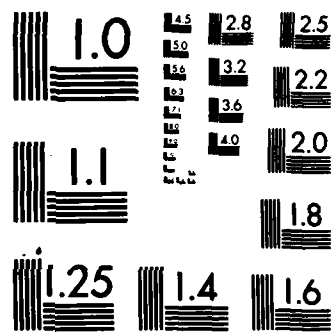
AD-A140 656 TRISTEN/FRAM IV ARCTIC AMBIENT NOISE MEASUREMENTS(U) 1/1
NAVAL UNDERWATER SYSTEMS CENTER NEW LONDON CT NEW
LONDON LAB R J NIELSEN ET AL. 26 MAR 84 NUSC-TD-7133

UNCLASSIFIED F/G 20/1 NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6

(12) DTIC

NUSC Technical Document 7133
[illegible] March 1984

AD-A140 656

TRISTEN/FRAM IV Arctic Ambient Noise Measurements

A Paper Presented at the 106th Meeting of the Acoustical Society of America, San Diego, California, 7-11 November 1983

Richard J. Nielsen
Frederick R. DiNapoli
Michael P. Pecher
Norbert P. Fisch
David M. Potter
Surface Ship Sonar Department

P. L. Stocklin
Analysis and Technology
North Stonington, CT 06359

Naval Underwater Systems Center
Newport, Rhode Island / New London, Connecticut

Approved for public release; distribution unlimited.

Preface

This document was prepared under the sponsorship of the Office of Naval Research, Program Manager Dr. L. Johnson (Code 425AR) under NUSC Project No. A64006 and under the sponsorship of the Naval Sea Systems Command, Undersea Warfare Technology Office, D. Porter (Code 63R), NUSC Project No. A64011, NUSC Principal Investigator Dr. F. R. DiNapoli (Code 01Y).

Reviewed and Approved: 26 March 1984

Peter G. Cable

Peter G. Cable
Head, Arctic Warfare Office

Inquiries may be referred to the Naval Underwater Systems Center
(Code 01Y), New London Laboratory,
New London, Connecticut 06320.

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
TD 7133

2. GOVT ACCESSION NO.
AD-A140 656

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
TRISTEN/FRAM IV ARCTIC AMBIENT NOISE MEASUREMENTS

5. TYPE OF REPORT & PERIOD COVERED

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Richard J. Nielsen
Frederick R. DiNapoli
Micheal P. Fecher
Norbert P. Fisch
David M. Potter
P. L. Stocklin

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Naval Underwater Systems Center
New London Laboratory
New London, Connecticut 06320

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
A64006

11. CONTROLLING OFFICE NAME AND ADDRESS
Office of Naval Research and
Naval Sea Systems Command
Washington, DC 20360

12. REPORT DATE
26 March 1984

13. NUMBER OF PAGES

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Ambient Underice Noise
Arctic
Depth Dependence
Isotropy
Narrowband Amplitude Statistics
Power Spectrum
Stability

A1

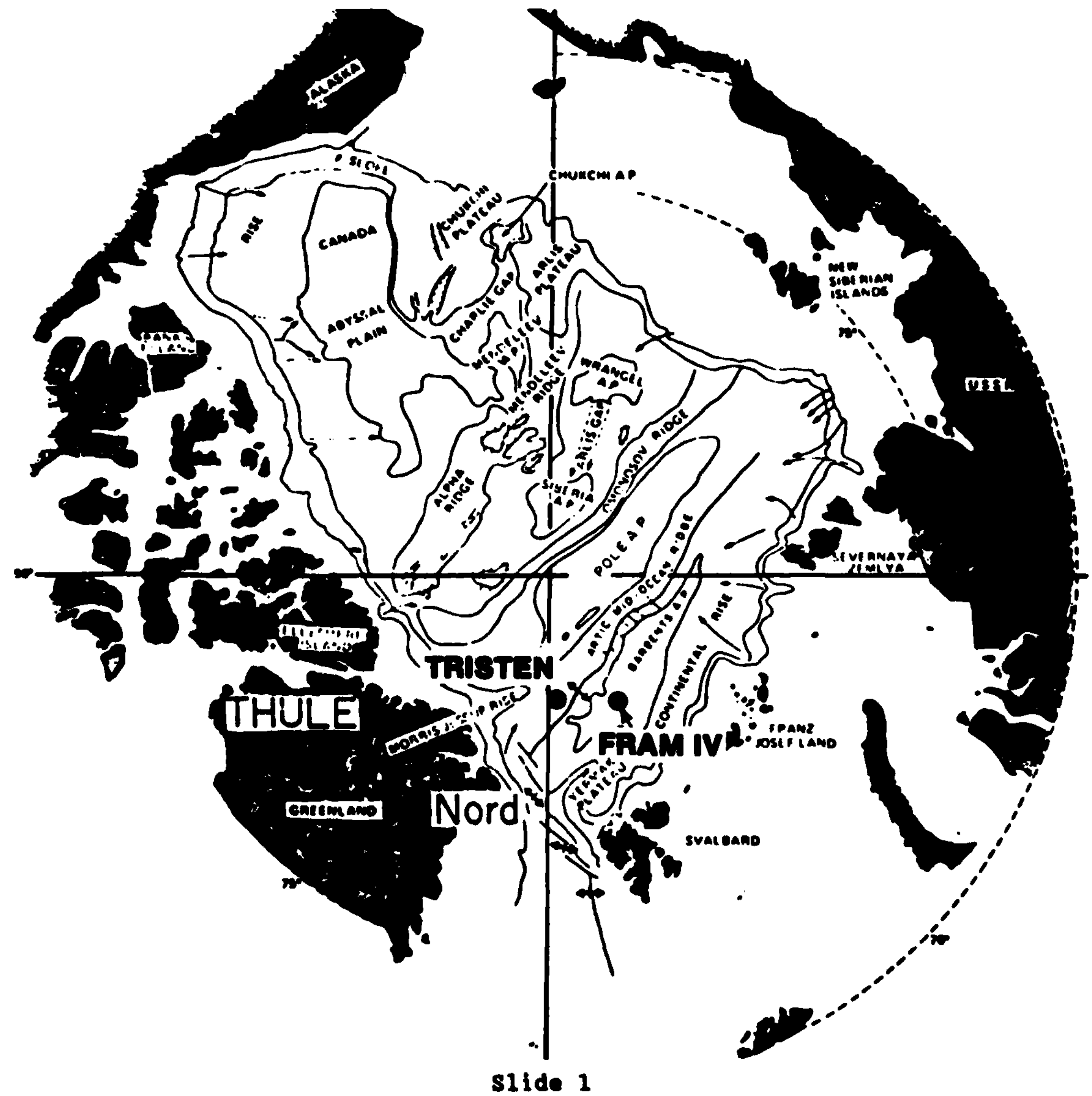
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Multichannel ice camp ambient noise data were recorded by NUSC during the TRISTEN/FRAM IV experiment in the Barents Abyssal Plain, Arctic Ocean during April 1982. Single-hydrophone data were recorded from various elements of both the Massachusetts Institute of Technology/Woods Hole Oceanographic Institute horizontal array and the Naval Research Laboratory vertical array. This paper characterizes the average ambient noise level and its variance as a function of frequency (to 2500 Hz), depth, and time.

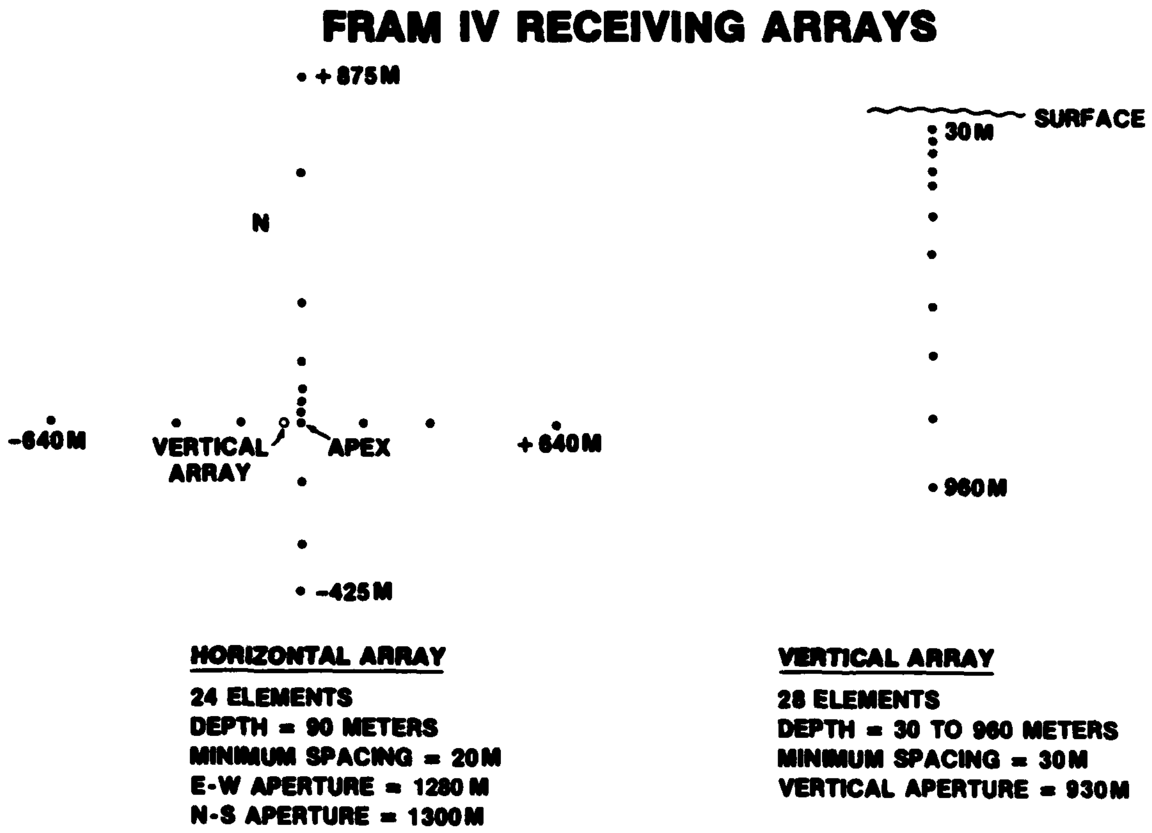
TRISTEN/FRAM IV ARCTIC AMBIENT NOISE MEASUREMENTS

The TRISTEN/FRAM IV experiment was conducted during early spring of 1982. The experiment was sponsored by the Office of Naval Research and included participants from both government laboratories and private institutions. The tests performed were broadbased in nature and designed to study the acoustic and environmental properties of Eastern Arctic. This paper describes the ambient noise measured during the exercise.

The geographic locations of the two ice camps are indicated on this map. Signals, designed to study propagation conditions, were transmitted from the TRISTEN camp located over an extension of the mid-Atlantic ridge. The receiving site was the FRAM IV camp located over the Barents Abyssal Plain. The nominal distance between the two camps was approximately 130 nmi. Both camps were located on stable multi-year ice. The stable environment during this experiment undoubtedly influenced results obtained from the measured data.



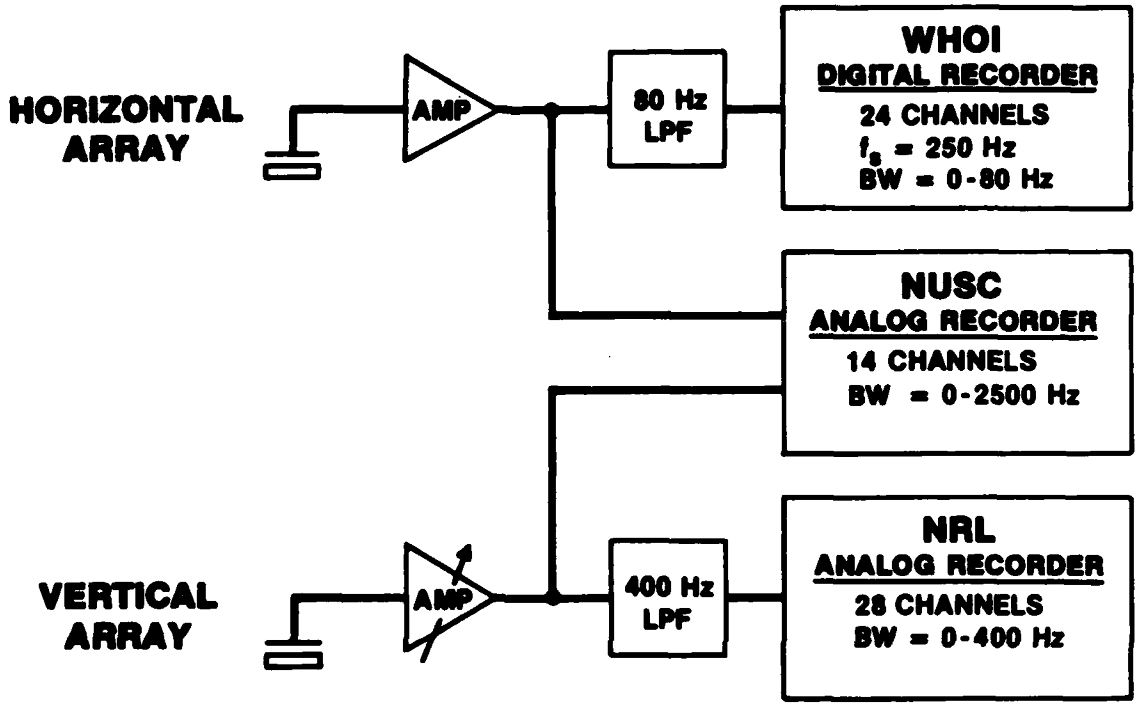
Slide 1



Slide 2

There were two receiving arrays installed at the FRAM IV camp. One array was a horizontal array installed by the WHOI/MIT contingent. The other was a vertical array installed by the Naval Research Laboratory. The horizontal array consisted of 24 elements suspended at 90 meters and arranged in an "x" pattern. The configuration of the elements was exponential with minimum spacing of 20 meters at the apex and a maximum aperture of approximately 1300 meters. The vertical array was located approximately 40 meters west of the apex hydrophone. The array was tapered and consisted of 28 elements with a minimum spacing of 30 meters and a maximum vertical aperture of 930 meters. The array was suspended in the water column to cover depths from 30 to 960 meters.

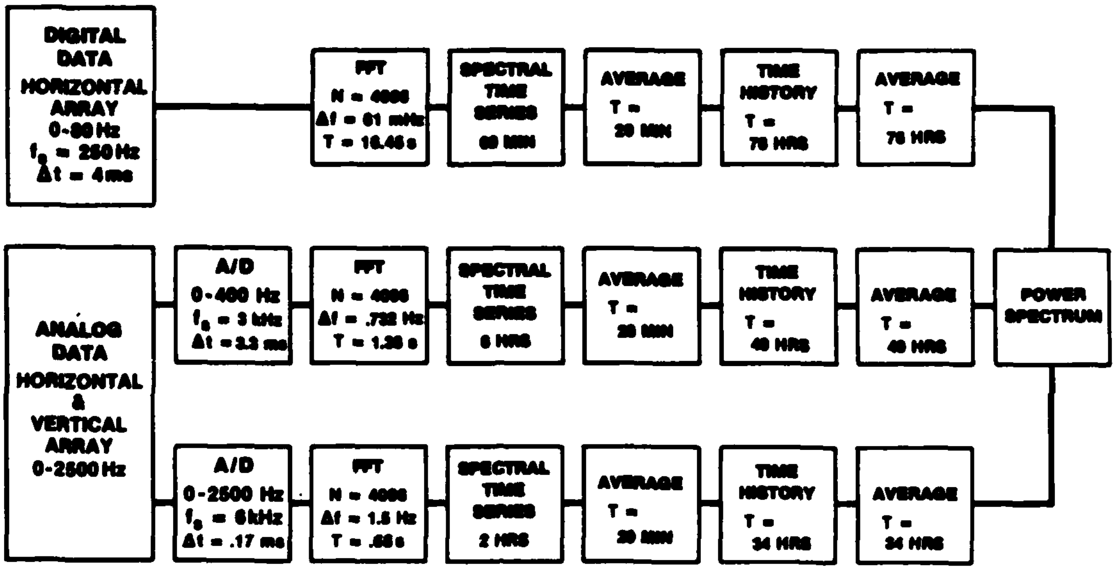
FRAM IV DATA ACQUISITION



Slide 3

Acoustic data were recorded on three systems. The Woods Hole digital recorder had 24 channel capability, a dynamic range of approximately 120 dB, and an anti-aliasing filter that limited the high frequency response to 80 Hz. This system was used primarily to record data from the horizontal array. The NRL analog recorder was used to record data from the vertical array. It had 28 channel capability with a low pass filter which limited the high frequency response to 400 Hz. The NUSC analog recorder had 14 channels which were used to record selected hydrophones from both the horizontal and vertical arrays. The recording characteristics of this recorder limited the high frequency response to 2500 Hz on this system.

DATA PROCESSING

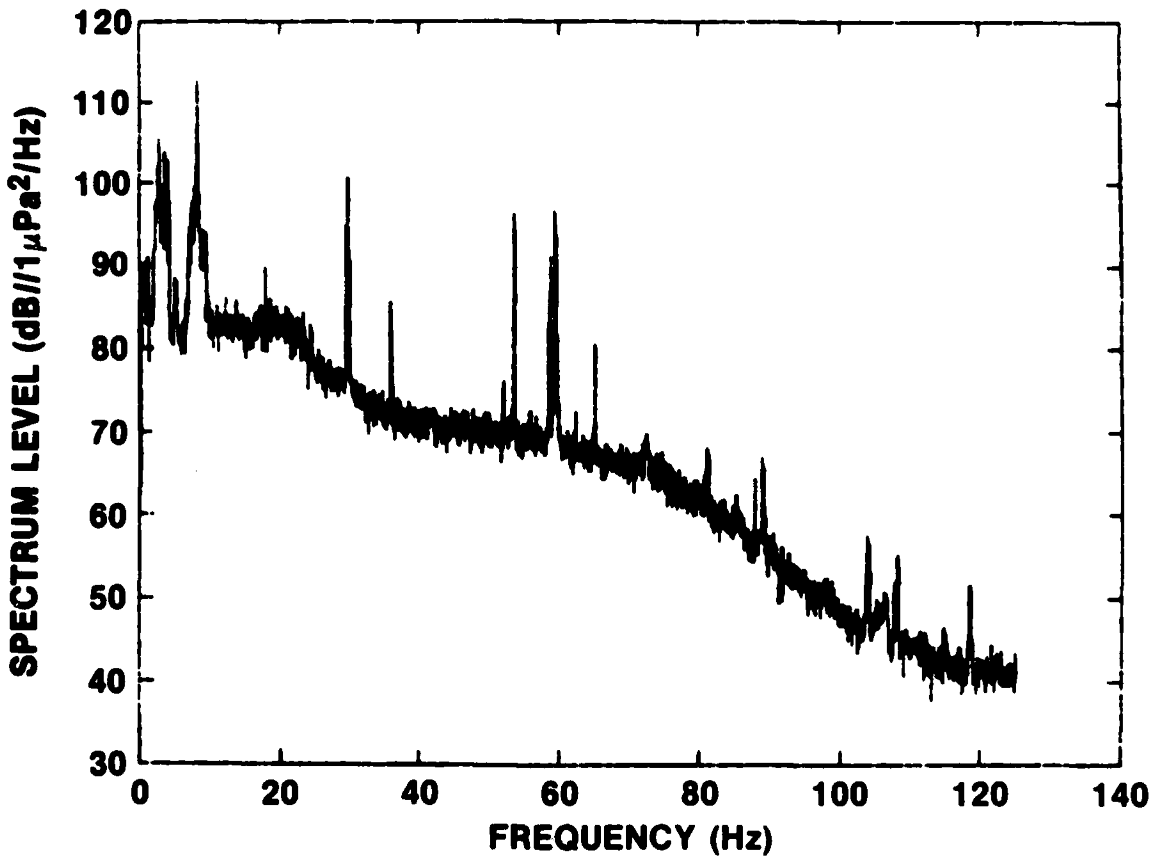


Slide 4

The recorded data were processed three times at different sample rates. This was desirable to control the quantity of digital data produced at the higher frequencies. Thus, more data were analyzed at the lower frequencies. The processing sequence was, however, identical for all three passes of the data. After the analysis frequencies were established, the data were processed as shown. The results of the FFT were used to produce a spectral time series. Because of the high variability of this series, the results were averaged to produce a time history of all the processed data. The time histories were further averaged to produce a resultant spectrum that represents ambient noise typifying the entire time period during which data were collected. The specific bandwidths and integration times are shown in the various blocks on the viewgraph. I will now show a series of plots depicting typical results of the steps in the process.

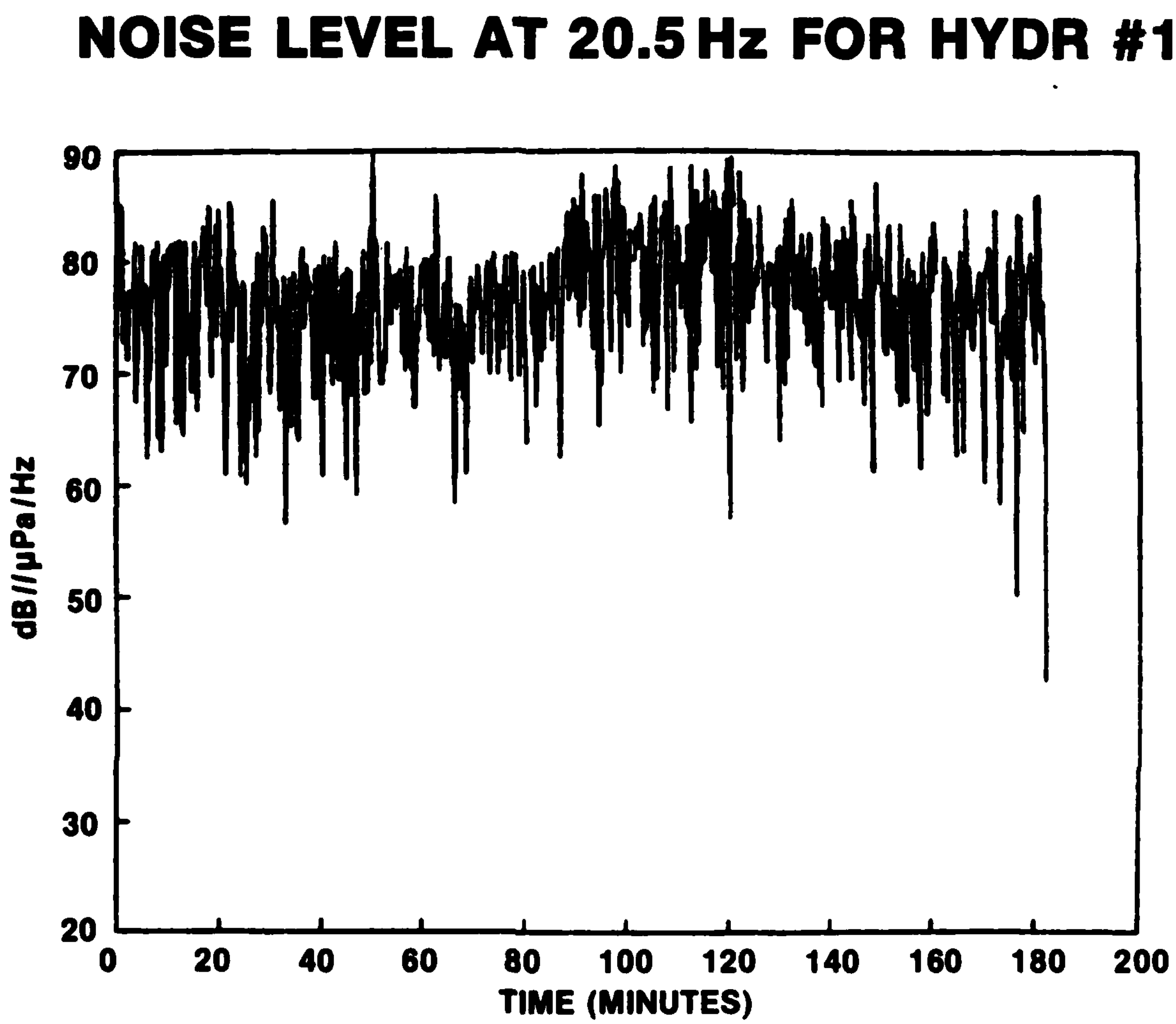
TYPICAL POWER SPECTRUM

20-MINUTE AVERAGE



Slide 5

This power spectrum represents 20 minutes of data recorded from one of the hydrophones of the horizontal array. It is typical of much of the data observed during this experiment. The peaks below 10 Hz are due to cable strumming. This strumming did cause some difficulty in setting proper levels for the horizontal array on the analog recorder. The digital recorder, however, had a large dynamic range and experienced no problem. The peak at 30 Hz is caused by acoustic coupling of the camp power generator to the hydrophone sensor. Other than 60 Hz and related generator artifacts, most of the remaining lines are due to signals transmitted from the TRISTEN ice camp. The roll-off at 80 Hz is due to the anti-aliasing filter mentioned previously. Plots such as this and similar plots for the vertical array were used to select analysis frequencies that were uncontaminated by signals.

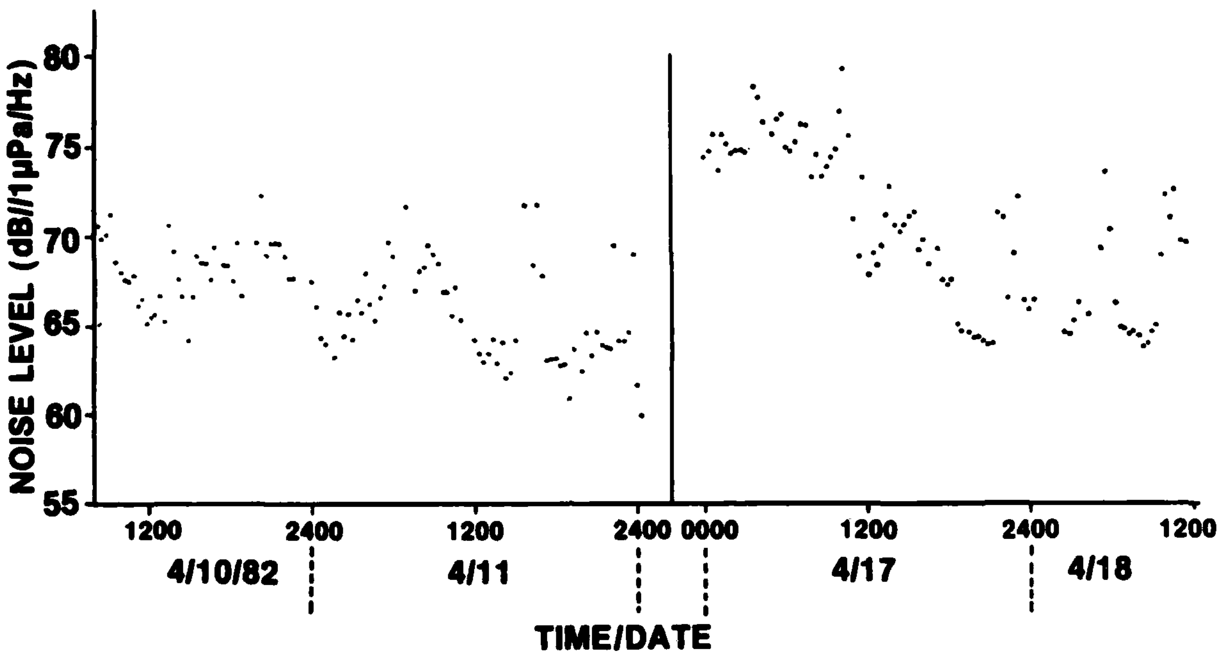


Slide 6

This is a sample time series of ambient noise processed from digital recordings of horizontal array data. The plot represents nine 20 minute sections of data totaling 180 minutes. Each 20 minute section is comprised of approximately 74 individual spectral estimates.

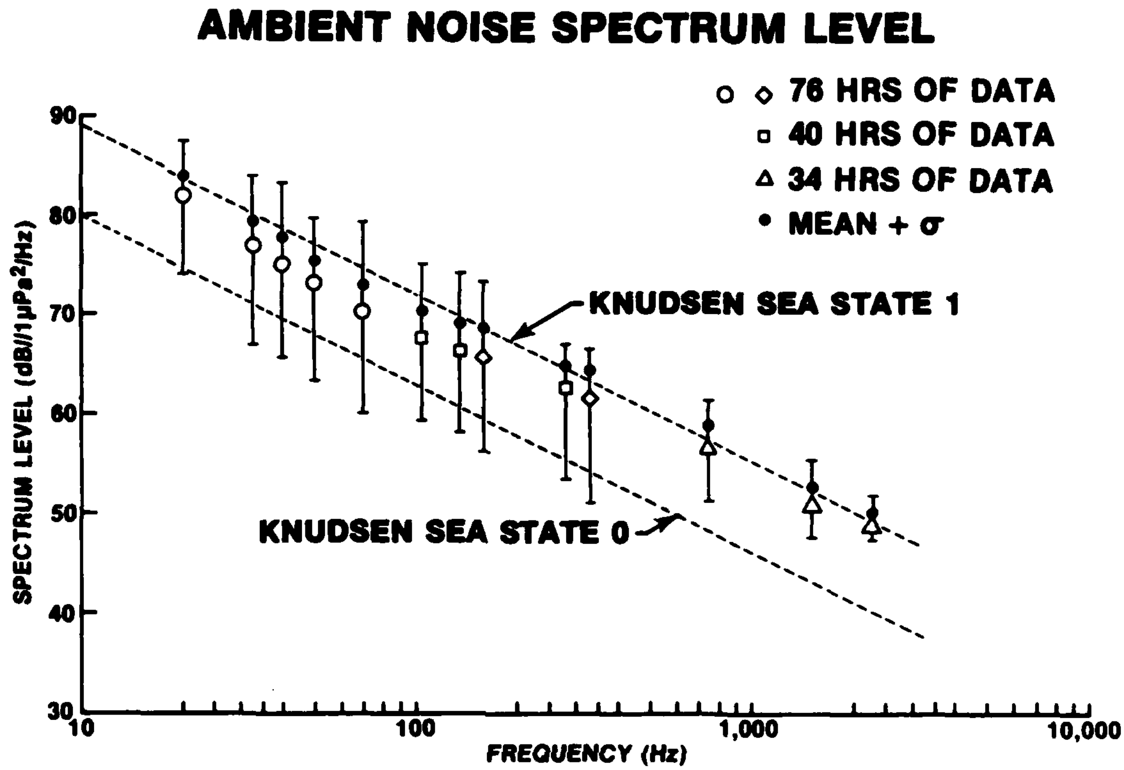
This step in the process was required to eliminate transient signals. An air gun, operated every 20 minutes during much of this experiment, and occasional explosive signals caused most of the problems. These were removed be previewing this spectral time series to determine a detection threshold slightly in excess of the largest ambient levels and then eliminating all samples that exceeded, or were near, the detected signals.

TIME HISTORY OF AMBIENT NOISE @ 70 Hz



Slide 7

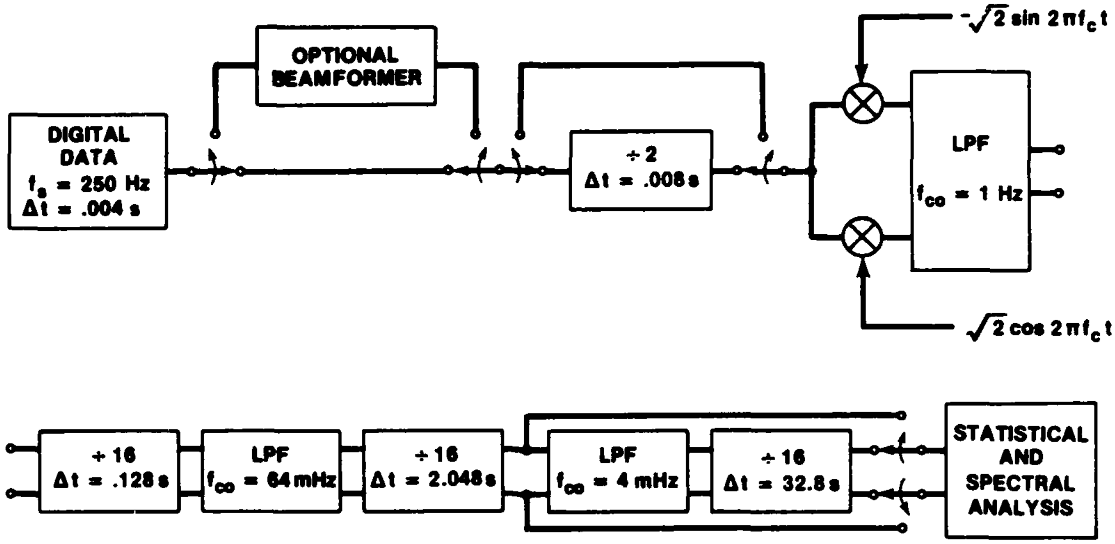
This is a sample time history at 70 Hz of most of the data acquired during the experiment. We feel that this major portion is typical of the range of conditions encountered at the FRAM IV camp and that any additional data coverage would have little impact on these results. Each dot on the graph represents a data segment averaged over a 20 minute period.



Slide 8

The final step in the averaging process combined the processed data into one power spectrum. Each frequency processed has a symbol (σ, ◇, □, △) indicating its mean value. The quantity of data used in establishing this mean is identified by this symbol. The vertical lines represent the extremes of the observed data. The dots indicate "+" one standard deviation. The sloping lines are Knudsen's curves for sea state zero and sea state one. The principal features of this spectrum are the low variability and relatively low levels experienced. These results are consistent with effects that would be produced by the stable multi-year ice on which the FRAM IV camp was located. All of the data presented are for a depth of 90 meters. A study of ambient noise at other depths on the vertical array showed no discernible depth dependence.

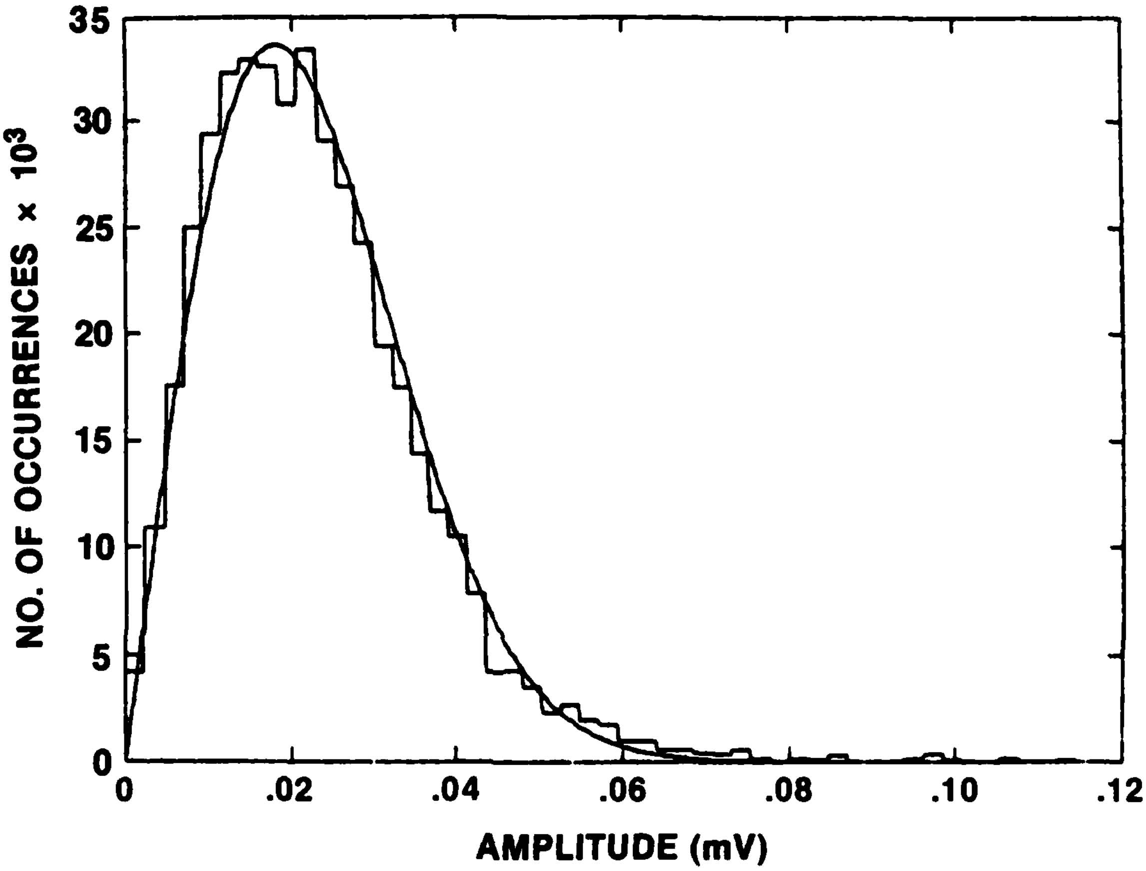
QUADRATURE DEMODULATION



Slide 9

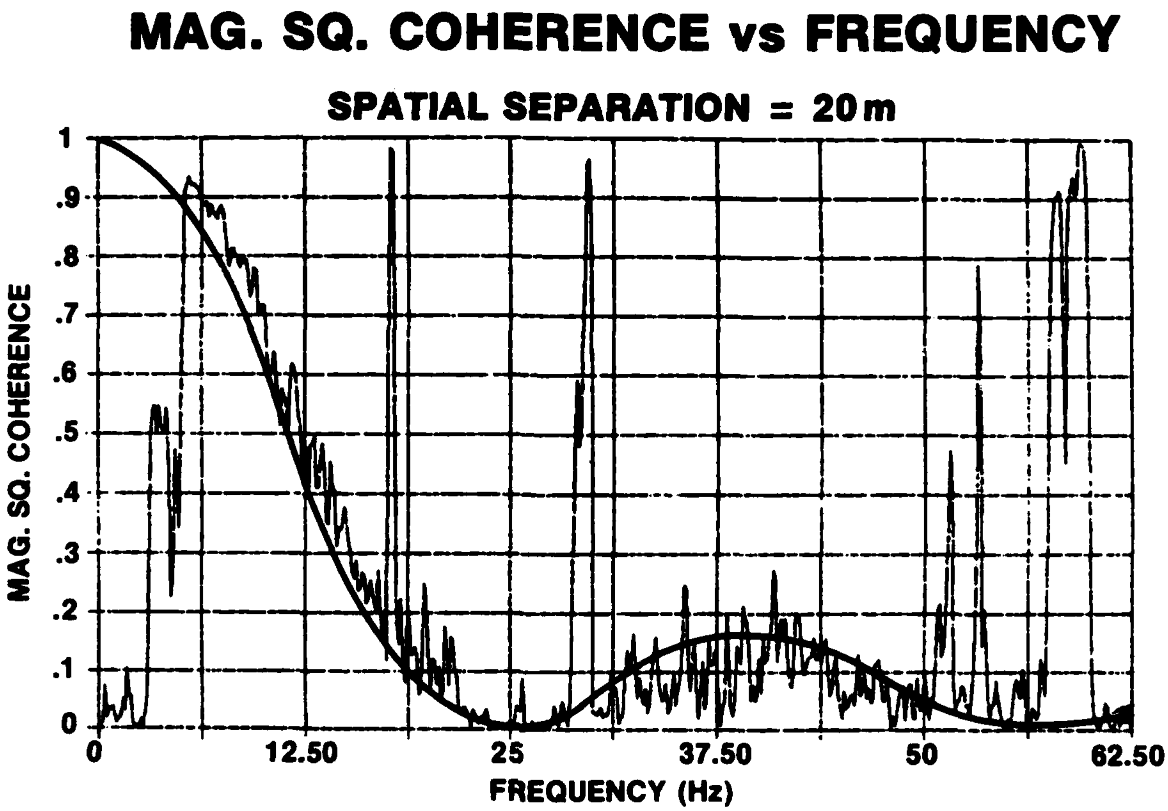
The narrowband amplitude statistics of the ambient noise were examined. This was accomplished utilizing the process of quadrature demodulation. The digital signal was multiplied by sine and cosine functions at the desired analysis frequency to produce the quadrature components. These components were then successively filtered and decimated until the desired bandwidth was obtained. The amplitude envelope time series was then reconstructed from the narrowband quadrature components. A statistical analysis was then performed on the resultant time series.

NOISE AMPLITUDE DISTRIBUTION



Slide 10

The assumption that the quadrature components of the noise are Gaussian results in a Rayleigh distribution of the amplitude envelope. To test this, the envelope statistics were examined at several frequencies in bandwidths from 8 to 250 mHz. In all cases the probability density functions were determined to be Rayleigh by easily passing a Chi-square goodness-of-fit test performed at the 5% level of significance. Shown is an example of 3 hours of 50 Hz data processed in an 8 mHz bandwidth. The histogram represents the actual data points while the smooth curve is a Rayleigh probability density function using the data variance as a parameter.



Slide 11

The spatial coherence of the ambient noise was examined through the use of the magnitude squared coherence function. The current viewgraph shows this coherence for frequencies from 0 to 62 Hz using two sensors with a spatial separation of 20 meters. The low coherence below 5 Hz is due to cable strumming, which is uncorrelated between sensors. The high peaks in the display are due to local artifacts and signals transmitted from the TRISTEN camp. The noise coherence behaves as a squared zero-order Bessel function, thus identifying the noise as isotropic. The argument of the Bessel function is wavenumber times spatial separation. The Bessel function model, using the appropriate values for the parameters, and shown as the smooth line, is a good fit to the measured data.

SUMMARY

- POWER SPECTRUM
  - LOW LEVELS
  - LOW VARIABILITY
  - LITTLE DEPTH DEPENDENCE
- NARROWBAND AMPLITUDE STATISTICS ARE GAUSSIAN
- ARCTIC AMBIENT NOISE IS ISOTROPIC
- STABLE ARCTIC PACK ICE PRODUCES STABLE, WELL DEFINED AMBIENT NOISE

Slide 12

In summary, a study of ambient noise under stable pack ice conditions shows the following:

The ambient levels are relatively low with little variability and no discernible depth dependence. The amplitude statistics in narrow bandwidths can be described by a Gaussian random process. Spatial coherence measurements show this Arctic ambient noise to be isotropic. These results, together with other measurements showing the propagation of signals in the Arctic to be very stable, make the Arctic a unique area of ocean acoustics.

INITIAL DISTRIBUTION LIST

Addressee	No. of Copies
COMSUBLANT, Code N3, N311 (LT M. Kinney, P. Adams, Science Advisor)	4
COMSUBDEVRON 12 (CAPT V. Hill, G. Levy, CDR O. B. Cooke)	3
COMSUBPAC, Code N3, CAPT McBride, N21 (Science Advisor)	4
CNO, OP-02, -226 (CAPT J. Asher), -224, -095T, -009E, -009G (E. Johnston), -21T (Dr. E. Harper), -22-T, -952 (CAPT E. Young, LCDR Fauquet), -951F (CAPT M. Schneider)	11
NAVSEA, PMS-409 (CAPT Van Metre), -409-C (Dr. Snuggs), -63R (D. Porter), -63D (CDR Schisler, Dr. Y. Y. Yam), -06, -409-53 (W. Johnston)	7
NAVELEX, PME-124 (L. Tritel, CDR C. Spikes), -612 (CDR Huffman, CDR S. Hollis, R. Mitnick), -611 (T. B. Hughes)	6
DARPA, Code STO (CDR K. Evans)	1
ONR, Code 425 AR (Dr. L. Johnson, Dr. R. Obracta, Dr. M. Mckisic)	3
NOSC Arctic Submarine Laboratory (Dr. W. Lyon, CAPT J. Sabol)	2
MIT (Dr. I. Dyer, Dr. A. Baggeroer, Dr. G. Duckworth, Dr. P. N. Mikhalevsky, LT J. Polcari)	5
ONT (CAPT J. Harlett, G. Spalding)	
NRL (O. Diachok, C. Votaw, T. C. Yang, S. Wolfe)	4
NORDA (R. Martin, W. Kuperman, R. Lauer, E. Chaika)	4
SACLANT ASW Research Center (Dr. F. Jensen, Dr. R. Goodman)	2
NAVPGSCOL (Dr. Burke, Dr. H. Medwin)	2
NISC, Code 23235 (E. Hansen)	1
Texas Instruments (Dr. D. Hyde)	1
Signatron (Dr. J. Pierce)	1
Operations Research Inc. (Dr. V. Simmons)	1
Analysis and Technology (Dr. P. L. Stocklin)	1
OMNI Analysis (Dr. W. Hayne, H. Holmes)	2
B. K. Dynamics (Dr. R. Mellen)	1
Sparton ASW Tech Center (E. G. Faris)	1
Bell Laboratories (Dr. J. Shoenfelt)	1
Polar Research Laboratory (B. Buck)	1
Canadian Defense Research Establishment Pacific (Dr. R. Chapman, Dr. Brooke, Dr. R. P. Chapman, Dr. J. M. Thorleifsen)	4
Norwegian Defence Research Establishment (I. Engelsen, J. Marthins, E. Hug)	3
University of Miami (Dr [illegible] Tappert, Dr. H. DiFerrari)	2
Colorado University [illegible] (Dr. J. DeSanto)	1
Scripps Oceanographic [illegible]e (Dr. W. Munk, Dr. F. Fischer)	2
Lamont Doherty Geolo[illegible] tute (Dr. H. Kutschale)	1
FWG (Dr. H. J. Schneide[illegible])	1
Technical University [illegible]mark (Dr. Leif Bjorno)	1
Dr. D. Middleton (127 East 91st St. NY, NY 10128)	1
Robert S. Gales	1
DTIC	12

END

FILMED

6-84

DTIC