Report no. changed (Mar 2006): SM-334-UU

SACLANTCEN MEMORANDUM
serial no.: SM-334

SACLANT UNDERSEA RESEARCH CENTRE MEMORANDUM

RAPID RESPONSE, SEPTEMBER 1996: MODELLING OF BROADBAND TRANSMISSION LOSS ALONG SELECTED TRACKS IN THE STRAIT OF SICILY

C.M. Ferla, F.B. Jensen and T. Akal

July 1997

Report no. changed (Mar 2006): SM-334-UU

This document is approved for public release.
Distribution is unlimited

SACLANT Undersea Research Centre
Viale San Bartolomeo 400
19138 San Bartolomeo (SP), Italy

tel: +39-187-540.111
fax: +39-187-524.600

e-mail: library@saclantc.nato.int

NORTH ATLANTIC TREATY ORGANIZATION

Rapid Response September 1996: Modelling of broadband transmission loss along selected tracks in the Strait of Sicily

Carlo M. Ferla, Finn B. Jensen,
and Tuncay Akal

The content of this document pertains to work performed under Project 011-1 of the SACLANTCEN Programme of Work. The document has been approved for release by The Director, SACLANTCEN.

Jan L. Spoelstra
Director

intentionally blank page

Rapid Response September 1996: Modelling of broadband transmission loss along selected tracks in the Strait of Sicily

Carlo M. Ferla, Finn B. Jensen, and Tuncay Akal

Executive Summary: The Strait of Sicily is an ocean area of both strategic and scientific interest. This area is characterized by a high spatial and temporal variability of oceanographic features, including currents, eddies, and gyres. It also presents a complicated bottom structure, and the bathymetric changes commonly encountered along any given track, substantially increase the complexity of correct modelling of the acoustic propagation.

In support of the operation Rapid Response 1996, an exercise was conducted at the beginning of September 1996 in the Sicilian Channel and the Maltese Channel which encompassed the collection of broadband acoustic data from explosive charges dropped from a ship and an aircraft, and 3.5 kHz CW data from a towed sound source. Monitoring of oceanographic features and of bottom topography along the various tracks was also performed, in order to acquire a set of parameters influencing acoustic propagation.

This report addresses the problem of determining an appropriate geoacoustic model, qualifying the degree of predictability of the acoustic propagation in this area, and identifying the required level of sophistication of the acoustic models to be used.

intentionally blank page

Rapid Response September 1996: Modelling of broadband transmission loss along selected tracks in the Strait of Sicily

Carlo M. Ferla, Finn B. Jensen, and
Tuncay Akal

Abstract: A large set of experimental acoustic broadband data in the 50-3200 Hz band is analyzed with the objective of deriving average geoacoustic models for three sites in the Strait of Sicily. The experimental data were obtained by using explosive charges as sound sources and a vertical array of hydrophones as the receiver. CW data at 3.5 kHz is also analyzed. The acoustic data is complemented by a set of oceanographic data and bathymetry measurements. The model/data comparison results from each site, obtained after selecting appropriate average geoacoustic models, are presented as propagation losses over range for fixed source and receiver depths. We also indicate the propagation loss models chosen for the prediction and their limits. The results demonstrate the strong effect of bottom properties on acoustic propagation in this area, the limited amount of the existing information available for model prediction, and the difficulty in automating model selection and validating model results.

Keywords: geoacoustic model ∘ model/data comparison ∘ predictability ∘ Strait of Sicily ∘ Maltese Channel ∘ Sicilian channel.

Contents

1

Introduction

As a part of the MILOC programme of which rapid environmental assessment is an integral element, exercise Dynamic Mix 96 was conducted in the first half of September 1996 in the Strait of Sicily. A receiving array was deployed in three locations, AA, BB and CC, and transmission loss measurements were conducted along the tracks shown in Fig. 1.

The model/data comparison presented for the three different sites is based on our derivation of appropriate average geoacoustic models. Their determination was made under the constraints of the available knowledge of sea floor properties in the three areas as well as from the experimental broadband propagation loss results obtained for different source/receiver depth combinations.

It is well known that the ability to make reliable sonar performance predictions depends, *inter alia*, on the accuracy of the propagation loss term in the sonar equation. It is also clear that the determination of this term can be significantly degraded by poor knowledge of environmental inputs, particularly by the bottom effects or geophysical constraints.

A limit on accuracy of the geoacoustic model is imposed by the approximations incorporated in the measured data as well as the inputs to the propagation loss model. In addition, bottom properties need to be defined in an average sense, and ultimately the proposed geoacoustic model should possess such desirable features as simplicity and widespread applicability.

Accordingly we have defined simple geoacoustic models of the sea floor consisting of only two layers: an upper layer with constant density ρ, attenuation α, and relative sound speed C_p/C_w overlying a semi-infinite homogeneous layer where density, attenuation and compressional sound speed C_b are held constant. The sound speed in the sediment and bottom layers was considered as having a zero gradient. The resulting geoacoustic models are given by the following tables with an indication of the areas for which they are applicable.

Layer	Depth (m)	C_p/C_w	$C_b(m/s)$	ρ (g/cm^3)	α (dB/λ)
1	6.0	1.017		1.4	0.3
2	∞		1580	1.5	1.5

Table 1 *Geoacoustic model in area AA.*

Layer	Depth (m)	C_p/C_w	$C_b(m/s)$	ρ (g/cm^3)	α (dB/λ)
1	3.0	0.985		1.5	0.12
2	∞		1630	1.9	0.7

Table 2 *Geoacoustic model along track BB-BC.*

Layer	Depth (m)	C_p/C_w	$C_b(m/s)$	ρ (g/cm^3)	α (dB/λ)
1	3.0	0.985		1.5	0.15
2	∞		1630	1.9	0.5

Table 3 *Geoacoustic model along track BB-BD.*

Layer	Depth (m)	C_p/C_w	$C_b(m/s)$	ρ (g/cm^3)	α (dB/λ)
1	3.0	0.985		1.5	0.15
2	∞		1630	1.9	0.5

Table 4 *Geoacoustic model along track BB-BE.*

Layer	Depth (m)	C_p/C_w	$C_b(m/s)$	ρ (g/cm^3)	α (dB/λ)
1	5.0	0.985		1.5	0.10
2	∞		1580	1.9	0.7

Table 5 *Geoacoustic model in area CC.*

2

The measurement technique

Explosive charges (SUS) dropped from a ship or an aircraft were used as sound sources, and the transmitted signal was acquired with a vertical array of hydrophones at the end of the track. A towed sound source transmitted 3.5 kHz CW data.

Environmental parameters were collected during the measurement period to provide data for modelling and interpretation of results.

During the experiment all explosive charges were set to detonate at a depth of 18 m, while the depth of the towed sound source was 14 m.

2.1 The receiving array

As shown in Fig. 2 the receiving array consisted of a string of six omnidirectional hydrophones. A selection between two different groups of four hydrophones each was used throughout the experiment. The choice between the two groups was based on the water depth at the measurement site (receiving array) or as dictated by occasional failures. After a choice was made, it was maintained along over the full track length. Both groups included receivers at depths of 20 and 30 m, and were completed by including either receivers at 50 and 80 m or at 102 and 143 m.

3

Acoustic modelling

3.1 The acoustic models

Due to the complexity of the environmental features affecting the acoustic propagation along the various tracks in this area, a number of 2-D range dependent and range independent models were applied to the various shallow and deep water scenarios at low and high frequencies. Ray based models such as GSM [1], MOCASSIN [2] and HODGSON [3] were selected for deep water problems. Wave models such as PAREQ [2], RAM [4] and C-SNAP [2] were used for modelling in the shallow water regions. The computational speed, and the ability to treat bottom effects and sloping bottoms were among the main selection criteria. Whenever appropriate, inter-model comparison was performed.

The first step in the determination of a geoacoustic model was to estimate a homogeneous bottom to fit the experimental results at 50 Hz, followed by the addition of a top layer with properties to fit the results at 630 and 3200 Hz. At 50 Hz we have used the wave models RAM, PAREQ and C-SNAP. At higher frequencies the choice between wave and ray based models varied from case to case.

SAFARI [2] was used to convert from a geoacoustic model to a bottom reflection loss table as required by ray models.

As the acoustic experimental data is presented as propagation loss in a 1/3 octave band, to obtain equivalent model results the models were generally run for several frequencies in a 1/3 octave band to allow propagation loss averaging. The random phase addition of ray contributions, available from GSM, was a quick and satisfactory solution to the problem.

3.2 Inputs to the acoustic models

Throughout the measurement period, and along all the tracks, XBTs were taken by the launching ship (HMS *HERALD*), together with bathymetry measurements and meteorological observations. CTD measurements were also made by the NRV *ALLIANCE* in the vicinity of the receiving array.

Average bottom properties as relative density, sound speed and porosity were derived from previous studies on bottom reflection losses in the same areas in the Strait of Sicily as reported in [5, 6, 7].

4

Comparison of experimental and model results

The model/data comparison presented here is intended to give a qualitative and quantitative illustration of the degree of predictability which can be obtained in the three areas.

Results are presented as propagation losses as a function of range for selected tracks at 50, 630, 3200 Hz (1/3 octave bands, from SUS charges), and 3500 Hz (CW, from towed source). Throughout the experiment the source depth was fixed at 18 m for the broadband data and at 14 m for the 3.5 kHz CW data. The data acquired was generally available at four receiver depths.

The modelling of a range dependent transmission loss experiment with a moving source and a fixed receiver can be conveniently modelled as a fixed source experiment provided the source and the receiver depths are exchanged.

Finally, for each track we also indicate the models that we have found most suitable, as well as any major problems encountered.

4.1 Area A

In this area we have elected to model the measurements made along tracks AA-AB and AA-AC which have an almost identical course towards the north. The first experiment was conducted along track AA-AC by dropping explosive charges from an aircraft. The experiment along track AA-AB was conducted both by dropping explosive charges (HMS *HERALD*) and by towing a 3.5 kHz source (*PATHFINDER*). The bathymetry measured along tracks AA-AB and AA-AC shown in Fig. 3 and 4 reveals the presence of a seamount in the first 10 km. Apart from the seamount the area is characterized by a gentle slope with an average water depth of about 3300 m.

This is a typical deep water, range dependent scenario, best suited for investigation through ray based models. The effect of this seamount on acoustic propagation is not easily modelled using range dependent models such as MOCASSIN or HODGSON. Better results are obtained by treating the environment as a simple flat bottom.

The SVPs obtained from the XBTs taken by the launching ship along the AA-AB track are shown in Fig. 5. They were taken at almost regular intervals during the experiment conducted on 03 Sep 1996 in the period from 11:00 to 16:30. For a better representation of their variability we display the first 200 m only. A similar structure and a similar degree of variability was also found in the SVPs measured the following day, in the period from 00:00 to 04:30 along the segment AB-AC.

CTD measurements were taken from the *ALLIANCE* which was stationed near the receiving array during the data acquisition period. For the input to the acoustic models we have taken one such CTD, shown in Fig. 6, to represent average features, and we have maintained it constant along the AA-AB and AA-AC tracks.

The model results presented for this area were obtained by running GSM, with MOCASSIN and HODGSON used for inter-model comparison. RAM was used to estimate the bottom properties at 50 Hz. We present transmission loss in a third octave band, obtained by averaging the results over 5 equally spaced frequencies. A 0.5 km running window is also applied for smoothing the frequency averaged results. Except for the 50 Hz case, a similar answer could be obtained by running GSM at the centre frequency with random phase addition of rays.

A first feature observed for all frequencies in the model/data comparison for tracks AA-AB and AA-AC, shown in Figs. 7, 8, and 9, is the similarity of the propagation loss dependence on receiver depth, particularly in the first 25 km. The main trends are also correctly predicted at all frequencies, while good agreement in levels is generally seen at 50 and 630 Hz only.

At 3.2 kHz the model prediction shows much lower propagation loss, particularly at 40 and 80 km corresponding to the convergence zones, a fact that could be linked to surface layer variability and to the seamount effects.

Alhough at 3.5 kHz a few of experimental data points are clearly wrong, (group of curves with spikes in Fig. 9) the comparison in the 5 to 20 km range interval clearly indicates that the model predicts higher losses. This is in contradiction with the result observed for the 3.2 kHz case, for which a calibration problem in the processing of the experimental data, may be the reason.

4.2 *Area B*

From this area we present the modelling of the measurements made along the tracks from point BB to points BC, BD, and BE. The bathymetry and the XBTs were obtained from the launching ship *HERALD* while CTD measurements were taken from the *ALLIANCE* which was stationed near the receiving array.

4.2.1 *Track BB-BC*

The bathymetry and the SVPs along this track are shown in Fig. 10 and Fig. 11. The first figure indicates a typical, upslope, range dependent, shallow water environment suitable for modelling with a wave model such as PAREQ. The SVPs shown in the second figure reveal a variable surface layer depth, with none of the profiles really standing out as a good candidate of average properties. In this case our criteria for the input to the acoustic models was to use a similar profile, the one shown in Fig. 12, obtained from accurate CTD measurements made during the experiment by the *ALLIANCE* while stationed by the receiving array.

As illustrated in Fig. 13 the model/data comparison for the 50 Hz case shows good agreement at all receiver depths. With the only exception of the results with the receivers at 20 m a similar good agreement can be seen in Figs 14 and 15 for the 630 and 3200 Hz case. The large variability in the surface layer may well be considered responsible for the poor agreement.

Also the model/data comparison for the 3.5 kHz CW case shown in Fig. 16 indicates very good agreement. In this case, the experimental data covers only the first 10 km from the receiving array and the results for the receiver at 30 m are not available because of hardware problems.

4.2.2 *Track BB-BD*

The bathymetry for the BB-BD track presented in Fig. 17 shows in the first 16 km an initial shallow water region with a very gentle bottom slope (0.2°), followed by a region with a gradual increase of water depth with a maximum bottom slope of 6° in the range interval from 26 to 42 km. The modelling of this range dependent environment requires the ability to handle both shallow and deep water propagation problems simultaneously. To solve this particular case, we have selected C-SNAP which is is well suited to computing the acoustic field in this shallow water region and can also correctly march the field out in the deeper region, as the coupling process initiating at a range of 16 km is mainly dependent on a limited number of waterborne modes. RAM and PAREQ were successfully exercised at 50 Hz to obtain the initial estimate of bottom properties.

The SVPs measured by the launching ship along this track are shown in Fig. 18. They show a variability in the surface layer depth similar to that observed in the BB-BC track. However in this case it was easier to select one of these profiles, the one shown in Fig. 19, and use it as the input to C-SNAP.

As illustrated in Figs. 20, 21, and 22, the model/data comparison for this track is generally excellent. A few data points from the experimental results are clearly offset because of some malfunction.

The 3.5 kHz CW results, shown in Fig. 23 are in excellent agreement.

4.2.3 Track BB-BE

The bathymetry for the BB-BE track is shown in Fig. 24. It presents a shallow water environment with some range dependent bathymetry in the first 5 km which we considered suitable for modelling with PAREQ.

The SVPs obtained along this track, shown in Fig. 25, show less variability than any of the previous measurements, a fact that should lead to better model/data agreement. As we tested the effect from the various profiles without obtaining a significant difference, we chose a single progile from the above set, indicated in the figure with solid circles to represent average features, maintained constant along the propagation track.

As illustrated in Fig. 26 the model/data comparison for the 50 Hz case shows good agreement for the receivers at a depth of 50 and 80 m. For the receivers at 20 and 30 m, the comparison is good only up to mid-range, at which point the model predicts increasingly higher losses up to about 10 dB at 30 km.

With the exception of the results for the receiver at 20 m, good agreement can again be seen in the 630 Hz case shown in Fig. 27. For this receiver, the model predicts better propagation increasing over range up to 10 dB at 35 km.

A similar result is shown in Fig. 28 for the 3.2 kHz case, except that the model prediction indicates an even better propagation.

The CW experimental results at 3.5 kHz are available only up to 15 km. The model/data comparison for this case, shown in Fig. 29, indicates the usual poor agreement found for the receiver at 20 m. Though some good agreement is found with the remaining receivers after a range of 10 km, some doubts exist as to the quality of the experimental results given their limited degree of range dependence.

4.3 Area C

This is a relatively deep water area with a considerable level of range dependency. The water depth is 950 m at the receiver array which is the maximum depth in a 40 km radius. For this area we present the modelling of the results along track CC-CD for which we have data from explosive charges as well as from the towed CW source. Because of hardware problems at the receiving array, the experimental results are available only for the receivers at 20, 30 and 50 m. The experimental results from air dropped charges are not available along this track.

As illustrated by the bathymetry shown in Fig. 30, this track consists of a substantially flat, initial region extending for 8 km from the the receiving array, followed by a 4° upsloping bottom which reaches a depth of 620 m at a range of 12.5 km. For the remainder of the track, the bottom is very gently upsloping (0.3°) until the end of the track.

The SVPs obtained from data measured along the track b, the launching ship are shown in Fig. 31. As usual they were taken at regular intervals during the experiment. For a better representation of their variability we display the first 70 m only. As these profiles exhibit considerable variability, we have tested their effect on propagation loss by running C-SNAP with a number of them, each maintained constant along the full track, and finally with each profile placed at the location where it was measured. No appreciable difference in mean level was found in any of these cases. The results presented were obtained using the profile shown in Fig. 32 taken near the receiving array.

Mainly because of their fast execution time, range dependent, ray based models are the appropriate tools for the modelling of this track at high frequencies. Accordingly we initially determined the geoacoustic model at 50 and 630 Hz with C-SNAP and RAM, completing the modelling at 3.2 and 3.5 kHz by using MOCASSIN. For intermodel comparison we ran C-SNAP at high frequencies. The answer will be presented together with the results from MOCASSIN. The limit to the accuracy from C-SNAP in this deep water environment is due to its inability to account for the continuous spectrum contribution to the acoustic field, in the near range, a fact which is observed in the initial 7 km of the track and which is important when modelling unlimited beamwidth sources. C-SNAP was run to produce coherent loss results which have been subsequently averaged in a 1/3 octave band and smoothed through a 0.5 km running window.

The model/data comparison at 50 Hz, shown in Fig. 33, is generally good, with the best agreement obtained with the deepest receiver.

In the model/data results at 630 and 3200 Hz presented in Figs. 34 and 35 we observe a very poor agreement for the shallowest receiver which we found to be independent from choice of a profile.

Contrary to the above results the model/data agreement for the deepest receiver is generally good for both frequencies. while for the receiver at 30 m it is a trade off between the shallow and deep receiver case.

The features presented by the 3.2 kHz results are also found in the 3.5 kHz CW model/data comparison shown in Fig. 36. The change in frequency, in source depth, and in the time difference between the two experiments (3 hours) supports the idea that these results are stable.

The reason for the significant difference between the model/data results for the shallowest receiver at 630, 3200 and 3500 Hz is not clear. We have verified that none of the measured profiles can produce such a dramatic effect. In addition, the good inter-model comparison (MOCASSIN vs C-SNAP) gives confidence in the models's ability to properly predict the acoustic propagation along this track. If the data integrity is not be suspect a plausible explanation may be found in the need for a more elaborate geoacoustic model.

5

Summary

We have determined some simple average geoacoustic models of the sediment layer to be used in the prediction of the acoustic propagation in three specific areas in the Strait of Sicily. Though the parameters we have found, in particular the density and the relative sound speed, are within the range of measured values reported in the literature [5, 6, 7], the choice of a representative average quantity could only be assessed through an inversion process based on experimental acoustic data and the available acoustic models.

Although the model/data comparison obtained with our geoacoustic models is good at all frequencies and for the two receivers closest to the bottom, we could not improve on the rather poor agreement generally seen in the results obtained on a few tracks in areas BB and CC, when the receivers are located at 20 and 30 m, for frequencies from 630 to 3500 Hz. The explanation may be the need for a more complex geoacoustic model.

Another difficulty, modelling the effects of the seamount in the deep water track AA-AB requires a fast, high frequency, range dependent, and reliable 3D operational model.

We have observed that in spite of the progress, existing propagation loss models, whether laboratory or operational tools, are not yet amenable to efficient incorporation in an automated inversion process to produce average geoacoustic models.

References

[1] Weinberg H. *Generic Sonar Model.* NUSC, 1994.

[2] Schneider H.G. *Acoustic Models at SACLANTCEN.* SACLANTCEN SM-285, March 1995.

[3] Hodgson J.M. *WADER Global Ocean Information System, User Manual.* 'Pendower' Cornwall EX23 0AF, U.K., 1993.

[4] Collins M.D. *Range-dependent Acoustic Model.* NRL, September 1995.

[5] Hastrup O.F. and Akal T., *Acoustic Reflectivity of the Sea Floor in the Central Mediterranean.* SACLANTCEN SR-27, December 1978.

[6] Hastrup O.F. and Akal T. *Acoustic Reflectivity Measurements in the Mediterranean Sea. Volume 2.* SACLANTCEN SR-28, January 1979.

[7] Tonarelli B., Turgutcan F., Max M.D., Muzi E., and Akal T., *Sediment Analyses from the Sicilian-Tunisian Platform: A Summary of SACLANTCEN sites to December 1992. Area C - Central Malta Plateau [NU].* SACLANTCEN M-111, 1992.

Figures

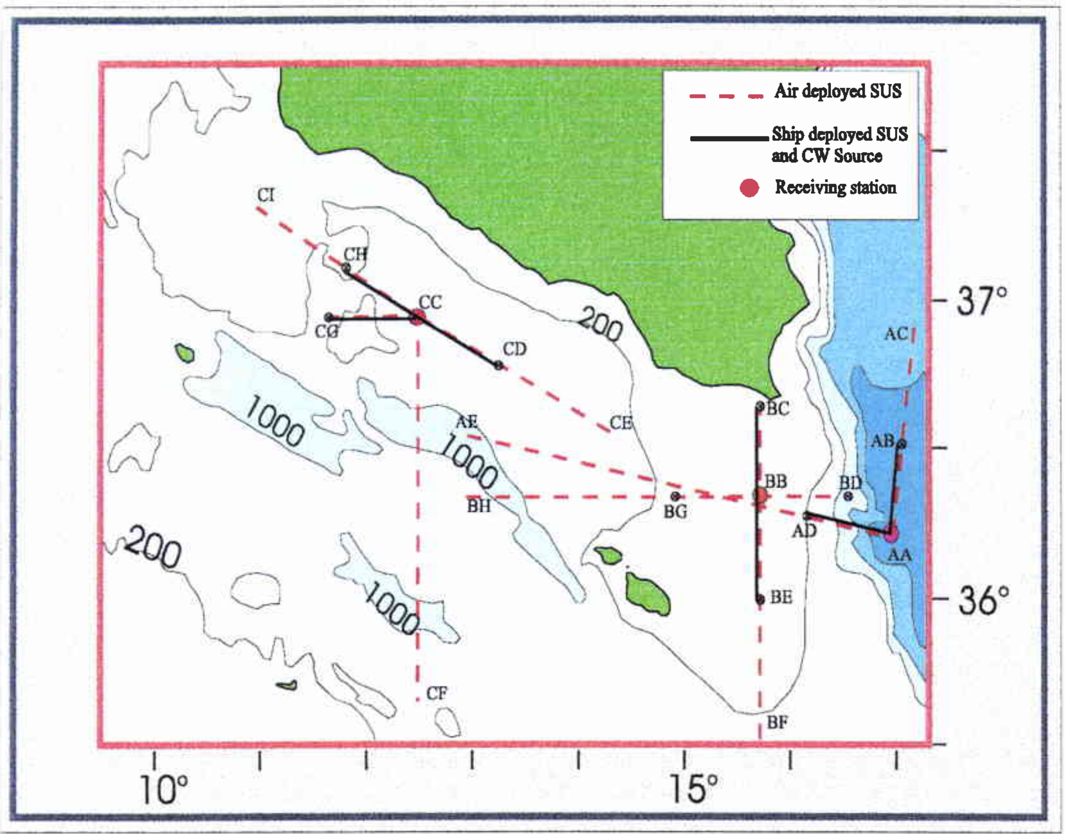

Figure 1 Experimental tracks in the Strait of Sicily.

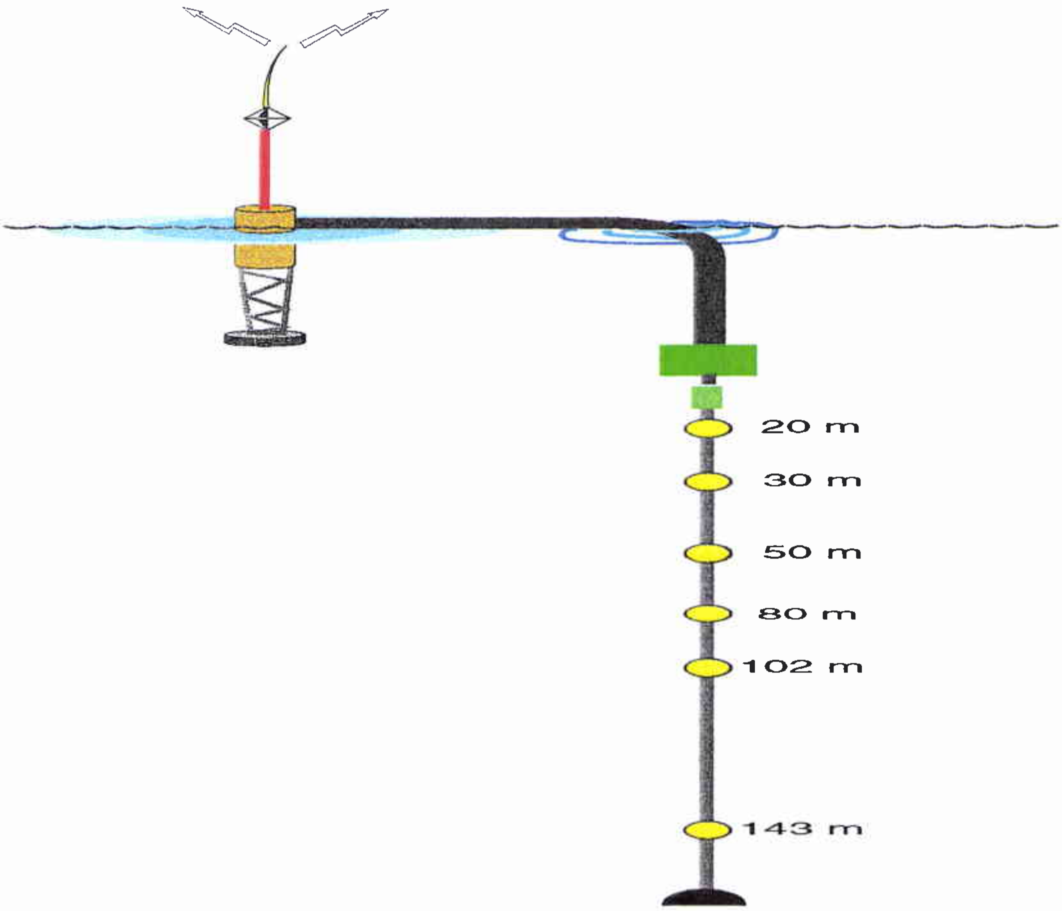

Figure 2 The Receiving Array.

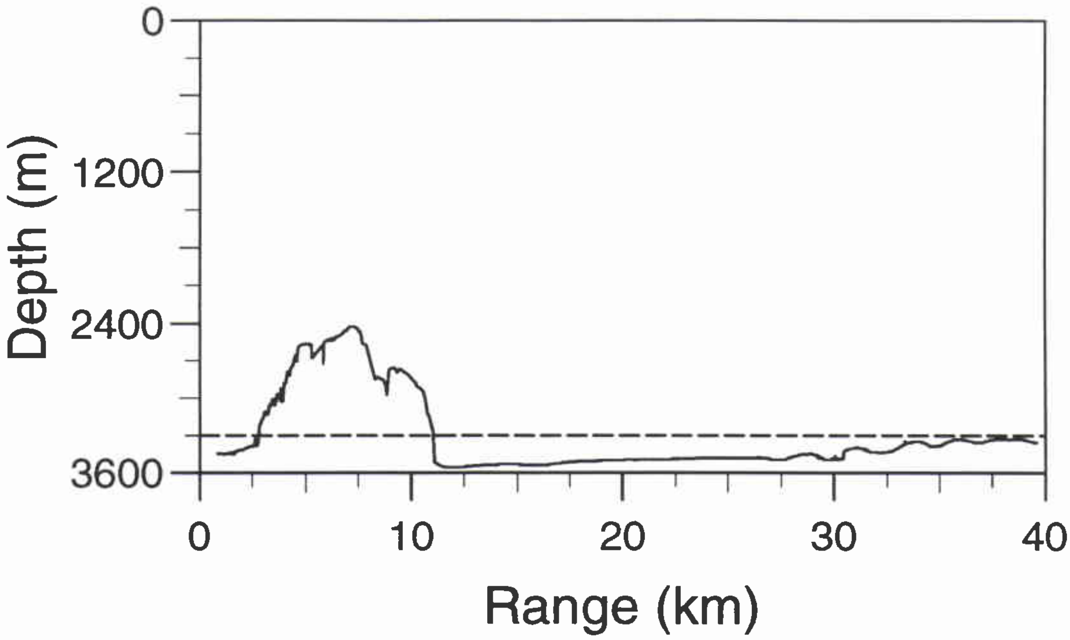

Figure 3 Measured bathymetry along track AA-AB. The broken line represents the approximation used for modelling.

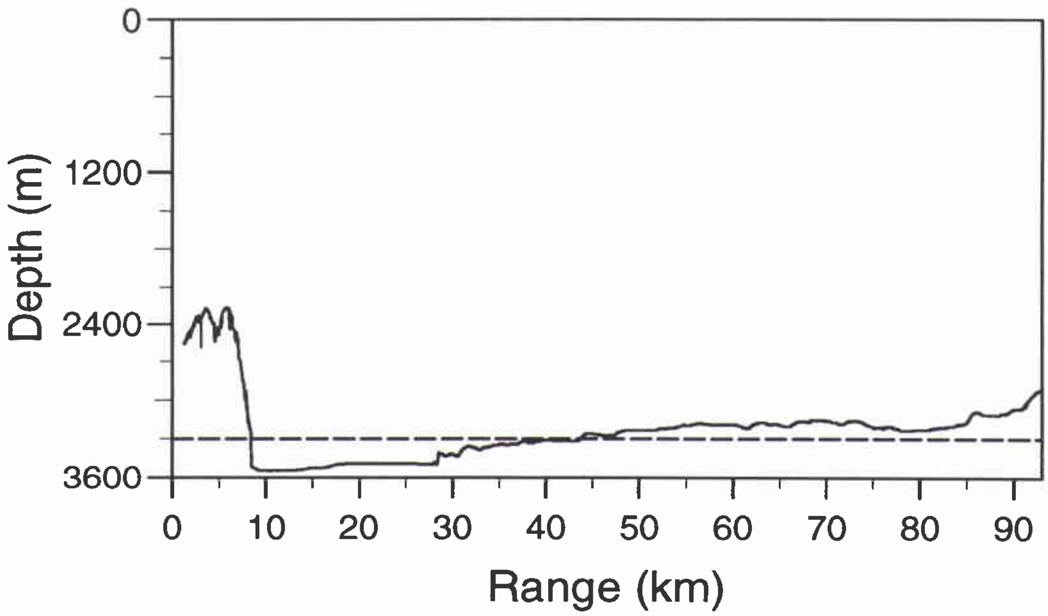

Figure 4 Measured bathymetry along track AA-AC. The broken line represents the approximation used for modelling.

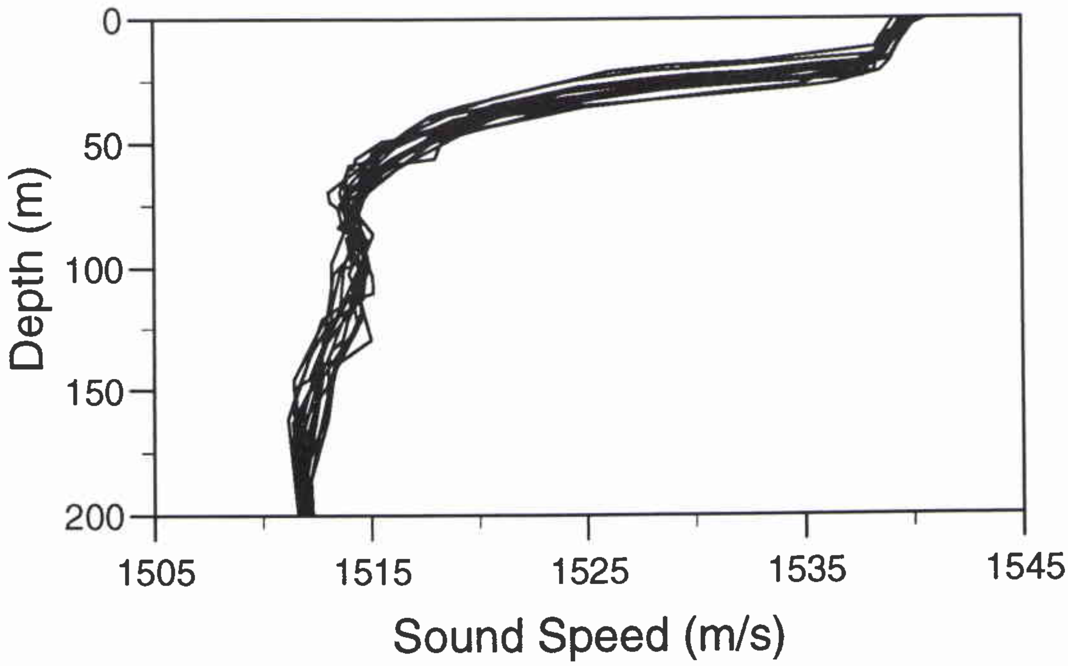

Figure 5 Upper 200 m of the SVP used for track AA-AB.

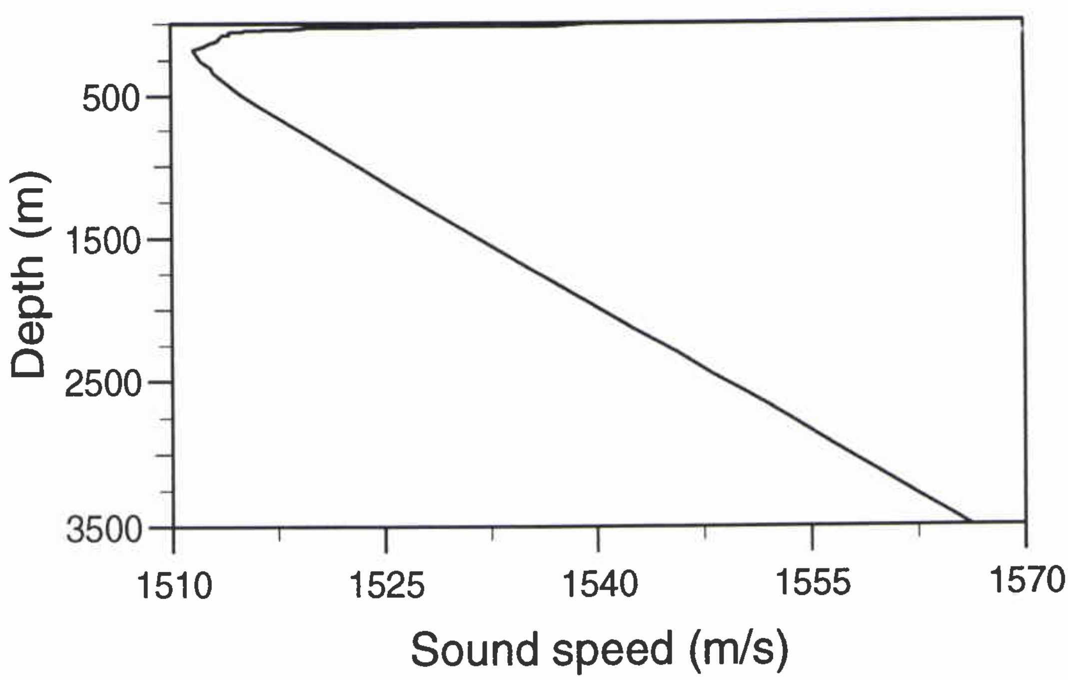

Figure 6 The SVP used for the AA-AB and AA-AC tracks.

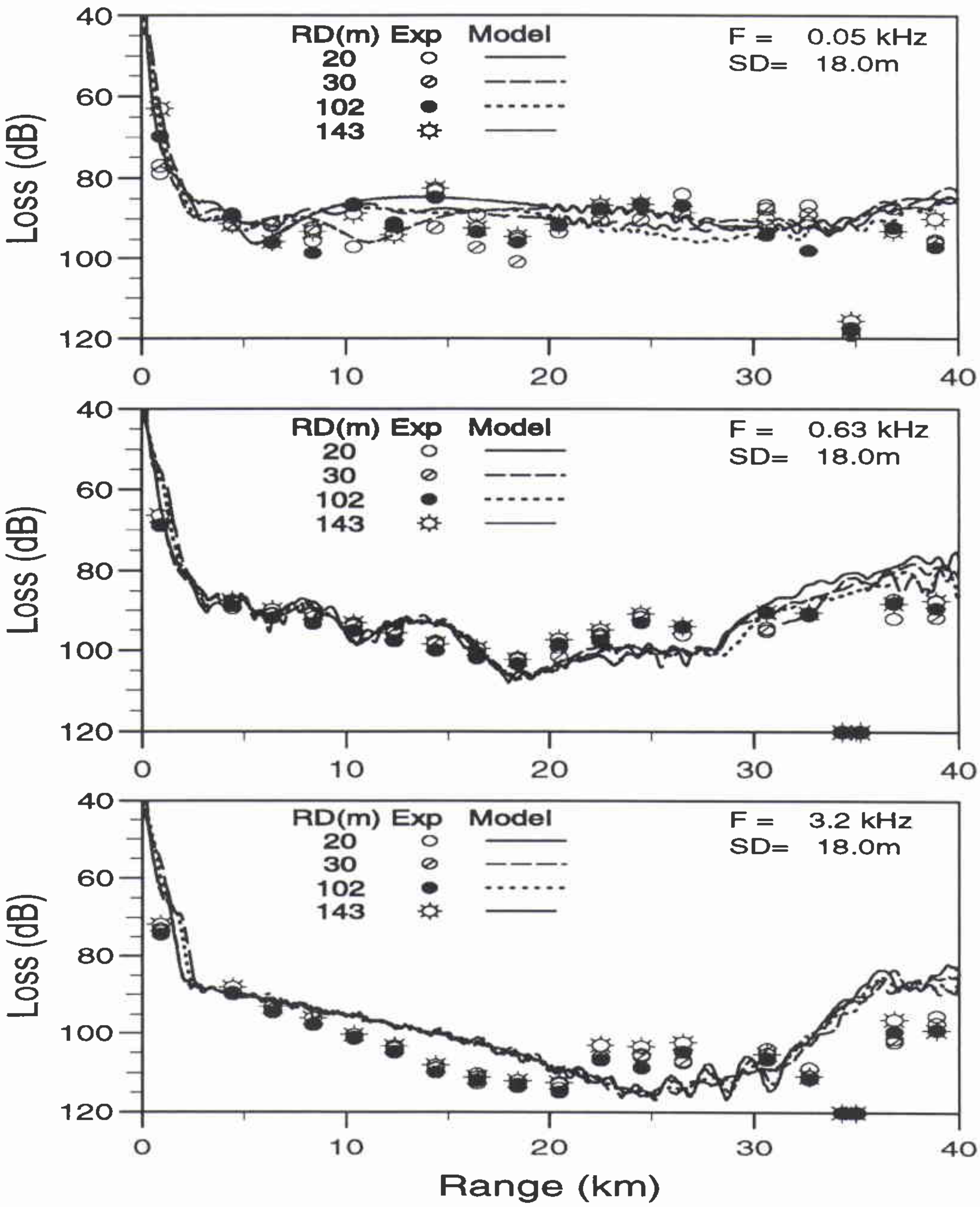

Figure 7 Experimental and model results along track AA-AB.

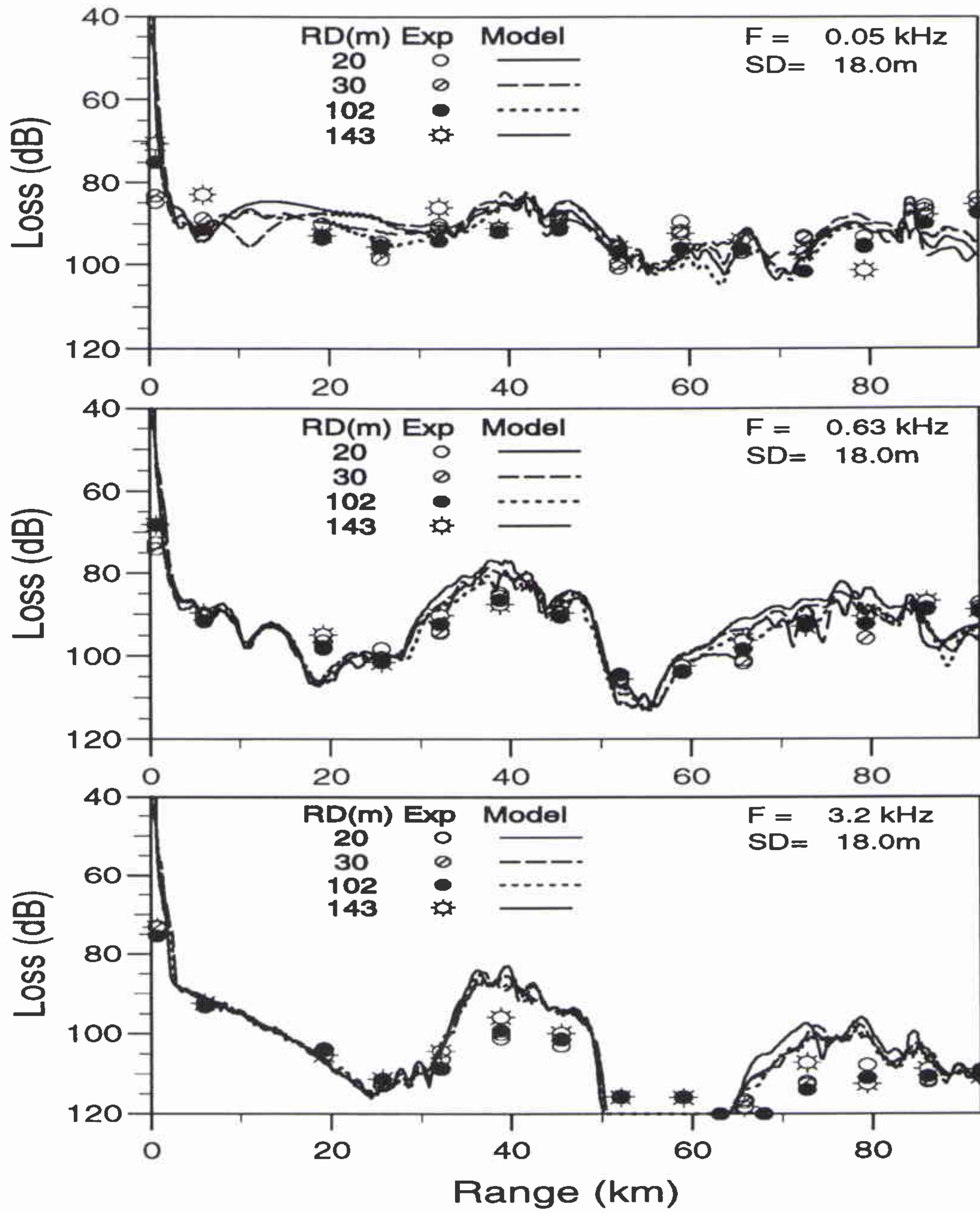

Figure 8 Experimental and model results along track AA-AC.

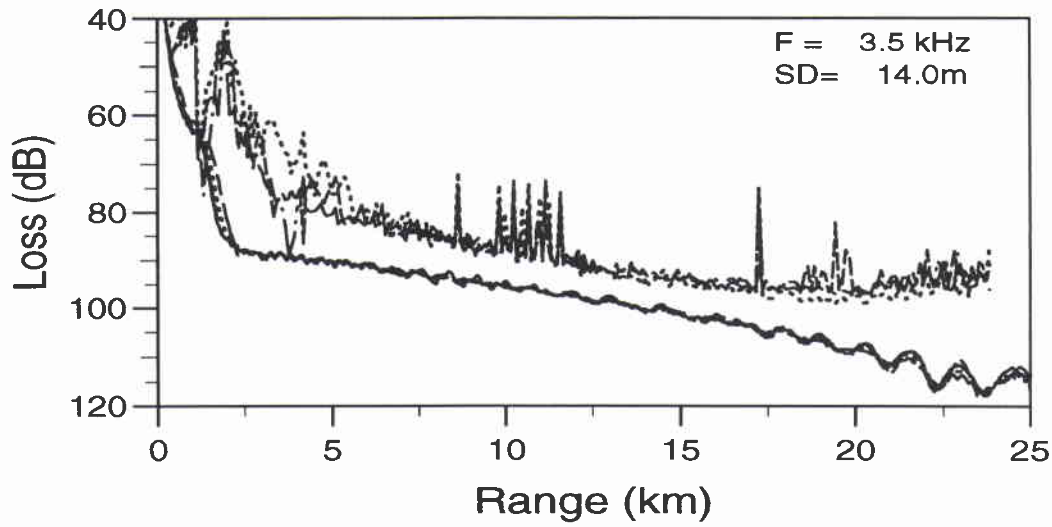

Figure 9 3.5 kHz CW model/data comparison along the track AA-AB. Curves are for receivers at 20, 30, 102, and 143 m. Model results extend to 25 km.

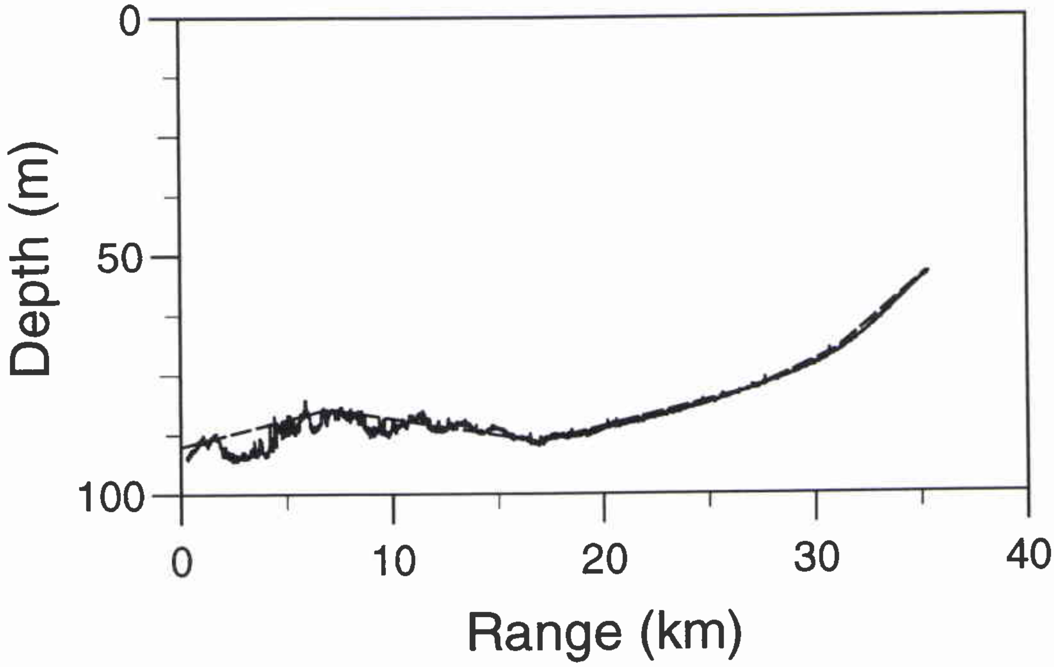

Figure 10 Measured bathymetry along track BB-BC. The broken line represents the approximation used for modelling.

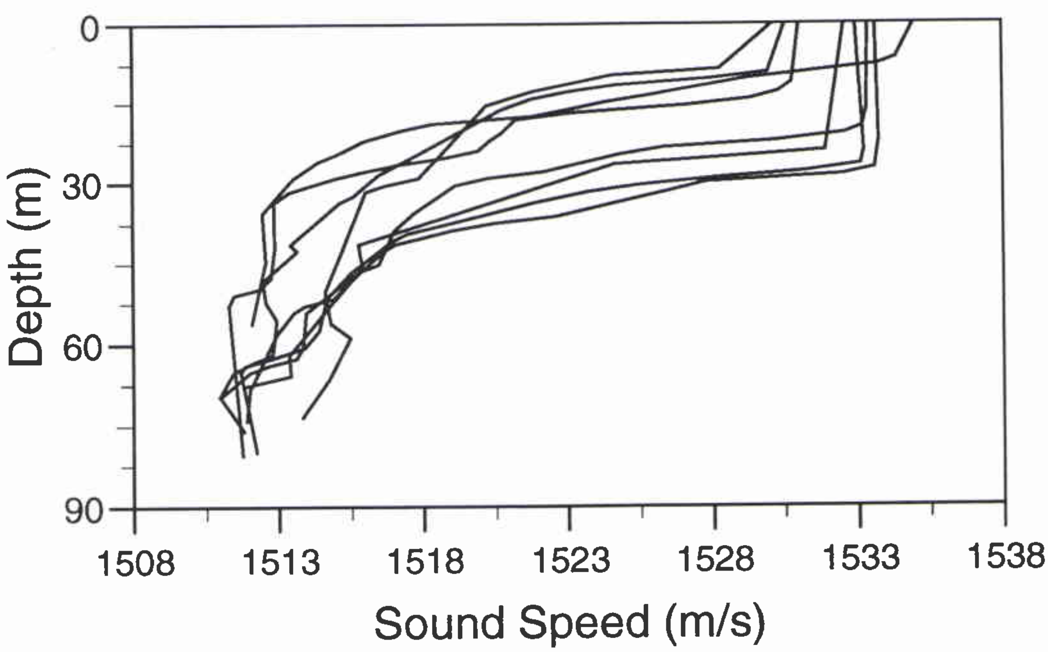

Figure 11 The SVP measured along track BB-BC.

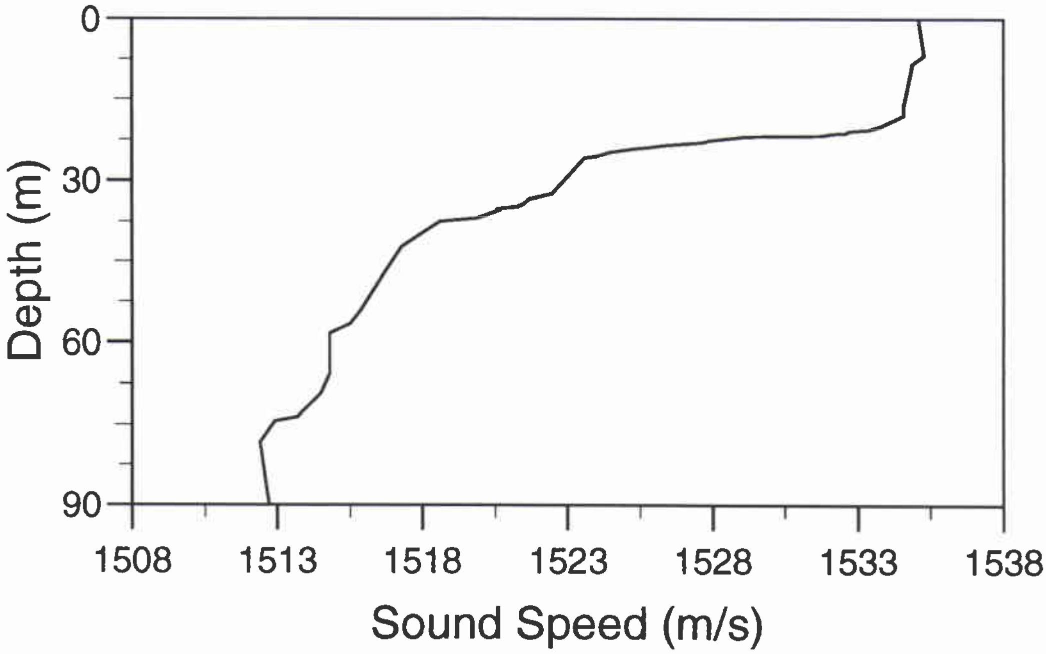

Figure 12 The SVP used to model track BB-BC.

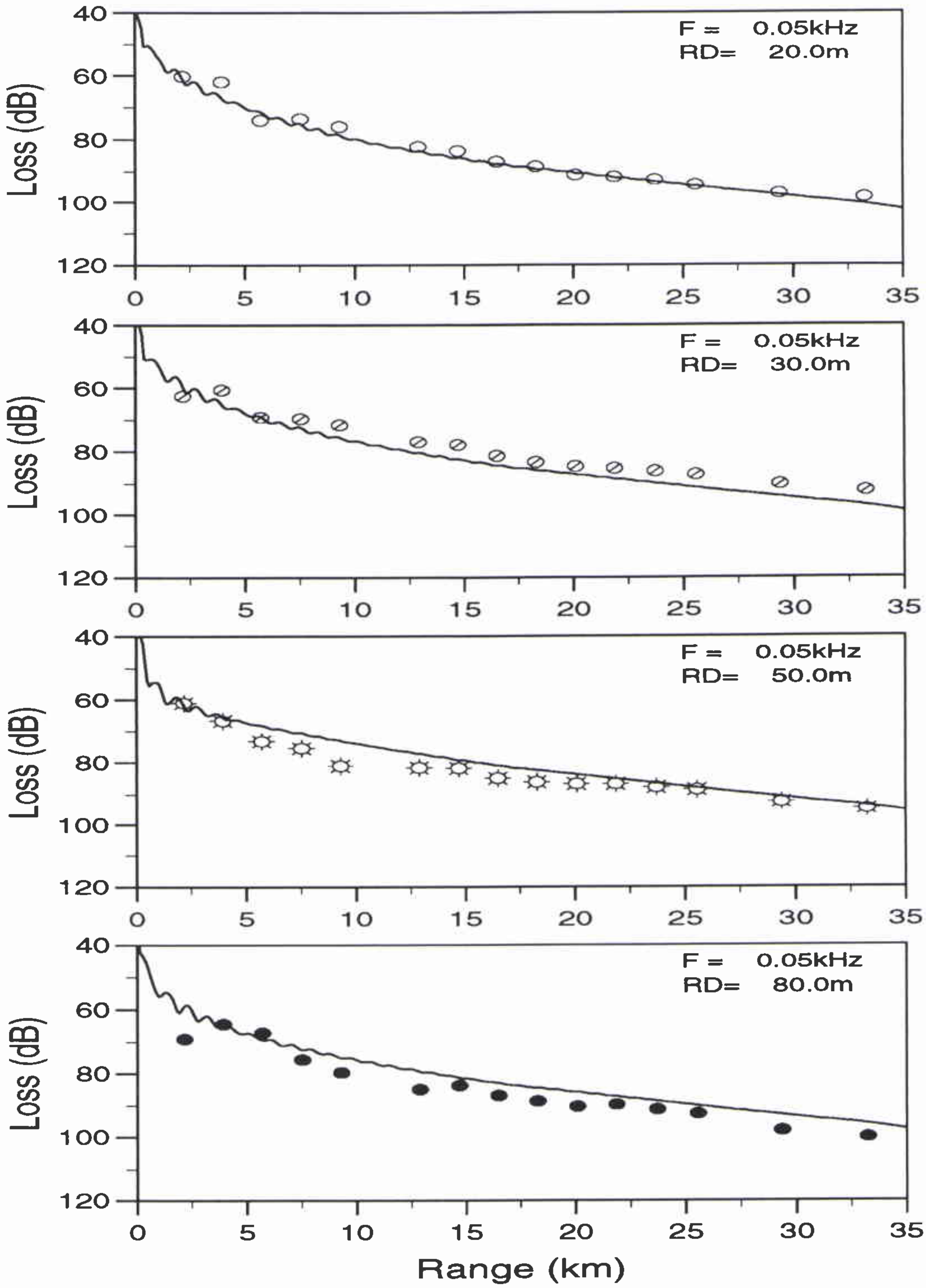

Figure 13 Track BB-BC: Experimental and model results at 50 Hz and source depth 18 m. The continuous line indicates model results.

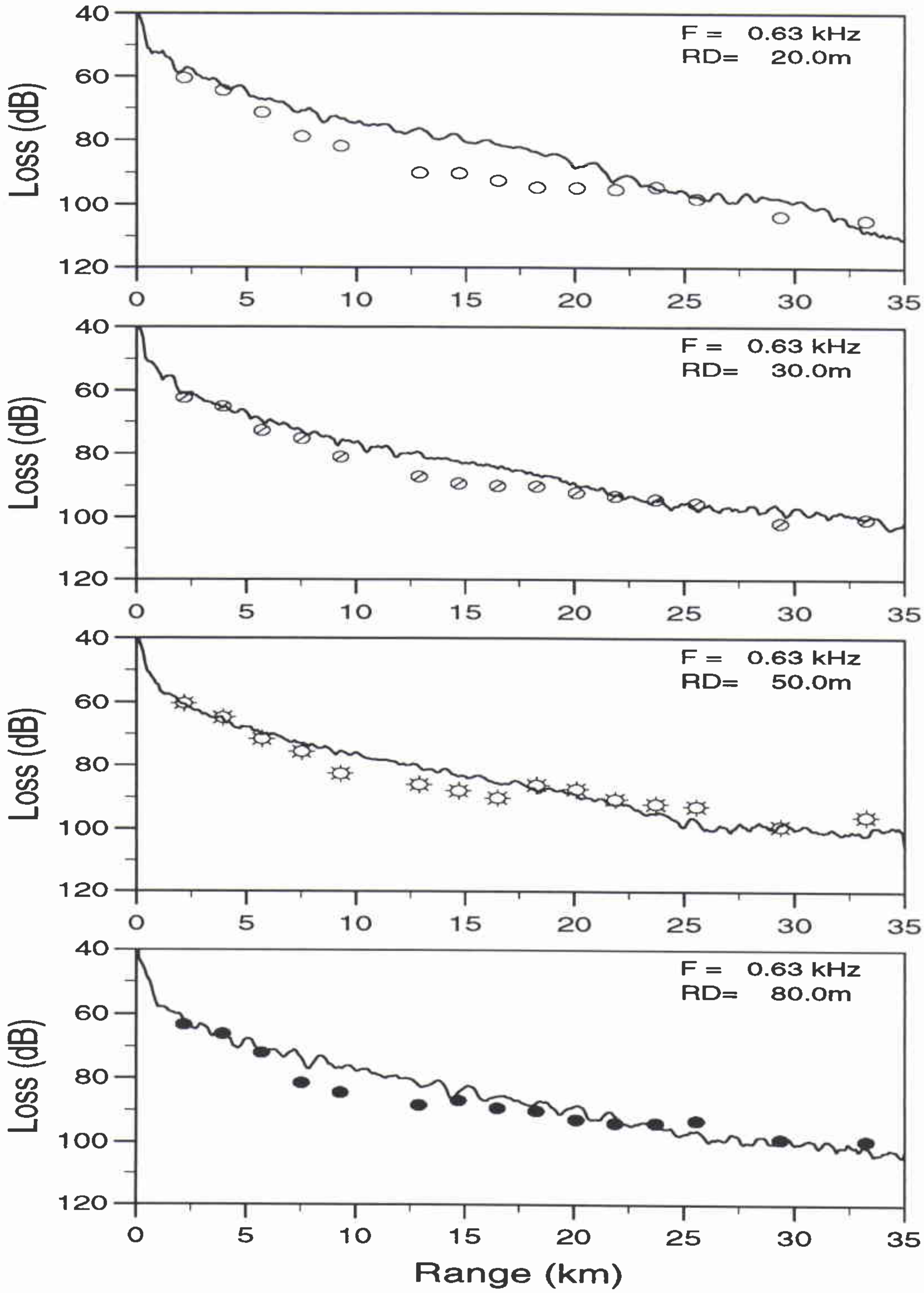

Figure 14 Track BB-BC: Experimental and model results at 630 Hz and source depth 18 m. The continuous line indicates model results.

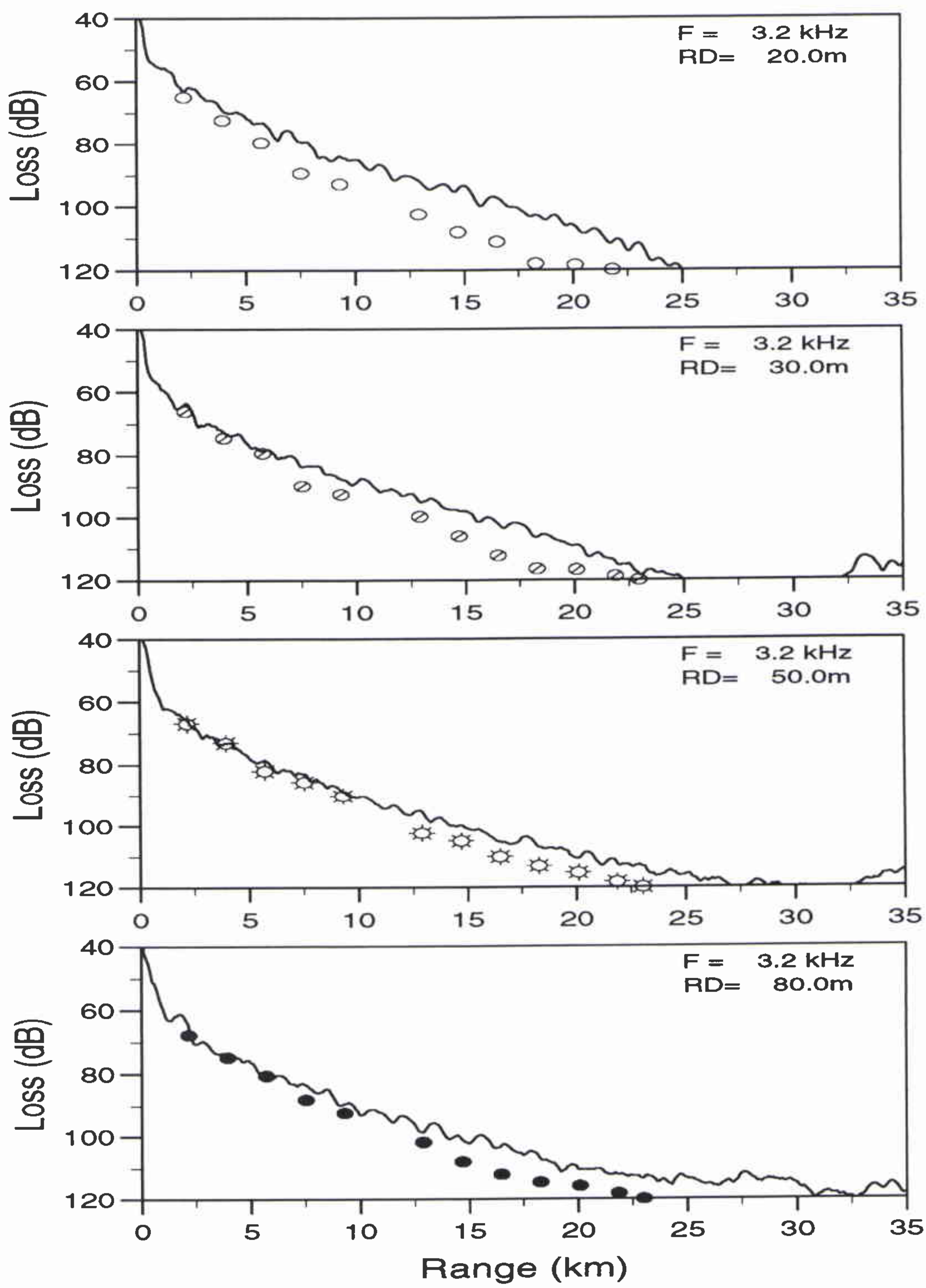

Figure 15 Track BB-BC: Experimental and model results at 3.2 kHz and source depth 18 m. The continuous line indicates model results.

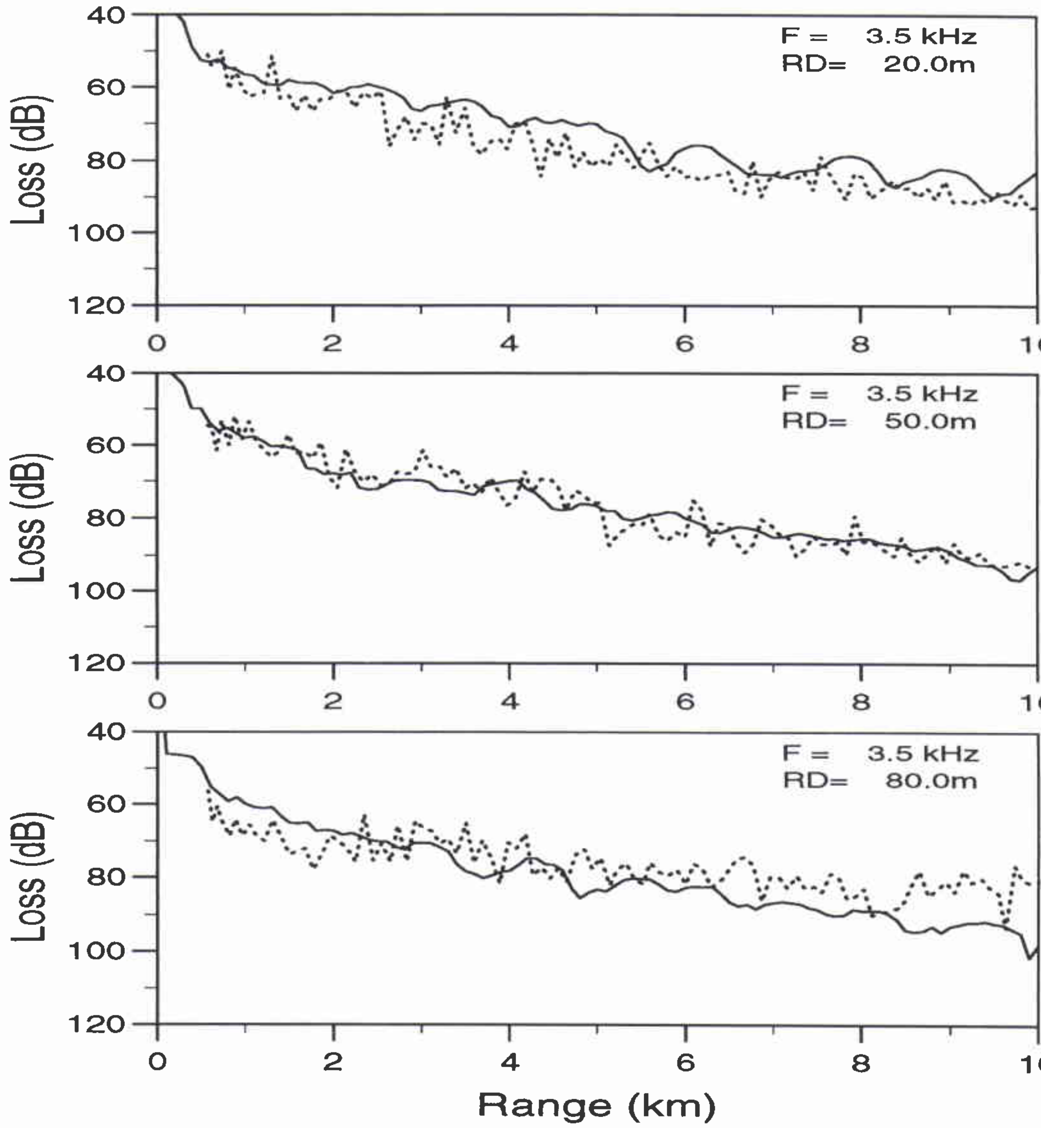

Figure 16 Track BB-BC, 3.5 kHz CW towed source: Experimental and model results at source depth 14 m. The continuous line indicates model results.

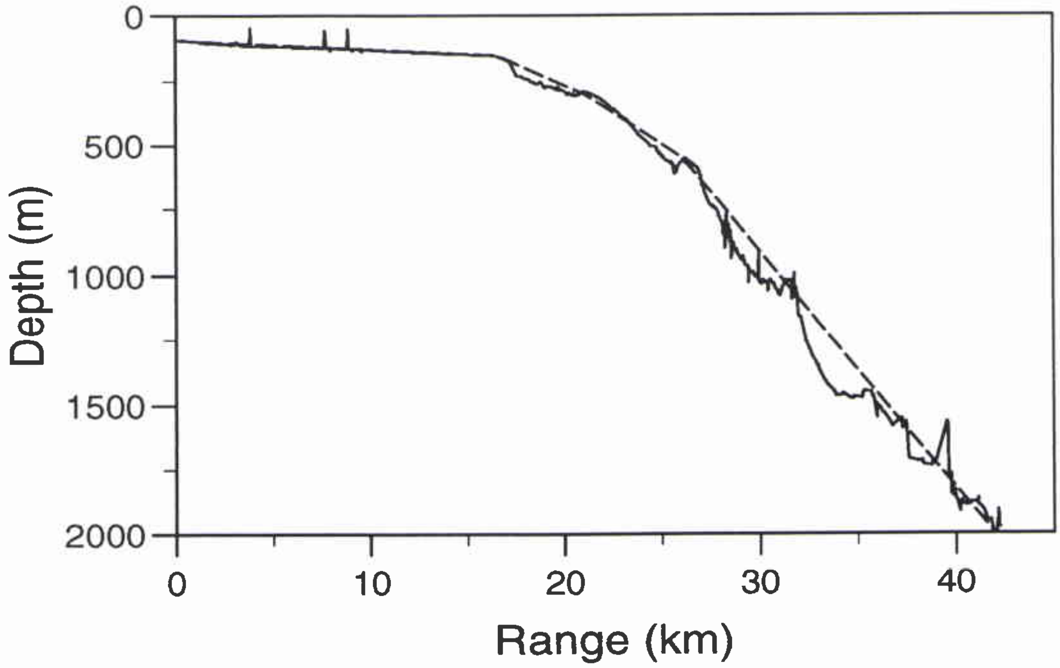

Figure 17 Measured bathymetry along track BB-BD. The broken line represents the approximation used for modelling.

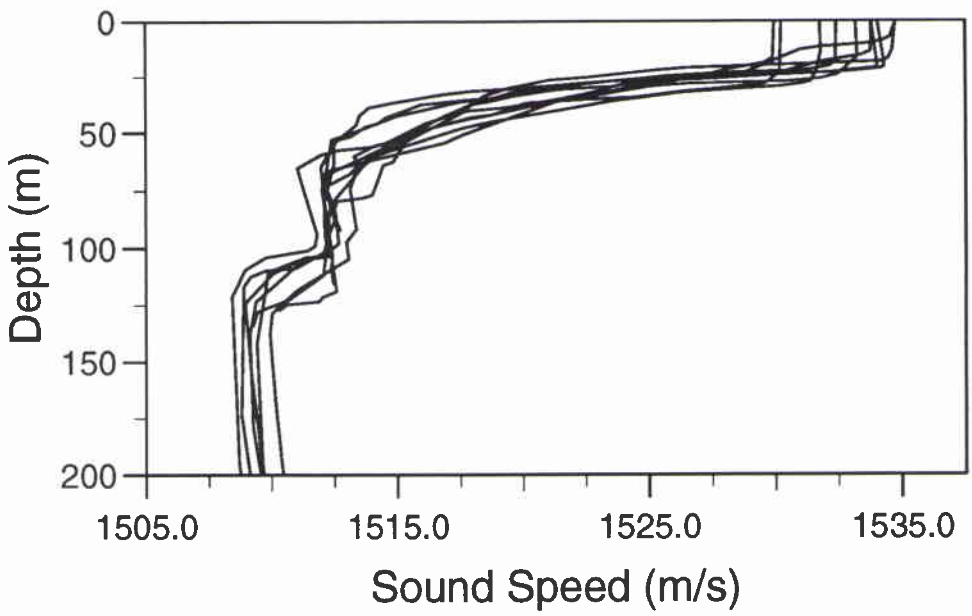

Figure 18 Upper 200 m of the SVP measured along track BB-BD.

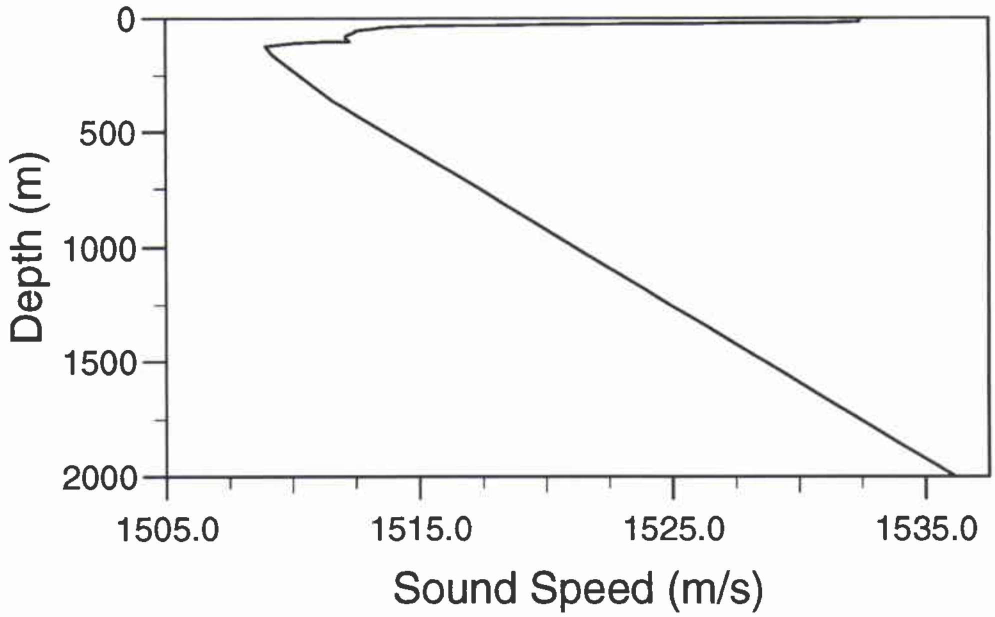

Figure 19 The SVP used for track BB-BD.

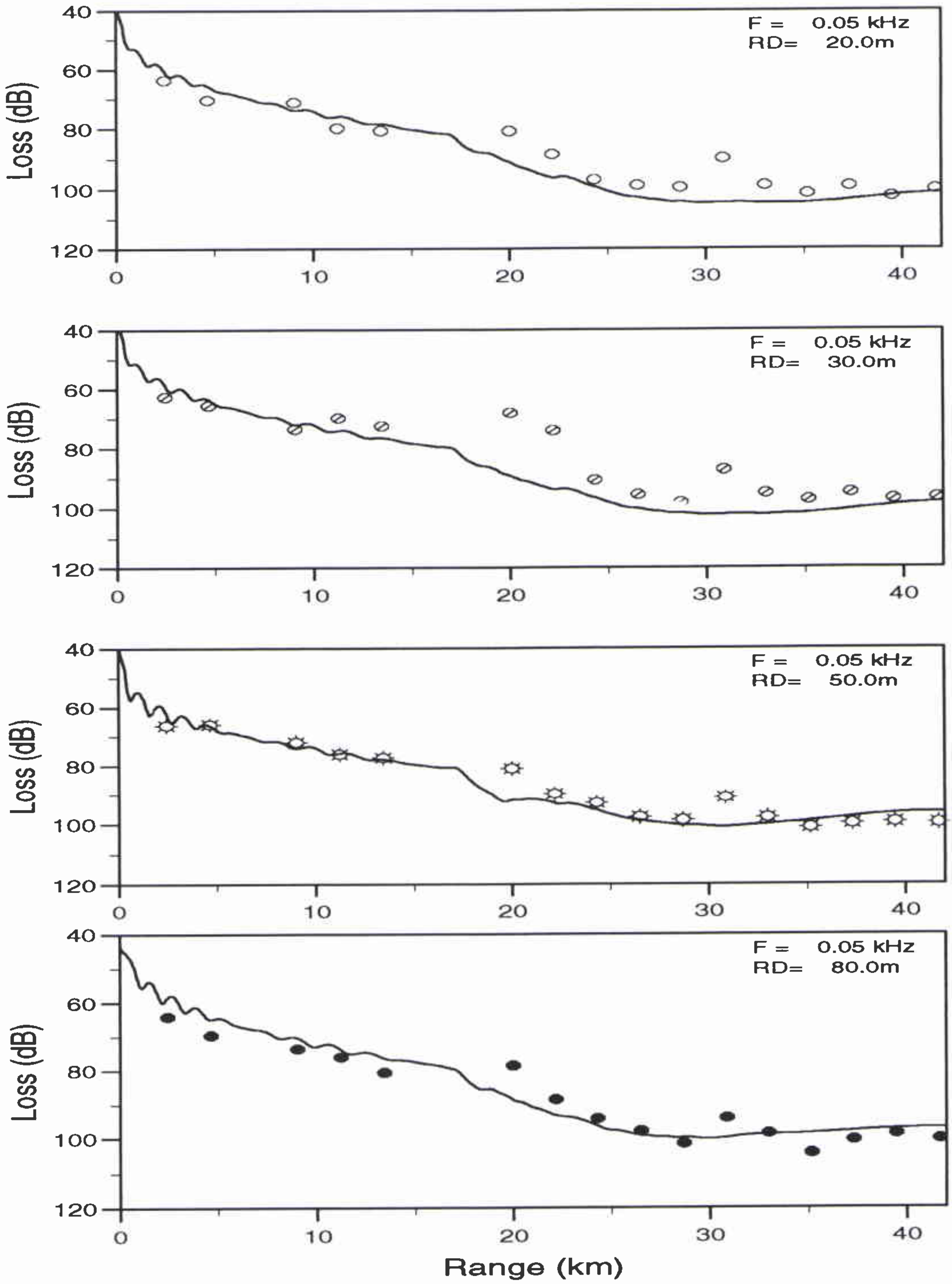

Figure 20 Track BB-BD: Experimental and model results at 50 Hz and source depth 18 m. The continuous line indicates model results.

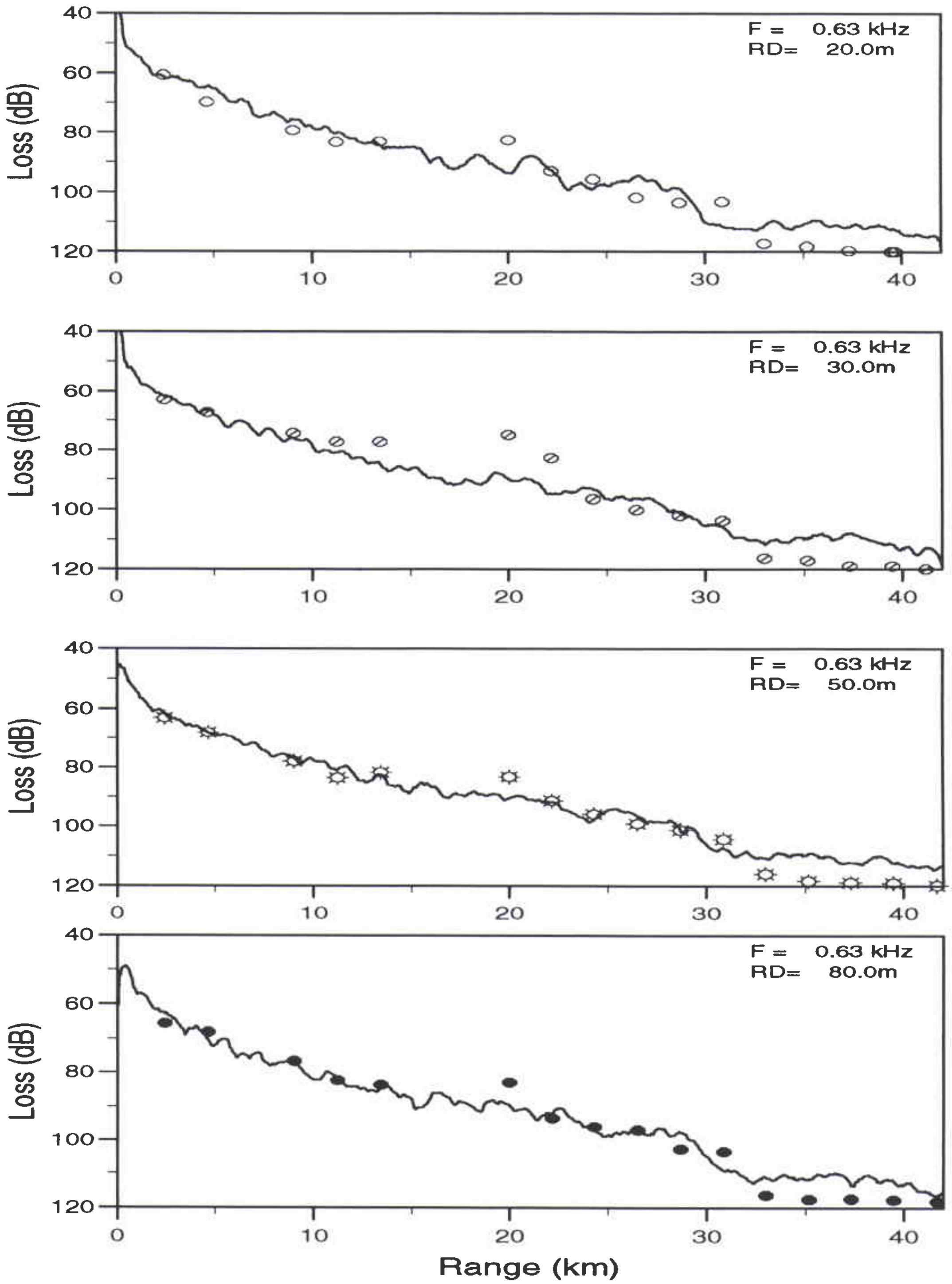

Figure 21 Track BB-BD: Experimental and model results at 630 Hz and source depth 18 m. The continuous line indicates model results.

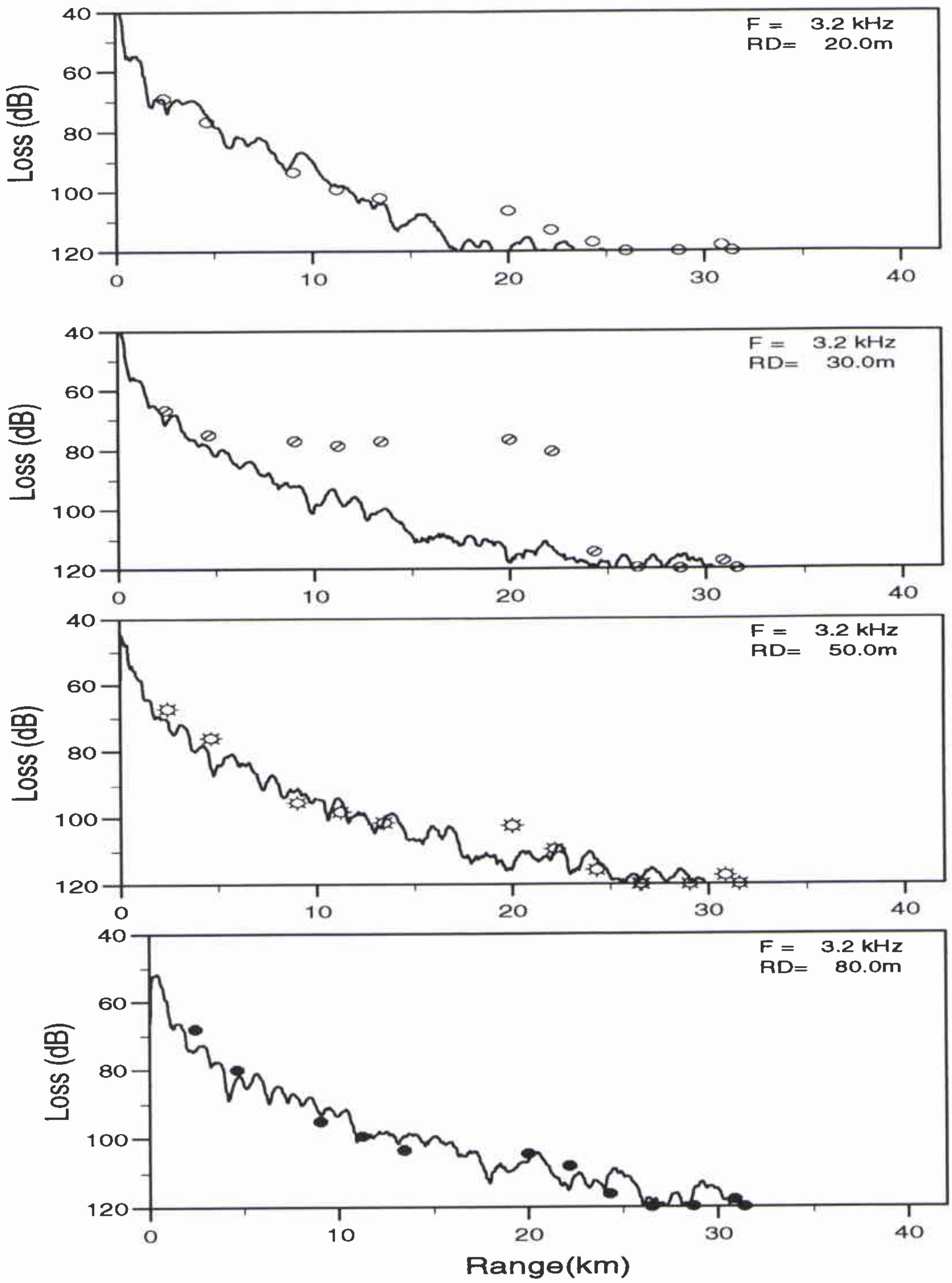

Figure 22 Track BB-BD: Experimental and model results at 3.2 kHz and source depth 18 m. The continuous line indicates model results.

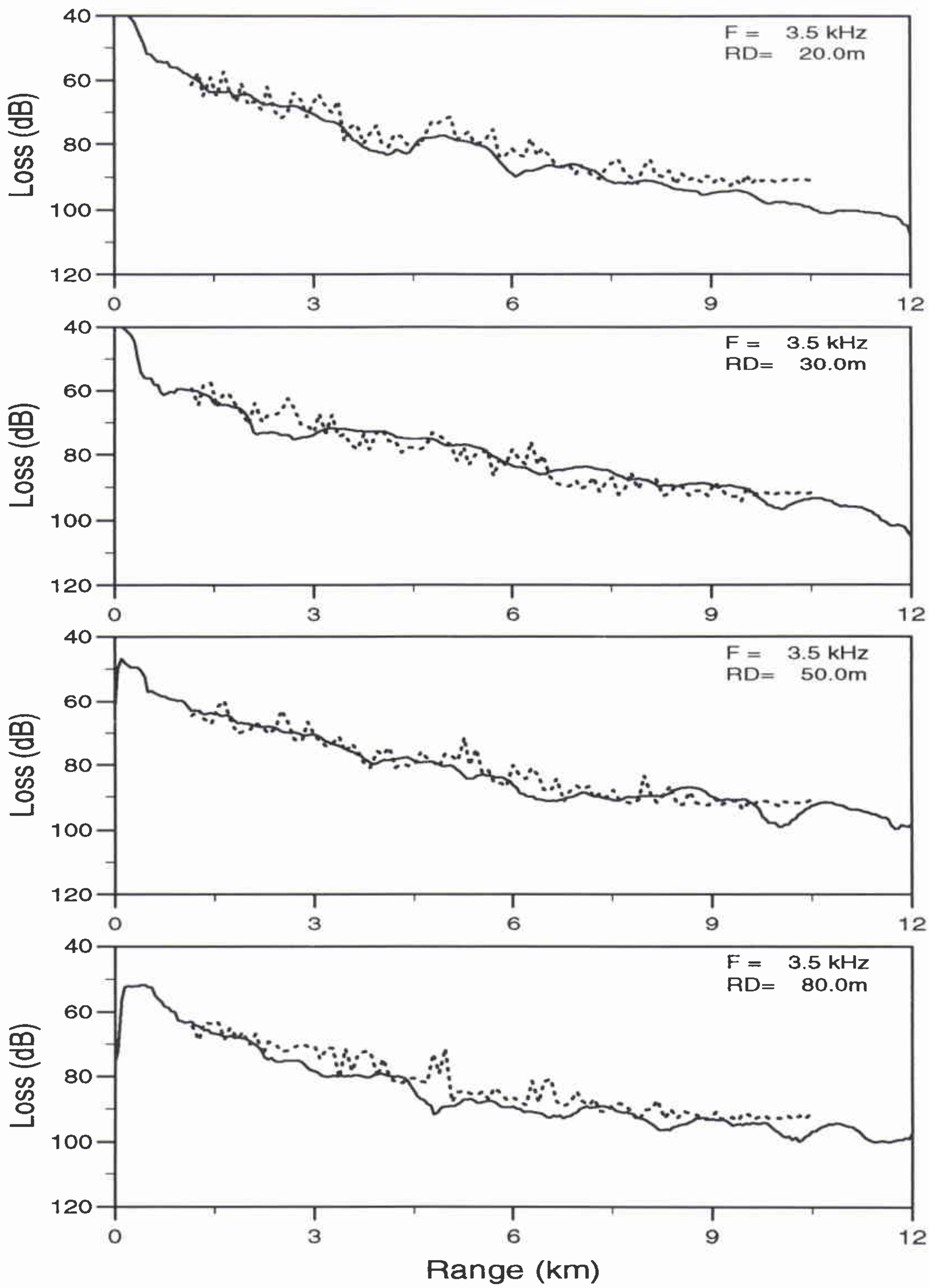

Figure 23 Track BB-BD, 3.5 kHz CW towed source: Experimental and model results at source depth 14 m. The continuous line indicates model results.

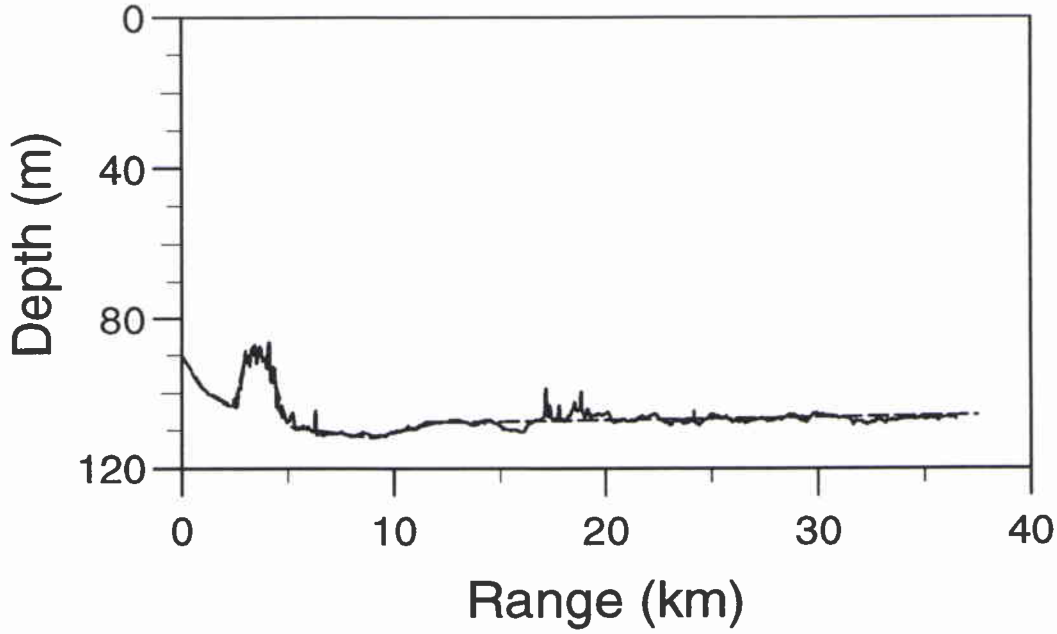

Figure 24 Measured bathymetry along track BB-BE. The broken line represents the approximation used for modelling.

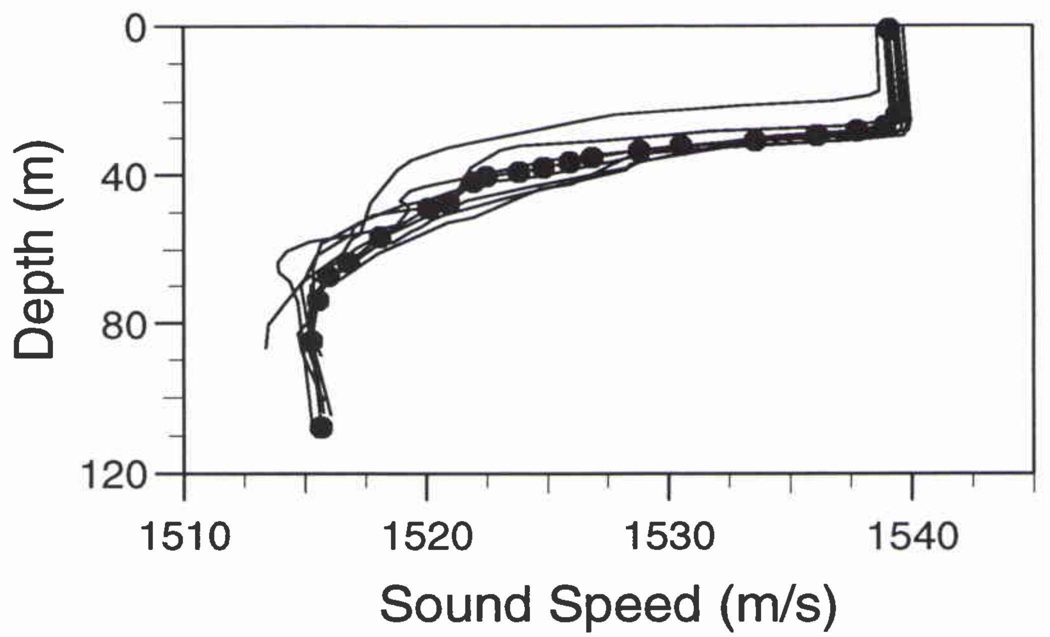

Figure 25 The SVPs measured along track BB-BE. The solid circles identify the SVP used for modelling.

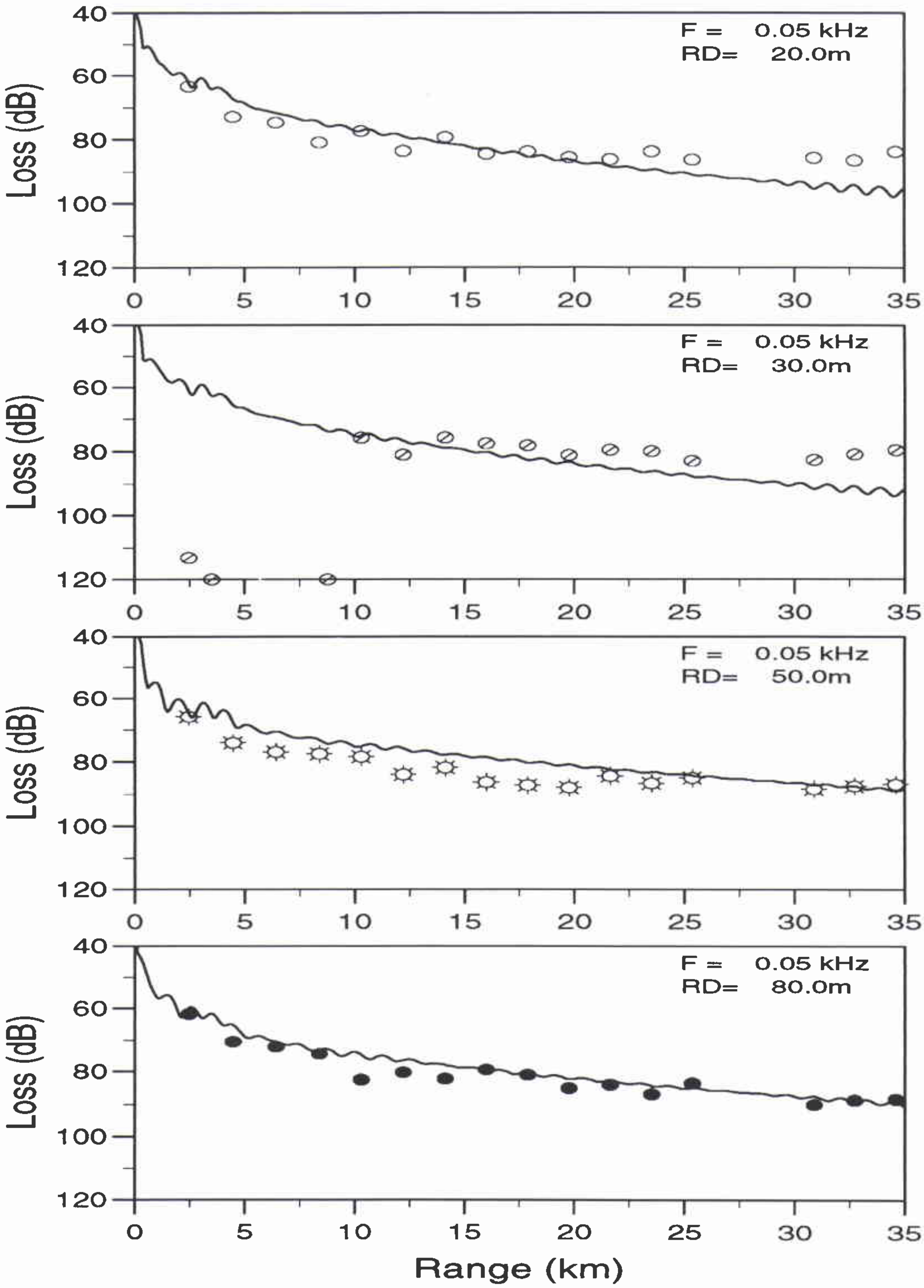

Figure 26 Track BB-BE: Experimental and model results at 50 Hz and source depth 18 m. The continuous line indicates model results.

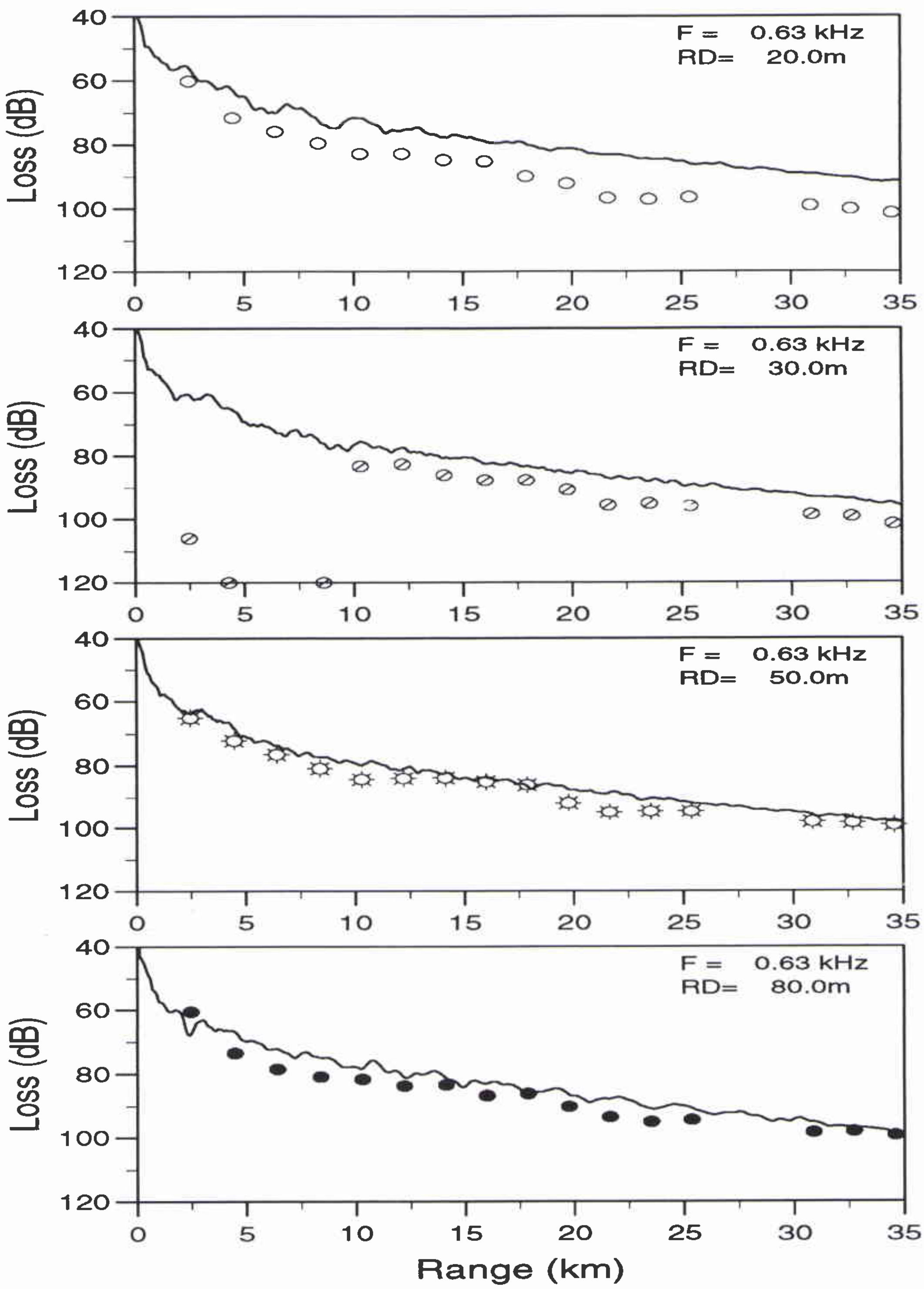

Figure 27 Track BB-BE: Experimental and model results at 630 Hz and source depth 18 m. The continuous line indicates model results.

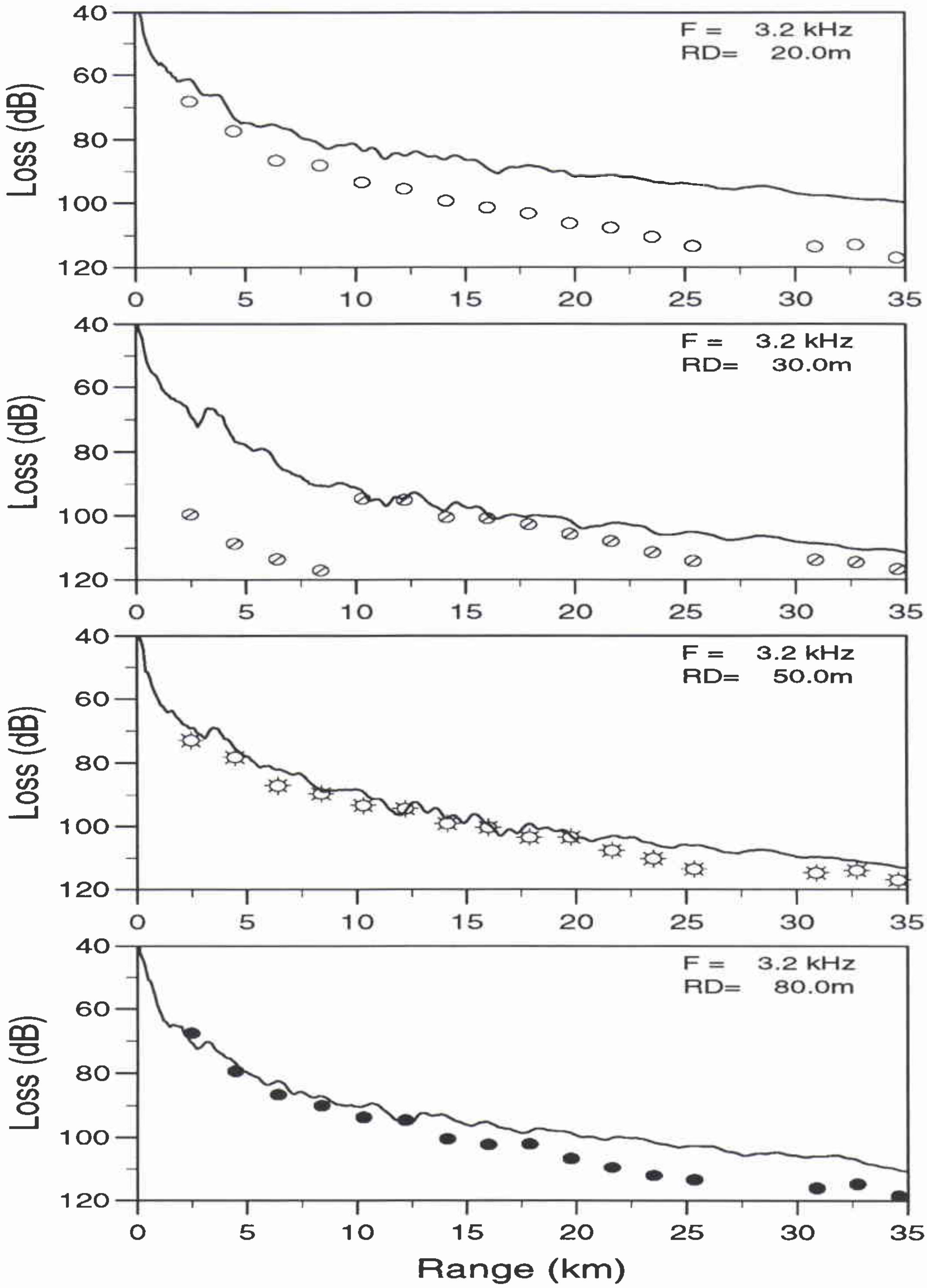

Figure 28 Track BB-BE: Experimental and model results at 3.2 kHz and source depth 18 m. The continuous line indicates model results.

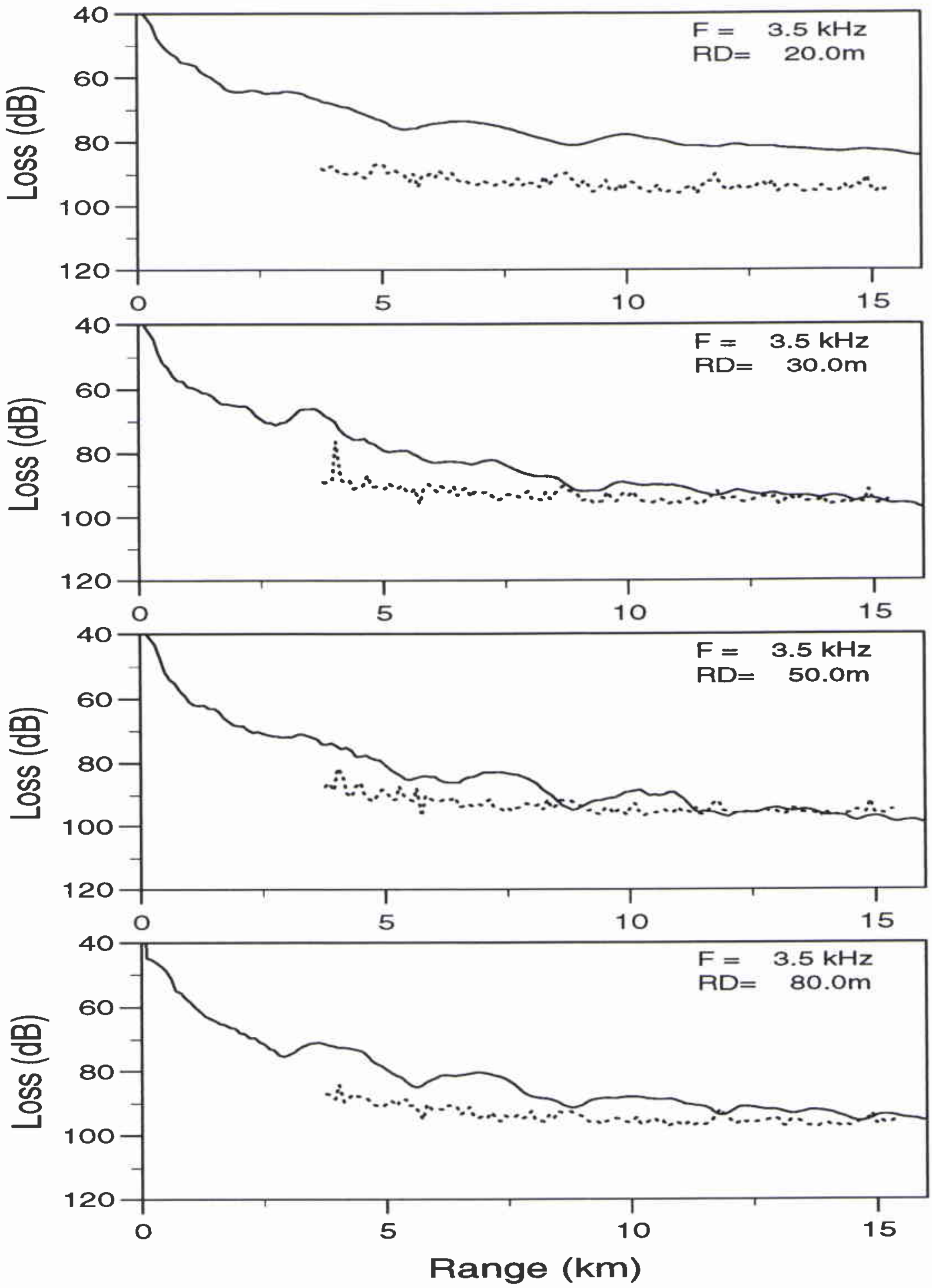

Figure 29 Track BB-BE, 3.5k Hz CW towed source: Experimental and model results at source depth 14 m. The continuous line indicates model results.

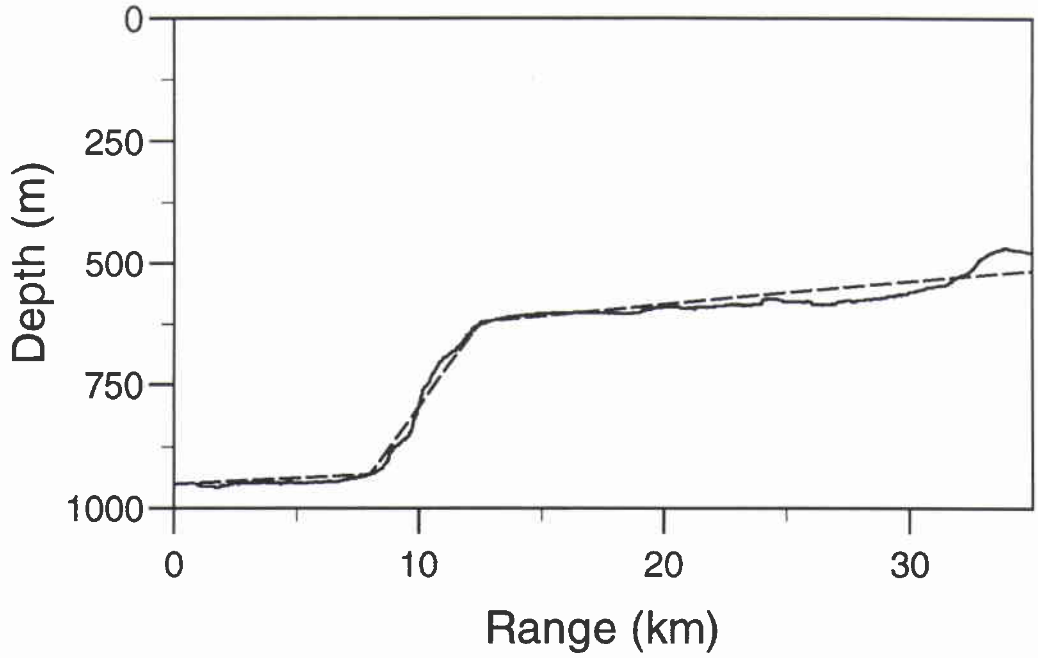

Figure 30 Measured bathymetry along track CC-CD. The broken line represents the approximation used for modelling.

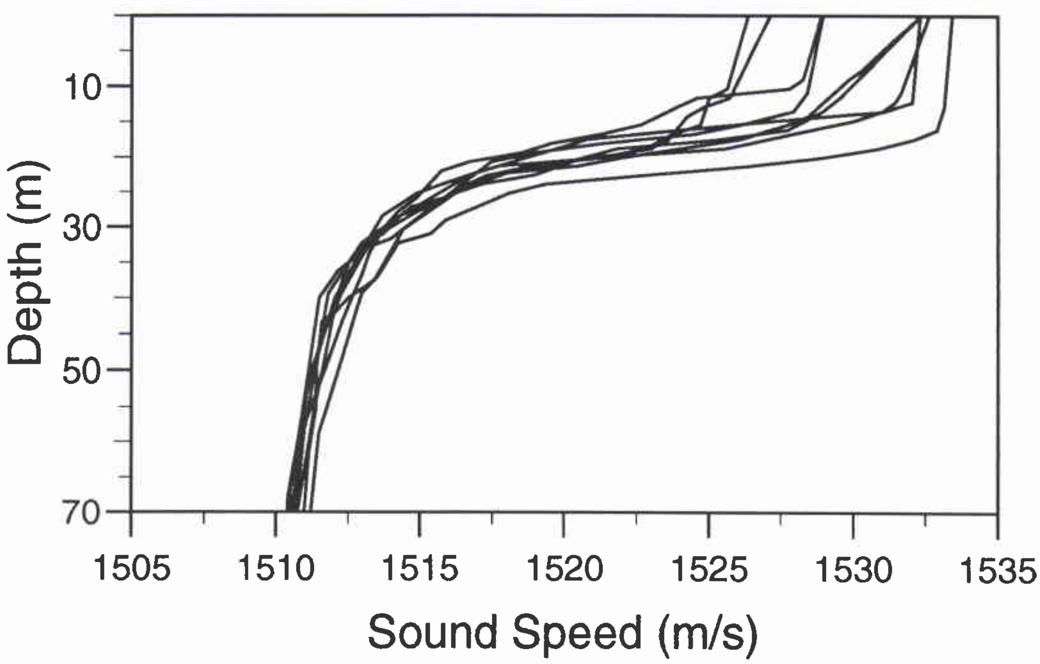

Figure 31 Upper 70 m of the SVPs measured along track CC-CD

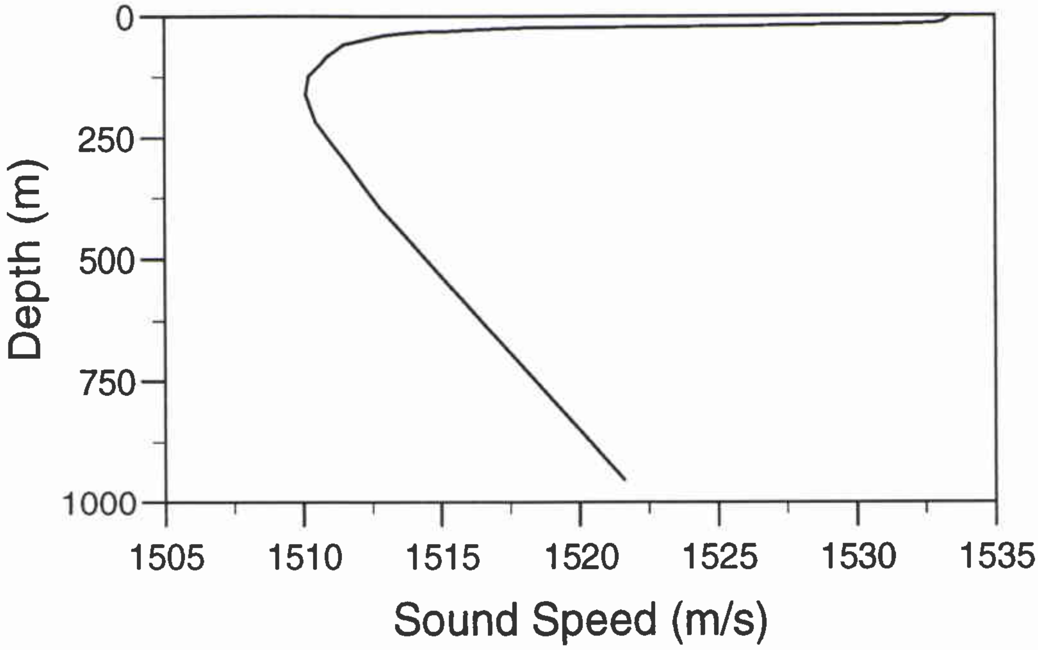

Figure 32 The SVP used to model track CC-CD.

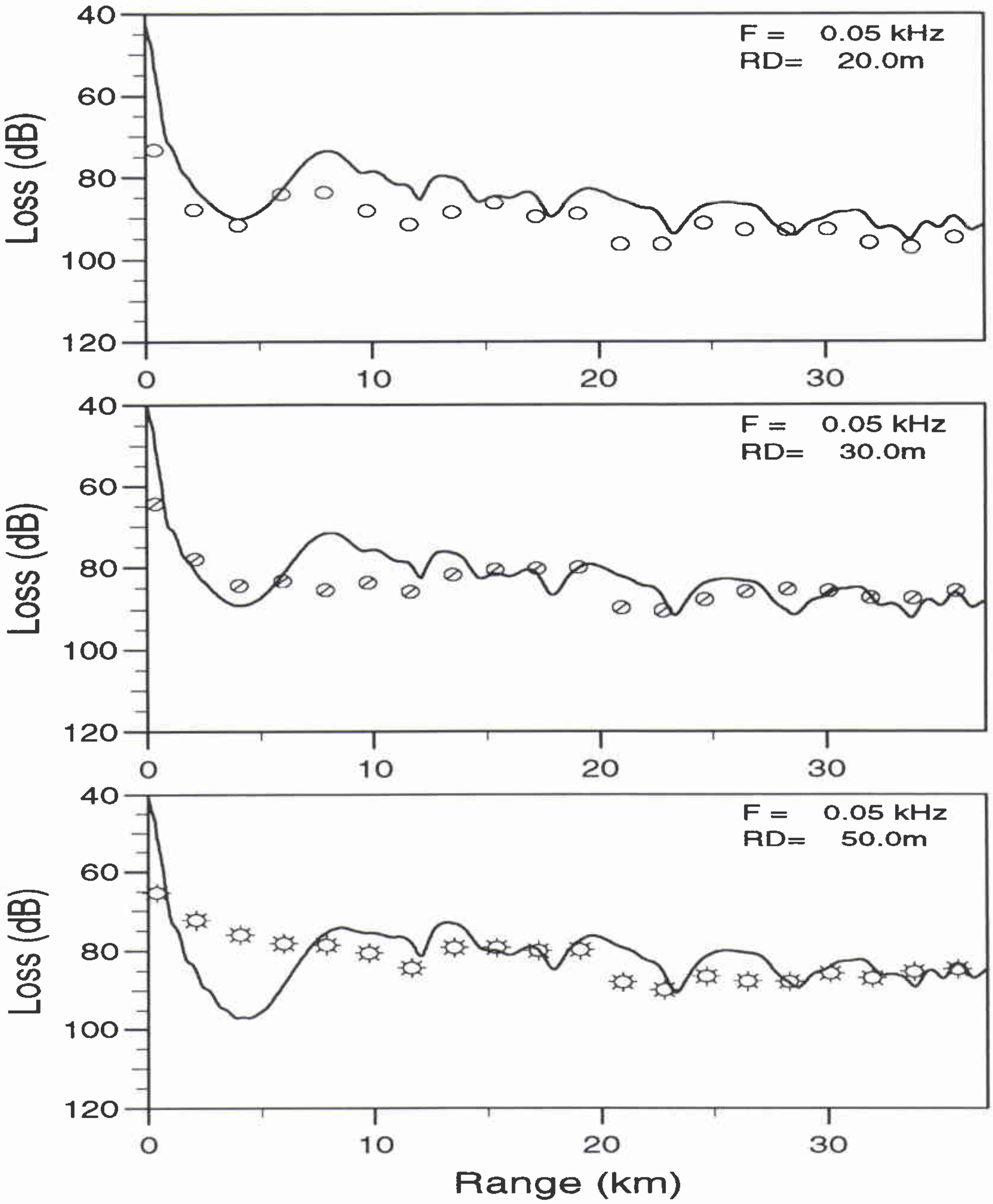

Figure 33 Track CC-CD: Experimental and model results at 50 Hz and source depth 18 m. The continuous line indicates C-SNAP results.

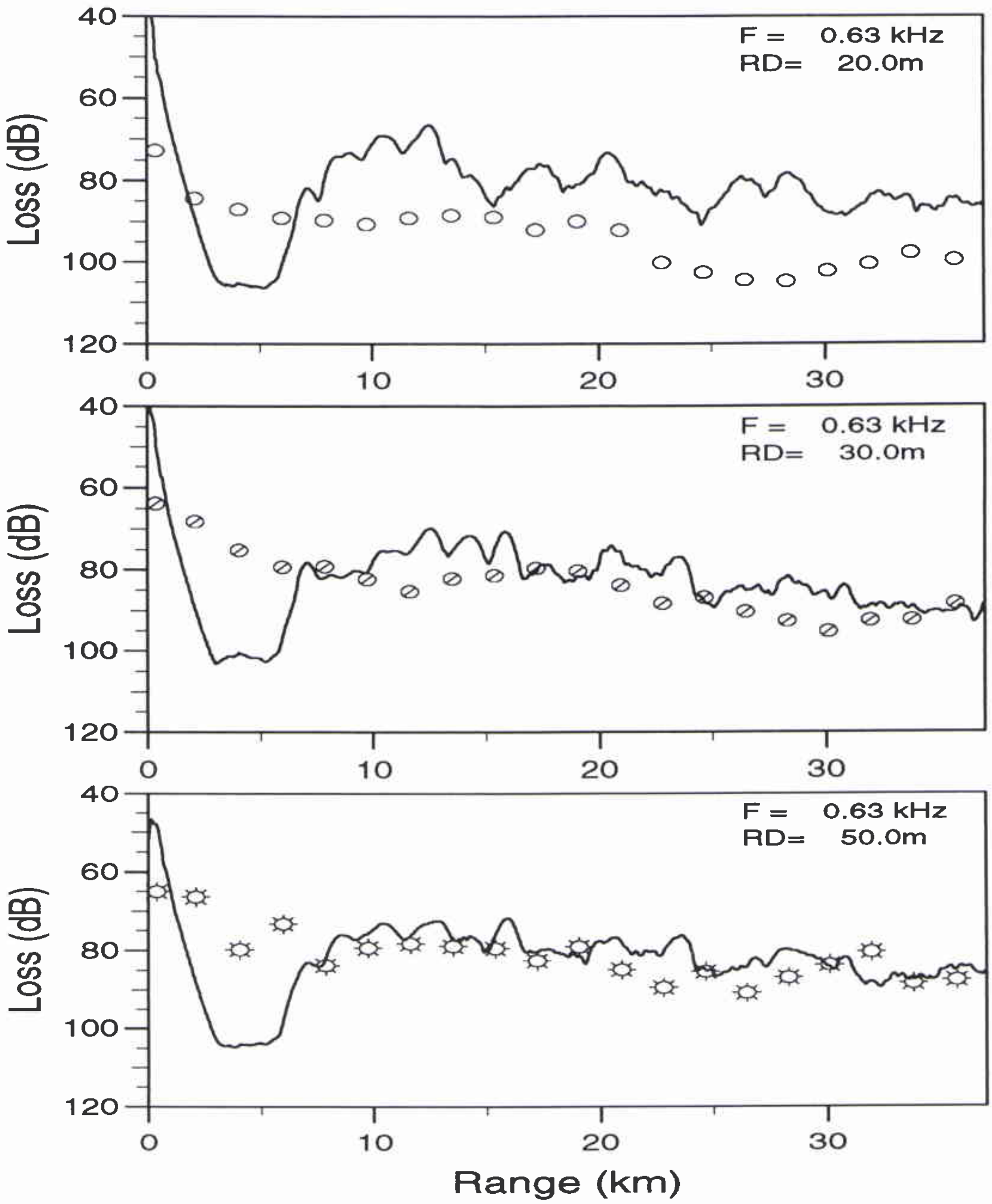

Figure 34 Track CC-CD: Experimental and model results at 630 Hz and source depth 18 m. The continuous line indicates C-SNAP results.

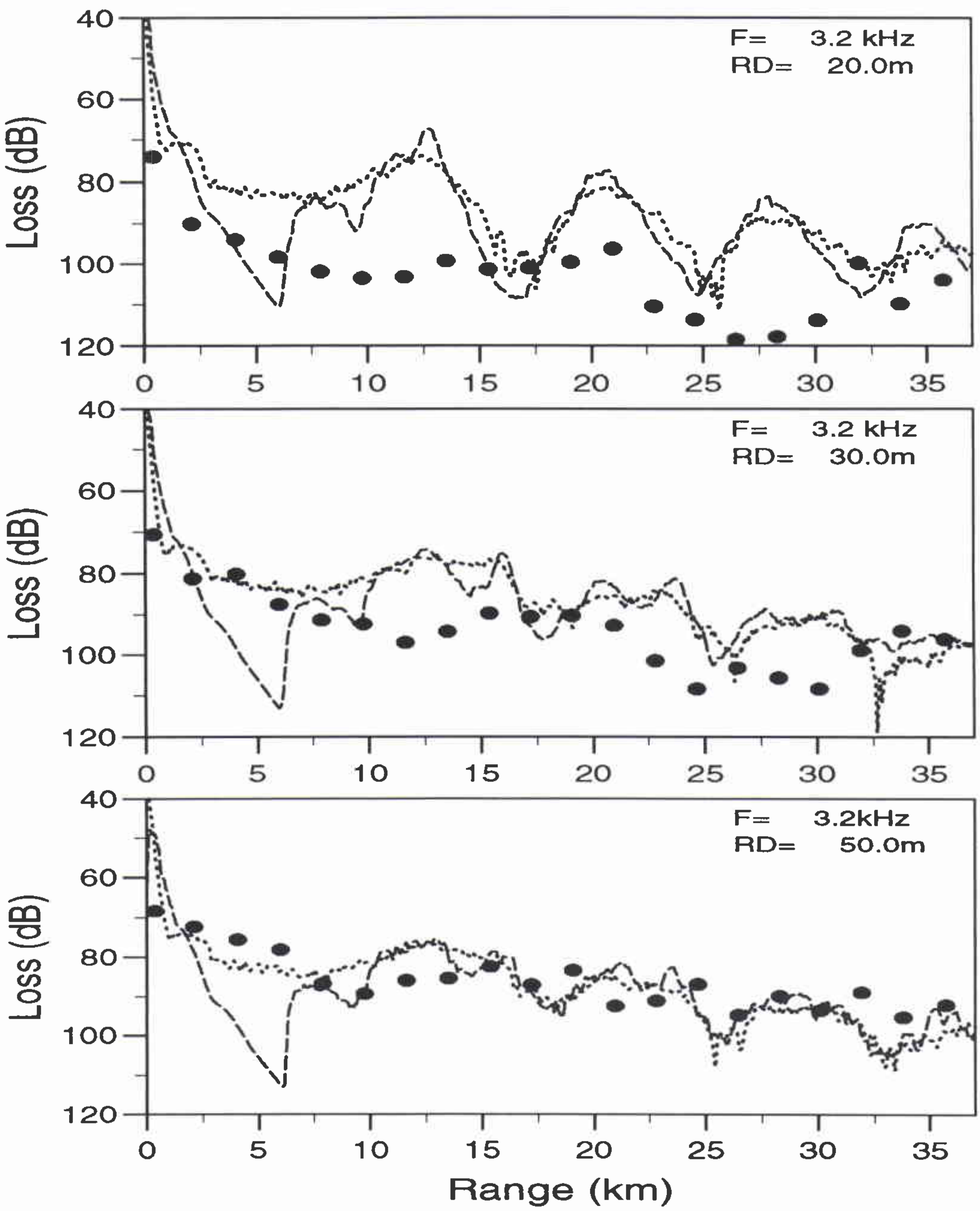

Figure 35 Track CC-CD: Experimental (solid circles), MOCASSIN (dotted line) and C-SNAP (dashed line) results at 3.2 kHz and source depth 18 m.

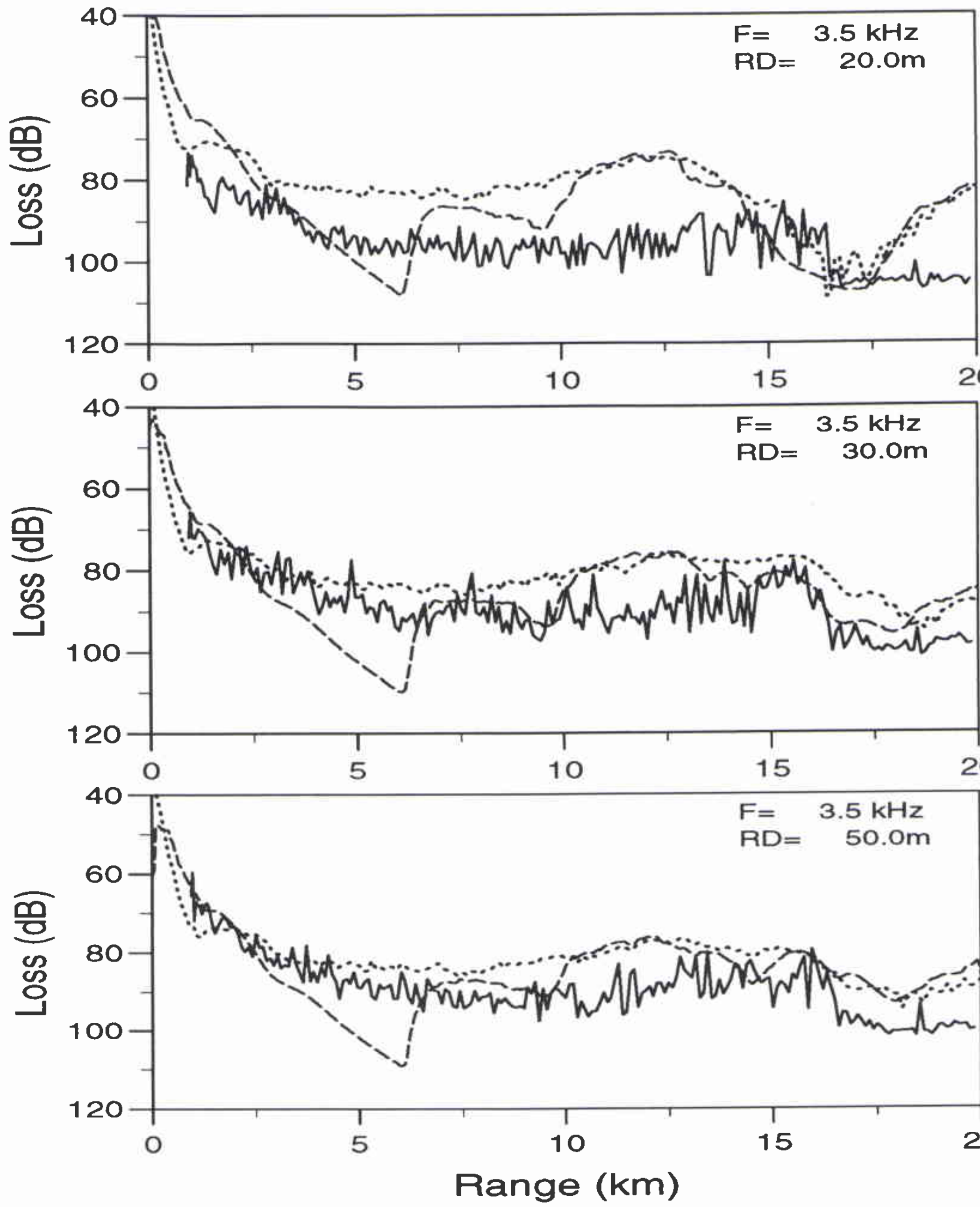

Figure 36 Track CC-CD, 3.5 kHz CW towed source: Experimental (continuous line), MOCASSIN (dotted line) and C-SNAP (dashed line) results for source depth at 14 m.

Report no. changed (Mar 2006): SM-334-UU

Document Data Sheet

NATO UNCLASSIFIED

Security Classification		Project No.
NATO UNCLASSIFIED		011-1
Document Serial No.	**Date of Issue**	**Total Pages**
SM-334	July 1997	51 pp.

Author(s)

Ferla, C.M., Jensen, F.B., Akal, T.

Title

Rapid Response, September 1996: Modelling of broadband transmission loss along selected tracks in the Strait of Sicily.

Abstract

A large set of experimental acoustic broadband data in the 50-3200 Hz band is analyzed with the objective of deriving average geoacoustic models for three sites in the Strait of Sicily. The experimental data were obtained by using explosive charges as sound sources and a vertical array of hydrophones as the receiver. CW data at 3.5 kHz is also analyzed. The acoustic data is complemented by a set of oceanographic data and bathymetry measurements. The model/data comparison results from each site, obtained after selecting appropriate average geoacoustic models, are presented as propagation losses over range for fixed sources and receiver depths. We also indicate the propagation loss models chosen for the prediction and their limits. The results demonstrate the strong effect of bottom properties on acoustic propagation in this area, the limited amount of the existing information available for model prediction, and the difficulty in automating model selection and validating model results.

Keywords

geoacoustic model – model/data comparison – predictability – Strait of Sicily – Maltese Channel – Sicilian channel

Issuing Organization

North Atlantic Treaty Organization
SACLANT Undersea Research Centre
Viale San Bartolomeo 400, 19138 La Spezia, Italy

[From N. America: SACLANTCEN (New York) APO AE 09613-5000]

Tel: +39 (0)187 540 111
Fax:+39 (0)187 524 600

E-mail: library@saclantc.nato.int

NATO UNCLASSIFIED

Initial Distribution for SM 334

Scientific Committee of National Representatives		***National Liaison Officers***	
SCNR Belgium	1	NLO Canada	1
SCNR Canada	1	NLO Denmark	1
SCNR Denmark	1	NLO Germany	1
SCNR Germany	1	NLO Italy	1
SCNR Greece	1	NLO Netherlands	1
SCNR Italy	1	NLO Spain	1
SCNR Netherlands	1	NLO UK	3
SCNR Norway	1	NLO USA	4
SCNR Portugal	1		
SCNR Spain	1	Sub-total	30
SCNR Turkey	1	SACLANTCEN library	21
SCNR UK	1		
SCNR USA	2	**Total**	51
French Delegate	1		
SECGEN Rep. SCNR	1		
NAMILCOM Rep. SCNR	1		