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MAR 82 J A SHOOTER, T E DEMARY, R A KOCH N00014-82-C-0049
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AMBIENT NOISE IN THE WESTERN GULF OF MEXICO

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Thomas E. DeMary
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11 March 1982

Technical Report

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

A brief 12 h segment of ambient noise from the Western Gulf of Mexico for a clear, calm period has been analyzed. The receiver depths were 170 m, 370 m, and 766 m; the bottom was at 3280 m. It was found that the ambient noise was dominated most of the 12 h by seismic exploration. To avoid this noise, quiet periods between seismic domination were used; the median noise levels at 50 Hz were found to be around 75-77 dB//1 μPa/√Hz with the slightly higher levels at the SOFAR channel axis. Overall median levels were

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20. 77-80 dB//1 μPa/$\sqrt{Hz}$. These levels are lower than the 85 dB levels for the Atlantic near Bermuda.

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I. INTRODUCTION

A 12 h segment of ambient noise has been analyzed at three shallow depths in the Western Gulf of Mexico during a calm and a clear period, 19-21 May 1979. The data were recorded using a programmable acoustic recorder (PAR)[1] with hydrophones at 170 m, 370 m, and 766 m. The bottom depth was 3280 m. The PAR location is shown in the bathymetry map (Fig. 1) at 25°46'N and 94°30.67'W, and the hydrophone depths relative to the sound velocity profile are shown in Fig. 2.

The ambient noise in the Gulf of Mexico is dominated by shipping noise and seismic exploration. Planning Systems, Inc., reported[2] 100-150 contacts of the noise sources in each 1° square along the Texas-Louisiana coast, including oil rigs and support boats. This high density was reported entirely within the 200 m depth contour. The "*" symbols on the map in Fig. 1 mark the location of seismic vessels[3] for 7 June 1979, which was two weeks after the data were recorded. If it is assumed the seismic crews operate fairly constantly and do not stray outside their leases, these locations should be representative of exploration in the Gulf in May 1979.

In spite of the heavy density of ships and an active petroleum industry, the median noise levels were found to be lower than the noise levels around Bermuda,[4] and approximately the same as some of the critical depth median noise levels for the Northeastern and Western Pacific.[5,6] The median level between 20 and 50 Hz was 80 dB//1 μPz/$\sqrt{Hz}$. Seismic exploration could be audibly detected virtually all of the time, and faded in and out in intensity. One of the high level exploration periods is shown in Fig. 3, which shows the broadband detected level from a dominating source pulsing with a period of 8.4 sec on all three receivers. The energy is nearly coincident at all receivers; the

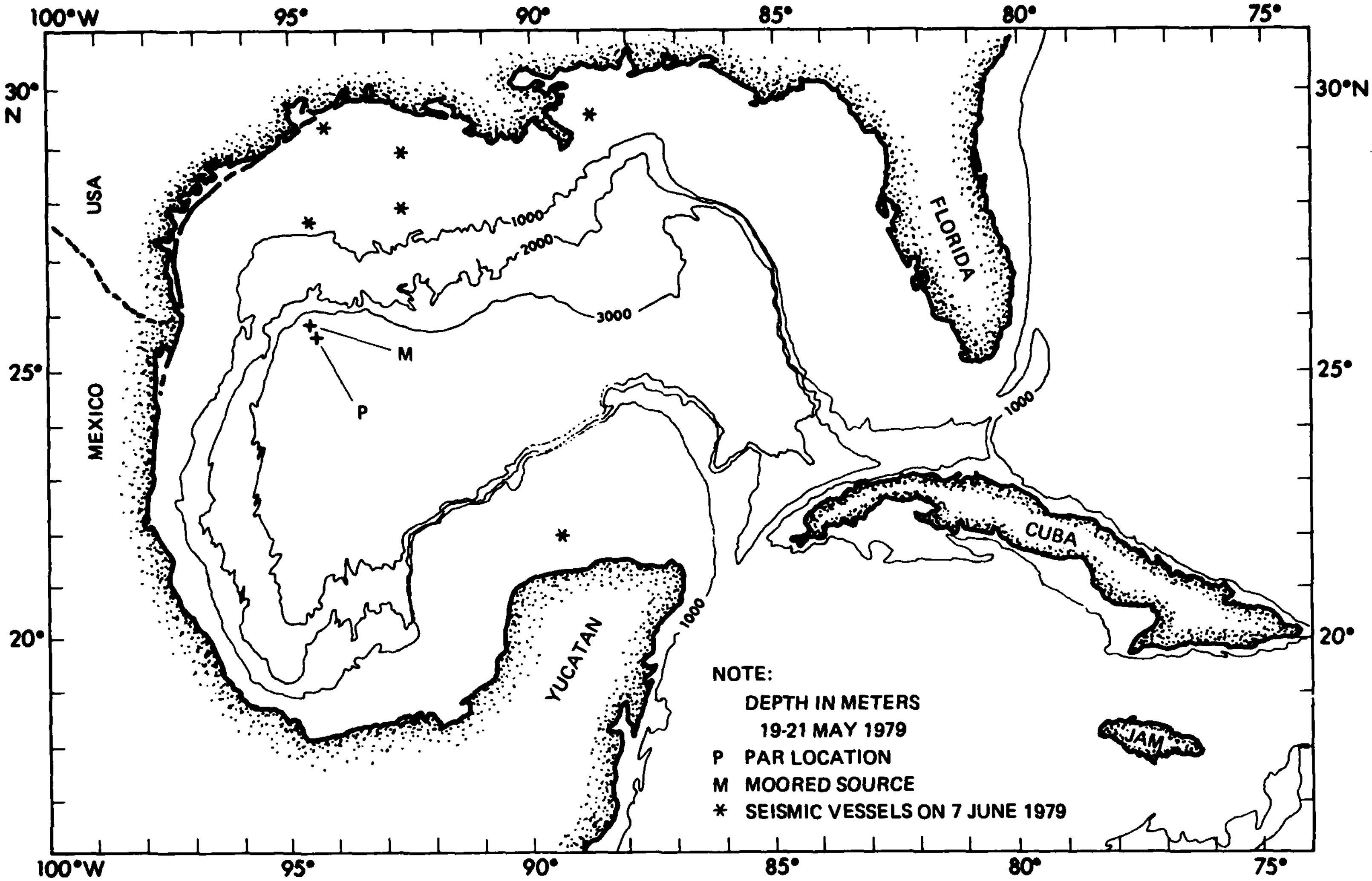


FIGURE 1
GULF OF MEXICO

ARL:UT
AS-81-883
MWH - GA
7 - 29 - 81
REV 3-16-82

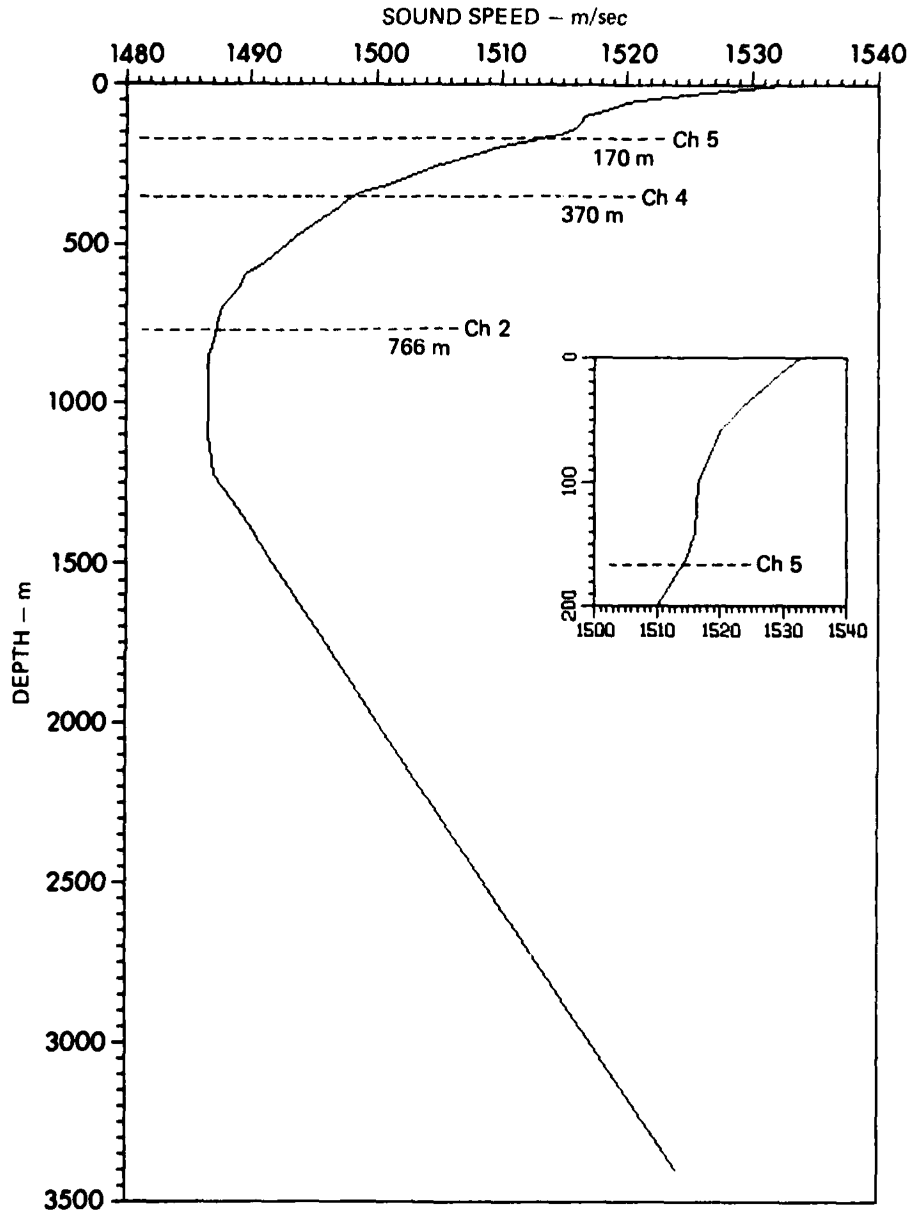


FIGURE 2
SOUND SPEED PROFILE FOR ENGINEERING TEST

ARL:UT
AS-81-1109
MWH - GA
8 - 25 - 81
REV 3-16-82

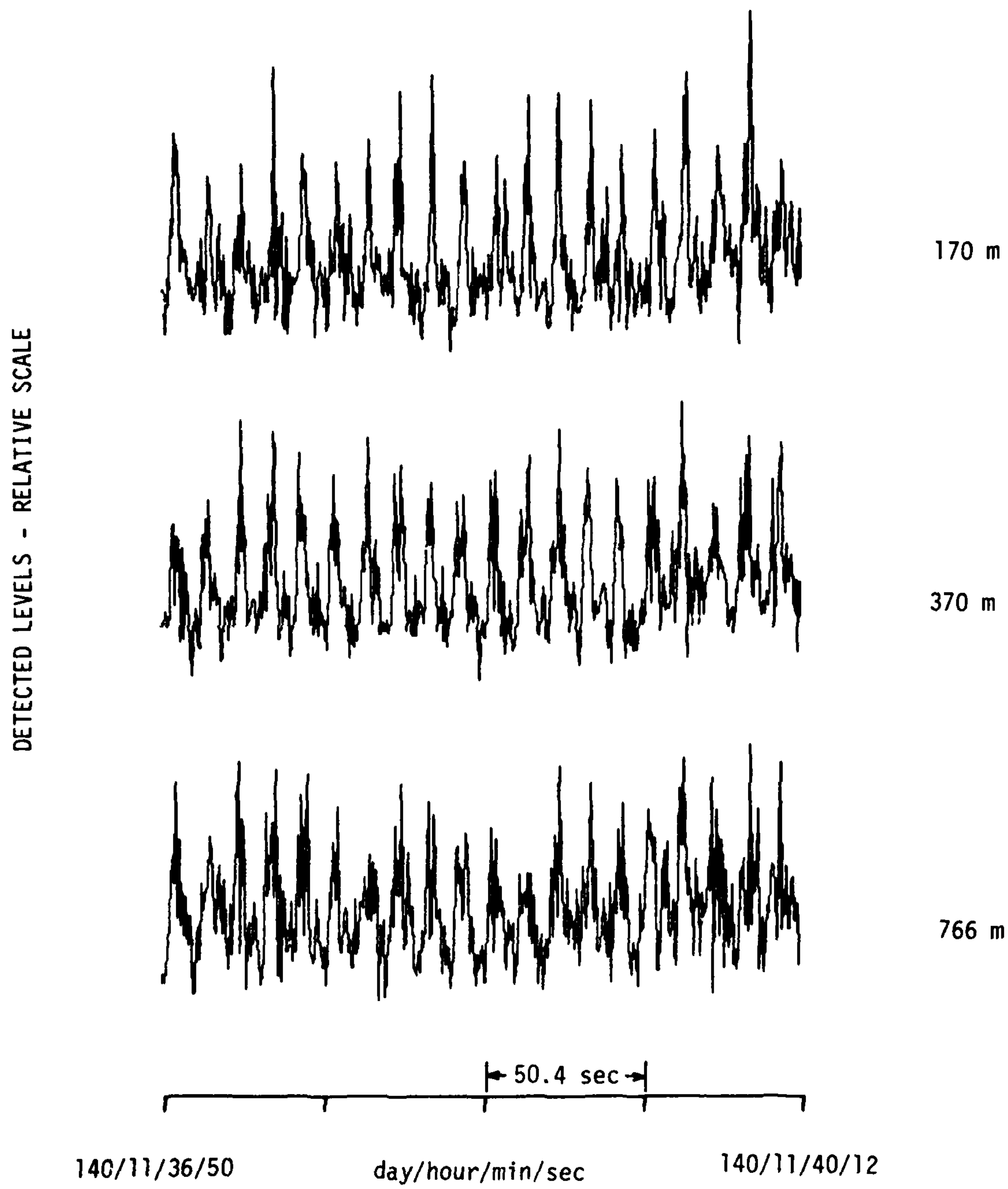


FIGURE 3
BROADBAND DETECTED TIME SERIES FOR THE THREE RECEIVERS SHOWING SEISMIC EXPLORATION SIGNAL ARRIVALS

energy arrives slightly earlier on the two deeper receivers. A slight depth dependence of the noise field was noted; the data from the SOFAR axis showed 2 dB higher levels in the region of 50 Hz for the percentile levels of 10-50%.

Section II presents an overview of the 12 h time period in the form of 1/10 octave band time series. This is followed by percentile spectral levels in Section III. The moored source and data processing parameters are discussed in Section IV and the Appendix. The analysis in Section V summarizes the results and briefly discusses the mechanisms of acoustic propagation from shallow to deep water.

II. TIME SERIES

An overview of the 12 h analysis period is shown in the selected 1/10 octave band time series for the three receivers. The 1/10 octave band data for the 170 m receiver are shown in Fig. 4(a), and the 370 m and 766 m data are shown in Figs. 4(b) and 4(c). These time series data represent 46 sec averages taken at 3 min intervals. The high level impulsive appearance of the data from 140/1200Z to 140/1500Z (Julian day 140 = 20 May 1979) actually represents compressed envelopes of the impulsive noise illustrated in Fig. 3, which is from a source probably near the edge of the continental shelf. The two deeper hydrophones detect the impulsive noise at 250 Hz at a higher level than the 170 m receiver.

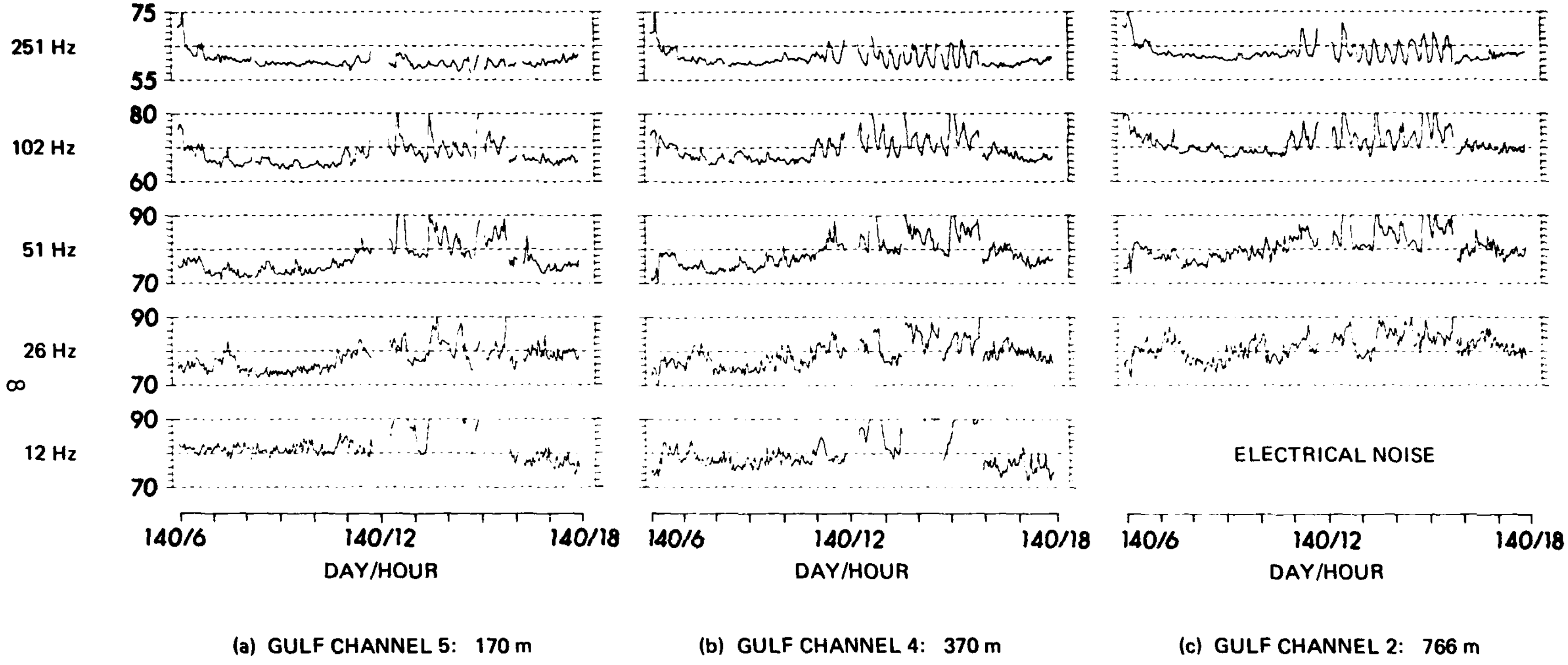


FIGURE 4
SELECTED 1/10 OCTAVE BAND TIME SERIES FOR THREE RECEIVERS

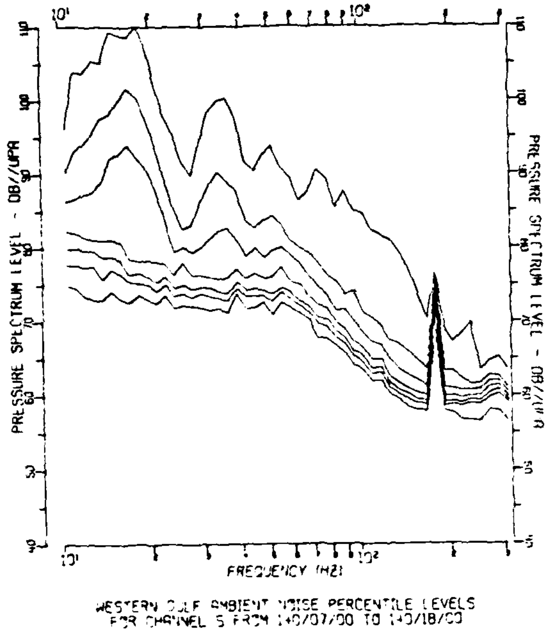
ARL:UT
AS-82-332
JAS - GA
3 - 30 - 82

III. PERCENTILE SPECTRA

The 1/10 octave percentile spectra for the 12 h period are seen in Figs. 5(a)-5(c) for the three receiver depths. The peak levels for the three depths are essentially the same and the bubble pulse frequency for the dominant source is 16-18 Hz. The moored source 8 miles north of the PAR is the source of the peak at 175 Hz. The lower percentile levels at 50 Hz show a slight increase (2 dB) in the level at the SOFAR axis.

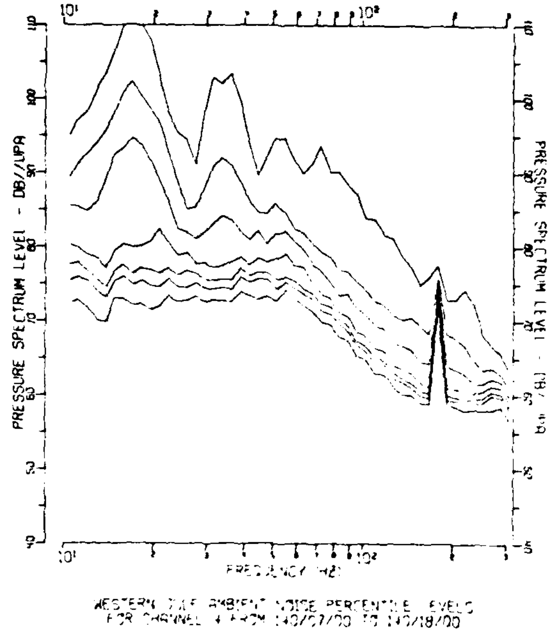
A better look at one of the time periods dominated by seismic exploration noise is shown in the 13 min period of Figs. 6(a)-6(c). There is a slight depth dependence for the frequencies between 150 and 250 Hz where the shallow 170 m receiver is detecting lower levels on the order of 5-10 dB. This dependence is also seen in the 1/10 octave time series of Figs. 4(a)-4(c).

A relatively quiet time is found at 140/0822-0837Z for all three receiver depths. The percentile spectra shown in Figs. 7(a)-7(c) again show a slight depth dependence from 25 to 100 Hz. The moored source is clearly detectable.



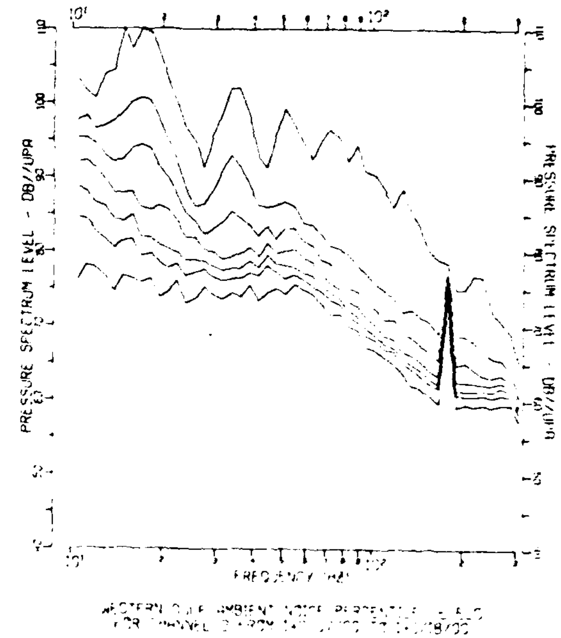
(a)

GULF CHANNEL 5: 170 m



(b)

GULF CHANNEL 4: 370 m



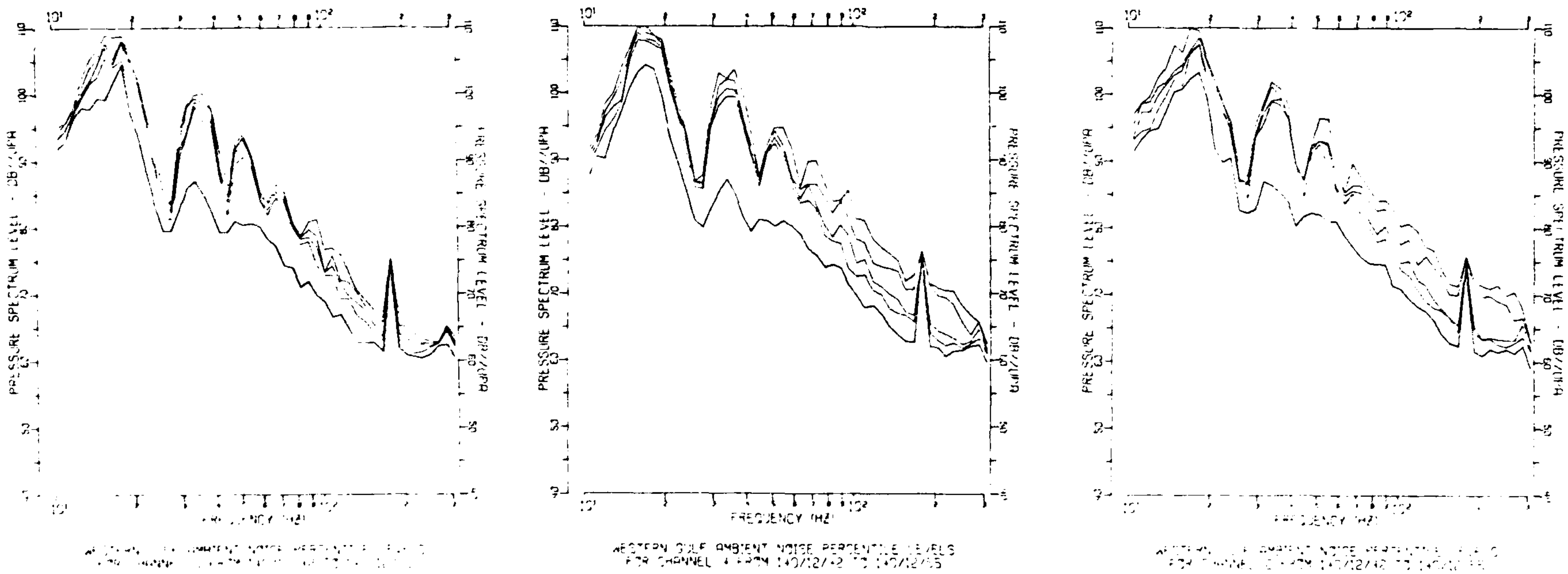
(c)

GULF CHANNEL 2: 766 m

FIGURE 5

PERCENTILE SPECTRAL LEVELS FOR THE TOTAL 12 HOUR ANALYSIS PERIOD
BASED ON 1/10 OCTAVE BAND DATA
PERCENTILES LEVELS DISPLAYED
MINIMUM, 10%, 25%, 50%, 75%, 90%, MAXIMUM

AS-82-328



(a)

GULF CHANNEL 5: 170 m

(b)

GULF CHANNEL 4: 370 m

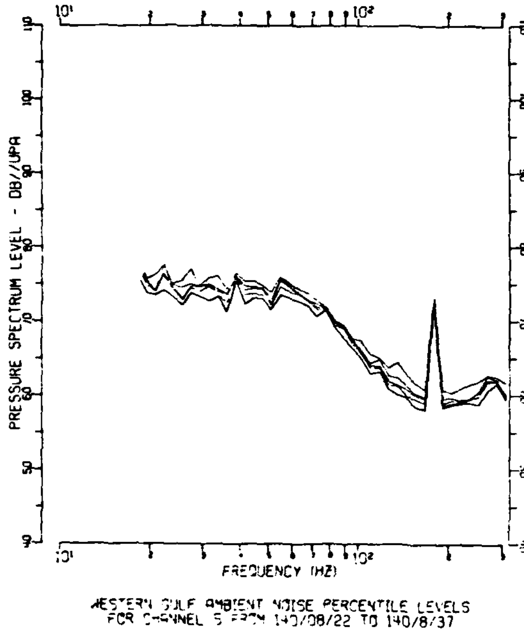
(c)

GULF CHANNEL 2: 766 m

FIGURE 6

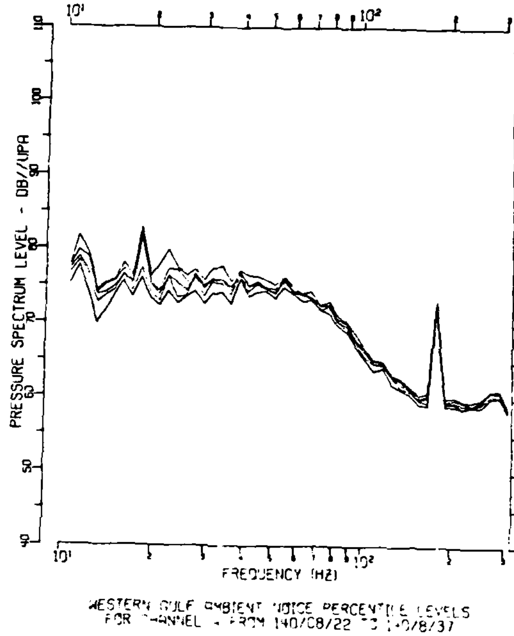
PERCENTILE SPECTRAL LEVELS DURING A PERIOD
OF INTENSE SEISMIC EXPLORATION

PERCENTILES LEVELS DISPLAYED
MINIMUM, 10%, 25%, 50%, 75%, 90%, MAXIMUM



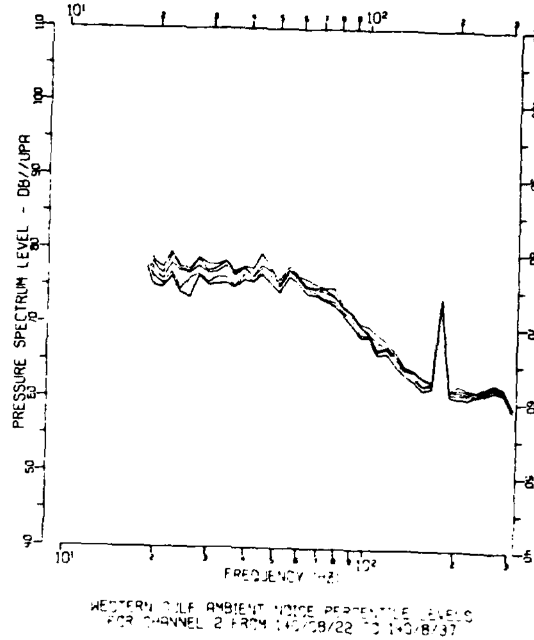
(a)

GULF CHANNEL 5: 170 m



(b)

GULF CHANNEL 4: 370 m



(c)

GULF CHANNEL 2: 766 m

FIGURE 7

PERCENTILE SPECTRAL LEVELS DURING A RELATIVELY QUIET TIME

PERCENTILES LEVELS DISPLAYED
MINIMUM, 10%, 25%, 50%, 75%, 90%, MAXIMUM

IV. MOORED SOURCE

The moored source was located at 25°54.2'N and 94°32.7'W, approximately 8 miles north of the PAR. The source depth was about 850 m; the bottom depth was 3177 m. The source level was 170 dB//1 μPa at 1 m and radiated at 175.15 Hz. The received levels for the three receivers shown in Fig. 8 were approximately 87 dB//1 μPa with variations of 6 dB. The propagation loss is almost pure spherical spreading which is reasonable for such a short range [20 log(range = 15,558 m) = 83.8 dB]. The measured propagation loss (PL) is 170 dB - 87 dB = 83 dB. The deep receiver at 766 m detects the highest level signal most of the time because it is on the acoustic axis with the source.

The first hour of the time series shows sharp level changes indicating the deployment of the PAR system. There are no strong diurnal variations over this 12 h period.

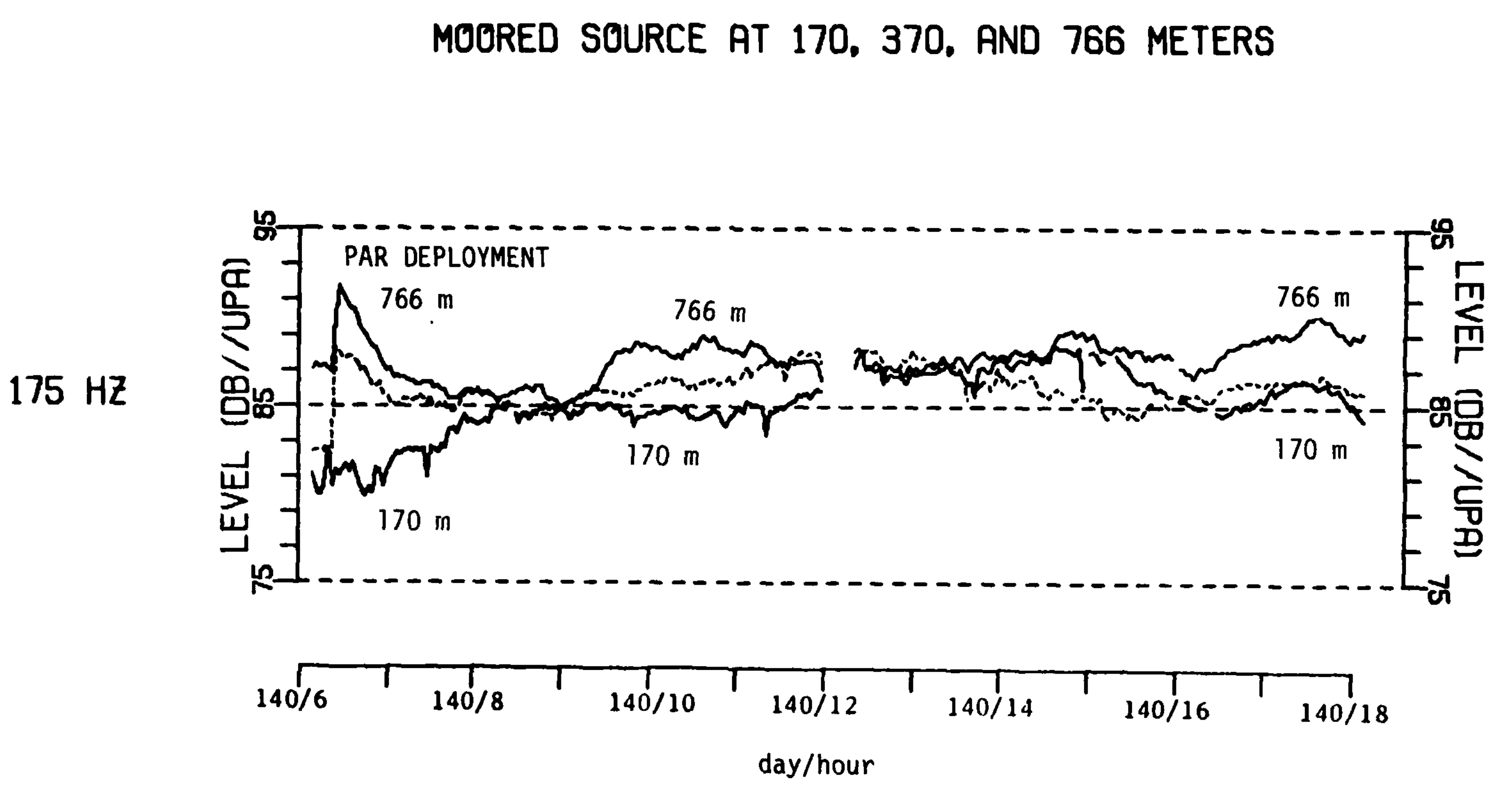


FIGURE 8

RECEIVED LEVELS FROM THE MOORED SOURCE

FOR THREE HYDROPHONE DEPTHS AS A FUNCTION OF TIME

V. ANALYSIS AND SUMMARY

A. Ambient Noise Relative to Number of Noise Sources

Ambient noise has been analyzed for a 12 h period for the Western Gulf of Mexico. The weather was calm and clear. A dominant feature in the acoustic field was the seismic exploration; one source with an 8.4 sec pulse rate was especially dominant. Percentile noise spectral levels show a large range of 73-110 dB//1 $\mu Pa/\sqrt{Hz}$ during the total 12 h period. The lower percentile spectral levels from minimum to 25% (from 25 to 70 Hz) represent times not so dominated by seismic exploration, and show noise levels near 73-80 dB//1 $\mu Pa/\sqrt{Hz}$. These levels are modest considering the large number of noise sources in the Gulf.

Within the 200 m depth contour along the Texas-Louisiana coast, there are 100-150 potential noise sources per 1° square. These include mobile rigs, production rigs, and service boats. As of 1978, there were over 780 production platforms, 1200 supply boats, and over 100 mobile rigs[7] in the area. In addition to noise from the petroleum industry, a significant number of ships in the deep basin contribute to the noise field. An example of the shipping density, 1-5 ships per 1° square, has been obtained from the aircraft flight of 14 June 1979. The locations of a number of radar contacts and the flight radar coverage are shown in Fig. 9.

Ignoring the noise from seismic exploration, the Gulf noise levels are a few decibels less than the deep water noise near Bermuda. These levels may be compared with the 93-95 dB//1 $\mu Pa/\sqrt{Hz}$ values observed in the Oman Basin with six or more ships per 1° square.

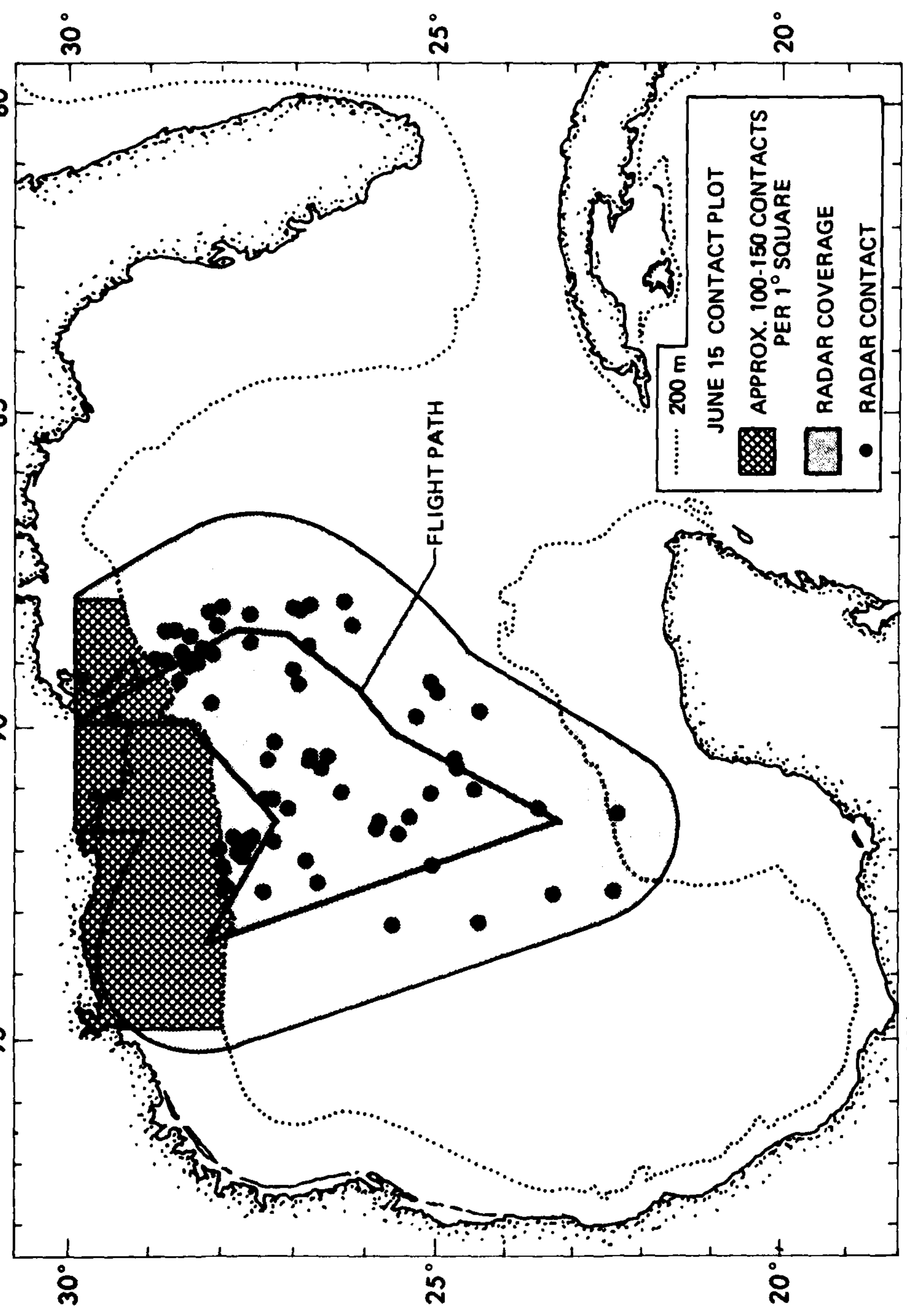


FIGURE 9
RADAR CONTACTS FOR THE WESTERN GULF

ARL:UT
AS-82-327
JAS - GA
3-30-82

B. Noise Depth Dependence

The noise depth dependence is of considerable interest. These data show only a slight (2 dB) depth dependence, which is just within the estimated ±1 dB calibration accuracy of the system. From 25 to 70 Hz the data show a slight increase in level at the SOFAR axis relative to the shallow receiver at 170 m depth. References 7 and 8 discuss the mechanisms whereby sound from shallow water sources propagates to deep water and produces large noise field gradients between the SOFAR axis and the near-surface or near-bottom portions of the water column. One mechanism is that the limited number of low frequency normal modes that are available for excitation by sources in shallow water are confined, in deep water, to depths near the SOFAR axis. On the other hand, the higher order modes, which could couple to near-surface or near-bottom receivers in deep water, are more strongly attenuated than lower order modes as the noise propagates through the shallower water. The geoacoustic parameter estimates for sediment velocity and attenuation[9] would support these arguments for a strong depth dependence of noise from shallow water sources. The fact that little depth dependence is seen suggests several possibilities. One is that the shallow water noise source levels are too low to be detected. Another possibility is that the ships in the deep basin, which would produce a more uniform noise field in the water column, are sufficiently numerous to mask the effect of shallow water sources.

APPENDIX

DATA PROCESSING PARAMETERS

These data were recorded on a 14-channel Geotech analog tape recorder. The recording speed was 15/120 ips and the data bandwidth was 300 Hz. Each data track recorded a deflutter/deskew tone at 892.86 Hz, including a large cycle every 256 cycles. The three data channels were digitized simultaneously (SSH) using channel 2 as the reference channel for deflutter/deskew. The data were reproduced at a 16:1 speedup (1-7/8 ips) and 45,000 samples were taken from each of the three channels every 3 min. The frequency bin spacing was 0.109 Hz (= 892.86/8192). Five 9.175 sec FFT's were power averaged for each 45.875 sec spectral estimate.

In the standard system, time in the form of day, hour, minute, second, and milliseconds is encoded into IRIG B code and recorded on channel 14.

Calibration was accomplished by recording a series of known sine wave frequencies and levels at the start of the tape and using post exercise calibration data from Naval Research Laboratory Underwater Sound Reference Detachment (NRL/USRD) for the hydrophone sensitivities.

A technical difficulty was the determination of the PAR gain during the data recording. The PAR was designed to record a dynamic range of more than 70 dB by automatically gain ranging in 6 dB steps every 1 min, and the gain state was normally encoded along with the time code. In this exercise the time code failed to record, knocking out the gain state information at the same time. This difficulty was overcome by detecting the moored source during the internal calibration sequence, which occurred 6 min every 6 h while the automatic gain control (AGC) was set to 0 dB gain. The detected moored source level could be tracked minute to minute from each periodic internal calibration sequence thereby establishing the PAR gain state minute to minute without ambiguity. The estimated calibration accuracy is ±1 dB across the data band.

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