WHOI-78-47

COMPARISON OF HIGH-RESOLUTION NORMAL-INCIDENCE 3.5 kHz
AND 12 kHz REFLECTIONS WITH GEOTECHNICAL PROPERTIES
OF GIANT PISTON CORES

By

Willard Dow

And

Charles D. Hollister

WOODS HOLE OCEANOGRAPHIC INSTITUTION
Woods Hole, Massachusetts 02543

June 1978

TECHNICAL REPORT

*Prepared for the Sandia Laboratories under
contract number 07-7923.*

*Reproduction in whole or in part is permitted
for any purpose of the United States Government.
In citing this manuscript in a bibliography,
the reference should be followed by the phrase:
UNPUBLISHED MANUSCRIPT.*

Approved for Distribution

John I. Ewing, Chairman
Department Geology & Geophysics

ABSTRACT

A deep operating self-contained high-frequency echo sounder known as Deep Probe was recently developed at W.H.O.I. under ERDA and Sea Grant contracts for the purpose of resolving fine details of bottom and sub-bottom sediment layering in the deep ocean. In August 1975 this system was mounted on R.V. KNORR for a coring expedition (KNORR #51) to the Rockall Trough area east of the United Kingdom under the direction of Dr. Charles Hollister.

The purpose of this exercise was to determine the correlation between the high frequency acoustic sounding records and the stratification of several Giant Piston Cores (GPC) taken in the same area.

Three of these cores, GPC-13, 17 and 19, have been analyzed and compared graphically with the acoustic survey of each core location, using Deep Probe, near-bottom, both as a 12 kHz echo-sounder, and as a deep receiver for detecting returns from a 3.5 kHz pinger mounted on the surface vessel. The acoustic traces for both frequencies were then compared for detail and depth of penetration with respect to the cores.

Good to excellent correlation with core stratigraphy is indicated at 12 kHz. Resolution ranged from fair to poor at 3.5 kHz although transmission losses through the core were lower at this frequency.

The general conclusion is that deep echo-sounding at 12 kHz is an excellent technique for delineation of shallow bottom and sub-bottom sediments in high detail, and that deep sounders having characteristics similar to Deep Probe could therefore prove valuable for detailed surveys of small areas preliminary to coring, or in deep-towed fish form, for general seismic profiling of shallow sediments over longer tracts in the deep ocean.

I. INTRODUCTION

Past experience has indicated that high frequency echosounders operating at 3.5-12 kHz in shallow water are capable of considerable sub-bottom penetration into silty and clayey unconsolidated sediments. High resolution and substantial penetration with high frequency sound can likewise be realized in deep water by operating a short-pulse transmitter and receiver close to the bottom, thus avoiding the significant attenuation of high frequencies over the long two-way transmission path between surface and bottom, and concentrating the full power of the transmitted pulse over a comparatively small bottom area. For example, if a sounder is operated near surface where water depth is 4000 meters, approximately 4 sq. kilometers of bottom would be ensonified compared with an area of only 23 sq. meters if the gear were positioned 10 meters off bottom. Near-bottom operation thus avoids the problem of wide region "average" returns, and side echoes from local relief. Also, water-borne noise, both ship-generated and otherwise, is significantly reduced at depth thus permitting detection of the first-motion phase reflectivity coefficient.

If the reflectivity of various common sediments were to be known from prior measurement, and if the transmitter and receiver in the deep sounder were calibrated, and the receiver made amplitude linear over a wide dynamic range, it might be possible not only to contour bottom and sub-bottom layers with high resolution, but eventually to predict from the character of the returns the general physical nature of the sediments.

Accordingly in 1974-1975 under Sea Grant and ERDA contracts an experimental deep sounder incorporating the design features outlined above was designed and constructed at W.H.O.I.

A complete description of this instrument known as Deep Probe is given in W.H.O.I. Blue Cover report entitled "Development of an Acoustic Probe for Detailed Ocean Bottom and Sub-Bottom Surveys" by Willard Dow (W.H.O.I. Ref. #76-35 dated April 1976).

A brief summary of specifications extracted from this paper is presented here, and Fig. 1 is a photograph of the deep instrument.

II. SPECIFICATIONS OF DEEP PROBE

The transmitter emits an extremely short (250 u sec) high level pulse containing only 1-2 cycles of energy at 12 kHz, and a peak acoustic pressure approaching 120 dB/microbar, or up to 30 dB higher than conventional pingers. The A.D.P. transducer used has the broad-bandwidth required to transmit this short sharp pulse. The receiver has a dynamic range of 80 dB to accommodate the wide range of amplitudes expected in bottom and sub-bottom returns, and a bandwidth of 5000 cycles in order to resolve events as short as 250 u sec. The deep sounder is self-contained, battery operated, and capable of being lowered to 6200 meters in the ocean by the 1/4" diameter single conductor logging cable which is standard equipment on most of our vessels. The electrical conductor serves to relay a trigger pulse, originating at a graphic recorder keying contact to fire the deep transmitter and also to conduct output signals from the deep receiver back to the same recorder for display purposes. A perfectly synchronized record is thus produced on line, and all data can be recorded on magnetic tape for future analysis.

III. SEA TRIALS

It was decided that the first step in trying to establish a relationship between sub-bottom acoustic returns as recorded by Deep Probe and the geologic nature of the reflecting sediments was to make a near-bottom survey of a small area with the probe, and then take a deep core at the same location. The stratigraphy of the core and the bottom and sub-bottom returns could then be compared directly as a first step in the correlative process.

An excellent opportunity to accomplish this was offered by Dr. Charles Hollister's expedition on R. V. KNORR to the Rockall Trough area west of the United Kingdom in August 1975. During this cruise a number of Giant Piston Cores (GPC) were taken in this area, and Deep Probe surveys made prior to coring at positions of major interest.

The acoustic records relating to three of these cores, GPC-13, 17 and 19, were then analyzed and compared with the stratigraphy of the cores. A 3.5 kHz 0.5 Ms pinger on the ship was operated concurrently with Deep Probe. The pinger returns were received near bottom on a special hydrophone mounted on the Deep Probe frame, and relayed, along with the 12 kHz information back to the ship via the logging cable.

This dual operation permitted comparison of returns at the two frequencies from a small well-defined bottom area. Both channels were tape-recorded on ship, and later played back to a computer and recorder which produced the amplitude traces aligned at the right side of the figures.

IV. DISCUSSION

Before analyzing the relationship between the core stratigraphy and these normal incidence echo-sounding recordings, it would be useful to review some of the general acoustic principles involved, and to clarify the contribution of the various graphs to the analysis.

The following parameters are graphed for each core: stratigraphy, shear strength, water content, and axial and in two cases cross-core compressional wave sound velocity. All of these parameters were measured on split cores in the shipboard laboratory shortly following retrieval of the core. The velocity profiles are determined by a velocimeter having closely spaced transmitting and receiving probes which are inserted into the core at successive intervals throughout its length.

From the above information, the acoustic impedance of the sediment layers (ρC) can be calculated and plotted as shown, where " ρ " is determined principally by sediment density and water content, and " C " is the velocimeter reading for the corresponding layer. In general, it is axiomatic that the higher the impedance contrast and rate of change across layer boundaries, the greater the reflectivity.

When an echo sounder is suspended close to the seafloor at the core site, the amplitude of the echo return should in general be proportional to this reflectivity (provided the attenuation due to the reflection and absorption of overlying sediments is taken into account). For example, in cores GPC-17 and GPC-19 sharp boundaries between high-density sand or silt layers and adjacent lutite (clay) usually correlated well with high amplitude peaks in the acoustic records.

The resolution in the acoustic record is affected by the relationship between sediment layer thickness and the wave length and pulse length of the transmitted sound. In general, if either wave length or the pulse train is long compared with the layer thickness, the layer will be poorly defined, or not detected at all. (However, groups of closely spaced reflectors may appear as a single return where the group thickness is comparable to the pulse or wavelength.)

Consequently, if high resolution of thin and/or closely spaced sub-bottom layering is to be realized, short wavelength, high-frequency sound must be used. Unfortunately, transmission losses cause depth of penetration into the bottom to vary inversely with frequency; therefore it is useful to simultaneously transmit a lower frequency, sacrificing definition for deeper penetration.

For this reason, as mentioned previously, acoustic records for two frequencies (12 kHz and 3.5 kHz) were made for the site surveys of GPC-17 and GPC-19. GPC-13 shows only the 12 kHz record because of recording problems with the 3.5 kHz channel. The 12 kHz signal was capable of penetrating to the maximum depth of the giant cores, partly due to use of the high powered acoustic transmitter (120 dB/dyne), and partly because of the close proximity of both transmitter and receiver to the bottom. All soundings were taken reasonably close to the core sites prior to coring, so that the stratigraphy of undisturbed sediments are represented in the sounder records. With the above considerations in mind we can now proceed with the examination of the individual core records.

V. CORE RECORDS

As explained previously the parameters which are major factors in determining acoustic impedance and reflectivity have been plotted for each core. The stratigraphy of the core is outlined at the far left of the figures and relative amplitude of acoustic returns versus depth at the far right.

The shaded horizontal bands are for convenience in aligning the major deflections in the acoustic traces with the corresponding parameters and stratigraphy of the core.

We will consider the core records in order of increasing complexity rather than chronologically in order to clarify the development.

CORE #GPC-19 (56°17.7'N, 12°31.8'W)

DEPTH	REFLECTOR
0-2 cms	Bottom return (water-seafloor interface).
50-70 cms	Concentrated foram Area. Although density change from surrounding lutite is small, there is a sharp drop in water content and peak in sound velocity.
105-135 cms	Adjacent sand and silt layers characterized by low water content and high peaks in sound velocity and acoustic impedance. Since layer separation is only 5 cms (less than $1/2 \lambda$ at both frequencies) they register as a single reflector.
202-215 cms	Silt layer (similar to above but lower amplitudes on all curves).

CORE #GPC-19 (continued)

DEPTH	REFLECTOR
470-520 cms	Two fine sand-silt layers, separation about 35 cms. Both layers sharply defined at 12 kHz, since separation exceeds 2λ . Separation at 3.5 kHz is less than 1λ and phase cancellation flattens trace (PR).
665-690 cms	Significant return at 12 kHz apparently generated by large pebbles having high density and water content contrast with lutite. Impedance peaks at lower boundary. Wavelength at 3.5 kHz was too long to register any deflection.
740-810 cms	Numerous closely-spaced silt layers produce a "group response" (see Discussion) and high amplitude wave train at 3.5 kHz peaking at bottom interface between "wide black silt layer" and area of lutite with hydrotroilite. Note sharp drop in water content and high peaks in the sound velocity and impedance curves at this level. The 12 kHz trace was apparently flattened by phase cancellation here.
860-960 cms and 975-1060 cms	High amplitude response at 12 kHz originates from multiple closely-spaced silt layers alternating with lutite. The silt layers are characterized by low water content and small peaks in shear strength and velocity curves.

Since layer spacing throughout these ranges is small compared to λ at 3.5 kHz, phase cancellation affects this trace, but there is a definite overall increase in amplitude from 860-930 cms at this frequency also.

CORE # GPC-17
($56^{\circ}16.5'N$, $12^{\circ}30.2'W$)
16.3'

The composition of this core is similar to GPC-19 in that it is principally lutite with numerous silt and a few sand layers. However, there are in addition a number of areas of highly concentrated calcareous material (highly calcareous clay), which generally have a lower water content and slightly higher acoustic impedance than the surrounding lutite.

Most of the above are well defined at 12 kHz and correspond to relatively high amplitude areas at 3.5 kHz, except where layer separation is small versus wavelength causing phase reversal cancellation effects such as the one marked "PR" at 130-150 cms depth.

However, layer boundaries at 3.5 kHz are poorly defined because of the high wavelength to layer-thickness ratio as explained under DISCUSSION. An outstanding example of this is the group of six layers ranging in depth from 470-650 cms. Most of these are individually resolved at 12 kHz, but merely serve to maintain a constant amplitude wave-train at 3.5 kHz.

It is interesting to note the high amplitude returns at both frequencies corresponding to 50-65 cms core depth. The core analysis indicates the presence of forams in this depth range. A sharp peak in the 12 kHz trace opposite the foram area between 30 and 40 cms depth, give further indication that "foram-rich" material apparently provides sufficient impedance contrast with adjacent mineral clay to produce sizeable reflections.

While most acoustic returns are the result of impedance changes at water-content minima, this is not always the case. Note the 12 kHz return opposite the wide silt layer between 670 and 700 cms depth. There is little change in any parameter except shear-strength which shows a sharp increase (0.1 kg) in this layer. Further analysis of the physical properties of this layer, and perhaps more detailed velocity measurements to explain the wide deviation in axial versus cross-core values here might be interesting.

CORE #GPC-13
(54°28.5'N, 15°17.9'W)

Core #GPC-13, taken a considerable distance southwest of GPC-17 and GPC-19, shows an entirely different stratification and reflector pattern from the other two.

Instead of being principally lutite, the major part of this core is calcareous ooze. There are few sand or silt layers but many areas of burrows and forams.

The foram and other highly calcareous areas generally produce sizeable returns particularly at sharp interfaces with clay (see peaks in acoustic trace at 40, 60, 210, 350, 380 and 620 cms depth). These areas are characterized by low water content with respect to the clay resulting in sharp deviations

in the velocity and impedance curves. Outstanding examples occur at 40, 60, 75 and 585 cms, although at 75 cms the peak does not result in a large deflection in the acoustic trace due to a phase cancellation. In fact phase cancellations occur frequently throughout this core, apparently because most of the layering is thin compared to λ even at 12 kHz. These phase reversals make correlation with the physical properties of the core far more difficult than in the case of the other two cores, particularly in view of the generally lower impedance contrasts which would result in a less definitive acoustic trace even without cancellation.

An echo-sounder operating at a higher frequency would give better resolution here, and fewer phase problems because of the shorter wavelength, but sufficient penetration would be a problem. Note that even at 12 kHz the returns become severely attenuated below 650 cms apparently due to unusually high absorption in the overlying sediments.

CONCLUSION

This report has shown that a high-frequency, high-powered, short-pulse echo-sounder operating close to the seafloor can produce acoustic traces which in general correlate well with the stratigraphy of cores taken in the same area to depths of at least 10 meters.

The indications are that high impedance contrast between layers is not required to produce significant deflection in the acoustic records. This fact is well illustrated by GPC-13 where readable deviations in the acoustic trace are produced by small impedance changes throughout the core. This means, for example, that we can resolve areas of calcareous material, containing tests of foraminifera from surrounding clay.

The records from GPC-17 and GPC-19 show that individual bands of silt and sand only 15-20 cms thick can be resolved from surrounding lutite (clay) at 12 kHz.

However the resolution at 3.5 kHz is far less definitive, primarily due to the fact that most of the sediment layering, in these cores at least, is too thin to be resolved at the longer wavelength. While attenuation of the acoustic signal with depth is substantially less at 3.5 kHz (see GPC-17 traces), in no case did the 12 kHz signal fail to penetrate to the bottom of the giant core.

It appears from other subsequent operations using deep pingers but receiving aboard ship, that the resolution shown in these records cannot be achieved with such an arrangement in deep

water at 12 kHz. It is essential that the receiver be deep also in order to overcome acoustic spreading losses and eliminate the relatively high water and ship-generated noise at the surface.

One of the problems with a deep receiver is relaying the receiver information back to the surface. While this is not an instrumental difficulty if a separate lowering on conducting logging cable is made prior to coring (as in this case), there is a logistic problem in that the ship tends to drift off station before the core is finally lowered and penetrates the bottom.

An attempt is being made to mount the deep echo sounder on the core weight-stand and relay the receiver information via an acoustic carriersystem back to the surface vessel. Incorporating an electrical conductor in the coring cable is another alternative which may be more satisfactory, but is also more expensive.

In any case the use of deep operating high frequency echo-sounders to delineate and analyze shallow bottom and sub-bottom sediments in the deep ocean appears to be an important technique which is well worth the cost of further development.

Additional sea trials in conjunction with coring operations would provide additional data needed to advance the interpretation of acoustic returns in terms of the physical nature of the reflecting sediments.

Willard Dow
Charles D. Hollister

ACKNOWLEDGMENTS

The authors wish to acknowledge the contributions of the following to the data used in this report:

Dr. Charles D. Hollister made ship-time and cores available during cruise number 51 of R.V. KNORR, promoted funding for the development of Deep Probe and operation of this gear at sea, and assisted in the preparation of this report.

Alan H. Driscoll (W.H.O.I.) directed the coring operations and assisted with rigging Deep Probe on R.V. KNORR.

Edward Laine (U.R.I.) and Hartley Hoskins (W.H.O.I.) helped to operate the gear at sea, and subsequently, along with Sydney Knott (W.H.O.I.), assisted with the analysis of the acoustic records.

The following supplied data used in preparing the figures for this report: Core Stratigraphy - Edward Laine and James Broda (W.H.O.I.); Water Content and Shear Strength, courtesy Armand Silva (U.R.I.); and Sound Velocity (in core), Kenneth Baldwin (U.R.I.).

Development of Deep Probe was sponsored by National Oceanic and Atmospheric Administration (N.O.A.A.) Office of Sea Grant, Grant Number 044-158-8 and Environmental Research and Development Administration (ERDA), contract ERDA 11-2440.

Operations at sea and preparation of this report were funded under Office of Naval Research, contract N00014-74-C-0262; NR083-004, and ERDA contract 11-2440 and Sandia Laboratories contract 07-7923.

LIST OF FIGURES

- Fig. I. Deep Probe (Photo)
- Fig. II. Core #GPC-19 (KNORR Cruise #51)
- Fig. III. Core #GPC-17 (KNORR Cruise #51)
- Fig. IV. Core #GPC-13 (KNORR Cruise #51)

FIG. I

DEEP PROBE
W.H.O.I. Deep 12 kHz Echo Sounder (Photo)

DEEP PROBE

FIG.1

FIG. IIGIANT PISTON CORE #GPC-19 (Data Chart)

STA. #41

Date: 8/29/75

Loc: Rockall Trough, 56°17.72'N, 12°31.35'W

Sample Recov: 1492 cms

Core Wgt: 4750 lbs.

Water Depth: 2535 m.

Deep Probe Survey Loc: 56°17.80'N, 12°31.81'W

CORE NO. GPC-19 KNORR 51

W.H.O.I.
DOW - HOLLISTER

FIG. 2

FIG. IIIGIANT PISTON CORE #GPC-17 (Data Chart)

STA. #39

Date: 8/27/75

Loc: Rockall Trough, 56°16.26'N, 12°30.20'W

Sample Recov: 1010 cms

Core Wgt: 4979 lbs.

Water Depth: 2515 m.

Deep Probe Survey Loc: 56°16.30'N, 12°30.49'W

W.H.O.I.
LEGEND
PR = PHASE REVERSAL
DOW - HOLLISTER

LEGEND

- MIN. VANE
- TORVANE

— AXIAL VELOCITY
- - - CROSS CORE VELOCITY

LEGEND

☐ LUTITE

☒ SILT

LEGEND

WATER CONTENT = $W = \frac{\text{WT. of WATER}}{\text{WT. of DRY SOIL}} \times 100\%$

FIG. 3

FIG. IVGIANT PISTON CORE #GPC-13 (Data Chart)

STA. #36

Date: 8/24/75

Loc: Feni Drift 54°28.53'N, 15°17.85'W

Sample Recov. 1329 cms

Core Wgt: 4467 lbs.

Water Depth: 2665 m.

Deep Probe Survey Loc: 54°28.71'N, 15°17.30'W

FIG. 4

BIBLIOGRAPHIC DATA SHEET	1. Report No. WHOI-78-47	2.	3. Recipient's Accession No.
4. Title and Subtitle COMPARISON OF HIGH-RESOLUTION NORMAL-INCIDENCE 3.5 kHz AND 12 kHz REFLECTIONS WITH GEOTECHNICAL PROPERTIES OF GIANT PISTON CORES		5. Report Date June 1978	
7. Author(s) Willard Dow and Charles D. Hollister		8. Performing Organization Rept. No.	
9. Performing Organization Name and Address Woods Hole Oceanographic Institution Woods Hole, MA 02543		10. Project/Task/Work Unit No.	
		11. Contract/Grant No. 07-7923	
12. Sponsoring Organization Name and Address Sandia Laboratories		13. Type of Report & Period Covered Technical	
		14.	
15. Supplementary Notes			
16. Abstracts <p>A deep operating self-contained high-frequency echo sounder known as Deep Probe was recently developed at W.H.O.I. under ERDA and Sea Grant contracts for the purpose of resolving fine details of bottom and sub-bottom sediment layering in the deep ocean. In August 1975 this system was mounted on R/V KNORR for a coring expedition (KNORR #51) to the Rockall Trough area east of the United Kingdom under the direction of Dr. Charles Hollister.</p> <p>The purpose of this exercise was to determine the correlation between the high frequency acoustic sounding records and the stratification of several Giant Piston Cores (GPC) taken in the same area.</p> <p>Three of these cores, GPC-13, 17 and 19, have been analyzed and compared graphically with the acoustic survey of each core location, using Deep Probe **(Cont.)</p>			
17. Key Words and Document Analysis. 17a. Descriptors 1. High Definition Acoustic Soundings vs. Core Properties (Rockall Trough) 2. Deep Probe Acoustic Soundings vs. Core Strata (Rockall Trough)			
17b. Identifiers/Open-Ended Terms **(Cont.) near bottom, both as a 12 kHz echo-sounder, and as a deep receiver for detecting returns from a 3.5 kHz pinger mounted on the surface vessel. The acoustic traces for both frequencies were then compared for detail and depth of penetration with respect to the cores. Good to excellent correlation with core stratigraphy is indicated at 12 kHz.			
17c. COSA 11 Field/Group		(Cont. on back)	
18. Availability Statement		19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages
		20. Security Class (This Page) UNCLASSIFIED	22. Price

Resolution ranged from fair to poor at 3.5 kHz although transmission losses through the core were lower at this frequency.

The general conclusion is that deep echo-sounding at 12 kHz is an excellent technique for delineation of shallow bottom and sub-bottom sediments in high detail, and that deep sounders having characteristics similar to Deep Probe could therefore prove valuable for detailed surveys of small areas preliminary to coring, or in deep-towed fish form, for general seismic profiling of shallow sediments over longer tracts in the deep ocean.

Woods Hole Oceanographic Institution WHOI-78-47	1. High Definition Acoustic Soundings vs. Core Properties (Rockall Trough)	Woods Hole Oceanographic Institution WHOI-78-47	1. High Definition Acoustic Soundings vs. Core Properties (Rockall Trough)
COMPARISON OF HIGH-RESOLUTION NORMAL-INCIDENCE 3.5 kHz and 12 kHz REFLECTIONS WITH GEOTECHNICAL PROPERTIES OF GIANT PISTON CORES by Willard Dow and Charles D. Hollister. 14 pages. June 1978. Prepared for the Sandia Laboratories under Contract 07-7923.	2. Deep Probe Acoustic Soundings vs. Core Strata (Rockall Trough)	COMPARISON OF HIGH-RESOLUTION NORMAL-INCIDENCE 3.5 kHz and 12 kHz REFLECTIONS WITH GEOTECHNICAL PROPERTIES OF GIANT PISTON CORES by Willard Dow and Charles D. Hollister. 14 pages. June 1978. Prepared for the Sandia Laboratories under Contract 07-7923.	2. Deep Probe Acoustic Soundings vs. Core Strata (Rockall Trough)
A deep operating self-contained high-frequency echo sounder known as Deep Probe was recently developed at W.H.O.I. under EMDA and Sea Grant contracts for the purpose of resolving fine details of bottom and sub-bottom sediment layering in the deep ocean. In August 1975 this system was mounted on R/V KNOX for a coring expedition (KNORR #51) to the Rockall Trough area east of the United Kingdom under the direction of Dr. Charles Hollister.	I. Dow, Willard	A deep operating self-contained high-frequency echo sounder known as Deep Probe was recently developed at W.H.O.I. under EMDA and Sea Grant contracts for the purpose of resolving fine details of bottom and sub-bottom sediment layering in the deep ocean. In August 1975 this system was mounted on R/V KNOX for a coring expedition (KNORR #51) to the Rockall Trough area east of the United Kingdom under the direction of Dr. Charles Hollister.	I. Dow, Willard
The purpose of this exercise was to determine the correlation between the high frequency acoustic sounding records and the stratification of several Giant Piston Cores (GPC) taken in the same area.	II. Hollister, Charles D.	The purpose of this exercise was to determine the correlation between the high frequency acoustic sounding records and the stratification of several Giant Piston Cores (GPC) taken in the same area.	II. Hollister, Charles D.
Three of these cores, GPC-13, 17 and 19, have been analyzed and compared graphically with the acoustic survey of each core location, using Deep Probe, near-bottom, both as a 12 kHz echo-sounder, and as a deep receiver for detecting returns from a 3.5 kHz pinger mounted on the surface vessel. The acoustic traces for both frequencies were then compared for detail and depth of penetration with respect to the cores.	III. 07-7923	Three of these cores, GPC-13, 17 and 19, have been analyzed and compared graphically with the acoustic survey of each core location, using Deep Probe, near-bottom, both as a 12 kHz echo-sounder, and as a deep receiver for detecting returns from a 3.5 kHz pinger mounted on the surface vessel. The acoustic traces for both frequencies were then compared for detail and depth of penetration with respect to the cores.	III. 07-7923
Good to excellent correlation with core stratigraphy is indicated at 12 kHz. Resolution ranged from fair (Cont. on back)	This card is UNCLASSIFIED	Good to excellent correlation with core stratigraphy is indicated at 12 kHz. Resolution ranged from fair (Cont. on back)	This card is UNCLASSIFIED
Woods Hole Oceanographic Institution WHOI-78-47	1. High Definition Acoustic Soundings vs. Core Properties (Rockall Trough)	Woods Hole Oceanographic Institution WHOI-78-47	1. High Definition Acoustic Soundings vs. Core Properties (Rockall Trough)
COMPARISON OF HIGH-RESOLUTION NORMAL-INCIDENCE 3.5 kHz and 12 kHz REFLECTIONS WITH GEOTECHNICAL PROPERTIES OF GIANT PISTON CORES by Willard Dow and Charles D. Hollister. 14 pages. June 1978. Prepared for the Sandia Laboratories under Contract 07-7923.	2. Deep Probe Acoustic Soundings vs. Core Strata (Rockall Trough)	COMPARISON OF HIGH-RESOLUTION NORMAL-INCIDENCE 3.5 kHz and 12 kHz REFLECTIONS WITH GEOTECHNICAL PROPERTIES OF GIANT PISTON CORES by Willard Dow and Charles D. Hollister. 14 pages. June 1978. Prepared for the Sandia Laboratories under Contract 07-7923.	2. Deep Probe Acoustic Soundings vs. Core Strata (Rockall Trough)
A deep operating self-contained high-frequency echo sounder known as Deep Probe was recently developed at W.H.O.I. under EMDA and Sea Grant contracts for the purpose of resolving fine details of bottom and sub-bottom sediment layering in the deep ocean. In August 1975 this system was mounted on R/V KNOX for a coring expedition (KNORR #51) to the Rockall Trough area east of the United Kingdom under the direction of Dr. Charles Hollister.	I. Dow, Willard	A deep operating self-contained high-frequency echo sounder known as Deep Probe was recently developed at W.H.O.I. under EMDA and Sea Grant contracts for the purpose of resolving fine details of bottom and sub-bottom sediment layering in the deep ocean. In August 1975 this system was mounted on R/V KNOX for a coring expedition (KNORR #51) to the Rockall Trough area east of the United Kingdom under the direction of Dr. Charles Hollister.	I. Dow, Willard
The purpose of this exercise was to determine the correlation between the high frequency acoustic sounding records and the stratification of several Giant Piston Cores (GPC) taken in the same area.	II. Hollister, Charles D.	The purpose of this exercise was to determine the correlation between the high frequency acoustic sounding records and the stratification of several Giant Piston Cores (GPC) taken in the same area.	II. Hollister, Charles D.
Three of these cores, GPC-13, 17 and 19, have been analyzed and compared graphically with the acoustic survey of each core location, using Deep Probe, near-bottom, both as a 12 kHz echo-sounder, and as a deep receiver for detecting returns from a 3.5 kHz pinger mounted on the surface vessel. The acoustic traces for both frequencies were then compared for detail and depth of penetration with respect to the cores.	III. 07-7923	Three of these cores, GPC-13, 17 and 19, have been analyzed and compared graphically with the acoustic survey of each core location, using Deep Probe, near-bottom, both as a 12 kHz echo-sounder, and as a deep receiver for detecting returns from a 3.5 kHz pinger mounted on the surface vessel. The acoustic traces for both frequencies were then compared for detail and depth of penetration with respect to the cores.	III. 07-7923
Good to excellent correlation with core stratigraphy is indicated at 12 kHz. Resolution ranged from fair (Cont. on back)	This card is UNCLASSIFIED	Good to excellent correlation with core stratigraphy is indicated at 12 kHz. Resolution ranged from fair (Cont. on back)	This card is UNCLASSIFIED

to poor at 3.5 kHz although transmission losses through the core were lower at this frequency.

The general conclusion is that deep echo-sounding at 12 kHz is an excellent technique for delineation of shallow bottom and sub-bottom sediments in high detail, and that deep sounders having characteristics similar to Deep Probe could therefore prove valuable for detailed surveys of small areas preliminary to coring, or in deep-towed fish form, for general seismic profiling of shallow sediments over longer tracts in the deep ocean.

to poor at 3.5 kHz although transmission losses through the core were lower at this frequency.

The general conclusion is that deep echo-sounding at 12 kHz is an excellent technique for delineation of shallow bottom and sub-bottom sediments in high detail, and that deep sounders having characteristics similar to Deep Probe could therefore prove valuable for detailed surveys of small areas preliminary to coring, or in deep-towed fish form, for general seismic profiling of shallow sediments over longer tracts in the deep ocean.

to poor at 3.5 kHz although transmission losses through the core were lower at this frequency.

The general conclusion is that deep echo-sounding at 12 kHz is an excellent technique for delineation of shallow bottom and sub-bottom sediments in high detail, and that deep sounders having characteristics similar to Deep Probe could therefore prove valuable for detailed surveys of small areas preliminary to coring, or in deep-towed fish form, for general seismic profiling of shallow sediments over longer tracts in the deep ocean.

to poor at 3.5 kHz although transmission losses through the core were lower at this frequency.

The general conclusion is that deep echo-sounding at 12 kHz is an excellent technique for delineation of shallow bottom and sub-bottom sediments in high detail, and that deep sounders having characteristics similar to Deep Probe could therefore prove valuable for detailed surveys of small areas preliminary to coring, or in deep-towed fish form, for general seismic profiling of shallow sediments over longer tracts in the deep ocean.