of 500 samples/sec by an A/D multiplexer and fed to the computer where it is averaged and converted by an appropriate program to scattering strength. Subsequently, the data are placed on magnetic tape and are graphed by a high-speed printer.

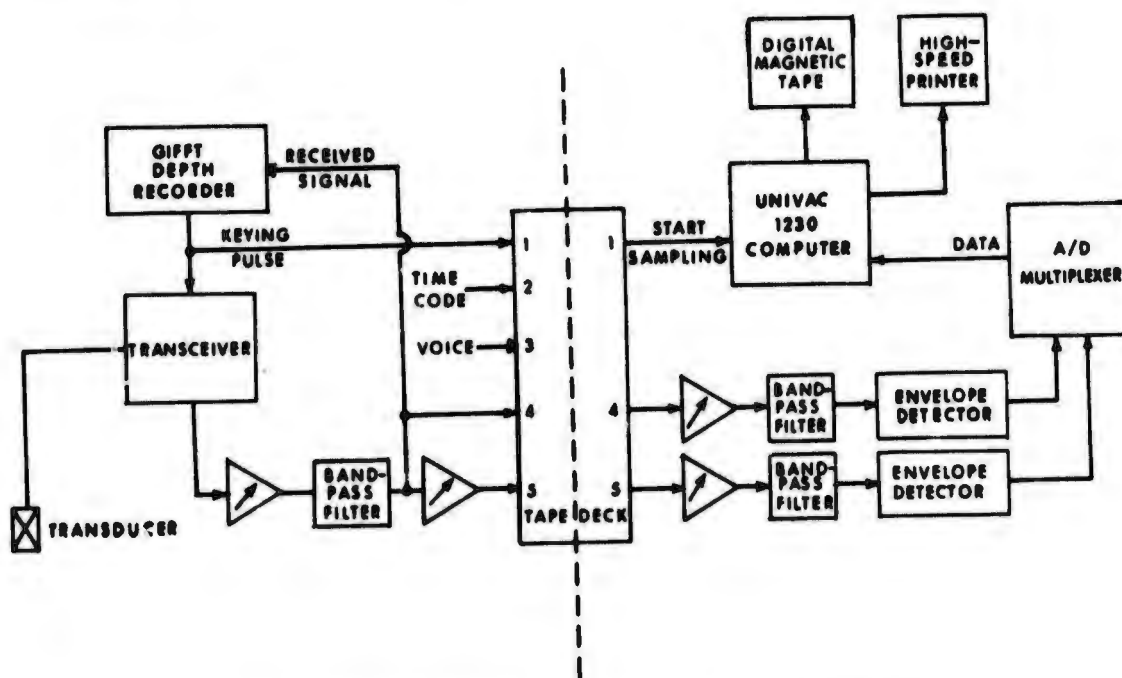


Fig. 1 - Block Diagram of Data Acquisition and Reduction System

THEORY

The scattering strength is defined³ as

$$S_v = 10 \log_{10} \frac{I_{\text{scat}}}{I_{\text{inc}}}$$

where I_{scat} is the intensity scattered by a unit volume of 1 yd^3 measured at a distance of 1 yd from the scattering volume and where I_{inc} is the incident intensity. In practice, the insonified volume is not 1 yd^3 and the scattered intensity is not measured at 1 yd . Thus, the actual received intensity must be normalized so that S_v is obtained. In addition, corrections must be made for inverse spreading. The method of obtaining Eq. (1) is explained by Urick,⁴ and, therefore, only the equation is presented here:

$$S_v = RL_v - SL + 40 \log r - 10 \log_{10} V \quad (1)$$
$$V = [(cr)/2] \Psi r^2$$

where

S_v = scattering strength in decibels,

RL_v = received reverberation level in decibels,

r = distance in yards from the receiver to the insonified volume,

V = insonified volume contributing to the returned reverberation at a given instant of time,

SL = source level,

c = velocity of sound in yards per second,

τ = pulse length in seconds, and

Ψ = equivalent beam width.

RESULTS

The scattering strength versus depth curves in this report present a composite of the results obtained during this experiment. The curves were obtained from an ensemble average of 8 pulses that occurred over a duration of about 30 sec. The graphs are actually composed of finite data points, each of which constitutes a 10-msec time average. The

³R. J. Urick, Principles of Underwater Sound for Engineers, McGraw-Hill Book Co, Inc, New York, 1967.

⁴Ibid.

reverberation data are corrected for noise by subtracting the mean square of an ambient noise sample from the actual reverberation level.

Figures 2a, 2b, and 2c show the morning, noon, and nighttime variations of volume scattering strength versus depth at constant frequency for measurements made on 28 April 1969. The system thresholds shown in the figures represent the minimum scattering strength for which values could be measured at the depths indicated for the associated frequency. The 3.5-kHz data were unmeasurable above depths of 650 ft because of ringing in the transducer. It is evident from the data at 13.5 and 15.5 kHz that a relatively thick layer was present throughout the day between 850 and 1750 ft. At these frequencies, the greatest variation in scattering strength (greater than 20 dB for some depths) occurred between the depths of 350 and 850 ft. Scattering strength variations between the interval of 100 to 250 ft increased on the order of 10 to 15 dB from noon to night.

Figures 3a, 3b, and 3c present a frequency comparison for the morning, noon, and nighttime profiles. As shown in Figs. 3a and 3b, the morning and noon profiles at 3.5 kHz were below the associated system threshold.

The morning profiles for 13.5 and 15.5 kHz show relatively good agreement in both the magnitude and structure of the layers. For those portions of the depth interval where data were observable, the noon profiles show excellent magnitudinal and structural agreement with the exception of the depth interval from 850 to 1100 ft, where the data at 15.5 kHz are about 10 dB greater than the 13.5 kHz data. The nighttime profiles exhibit good structural agreement at all three frequencies where data were measurable. The associated scattering strengths of the three frequencies are in close agreement down to a depth of 1350 ft. Below 1350 ft, the scattering strength at 3.5 kHz is 2 to 6 dB greater than that at the upper frequencies.

Figures 4a and 4b present nighttime profiles with a 21-hour separation for data obtained at 13.5 and 15.5 kHz, respectively. The magnitude and structure of these profiles are in excellent agreement.

Figures 5a and 5b present noontime profiles with a 48-hour separation for data obtained at 13.5 and 15.5 kHz, respectively. Again these comparisons show excellent correlation.

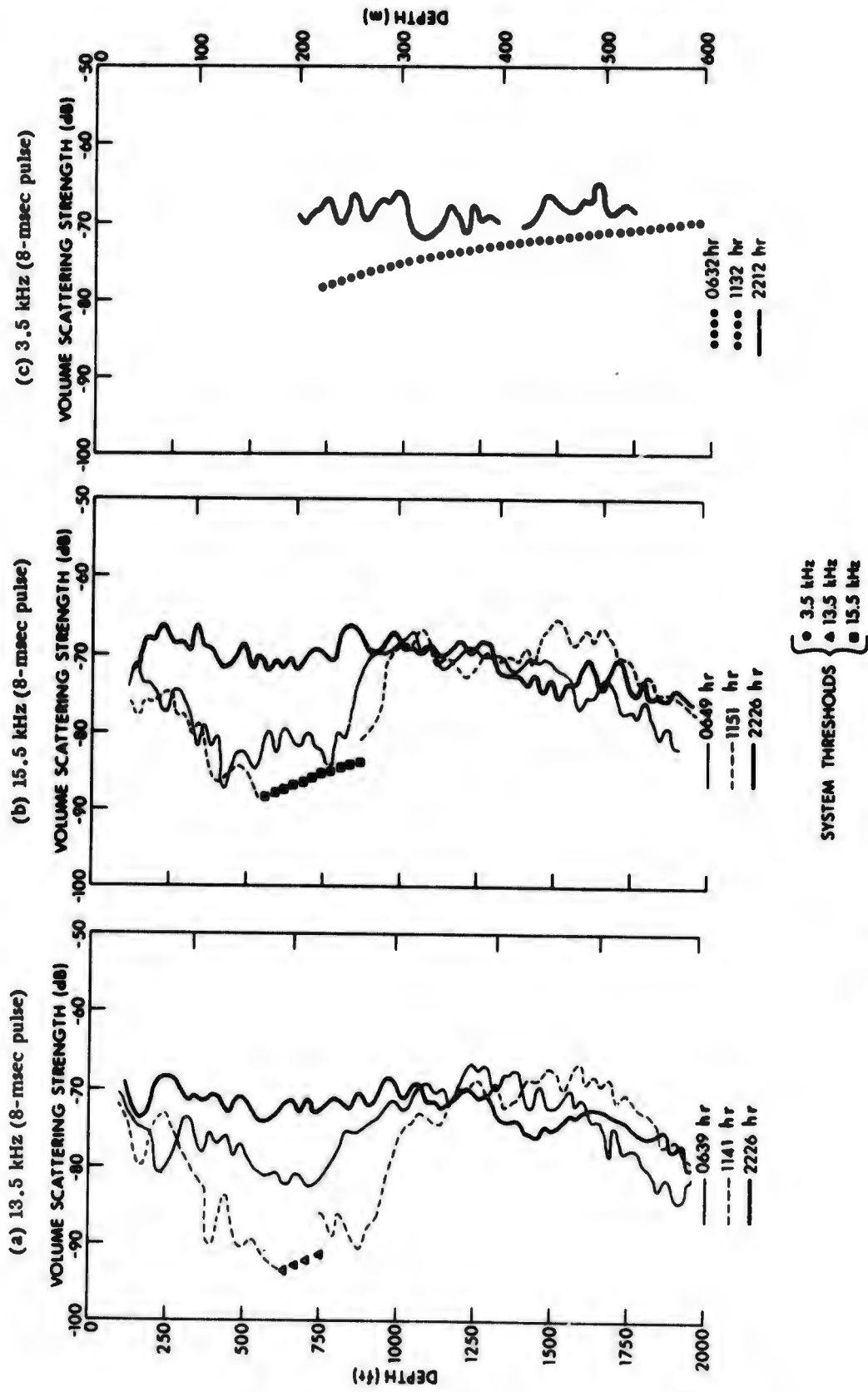


Fig. 2 - Diurnal Variations of Volume Reverberation Profiles For Ocean Acre Site (28 April 1969)

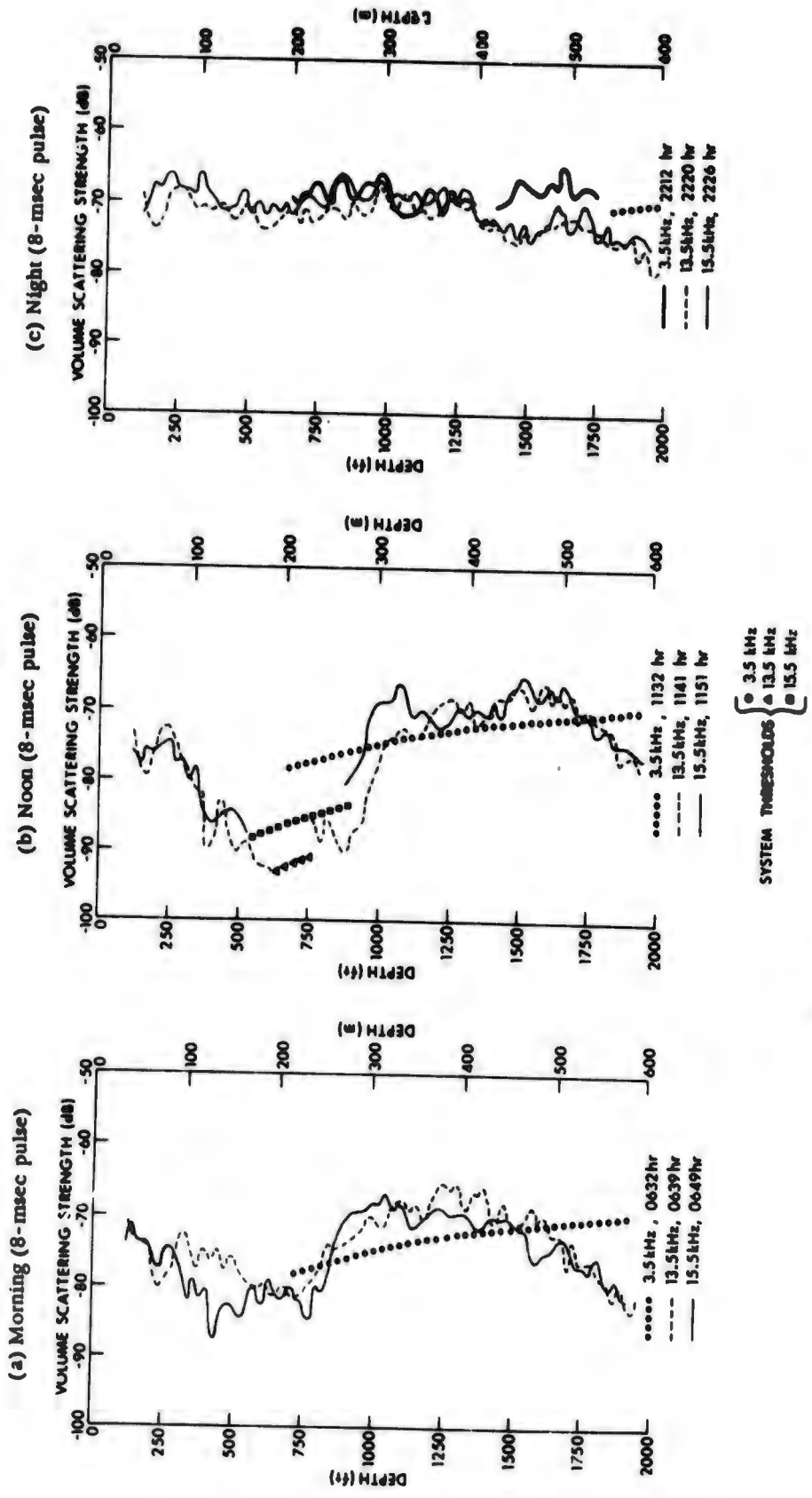


Fig. 3 - Frequency Comparison of Volume Reverberation Profiles For Ocean Acre Site (28 April 1969)

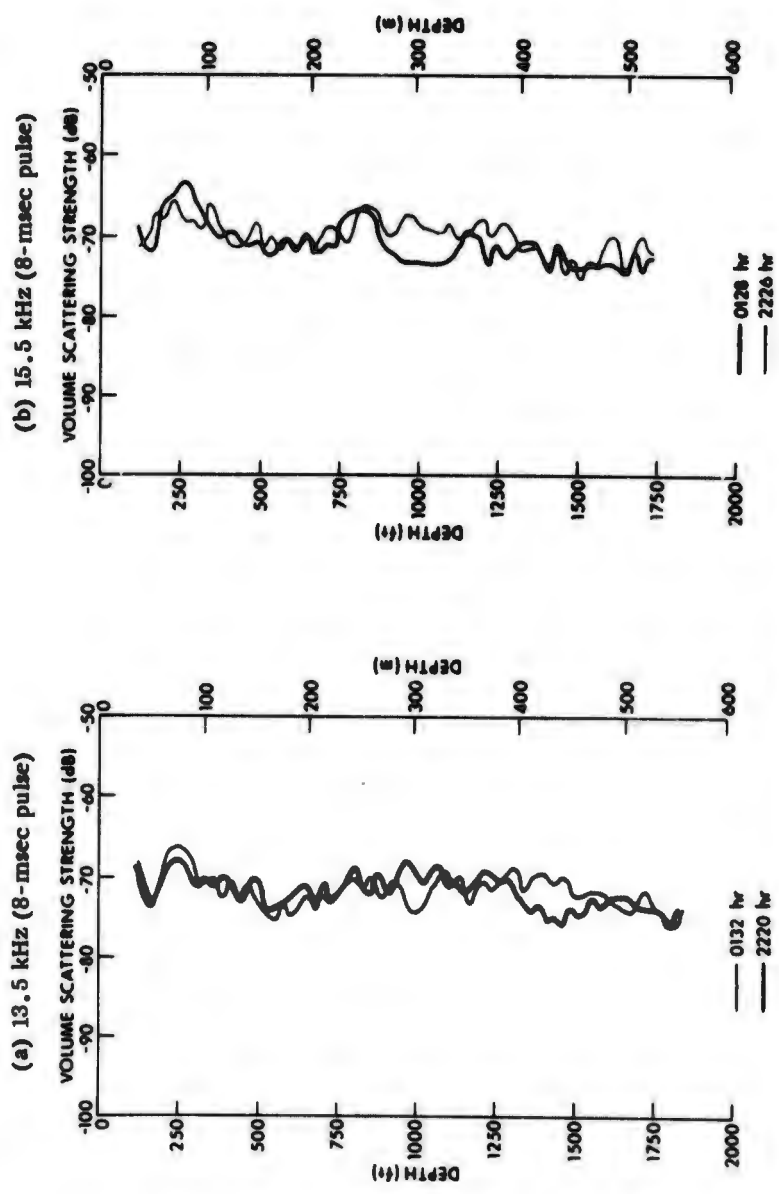


Fig. 4 - Nighttime Comparison of Volume Reverberation Profiles For Ocean Acre Site (28 April 1969)

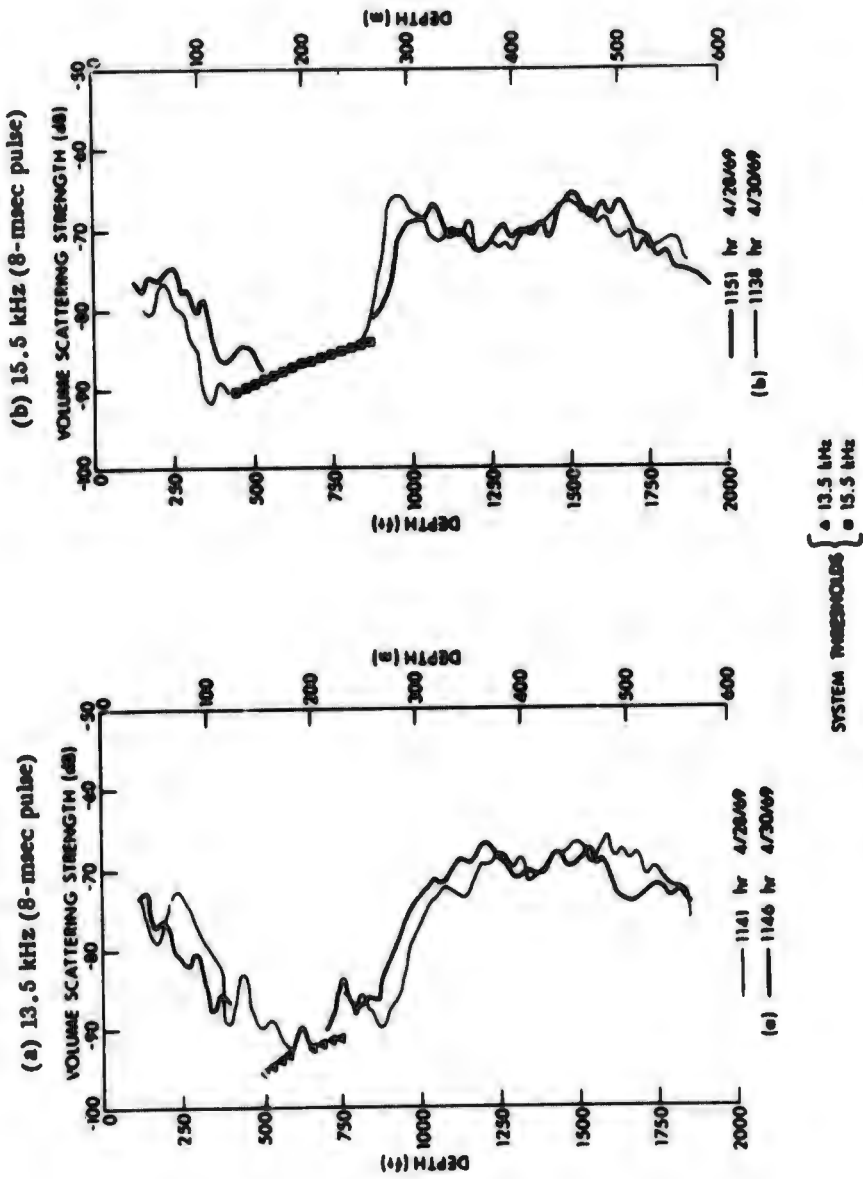


Fig. 5 - Noontime Comparison of Volume Reverberation Profiles For Ocean Acre Site (28 and 30 April 1969)

Figure 6 shows the morning, noon, and nighttime scattering strength profiles for data obtained on 24 November at 12.0 kHz. As in Fig. 2, the data show that the greatest variations in scattering strength (when compared with time of day) occur in the first 1000 ft. The scattering strengths below 1000 ft are relatively stable in comparison throughout the day.

Figure 7 presents a comparison of nighttime volume scattering strength profiles for data obtained during the spring and fall studies. With the exception of the 700- to 900-ft depth interval, the November scattering strength profile is 2 to 10 dB greater than the corresponding April scattering strength profiles. The increase in the overall reverberation measured in the fall, as compared with the reverberation measured in the spring, is in agreement with preliminary biological analysis over the same period.

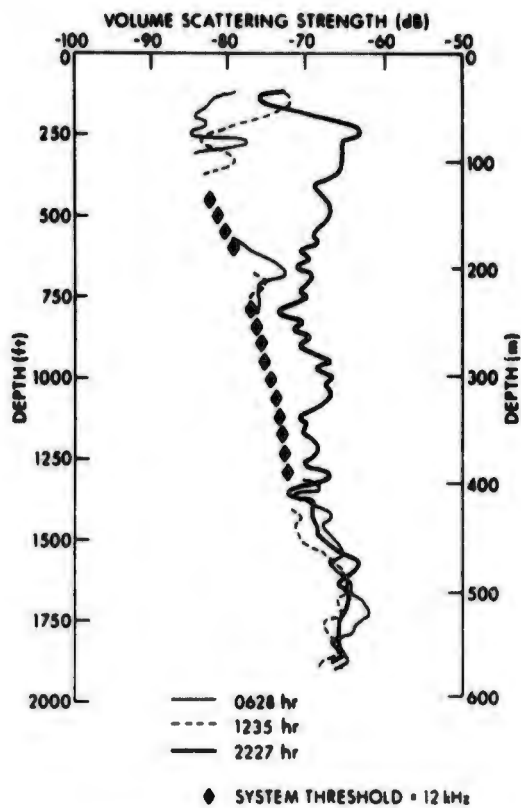


Fig. 6 - Diurnal Variation of Volume Reverberation Profile at 12 kHz for Ocean Acre Site (24 November 1969)

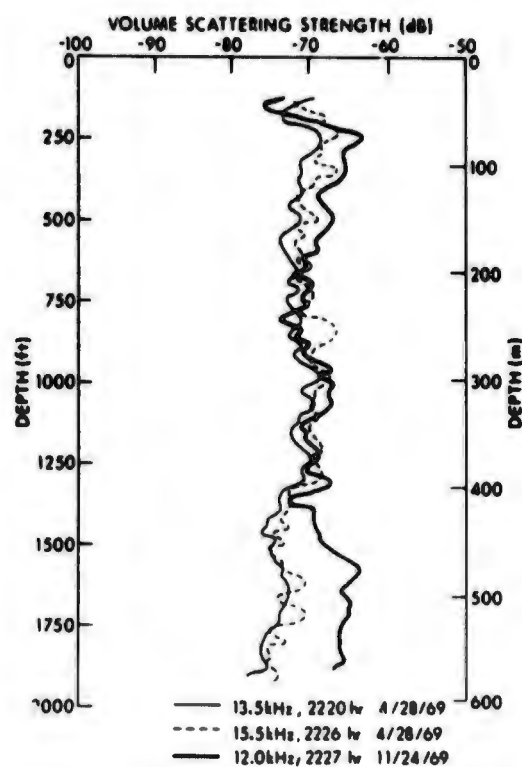


Fig. 7 - Nighttime Seasonal Comparison of Volume Reverberation Profiles for Ocean Acre Site

CONCLUSIONS

Definite trends in the acoustical characteristics of the DSL at the Bermuda Ocean Acre Site have been observed in the data analyzed in this report. The greatest variation in scattering strength from morning to night occurs between the depth interval of 250 to 750 ft. This variation is generally in the order of 20 dB. In the spring of 1969, the peak volume scattering strength profiles at 13.5 and 15.5 kHz exhibited good magnitudinal agreement throughout the day with a singular exception occurring at noontime in the depth interval from 850 to 1100 ft, where the 15.5 kHz data were approximately 10 dB greater than the 13.5 kHz data. Scattering strength data at 3.5 kHz, although not measurable during the daytime hours were equal to or greater than the corresponding upper frequency data at nighttime.

A noteworthy observation yielded by this investigation is that, when the DSL are relatively stable (i. e., noon or night), the magnitude and structure of the scattering strength over the entire water column is almost identical from day to day. This would indicate that the layer population and stratification remain constant on a day-to-day basis.

An observed seasonal increase in volume reverberation from the spring to the fall of 1969 indicates an increase in the population density and size of the scatterers. This final result agrees with preliminary biological measurements of the DSL over the same period.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D		
<i>Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified</i>		
1. ORIGINATING ACTIVITY (Corporate author) New London Laboratory Naval Underwater Systems Center New London, Connecticut 06320		2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED
		2b. GROUP
3. REPORT TITLE ACOUSTICAL INVESTIGATION OF THE DEEP SCATTERING LAYERS AT THE BERMUDA OCEAN ACRE SITE IN APRIL AND NOVEMBER 1969		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Research Report		
5. AUTHOR(S) (First name, middle initial, last name) Robert K. Dullea		
6. REPORT DATE 10 December 1970	7a. TOTAL NO. OF PAGES 16	7b. NO. OF REFS 2
8a. CONTRACT OR GRANT NO. b. PROJECT NO. A-403-00-00 SF 11552 001-112-11284 c. d.		9a. ORIGINATOR'S REPORT NUMBER(S) 3038 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
10. DISTRIBUTION STATEMENT This document has been approved for public release and sale; its distribution is unlimited.		
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY Department of the Navy
13. ABSTRACT <p>As a part of the Ocean Acre Program, experimental studies of volume reverberation were conducted near Bermuda during April and November of 1969. Downward looking transducers with CW pulse transmissions were used. The spring measurements were made at frequencies of 3.5, 13.5, and 15.5 kHz. The fall measurements were made at 12.0 kHz. The resultant data include frequency comparisons of peak scattering strength versus depth, as well as daily and seasonal comparisons of scattering strength. During the spring studies, daytime scattering at the upper frequencies was greater than that at 3.5 kHz. At nighttime, the reverberation at 3.5 kHz increased to a level comparable with that of the upper frequencies. Daily comparisons of the scattering strength profiles exhibited excellent structural repeatability. The fall reverberation measurements yielded generally greater peak scattering strengths when compared with the spring measurements.</p>		

UNCLASSIFIED

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Deep Scattering Layer Ocean Acre - Bermuda Volume Reverberation						