Til Tero

Ambient Noise in the Sea off Kap York, Melville Bay North West Greenland

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Report 82.53

AMBIENT NOISE IN THE SEA OFF KAP YORK, MELVILLE BAY NORTH WEST GREENLAND

Greenland Fisheries Investigations
Tagensvej 135, 1.
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Denmark

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Lars Thiele

FOREWORD

This investigation has been carried out as part of the assessment of the impact on the environment caused by the "Arctic Pilot Project", a proposal to ship liquefied natural gas in ice-breaking carriers through Baffin Bay and Davis Strait.

The measurements, the signal analysis, and the reporting have been performed by Ødegaard & Danneskiold-Samsøe.

The work has been financed by The Greenland Fisheries Investigations.

Special thanks should be expressed to the many Greenlanders, who helped during the measurements and without whose help this investigation would not have been possible.

CONTENTS

SUMMARY

This report describes measurements of ambient underwater noise from the ice off Kap York, North Greenland, carried out in the winter of 1982. The measurements were undertaken to evaluate the possible impact of the ice-breaking LNG-tankers planned by the "Arctic Pilot Project" on the natural underwater noise in these waters.

The measurements were carried out at three locations each with different ice conditions, and recordings were made at intervals over a period of 24 hours at each location.

The tape recordings were later analysed in the laboratory to give the statistical distribution of the underwater noise level.

The results of the measurements and the analysis show that the underwater noise consists partly of a steady broadband noise and partly of loud pulses probably caused by movements of icebergs.

The average noise level in this investigation expressed as the median level (level exceeded 50% of the time) is found to be 10 to 20 dB lower than previously measured in the summer at Baffin Bay, as published by Leggat and Merklinger, Ref. (1). However, the measured ambient noise levels are of the same order of magnitude as the levels reported from other underwater noise measurements made in arctic waters.

1. INTRODUCTION

In connection with the transportation of liquefied natural gas (LNG) in large icebreaking tankers as planned by the Canadian "Arctic Pilot Project", concern has been raised that the underwater noise from the propellers will influence the acoustic environment in the sea, on which especially the marine mammals are dependent. The tankers are planned to be sailing from Melville Island through Lancaster Sound, Baffin Bay and Davis Strait to a harbour in the South of Canada or in Europe, see Figure 1. On this route the LNG-tankers will pass areas which have never before been used for traffic like this.

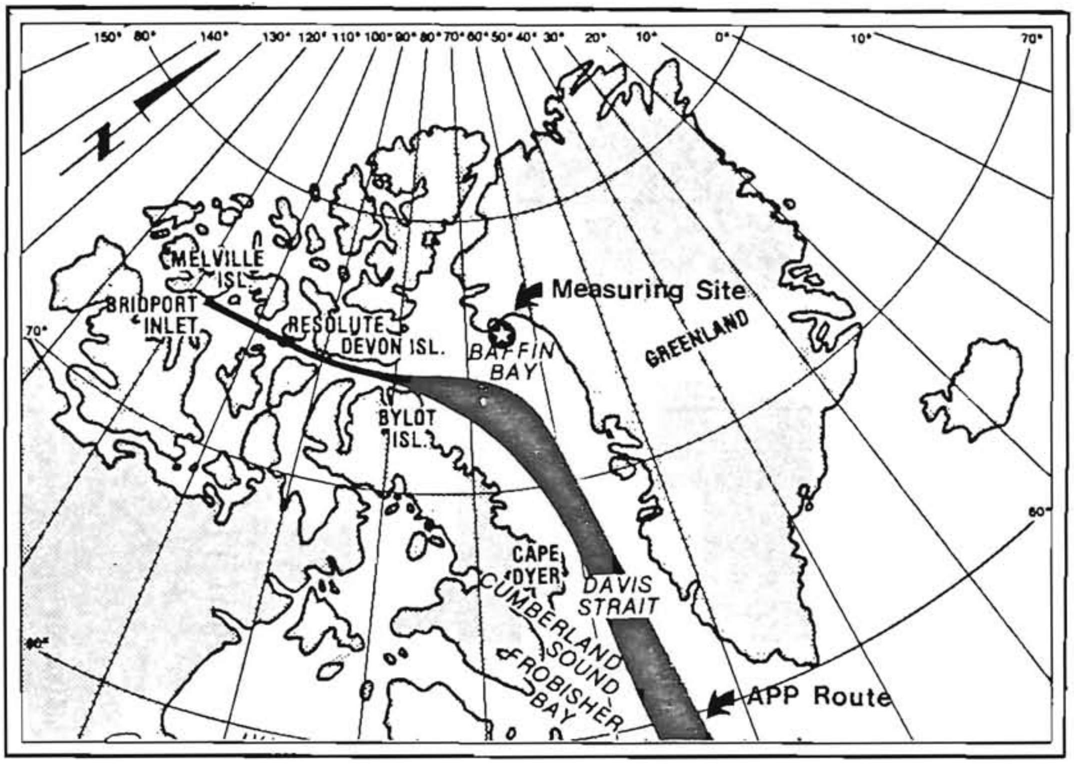

Figure 1
Planned route and measuring site

In order to evaluate the impact of the propeller noise on the ambient underwater noise in these until now undisturbed waters, it is necessary to know the following parameters:

- The route to be taken and the condition under which the LNG-tankers will be sailing.
- The source level of the propeller noise from the LNG-tankers under different conditions.
- The sound transmission properties in the sea along the route.
- The ambient noise caused by natural sources, e.g. by ice.

Many investigations have been performed to evaluate these parameters. The question of propeller noise has been dealt with in e.g. ref. (1), (6), and (7).

This report deals with the question of the ambient noise level. Most discussions concerning ambient noise along the route of the LNG-tankers have until now been based on measurements made in Baffin Bay in the summer, see Leggat, ref. (1). In this investigation very high noise levels have been recorded compared to e.g. measurements at the east coast of Greenland, see ref. (5). No information about the ambient noise level in Baffin Bay during the winter period has been available. This is, however, very important as the noise radiated from the LNG-tankers will be stronger during the winter period owing to the very heavy loads on the propellers when the ships are breaking ice. Other measurements as e.g. ref. (2) made in ice covered waters, but from other arctic areas, show that the ambient noise level under these conditions is lower than that measured in Baffin Bay by Leggat, ref.(1).

The measurements described in this report were made in the northern part of the Baffin Bay, as shown in Figure 1, to obtain some preliminary data of the ambient noise level in the winter. As the measurements were carried out in the course of a few days, they cannot give a complete description of the ambient noise in the Baffin Bay as an average over different positions, weather, ice conditions etc. But they still give a good indication of what ambient noise level should be expected at a location close to the planned route under typical winter conditions.

2. AMBIENT NOISE IN ARCTIC WATERS

The ambient underwater noise level in arctic regions is strongly affected by the presence of ice in the sea. The noise generated by the ice is due to the following processes:

- Cracking induced by thermal stress
- Movement of the ice by wind, currents or waves
- Breaking and crushing of the ice owing to tension or compression
- Icebergs capsizing or breaking
- Release of entrapped air in melting ice
- Ice interacting with the sea bottom or the shore

The thermal stress is due to changes in the air temperature and the correlation with the ambient noise level is observed in many investigations as for example by Milne and Ganton, Ref. (2).

There will always be some movements of the ice cover because of tidal currents, wind force etc. This will cause the ice floes to rub against one another and thereby generate noise. In the summer this can be seen at the boundary between ice and open water where the noise generation is often high, as the movements of the ice are great because of waves and the open structure of the ice along the edge. The high underwater noise levels under the ice edge were recorded in the investigation carried out by Diachok and Winokur, ref. (3) where levels measured near the ice edge were about 10 dB higher than under the ice cover or in the open water.

The tension or compression of an ice cover can be formed by wind or currents resulting in areas with open water or with hummocks of ice. In that case the underwater noise is generated when the ice cracks because of tension, or when the ice is compressed.

Owing to melting or to thermal stresses the icebergs sometimes break apart or lose balance and capsize. This will generate a very large underwater noise "pulse", which propagates far away because of the low transmission loss in arctic waters. High sound pressure levels at low frequencies were measured close to a small iceberg capsizing as described by Leggat in Ref. (1).

In melting ice a steady release of entrapped air bubbles gives rise to underwater noise. This phenomenon has been described by divers, who say that close to an iceberg the visibility is very poor and that it is like diving in "soda water".

Icebergs sometimes interact with the sea bottom, even in areas with relatively deep water. This interaction between the icebergs and the sea floor will inevitably result in a considerable amount of noise when currents and wind move the icebergs.

Apart from the ice, also other sources influence the ambient noise level, such as waves in open water or snow drifting over the ice. Furthermore, the biological sounds from marine mammals, fish, and invertebrates contribute to the ambient noise level.

3. GEOGRAPHICAL LOCATIONS AND MEASURING CONDITIONS

The recording of the ambient underwater noise was carried out from the ice off Kap York in North Greenland. Travelling to and from the measuring sites was achieved by dog sledges, which made it possible to bring the measuring instruments, tents, food etc., see Figure 2.

In order to obtain measurements under different ice conditions, the recordings were made at three different locations. A chart from the area with the measuring positions is shown in Figure 3. The longitude and latitude of each position are given in Table 1.

Each position is described below and photos from the measuring sites are shown in Figures 4, 5, and 6.

Figure 2
Travelling by dog sledges

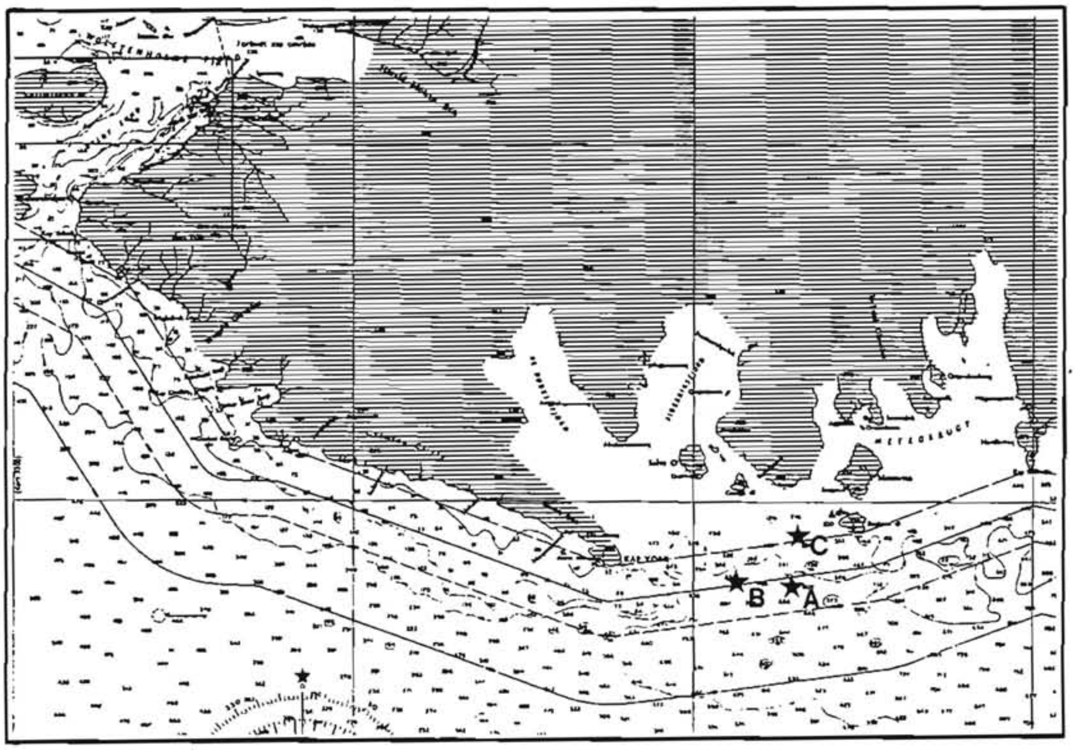

Figure 3.
Chart of the area with indications of the measuring positions

Position	Latitude	Longitude	Comments
A	75°52'50 N	65°25' W	Near a lead with open water
B	75°53' N	65°46' W	Consolidated pack ice
C	75°57' N	65°23' W	Shore fast ice

Table 1.
Measuring positions

Position A

This position was close to an open water lead which divided the fast ice from the drifting pack ice, as shown on the ice maps in Appendix B. During the measurements no movement in the ice was observed.

The width of the lead was approximately 200 m. During the night the lead was covered with thin ice.

The water depth was approximately 800 m and the distance to the nearest coast (Bushnans Island) was 13 km. The hydrophone was placed at a depth of 50 m below the fast ice cover. The ice thickness was 30 cm and the nearest iceberg was approximately 4 km away. A photograph taken from the measuring site is shown as Figure 4.

During the measurements the weather conditions were calm with 0-5 m/s wind in different directions. Temperature: -16 to -21°C.

Figure 4
Photograph from measuring position A

Seven recordings each of approximately 25 minutes' duration were made on the 82.04.17 at 20.50 and 23.30 and on the 82.04.18 at 03.45, 09.55, 13.45, 17.00 and 17.35.

The temperature, salinity, and velocity profiles are shown in Appendix A.

Position B

This position was in an area of refrozen pack ice, approximately 2 km from the open water lead, as shown in Figure 3 and Appendix B.

The water depth was approximately 800 m and the distance to the nearest coast (George Island) was approximately 15 km. The hydrophone was placed at a depth of 50 m below the ice cover. The ice thickness was 50 cm and the nearest iceberg was approximately 8 km away. A photograph taken from the measuring site is shown as Figure 5.

Figure 5.
Photograph from measuring position B

During the measurements the weather conditions were calm with easterly wind 0-6 m/s. Temperature: -16 to -23°C.

Nine recordings each of 25 minutes' duration were made on the 82.04.19 at 14.05, 14.40, 18.05, 20.00, and 23.20, and on the 82.04.20 at 02.55, 06.00, 09.00 and 12.15.

Temperature, salinity and velocity profiles are shown in Appendix A.

Position C

This position was in an area of flat fast ice. The position is shown in Figure 3 and Appendix B.

The water depth was approximately 200 m and the distance to the nearest coast (Bushnans Island) was approximately 8 km. The hydrophone was placed at a depth of 50 m below the ice cover. The ice thickness was 75 cm and the nearest iceberg was approximately 1 km away. A photograph taken from the measuring site is shown as Figure 6.

Figure 6.
Photograph from measuring position C

During the measurements the weather conditions were calm with north easterly wind, 0-5 m/s. The temperature was -19 to -26°C.

12 recordings each of 25 minutes' duration were made every 2 hours starting on the 82.04.20 at 10.00.

Temperature, salinity and velocity profiles are shown in Appendix A.

4. AMBIENT NOISE MEASUREMENTS

4.1. Method

All recordings were made with a hydrophone submerged into the water through a hole drilled into the ice. The measuring instruments were kept in a small tent, which was heated to approx. 0°C, see Figure 7. As the movements of the sledge dogs could be heard clearly through the hydrophone, all measurements were made when the dogs were well fed and asleep most of the time. The people on the ice were also quiet and did not move.

Figure 7
Tent with the instruments

Parallel to the noise measurements, measurements were made of wind, air temperature, water temperature and salinity. The positions were determined by several sextant observations at each position.

4.2. Instrumentation

The measurements of the underwater noise were carried out with a high sensitivity piezoelectric hydrophone with a built-in preamplifier connected to a power supply and a measuring amplifier through a special watertight extension cable. The signals from the amplifier were recorded on a precision measuring tape recorder. The instruments employed are listed in Table 2.

Hydrophone	Bruel & Kjaer, Type 8101
Hydrophone calibrator	Bruel & Kjaer, Type 4223
Extension cables	Bruel & Kjaer, Type A00113
Power supply	Bruel & Kjaer, Type 2804
Sound level meter	Bruel & Kjaer, Type 2209
Tape recorder	Nagra Kudelski,Type IS-D

Table 2.
Instruments used for the measurements

4.3. Signal analysis

When analysing this kind of non-stationary noise it is necessary to make a statistical analysis of the tape-recorded noise signals. This was undertaken in the laboratory after the return from Greenland. At the statistical analysis the levels exceeded for 1, 50 and 99 per cent of the time were found for the 1/1 octave frequency bands with centre frequencies from 31.5 Hz to 4000 Hz. Duration of the analysis was approximately 22 minutes from each of the recordings and the integration time used was 250 ms. The instruments used for the analysis are listed in Table 3.

Taperecorder	Nagra Kudelski	Type IS-D
Digital frequency analyser	Bruel & Kjaer	Type 2131
Computer	Hewlett Packard	Type 1000 F

Table 3.
Instruments used for analysis

5. RESULTS

The results of the statistical analysis for each of the 28 recordings are given in Appendix C where the spectrum levels L_1, L_{50} and L_{99} (levels exceeded for 1, 50 and 99 per cent of the time) and a recording of the overall level are shown together with meteorological data etc. All levels given in the 1/1 octave frequency analysis are spectrum levels, which are found by dividing the intensity with the effective noise bandwidth of the 1/1 octave frequency bands and given in dB re. 1 $\mu Pa/\sqrt{Hz}$. The overall levels are recorded in the frequency interval 0-8000 Hz with an integration time of 250 ms.

An example of the statistical analysis is given in Figure 8 where the L_1, L_{50}, and L_{99} levels measured at midnight at location A (recording no. 2) are shown.

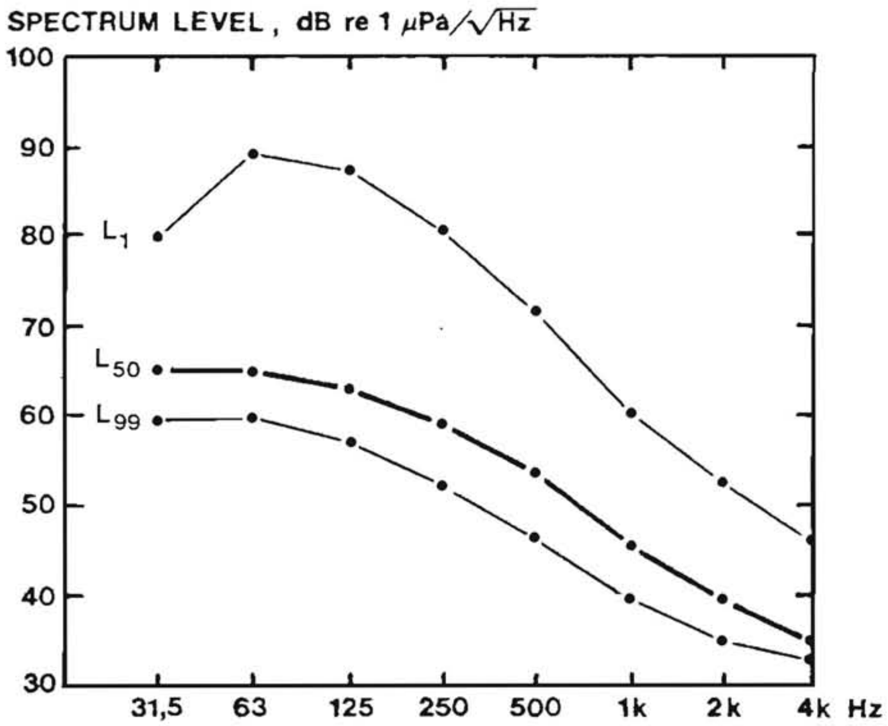

Figure 8
Example of ambient noise levels measured at location A.

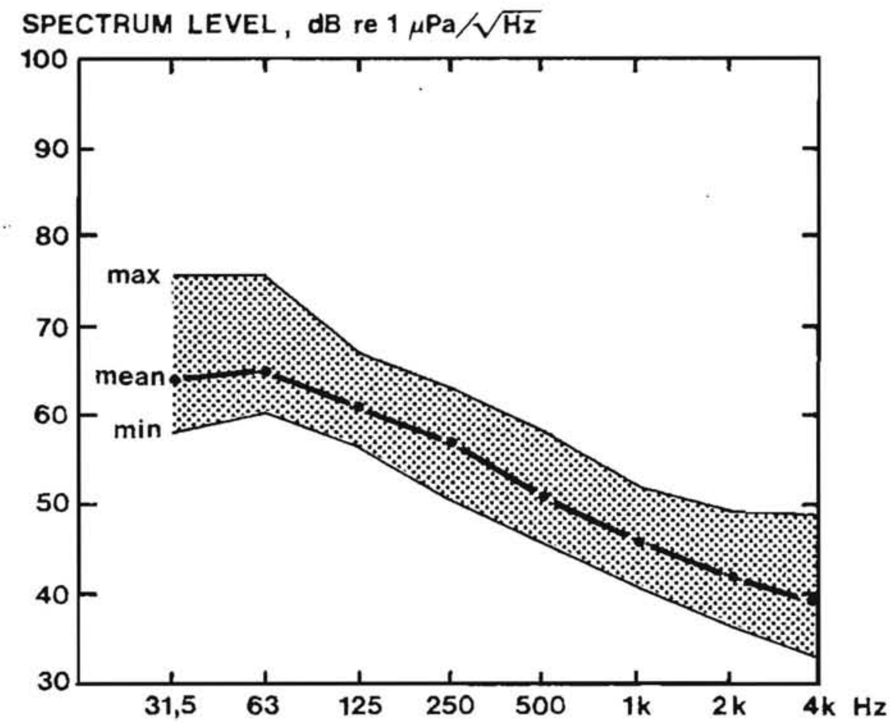

Figure 9
Range of the L_{50} spectrum levels measured at the three locations A, B, and C

The range of the measured underwater noise levels is illustrated in Figure 9, where the maximum, average and minimum L_{50} levels of all 28 recordings are shown. The average L_{50} levels are found as the arithmetic average of the 28 recordings.

It appears from Figure 9 that the variation in the noise levels is about 15 dB in the low frequency range and approximately 10 dB at the higher frequencies. The highest levels occur in the low frequency range and the levels decrease at higher frequencies with approximately 5 dB per octave.

The variation of the noise level with the time of the day is illustrated in Figure 10. In this figure the measured levels in the 1/1 octave frequency band with a centre frequency of 63 Hz are shown for the three locations, as a function of the time of the day.

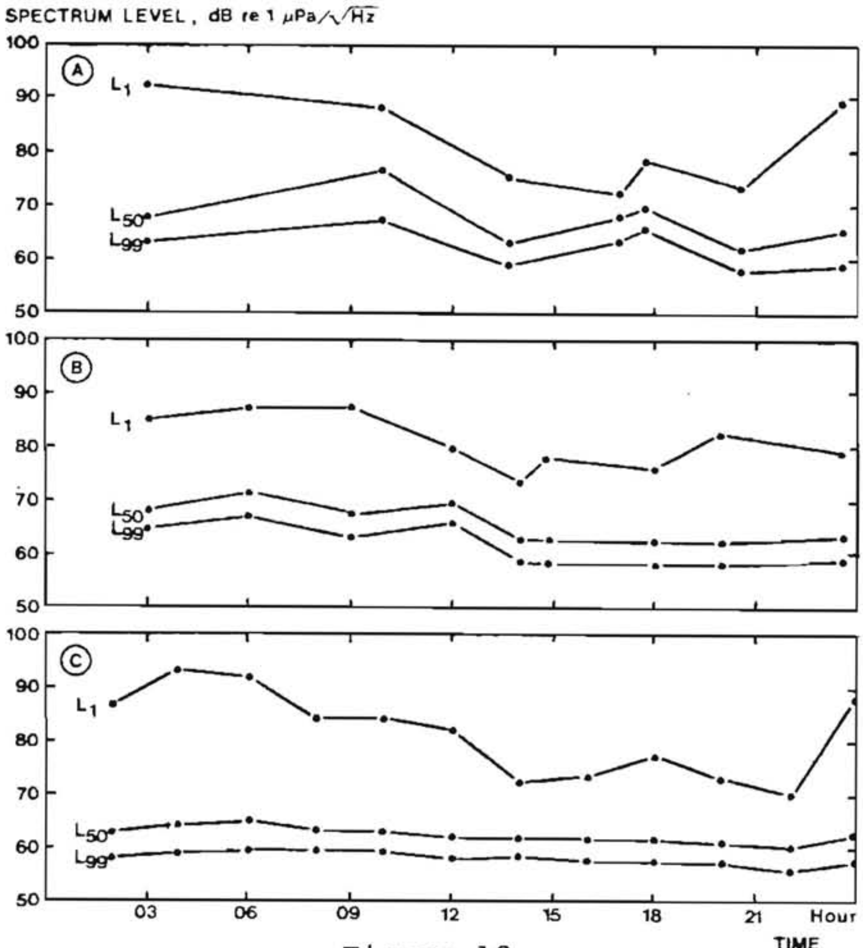

Figure 10
Measured ambient noise level versus time at location A, B, and C. Levels in the 1/1 octave frequency band with a centre frequency of 63 Hz are shown.

It appears from Figure 10 that the level has a tendency to be higher in the night and in the morning. This effect is very distinct for the L_1 levels as the loud pulses occur more frequently at night and in the morning. The same tendency is seen for 1/1 octave frequency bands with higher centre frequencies.

6. COMMENTS

When listening to the recordings, a constant broadband noise is heard, which probably originates from a number of different sources. Furthermore, loud "pulses" occur more or less frequently.

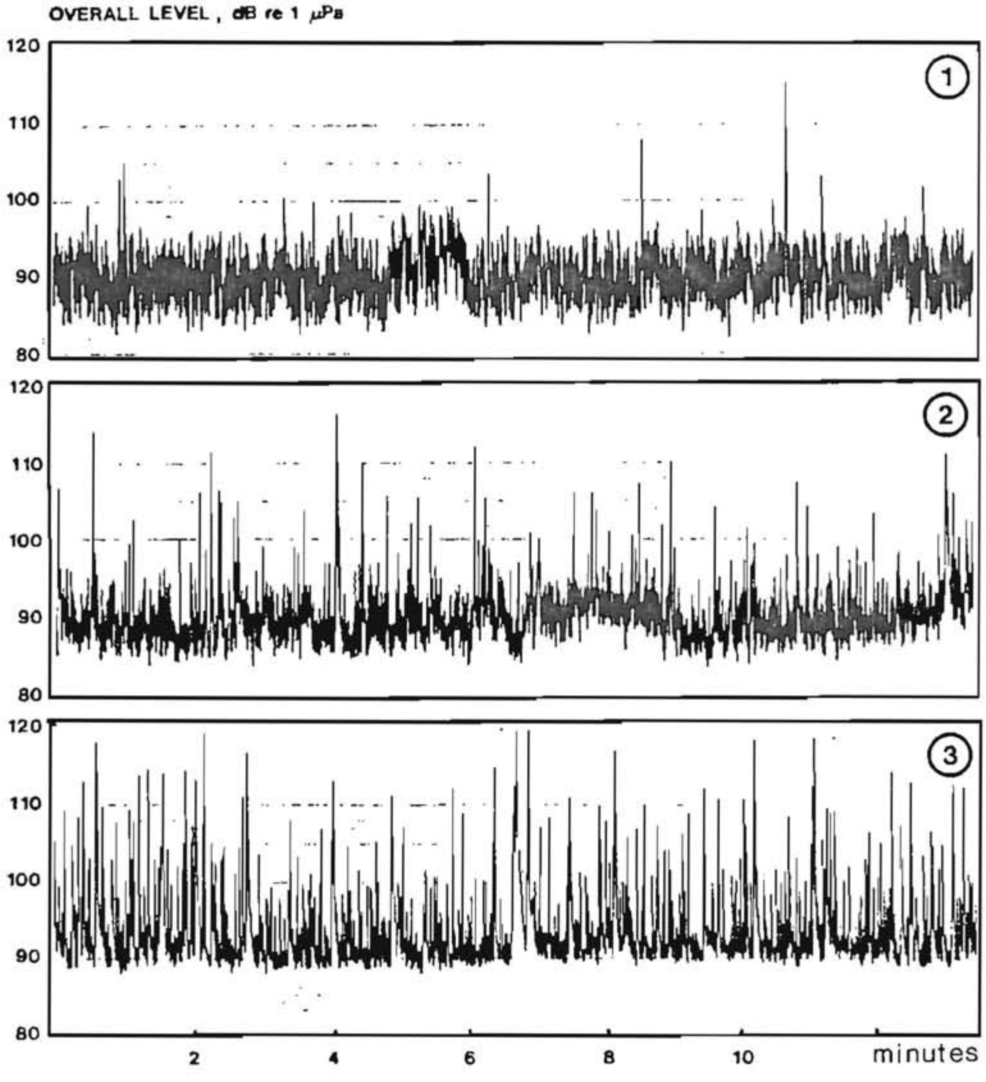

Figure 11
Examples of overall noise level versus time measured at location A. Recording no. 1 at 21.00, no. 2 at 23.30, and no. 3 at 04.00

These can be seen in the overall levels shown in Appendix C and in Figure 11, where some examples of overall level recordings are given.

Figure 11 shows that the pulses occur more frequently at night, which was also expected as the L_1 levels were highest at night. The variation with time of the constant broadband noise is small, as seen in Figure 11.

The influence of the weather conditions is illustrated by Figure 12, where levels measured under different wind conditions are shown.

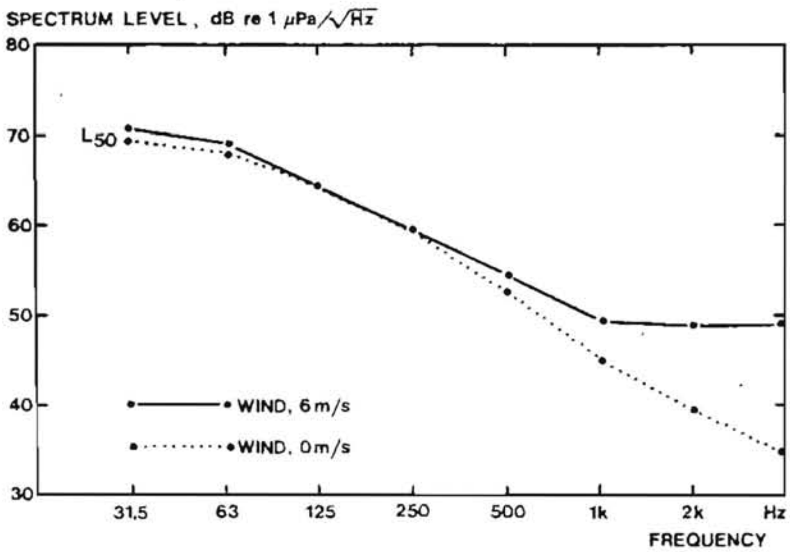

Figure 12
Underwater noise levels measured under different wind conditions

From Figure 12 it appears that the levels in the high frequency range rise with increasing wind force. This is probably due to the noise generated by drifting snow on the surface of the ice.

Another type of sound which was heard on all recordings was the sound of various marine mammals. Especially the vocalization of the bearded seal is heard frequently on many of the recordings. However, these sounds are not important for the determination of L_1, L_{50} and L_{99} as they appear with a lower level than the pulses which determine the L_1 level and they do not appear frequently enough to influence the L_{50} and L_{99} level.

7. CONCLUSION

When the results from the measurements described in this report are compared with other investigations of noise in arctic waters, as shown in Figure 13, the following appears.

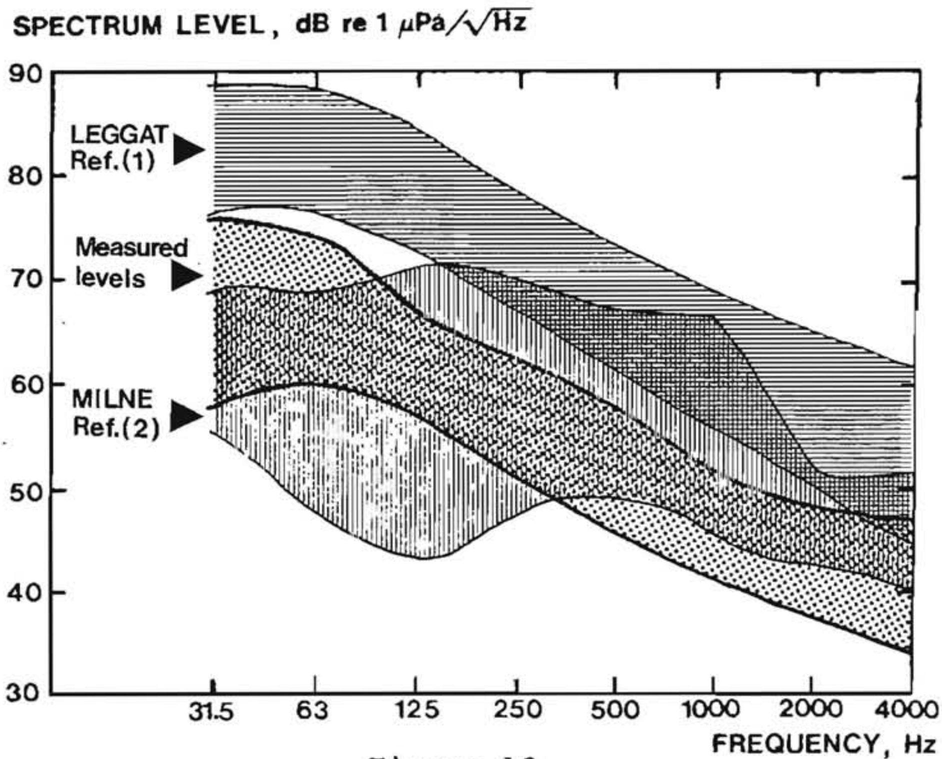

Figure 13
Comparison of measured data with other measurements in arctic waters

From Figure 13 it can be seen that the average ambient noise levels measured off Kap York in April are approximately 10 dB lower than the lowest levels reported by Leggat et al., ref (1), in Baffin Bay during the summer.

If the measured levels are compared to the results of other measurements made in arctic waters, see e.g. Milne, ref. (2), and Ødegaard & Danneskiold-Samsøe, ref (5), it can be seen that these levels are of the same order of magnitude.

This shows that it will be necessary to make further investigations to determine the ambient noise level in Baffin Bay. By this it will be possible to verify the influence of the geographical location, the time of the year, and the weather conditions on the ambient underwater noise level.

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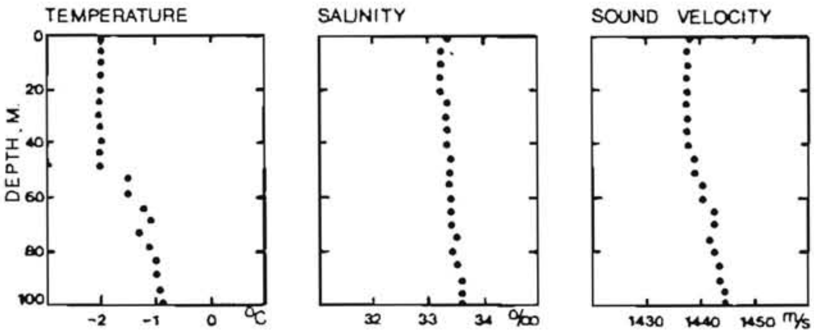
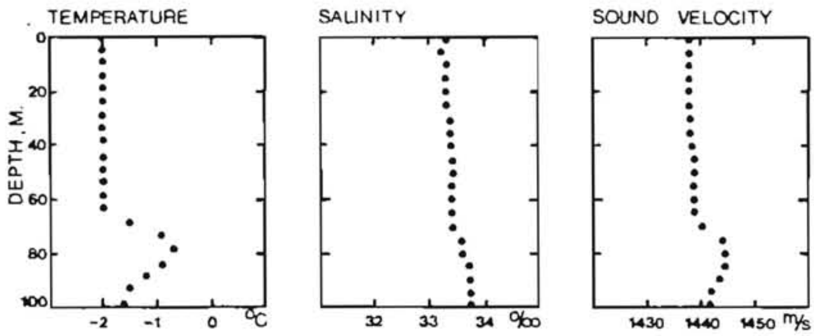
APPENDIX A

Temperature, salinity, and sound velocity profiles

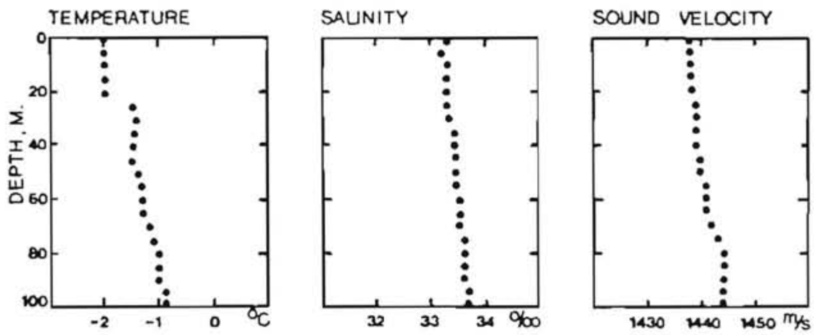
POSITION A



POSITION B

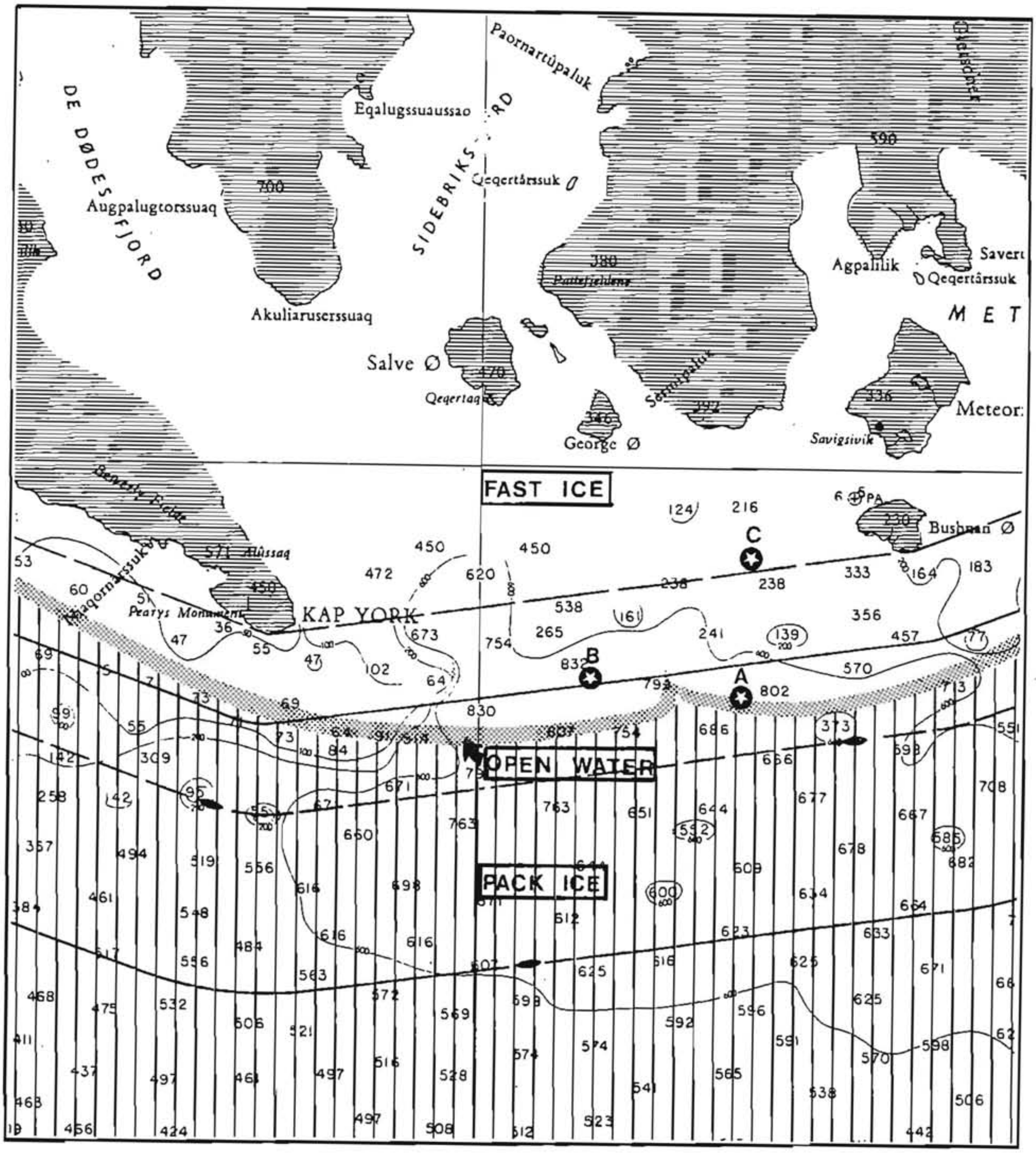


POSITION C



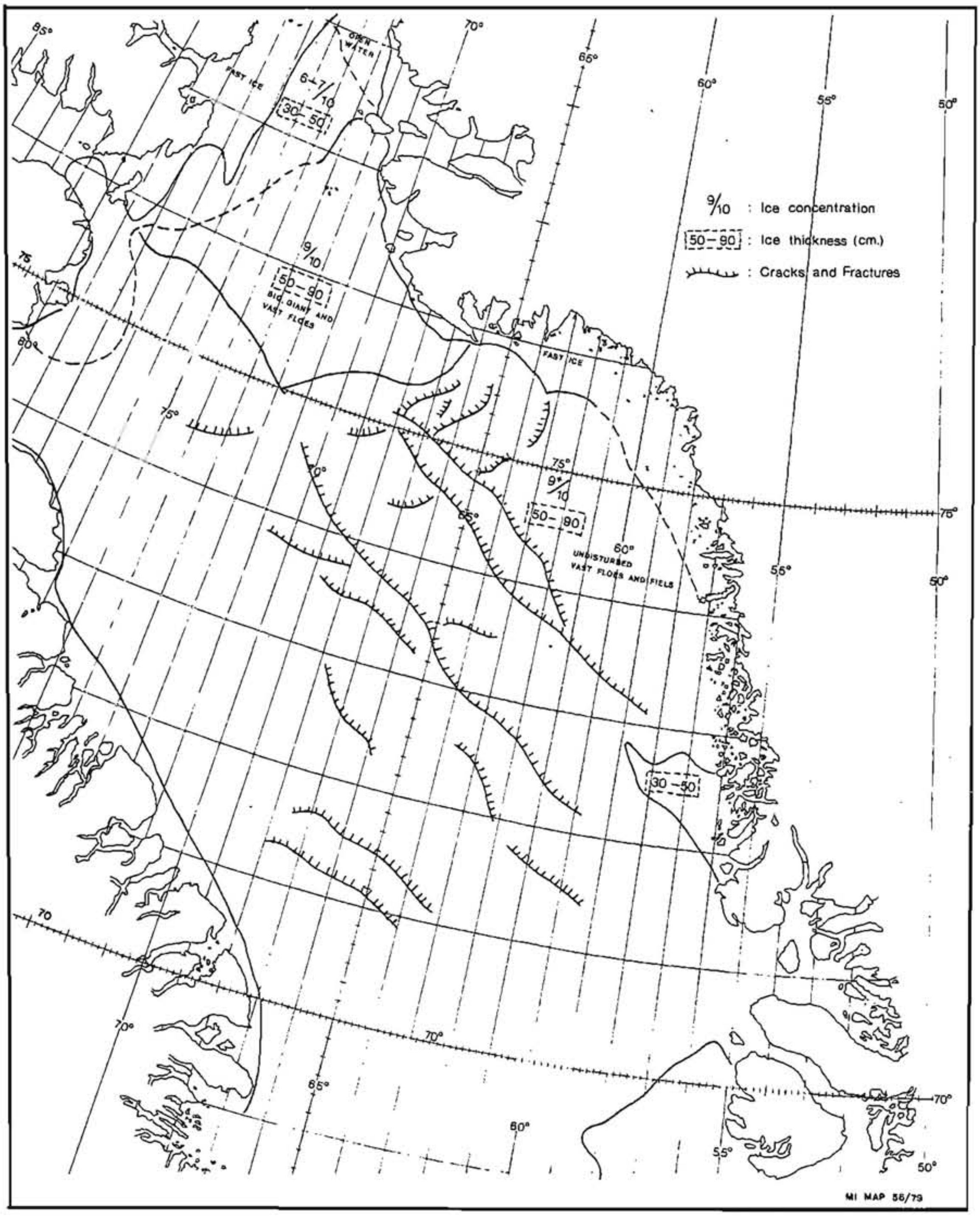
APPENDIX B

ICE MAP



Distribution of the ice during the measurements drawn from observations made during the voyage. Measuring positions marked with (✪).

ICE MAP



Distribution of the ice in the Baffin Bay.
Drawn by the Meteorological Institute from satellite data.
Date: 22nd April, 1982.

<u>Satellite photo</u>

Satellite photo of the area.
Date: 26th April, 1982.

APPENDIX C

Results and data from each recording.

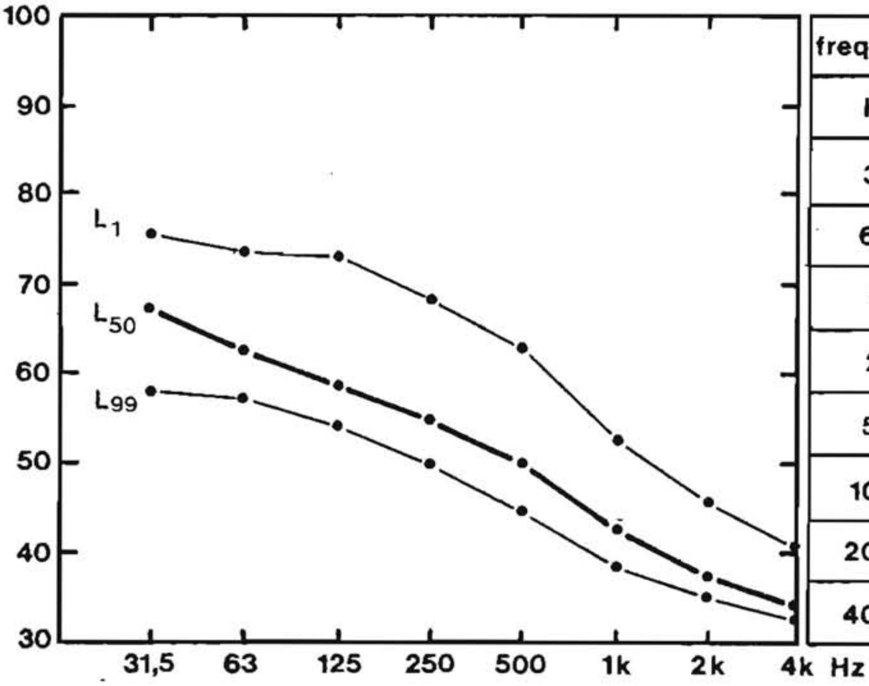
Recording No.	Position	Page
1	A	C 1
2	A	C 2
3	A	C 3
4	A	C 4
5	A	C 5
6	A	C 6
7	A	C 7
8	B	C 8
9	B	C 9
10	B	C 10
11	B	C 11
12	B	C 12
13	B	C 13
14	B	C 14
15	B	C 15
16	B	C 16
17	C	C 17
18	C	C 18
19	C	C 19
20	C	C 20
21	C	C 21
22	C	C 22
23	C	C 23
24	C	C 24
25	C	C 25
26	C	C 26
27	C	C 27
28	C	C 28

Recording no.: 1 C 1

Date: 17th April, 1982 Time: 20.50-21.12

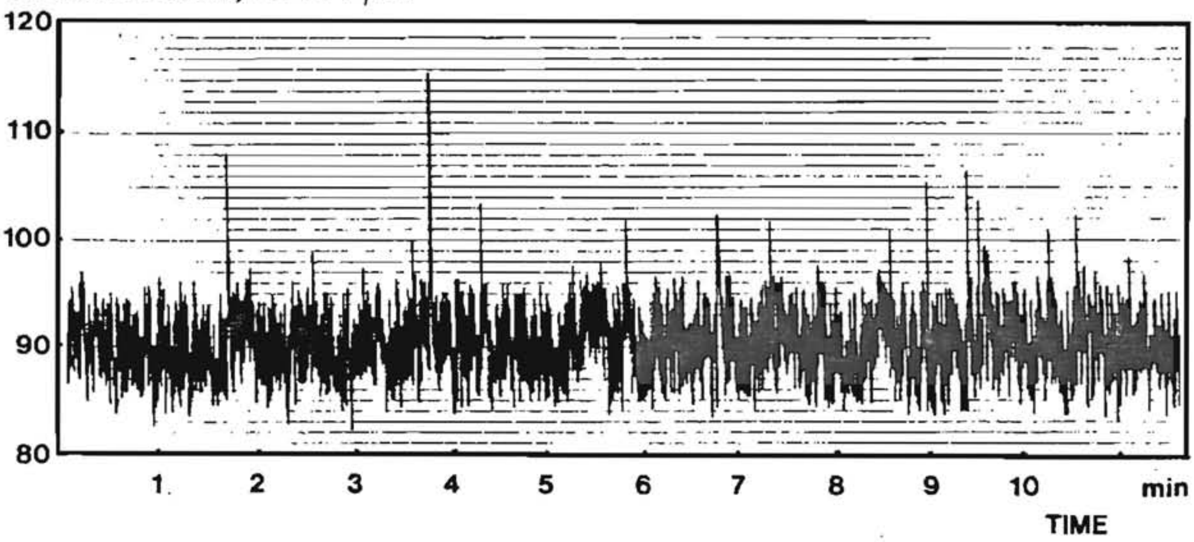
Measuring position: A Water depth: 800 m

SPECTRUM LEVEL, dB re 1 $\mu Pa/\sqrt{Hz}$



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	75	67	58
63.0	73	62	57
125	73	59	54
250	69	55	50
500	63	50	45
1000	53	43	39
2000	46	37	35
4000	41	34	33

OVERALL LEVEL, dB re 1 μPa



Wind: 3.3 m/s Wind direction: West

Temperature: -16 °C Weather conditions: Clear, sunshine

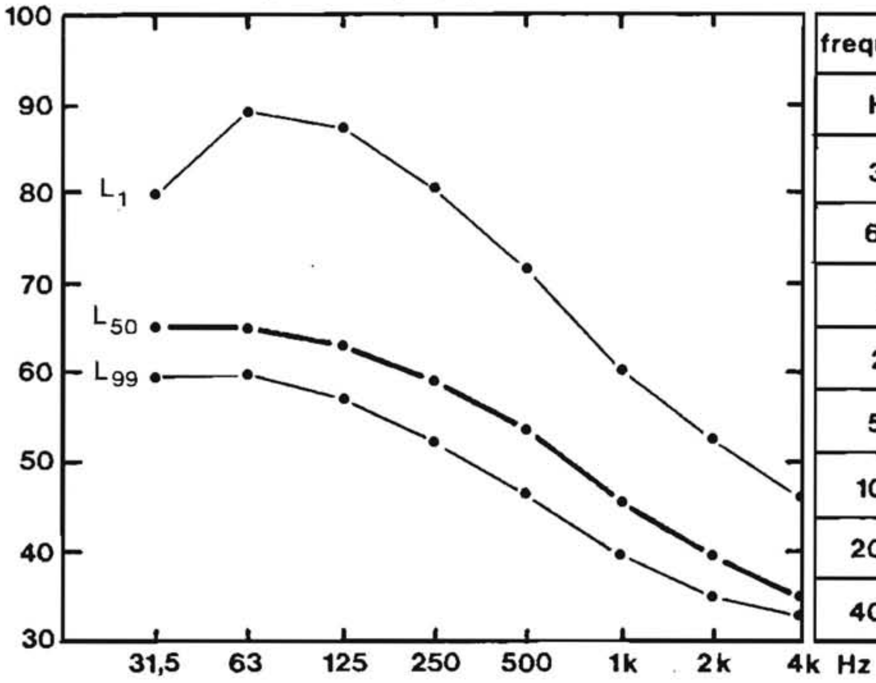
Remarks: Close to lead with open water. Small wavelets in the open water make noise.

Recording no.: 2

Date: 17th April, 1982 Time: 23.30-23.52

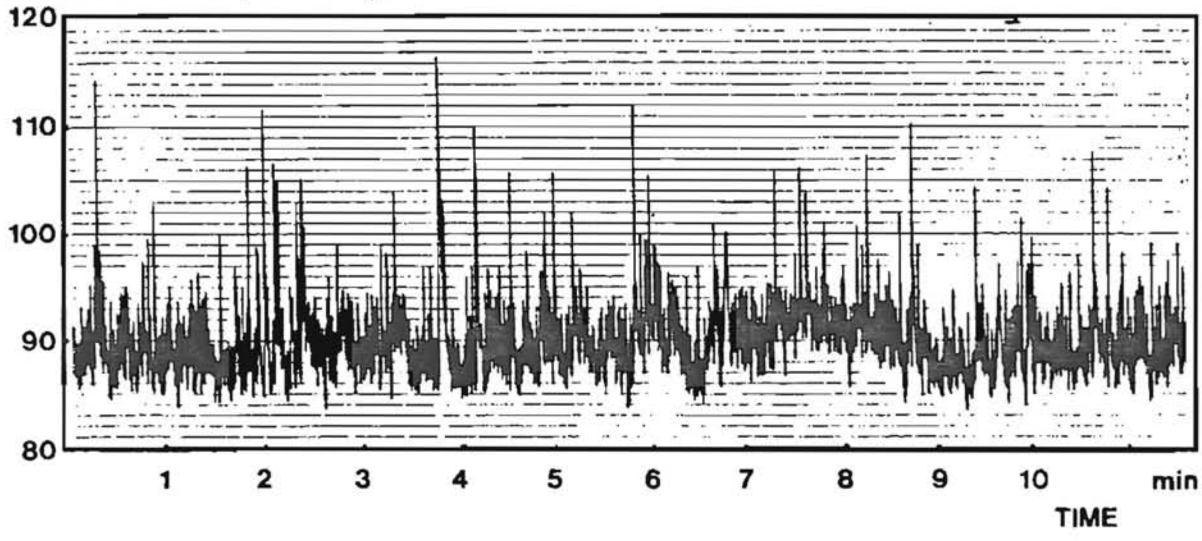
Measuring position: A Water depth: 800 m

SPECTRUM LEVEL, dB re 1 µPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	80	65	59
63.0	89	65	60
125	87	63	57
250	81	59	52
500	72	54	47
1000	61	46	39
2000	53	39	35
4000	46	35	33

OVERALL LEVEL, dB re 1 µPa



Wind: 2.7 m/s Wind direction: West

Temperature: -19°C Weather conditions: Clear, sundown

Remarks: The lead partly covered with thin ice

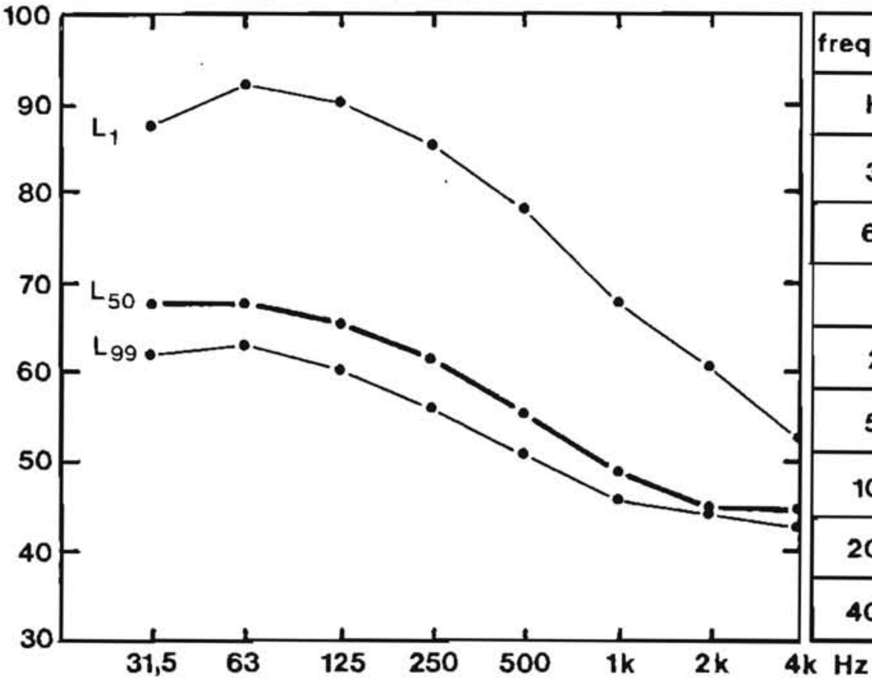
C 3

Recording no.: 3

Date: 18th April, 1982 Time: 03.45-04.06

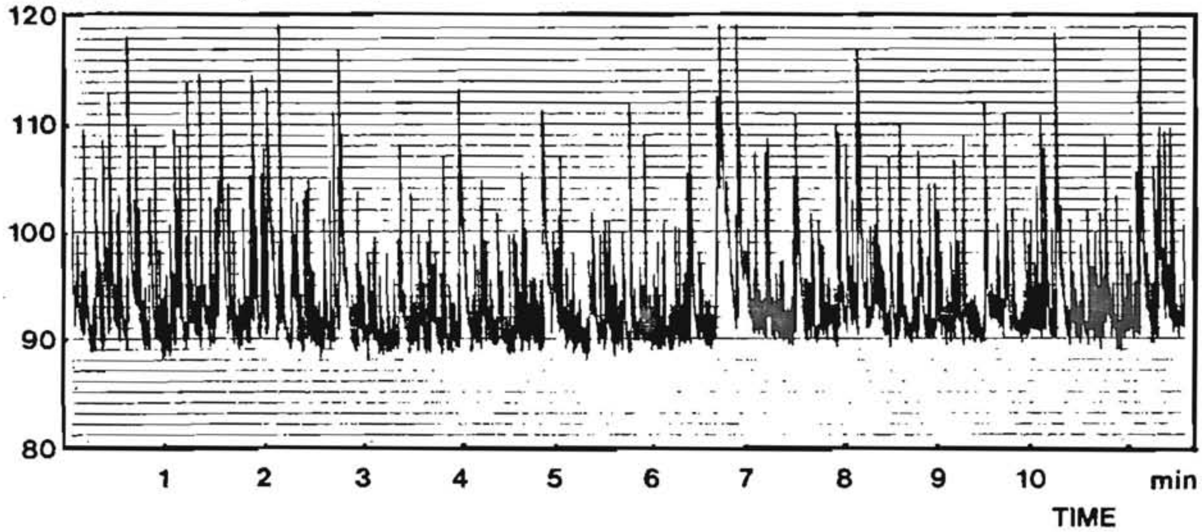
Measuring position: A Water depth: 800 m

SPECTRUM LEVEL, dB re 1 µPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	87	68	62
63.0	92	68	63
125	90	66	60
250	86	61	56
500	78	55	51
1000	68	49	46
2000	61	46	45
4000	53	45	44

OVERALL LEVEL, dB re 1 µPa



Wind: Zero

Temperature: -21°C Weather conditions: Clear, no sun

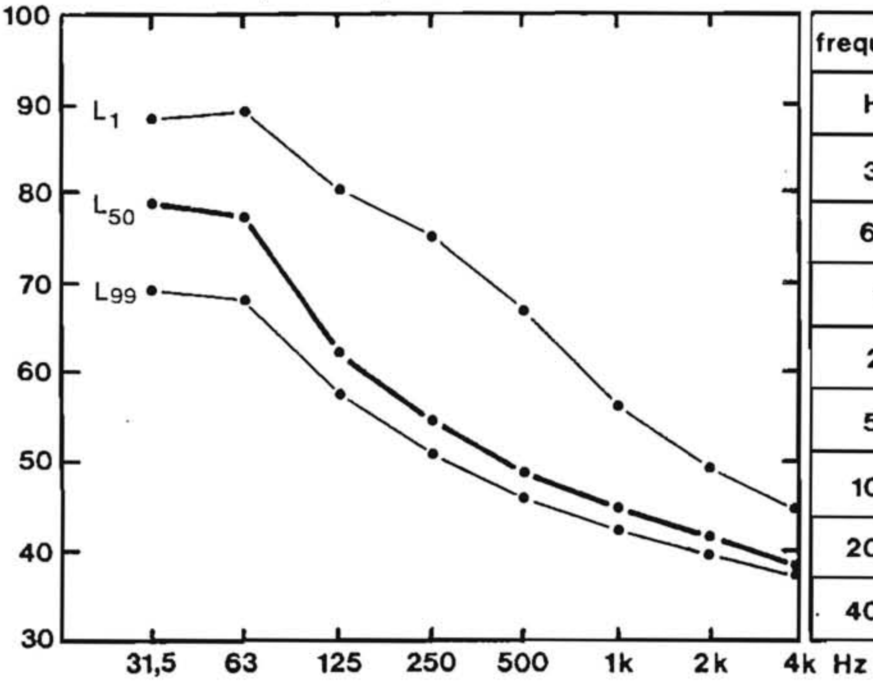
Remarks: The lead covered with thin ice

Recording no.: 4

Date: 18th April, 1982 Time: 09.55-10.15

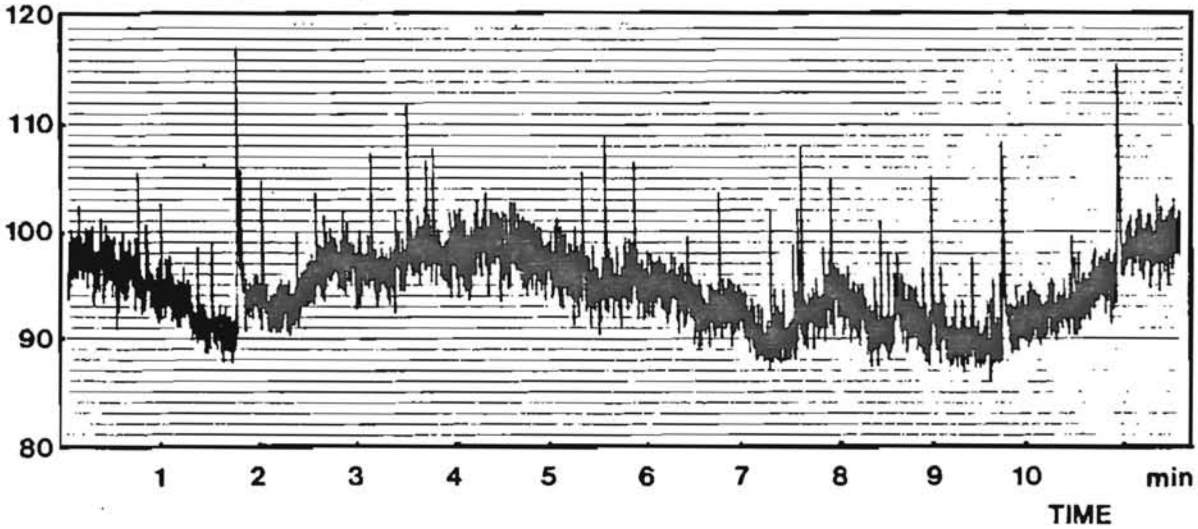
Measuring position: A Water depth: 800 m

SPECTRUM LEVEL, dB re 1 $\mu Pa/\sqrt{Hz}$



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	88	79	69
63.0	89	77	68
125	80	62	57
250	75	54	51
500	67	49	46
1000	56	45	42
2000	49	41	40
4000	44	39	37

OVERALL LEVEL, dB re 1 μPa



Wind: Zero

Temperature: -18°C Weather conditions: Clear, sunshine

Remarks: The lead still covered with thin ice. A strong, fluctuating low frequency noise is heard.

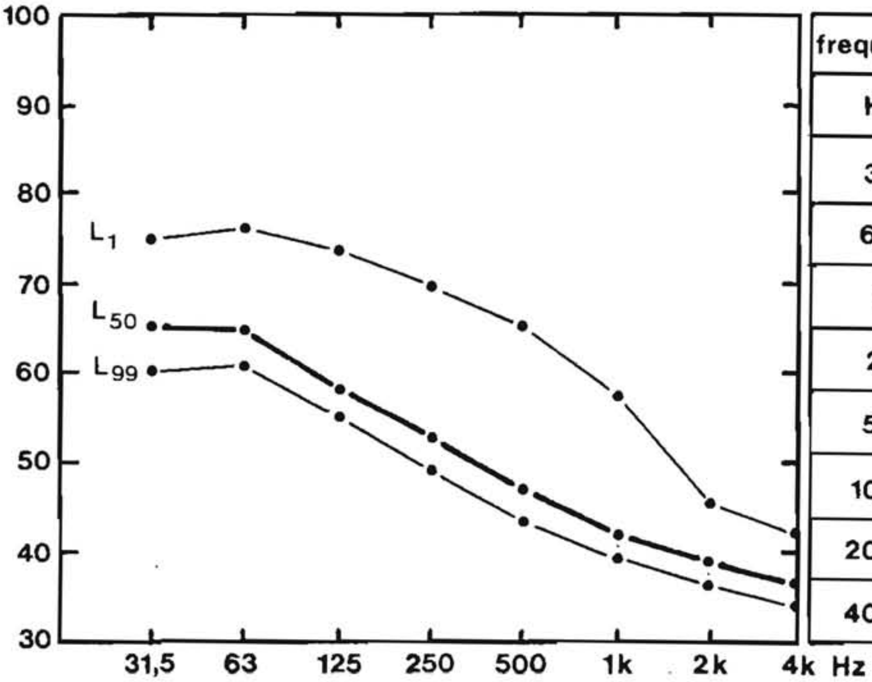
C 5

Recording no.: 5

Date: 18th April, 1982 Time: 13.45-14.10

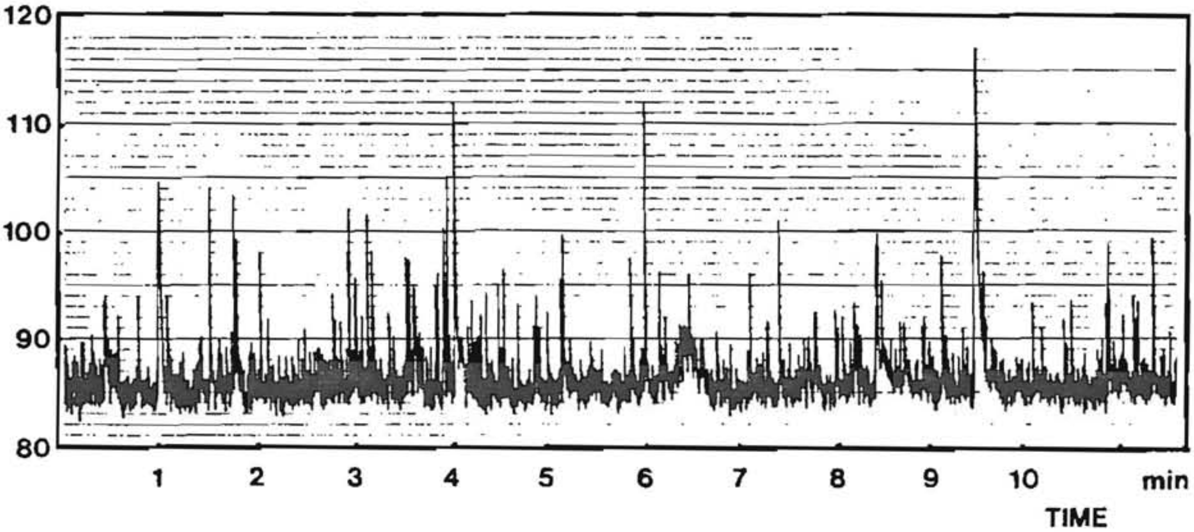
Measuring position: A Water depth: 800 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	75	66	60
63.0	76	64	61
125	74	59	56
250	70	53	50
500	66	47	44
1000	58	42	40
2000	46	39	37
4000	42	36	34

OVERALL LEVEL, dB re 1 μPa



Wind: 4.6 m/s Wind direction: East

Temperature: -17°C Weather conditions: Clear, sunshine

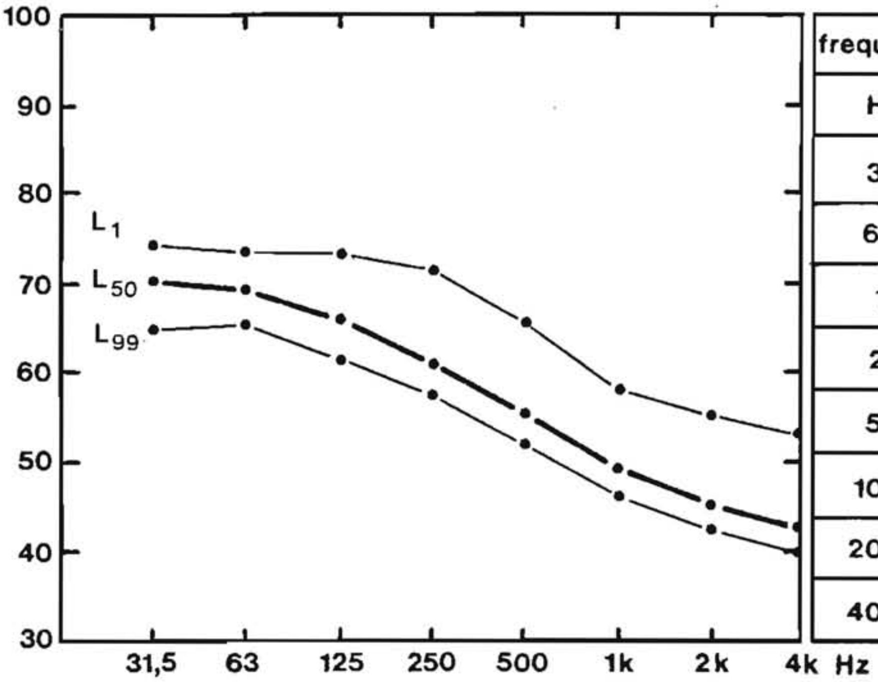
Remarks: The lead partly with open water again. Small wavelets in the open water.

Recording no.: 6

Date: 18th April, 1982 — Time: 17.01-17.22

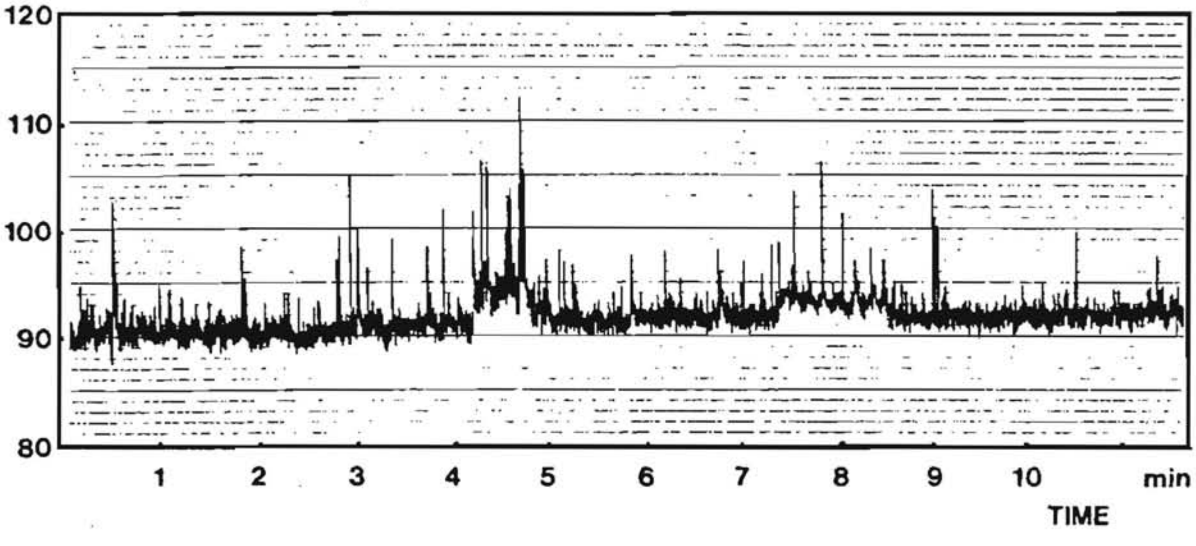
Measuring position: A — Water depth: 800 m

SPECTRUM LEVEL, dB re 1 μPa/$\sqrt{Hz}$



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	75	70	65
63.0	73	69	65
125	74	66	61
250	71	61	58
500	66	55	52
1000	58	49	46
2000	55	45	43
4000	53	43	40

OVERALL LEVEL, dB re 1 μPa



Wind: 3.8 m/s — Wind direction: East

Temperature: -16°C — Weather conditions: Clear, sunshine

Remarks: Only small areas with open water in the lead.

Recording no.: 7

C 7

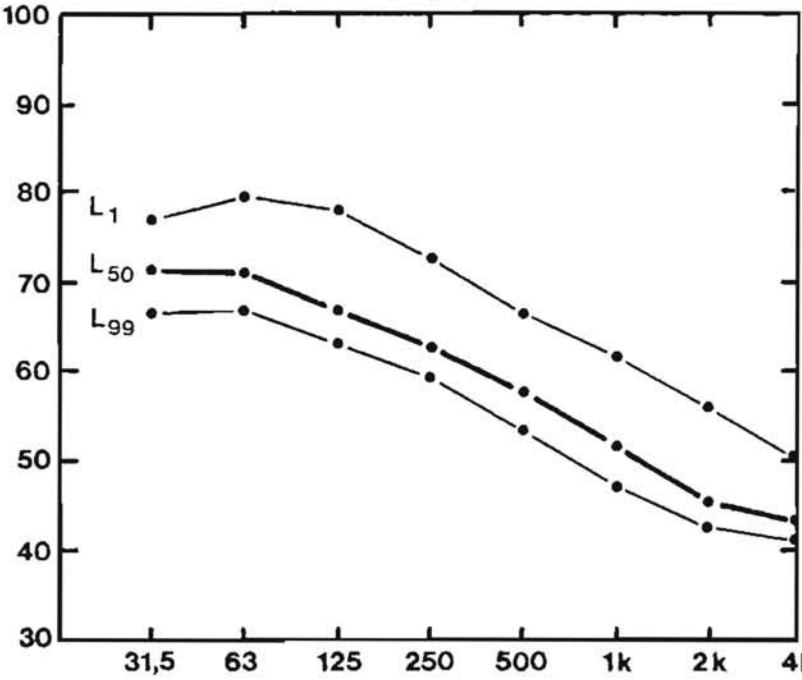
Date: 18th April, 1982

Time: 17.35-18.00

Measuring position: A

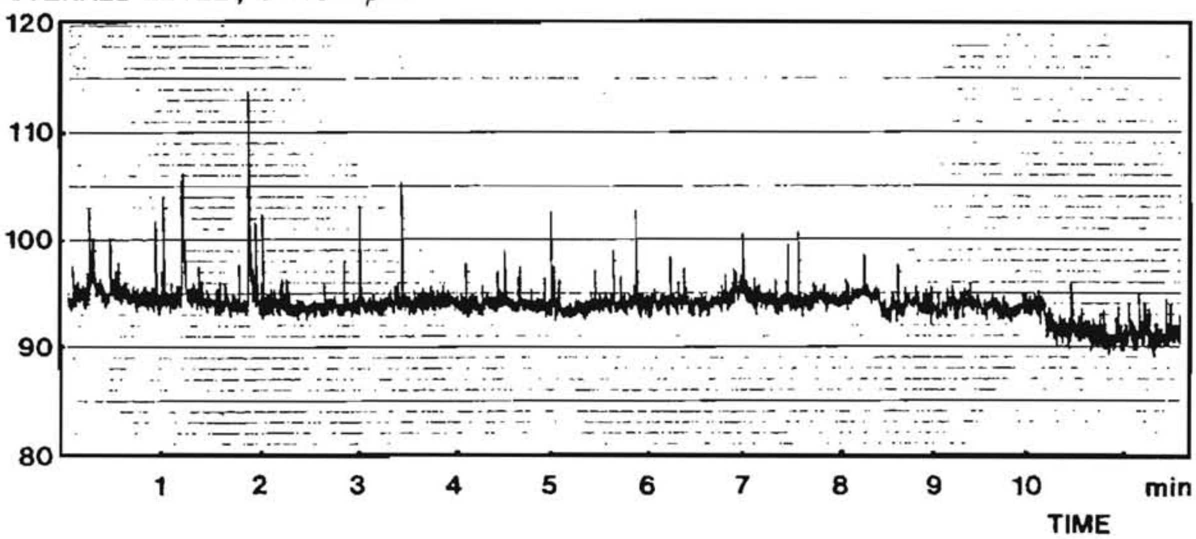
Water depth: 800 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	77	71	67
63.0	79	71	67
125	78	67	63
250	73	63	59
500	66	58	53
1000	62	52	47
2000	56	45	42
4000	50	43	40

OVERALL LEVEL, dB re 1 μPa



Wind: 3.8 m/s

Wind direction: East

Temperature: -16°C

Weather conditions: Clear, sunshine

Remarks: The lead covered with thin ice.

Recording no.: 8

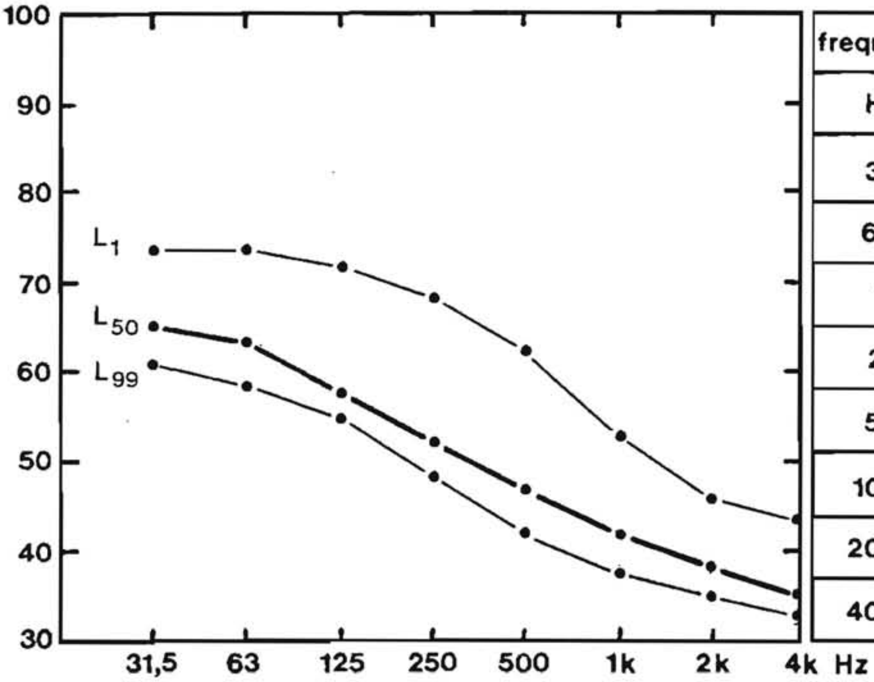
Date: 19th April, 1982

Measuring position: B

Time: 14.05-14.30

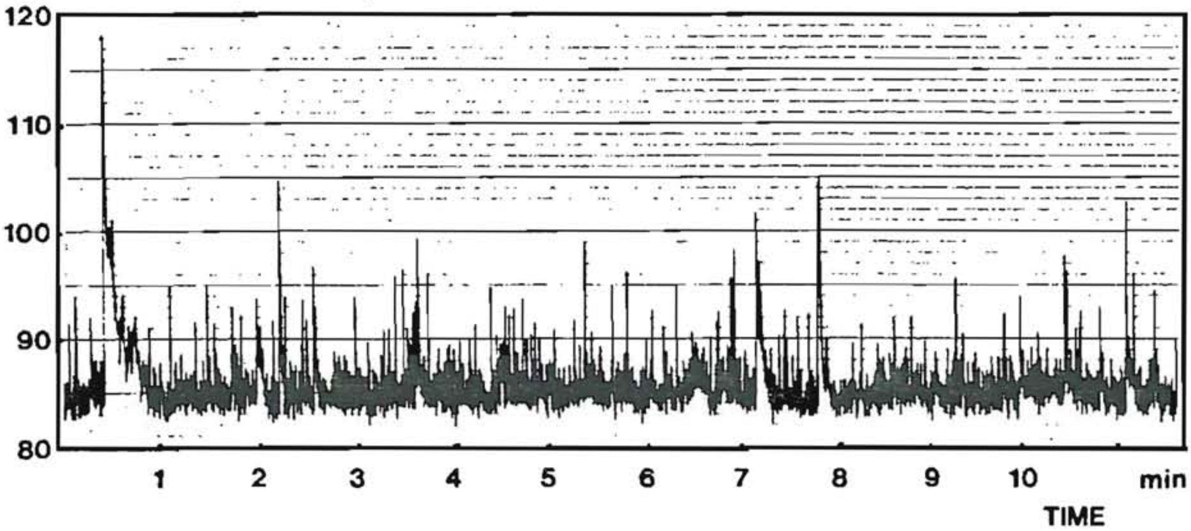
Water depth: 800 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	74	66	61
63.0	74	63	60
125	72	58	55
250	68	52	48
500	62	47	42
1000	53	42	38
2000	46	38	36
4000	43	35	33

OVERALL LEVEL, dB re 1 μPa



Wind: 0.7 m/s

Temperature: -16°C

Wind direction: East

Weather conditions: Misty, sunshine

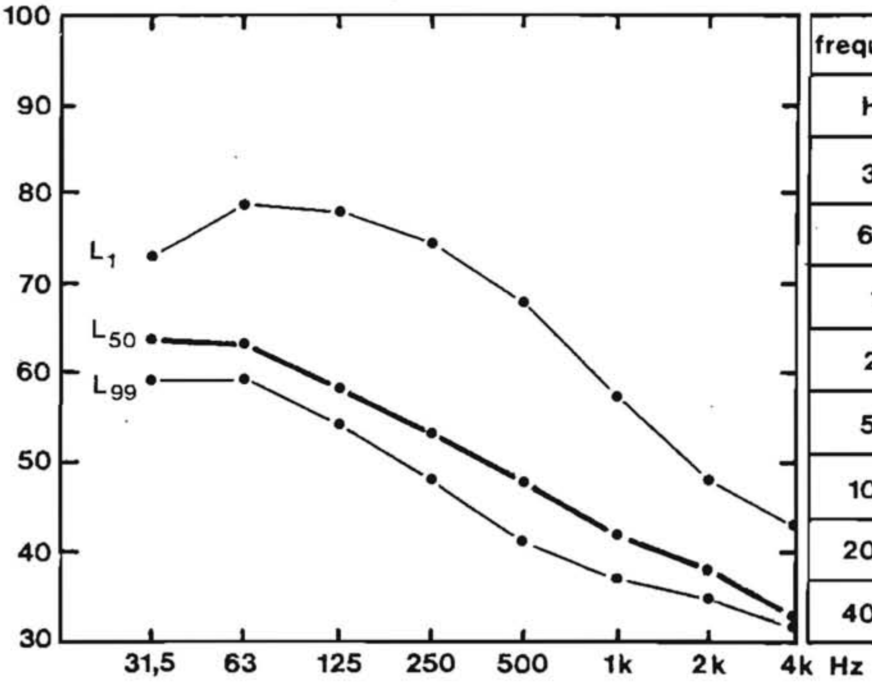
Remarks: Large area with refrozen pack ice.

Recording no.: 9

Date: 19th April, 1982 — Time: 14.41-15.00

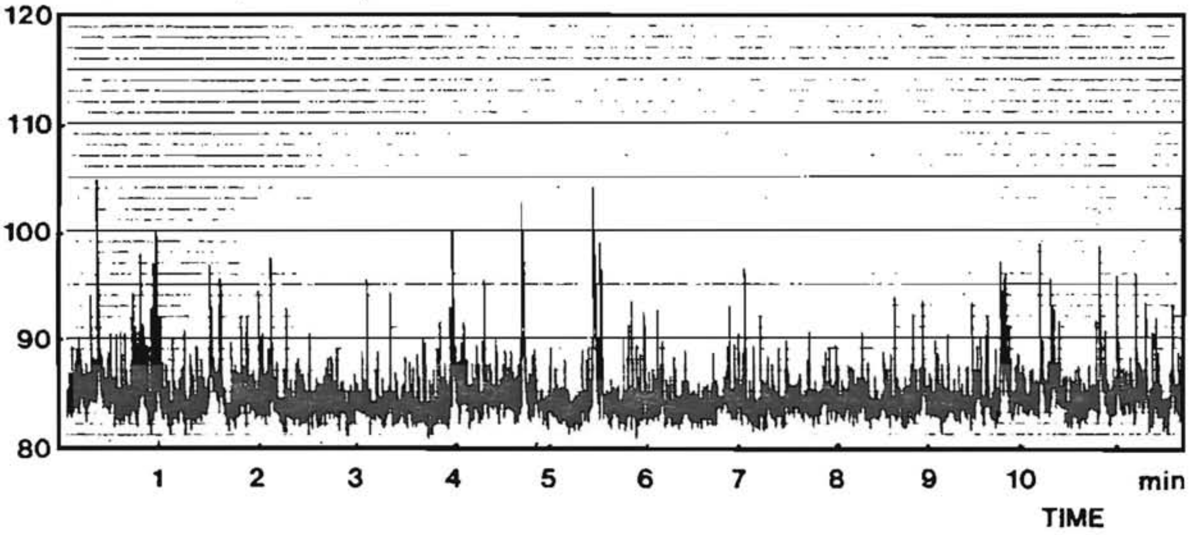
Measuring position: B — Water depth: 800 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	74	64	59
63.0	79	63	60
125	78	58	54
250	75	54	48
500	68	48	41
1000	58	42	37
2000	49	38	35
4000	43	34	32

OVERALL LEVEL, dB re 1 μPa



Wind: 0.7 m/s — Wind direction: East

Temperature: -16°C — Weather conditions: Misty, sunshine

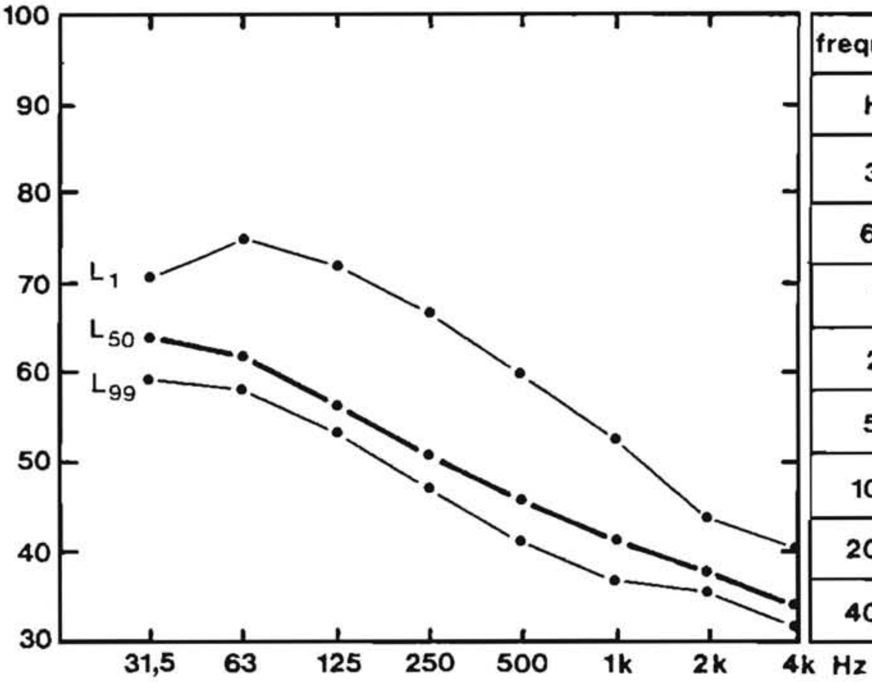
Remarks: A very large pulse occurs in the last part of the recording (not shown in the overall level).

Recording no.: 10

Date: 19th April, 1982 Time: 18.05-18.30

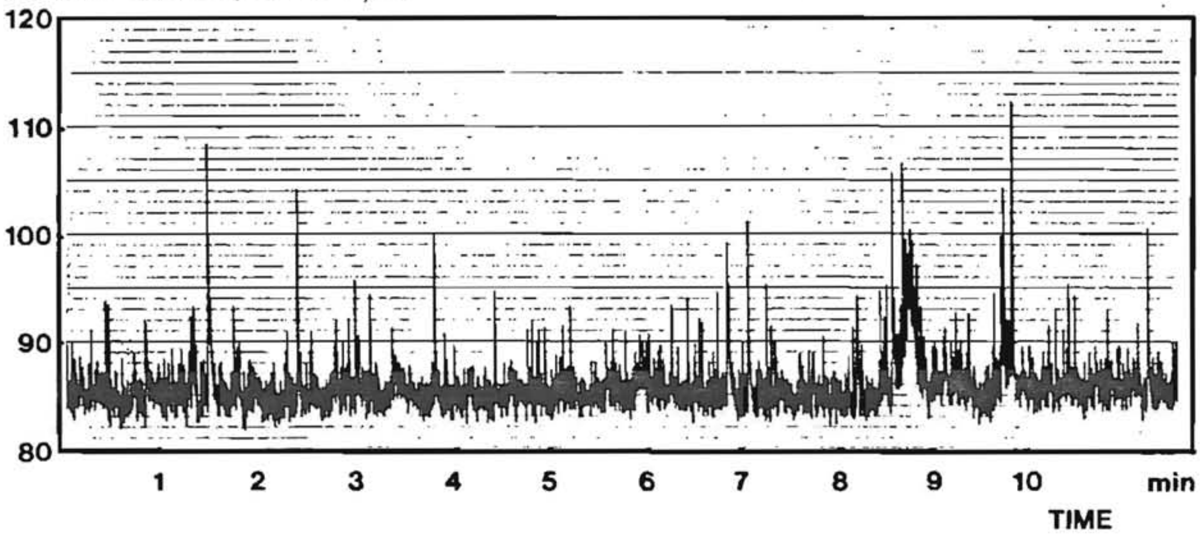
Measuring position: B Water depth: 800 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency Hz	L_1 dB	L_{50} dB	L_{99} dB
31.5	71	64	60
63.0	75	62	58
125	72	57	54
250	67	51	47
500	60	46	41
1000	53	41	37
2000	44	38	36
4000	41	34	32

OVERALL LEVEL, dB re 1 μPa



Wind: Zero

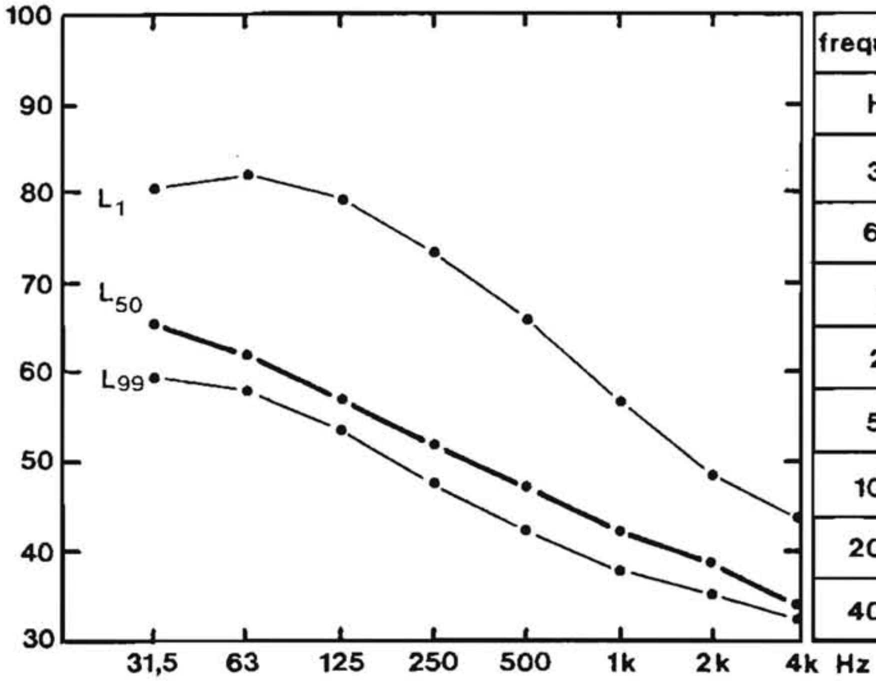
Temperature: -16°C Weather conditions: Misty, sunshine

Recording no.: 11

Date: 19th April, 1982 Time: 20.00-20.22

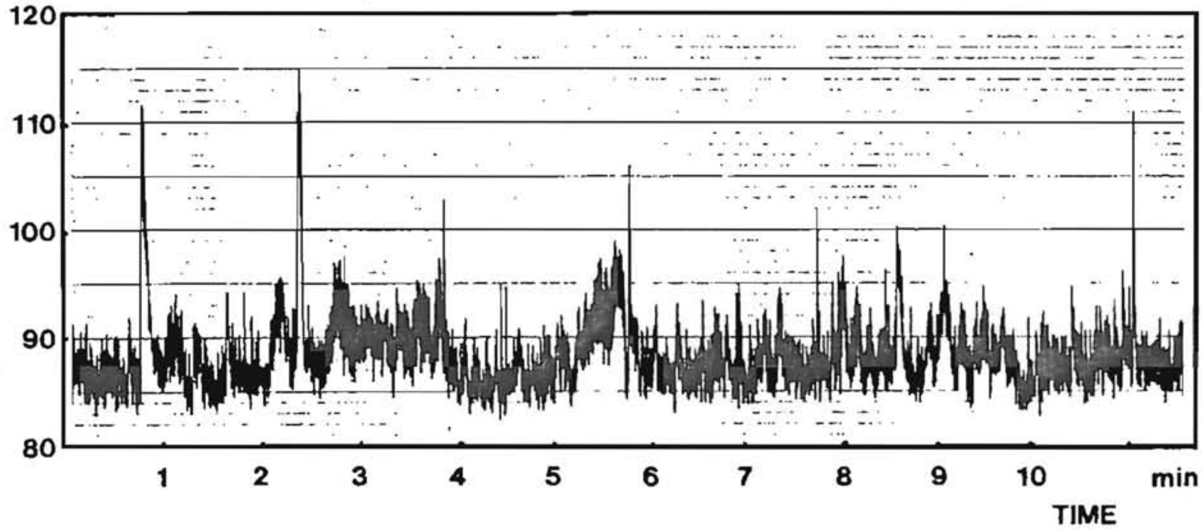
Measuring position: B Water depth: 800 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	81	65	60
63.0	82	62	58
125	79	57	54
250	74	52	48
500	66	47	42
1000	57	42	38
2000	49	39	36
4000	44	34	32

OVERALL LEVEL, dB re 1 μPa



Wind: Zero

Temperature: -16°C Weather conditions: Misty, sunshine

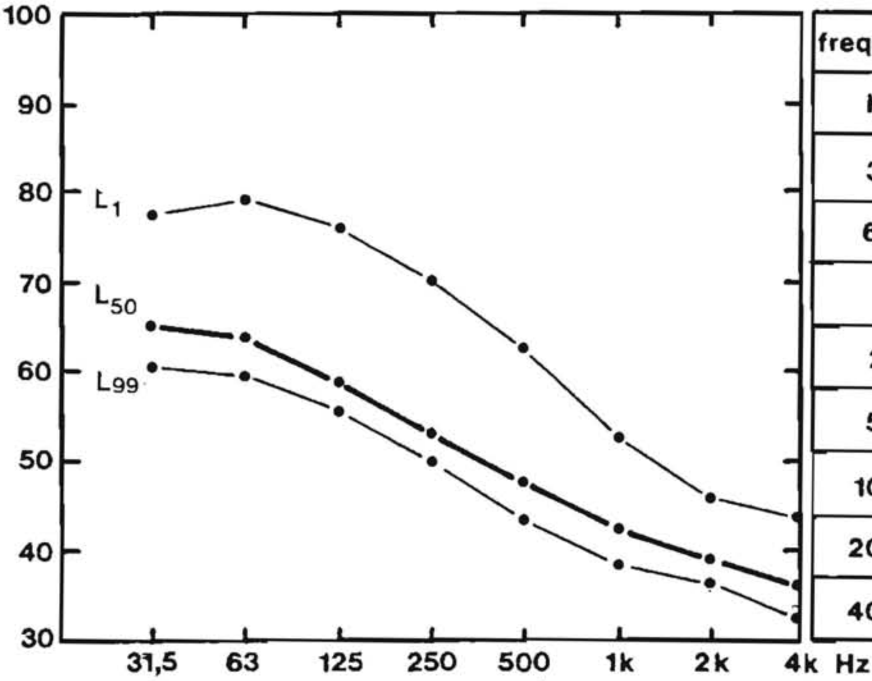
C 12

Recording no.: 12

Date: 19th April, 1982 Time: 23.20-23.42

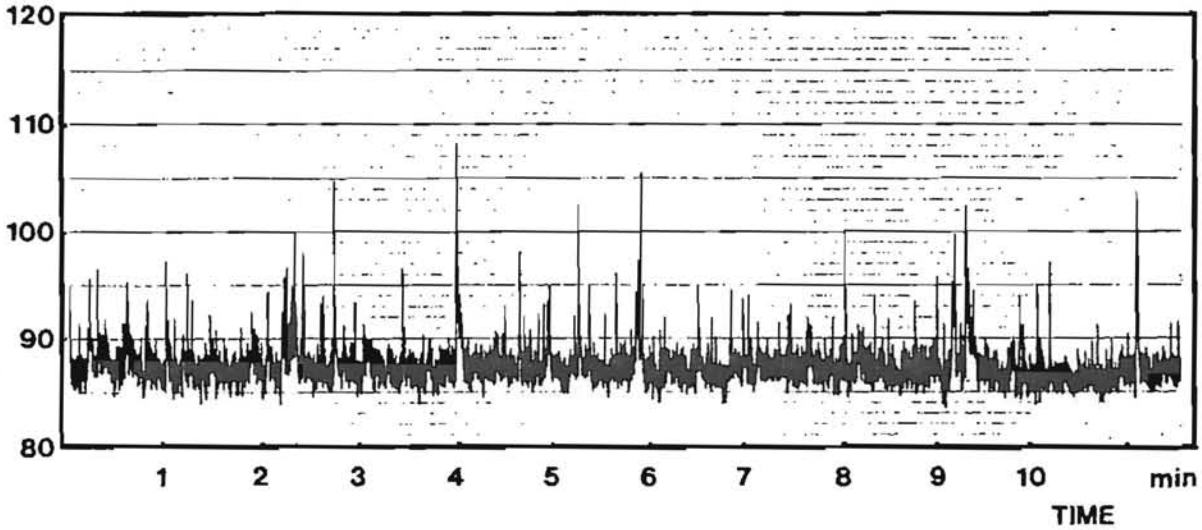
Measuring position: B Water depth: 800 m

SPECTRUM LEVEL, dB re 1 µPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	77	65	60
63.0	79	63	60
125	76	59	56
250	70	54	50
500	63	48	44
1000	52	43	39
2000	46	39	36
4000	44	36	33

OVERALL LEVEL, dB re 1 µPa



Wind: Zero

Temperature: -19°C Weather conditions: Misty

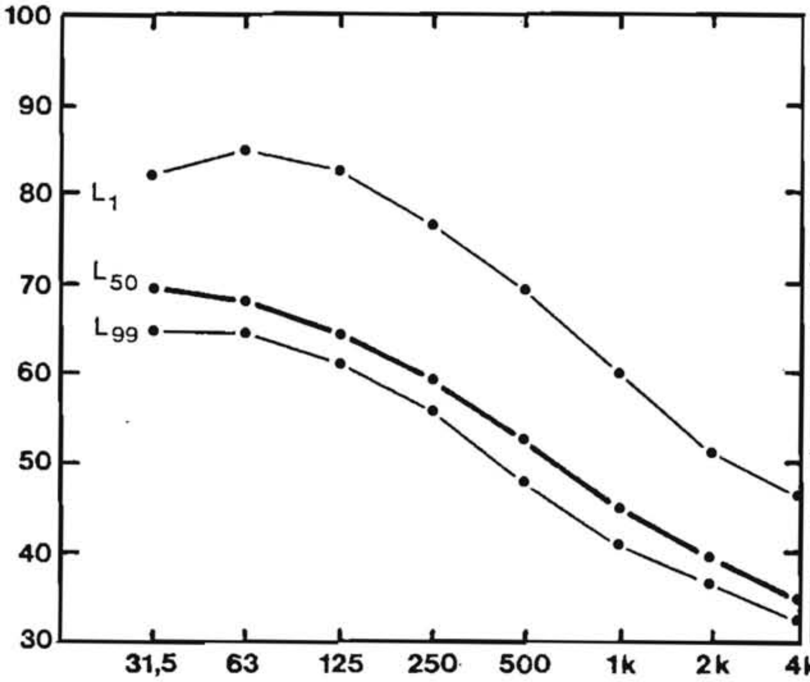
C 13

Recording no.: 13

Date: 20th April, 1982 Time: 02.55-03.18

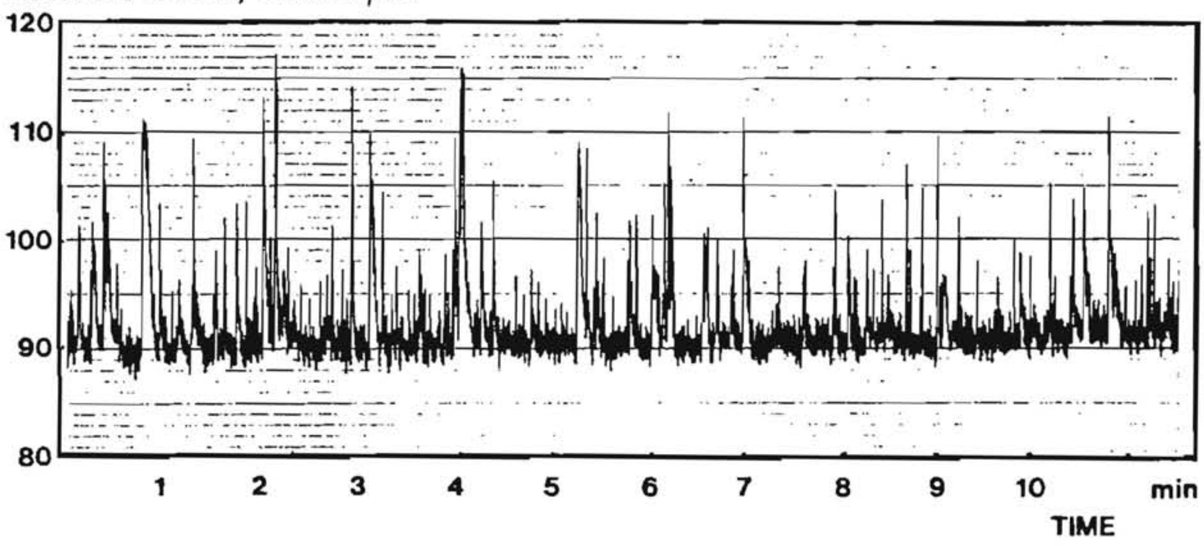
Measuring position: B Water depth: 800 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	82	70	65
63.0	85	68	65
125	83	65	61
250	77	60	56
500	70	53	48
1000	61	46	41
2000	51	39	37
4000	47	35	33

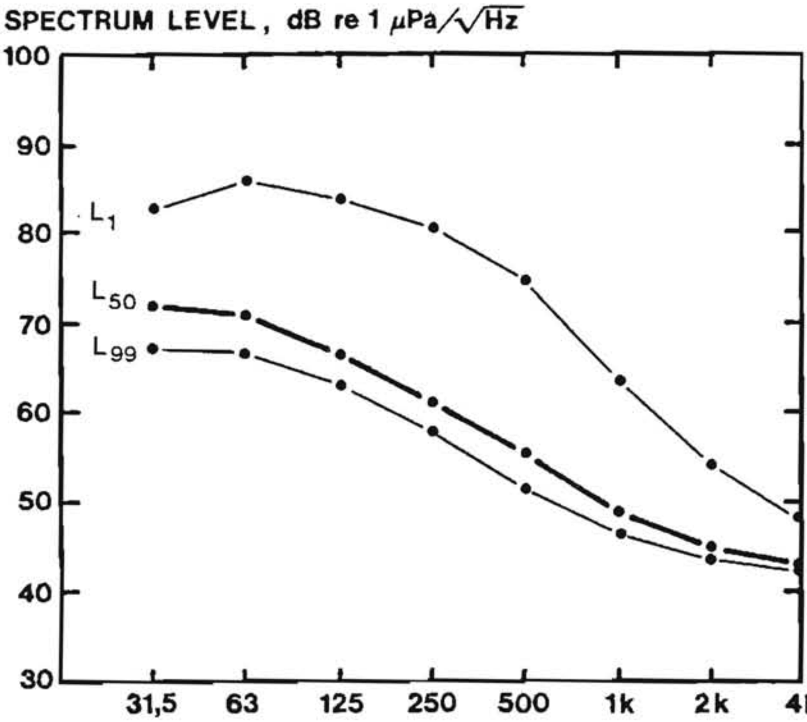
OVERALL LEVEL, dB re 1 μPa



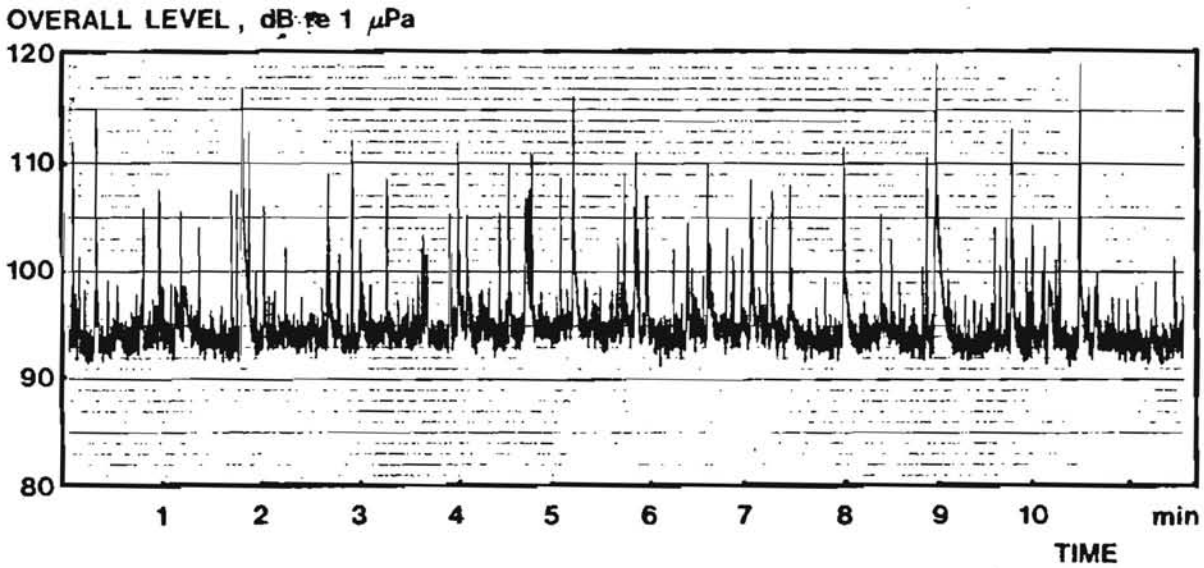
Wind: Zero

Temperature: -20°C Weather conditions: Misty

Recording no.: 14
Date: 20th April, 1982 Time: 06.01-06.22
Measuring position: B Water depth: 800 m



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	83	72	67
63.0	86	71	67
125	84	67	63
250	81	61	58
500	75	56	52
1000	64	49	47
2000	55	45	44
4000	48	43	42



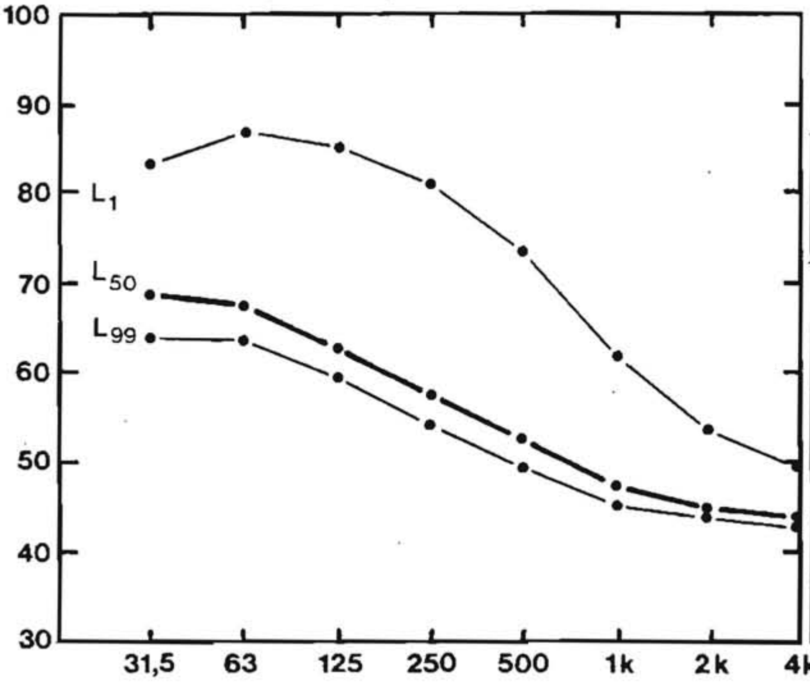
Wind: Zero
Temperature: -23°C Weather conditions: Clear, sunshine

Recording no.: 15 | C 15

Date: 20th April, 1982 | Time: 09.00-09.26

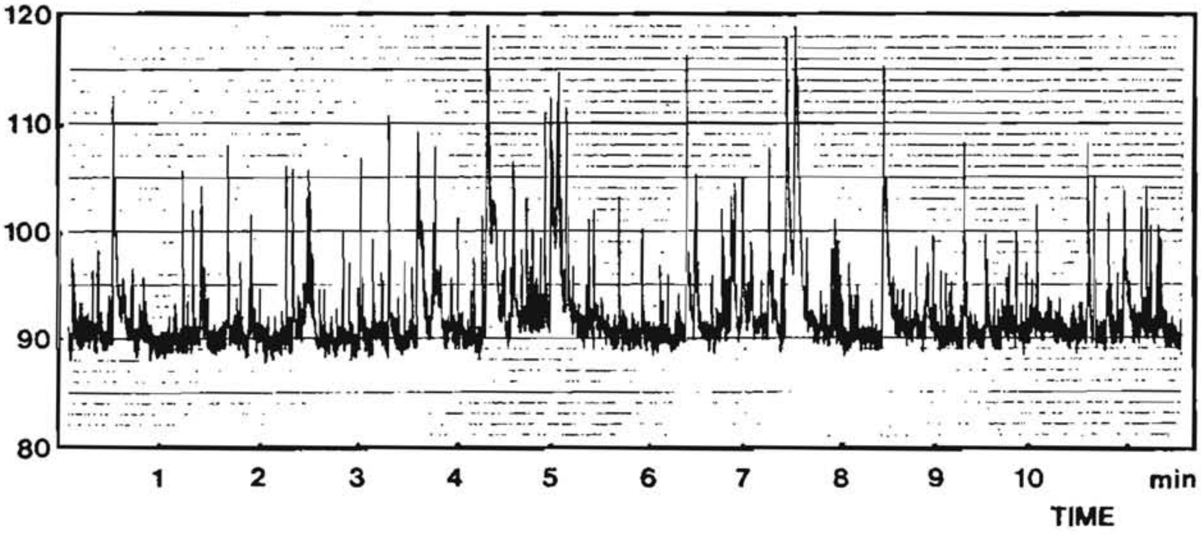
Measuring position: B | Water depth: 800 m

SPECTRUM LEVEL, dB re 1 $\mu Pa/\sqrt{Hz}$



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	84	69	64
63.0	87	67	64
125	85	63	60
250	81	57	54
500	74	53	49
1000	62	47	46
2000	54	45	44
4000	49	44	43

OVERALL LEVEL, dB re 1 μPa



Wind: 3.6 m/s | Wind direction: East

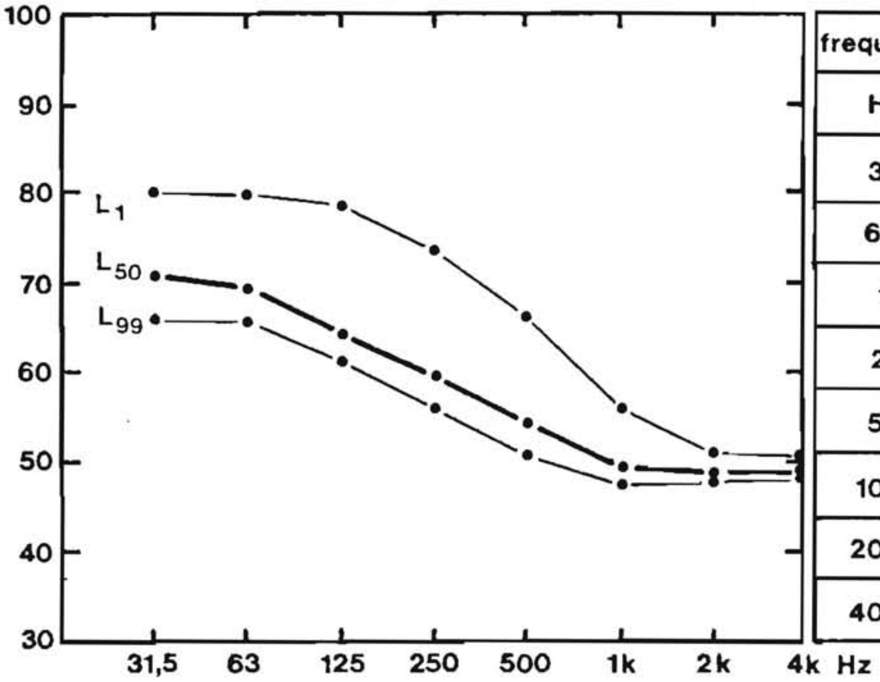
Temperature: -21°C | Weather conditions: Clear, sunshine

Recording no.: 16 C 16

Date: 20th April, 1982 Time: 12.15-12.40

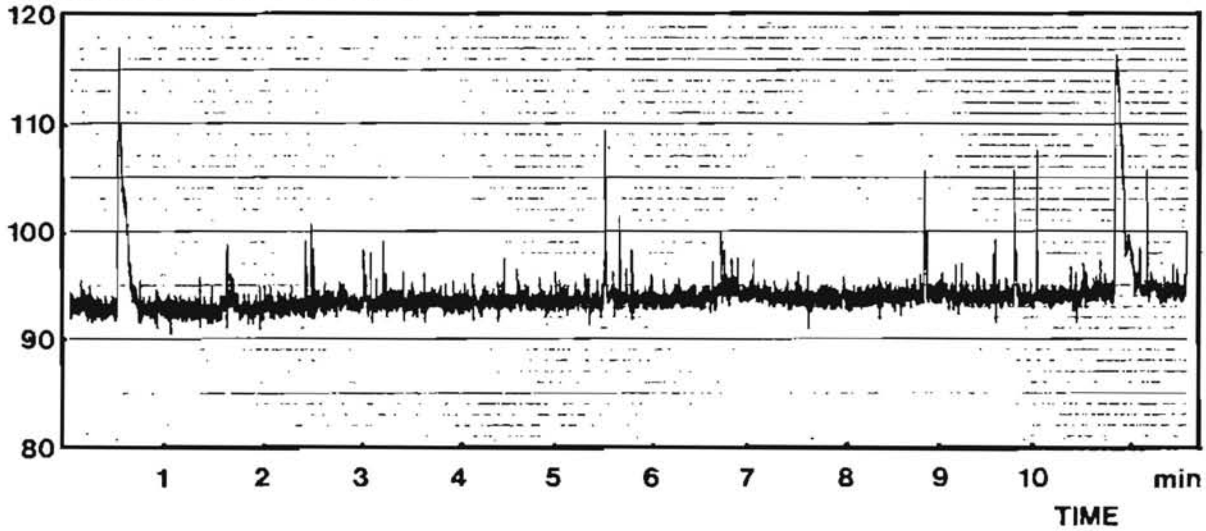
Measuring position: B Water depth: 800 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	80	71	66
63.0	80	70	66
125	79	65	61
250	74	60	56
500	67	55	51
1000	57	50	48
2000	51	49	48
4000	51	49	48

OVERALL LEVEL, dB re 1 μPa



Wind: 5.9 m/s Wind direction: East

Temperature: -20°C Weather conditions: Misty, sunshine

Remarks: Wind increasing and snow drifting over the ice.

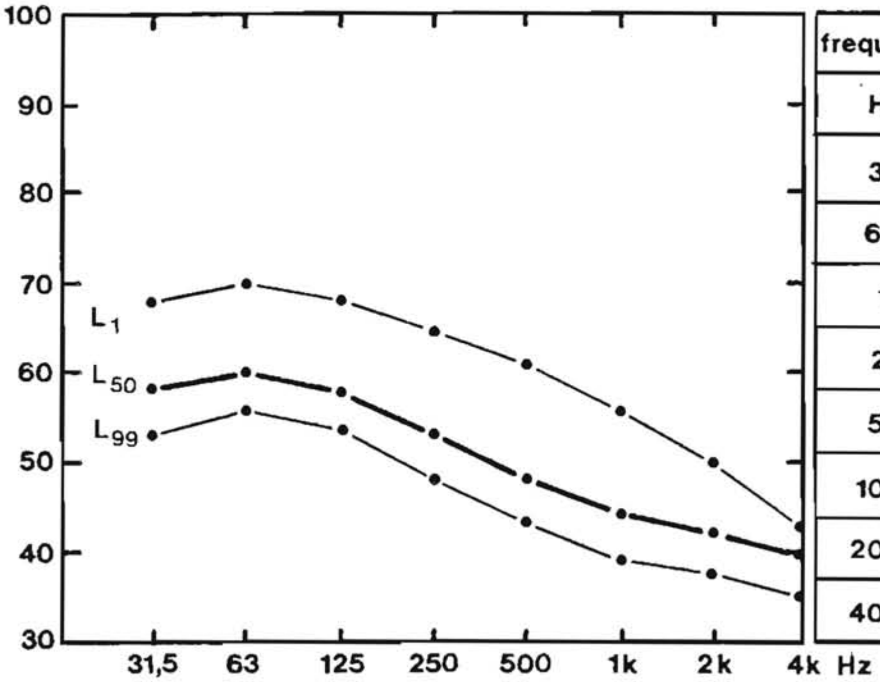
C 17

Recording no.: 17

Date: 20th April, 1982 Time: 21.55-22.18

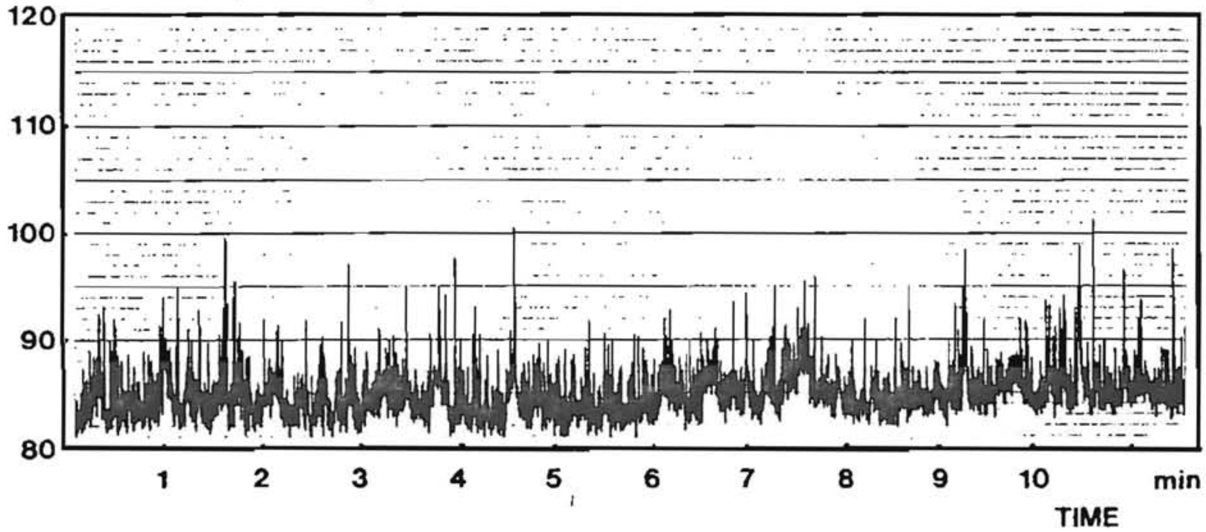
Measuring position: C Water depth: 200 m

SPECTRUM LEVEL, dB re 1 $\mu Pa/\sqrt{Hz}$



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	68	58	53
63.0	70	60	56
125	68	58	54
250	65	53	48
500	61	48	43
1000	56	44	39
2000	50	42	38
4000	43	38	35

OVERALL LEVEL, dB re 1 μPa



Wind: Zero

Temperature: -25°C Weather conditions: Clear, sunshine

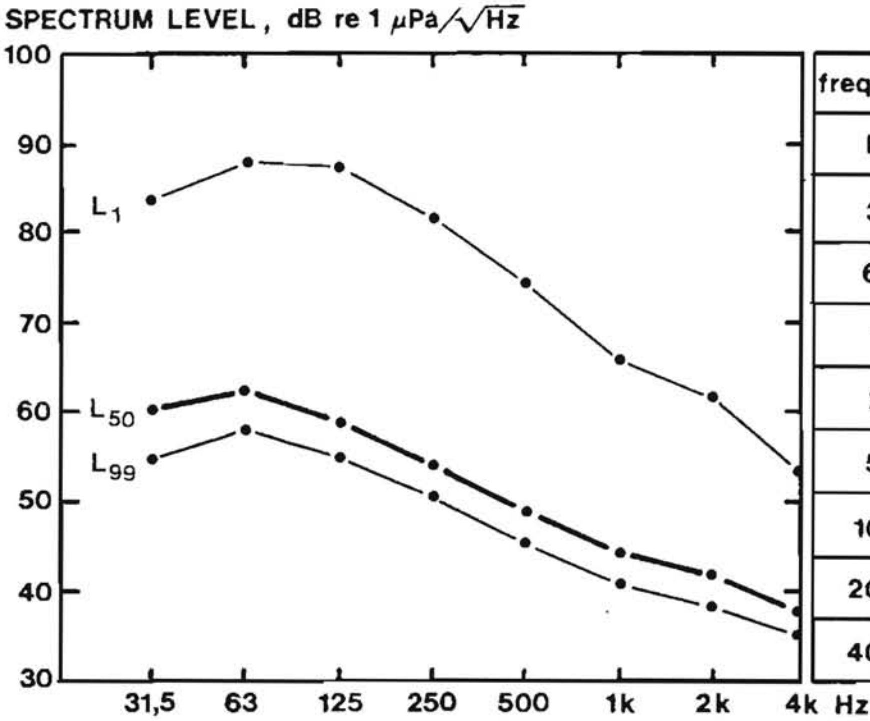
Remarks: First recording at position C placed in the middle of the shore fast ice.

C 18

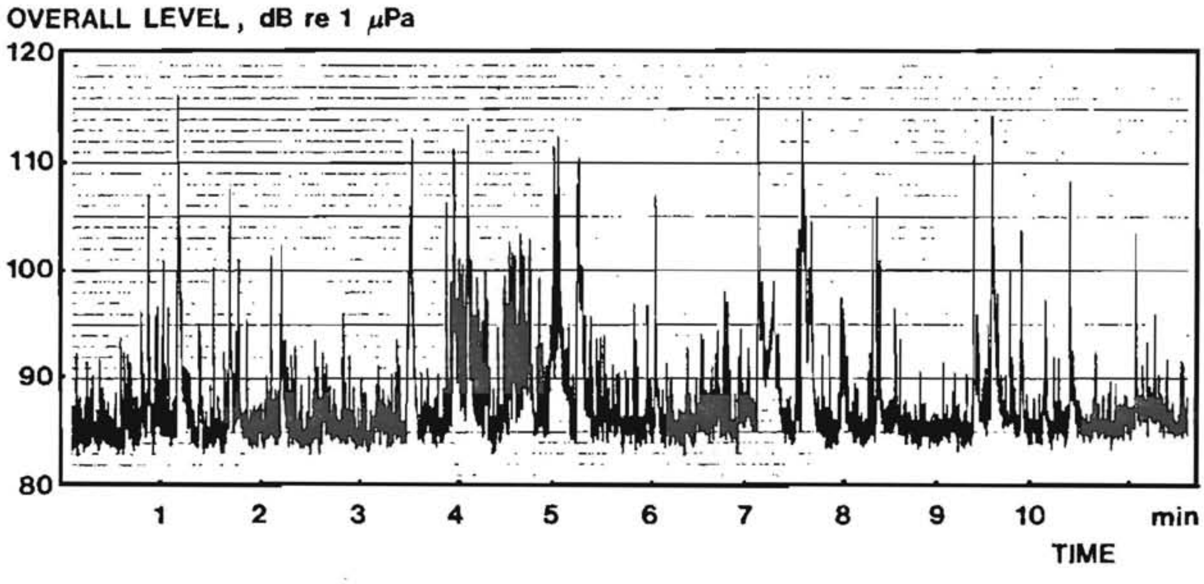
Recording no.: 18

Date: 21st April, 1982 Time: 00.00-00.23

Measuring position: C Water depth: 200 m



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	84	61	55
63.0	88	63	58
125	87	59	55
250	82	54	51
500	75	49	46
1000	66	45	41
2000	62	42	39
4000	54	38	35



Wind: Zero

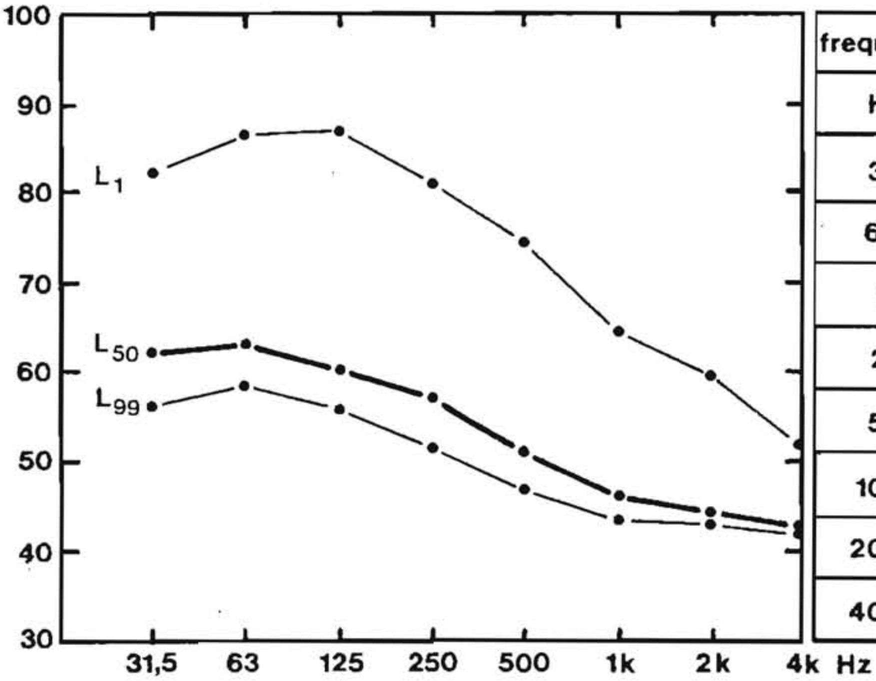
Temperature: -23°C Weather conditions: Clear

Recording no.: 19 C 19

Date: 21st April, 1982 Time: 02.05-02.28

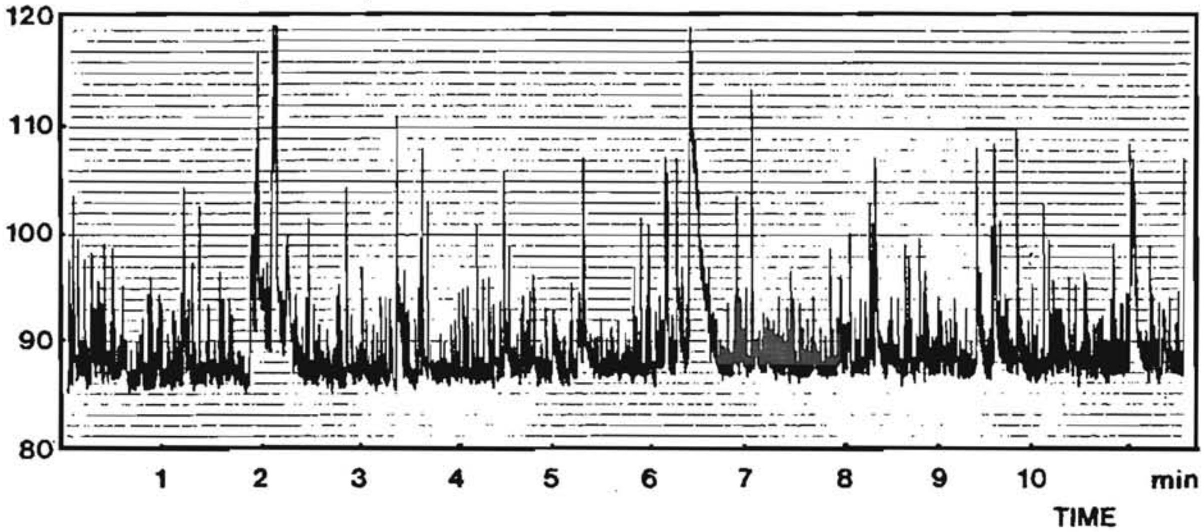
Measuring position: C Water depth: 200 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	82	62	56
63.0	87	63	59
125	87	60	56
250	81	57	52
500	75	51	47
1000	65	46	44
2000	60	45	43
4000	52	43	42

OVERALL LEVEL, dB re 1 μPa



Wind: Zero

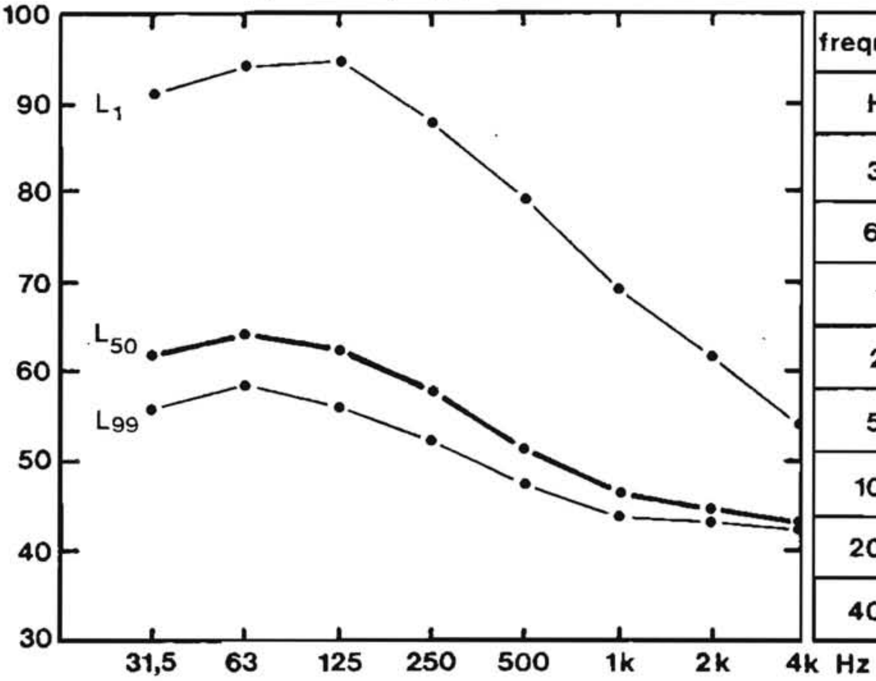
Temperature: -25°C Weather conditions: Clear

Recording no.: 20 C 20

Date: 21st April, 1982 Time: 03.55-04.17

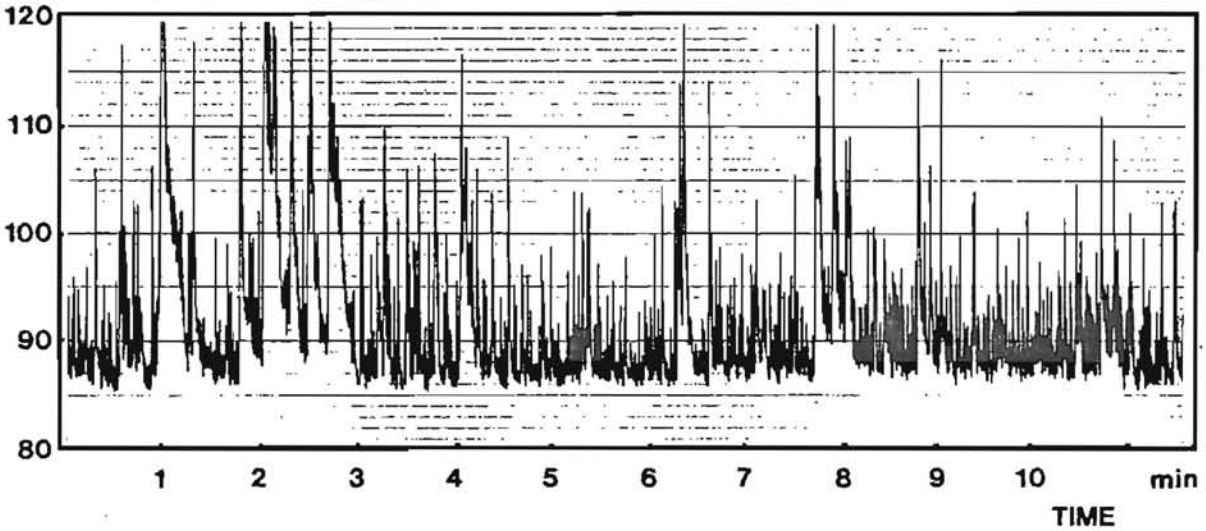
Measuring position: C Water depth: 200 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	91	62	56
63.0	94	64	59
125	95	63	56
250	88	58	52
500	80	51	48
1000	69	46	44
2000	62	45	43
4000	54	43	43

OVERALL LEVEL, dB re 1 μPa



Wind: Zero

Temperature: -25°C Weather conditions: Clear

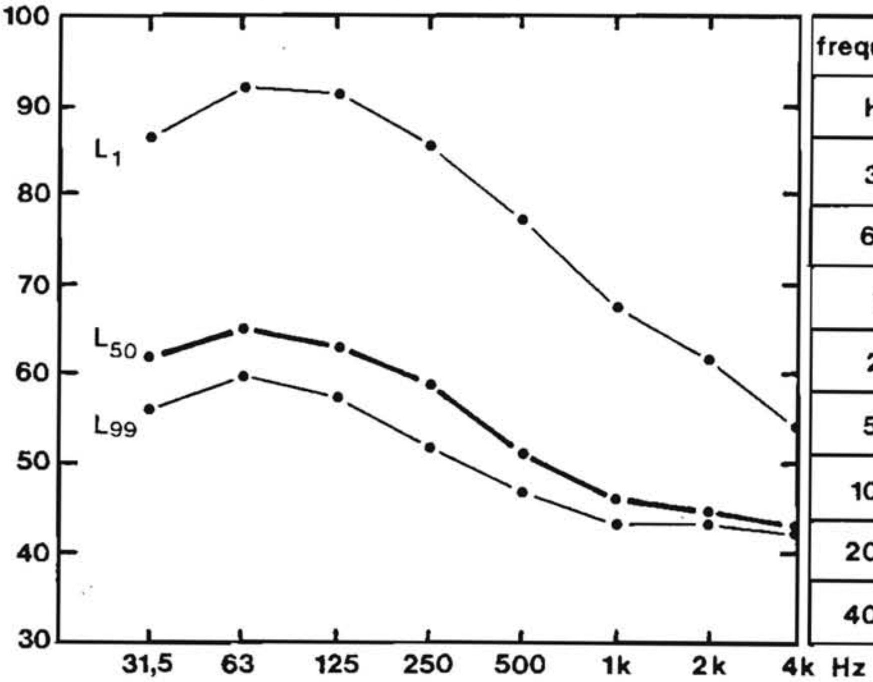
Remarks: Before sunrise

C 21

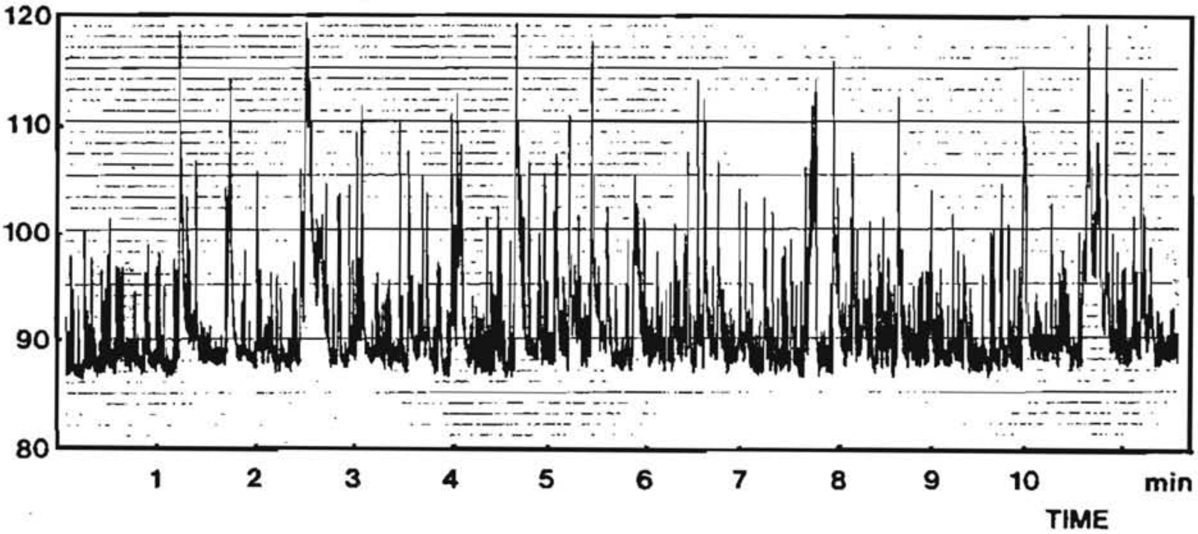
Recording no.: 21

Date: 21st April, 1982 Time: 06.05-06.30

Measuring position: C Water depth: 200 m



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	87	62	56
63.0	92	65	60
125	91	63	57
250	86	59	52
500	78	51	47
1000	68	47	44
2000	62	45	44
4000	54	43	43



Wind: Zero

Temperature: -26°C Weather conditions: Clear, sunshine

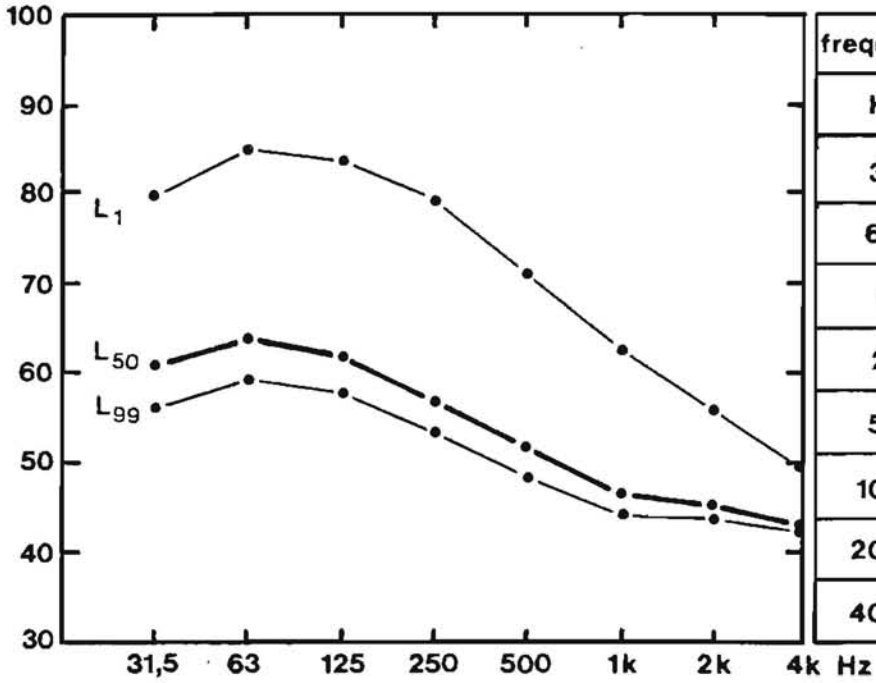
Remarks: After sunrise

Recording no.: 22

Date: 21st April, 1982   Time: 08.10-08.35

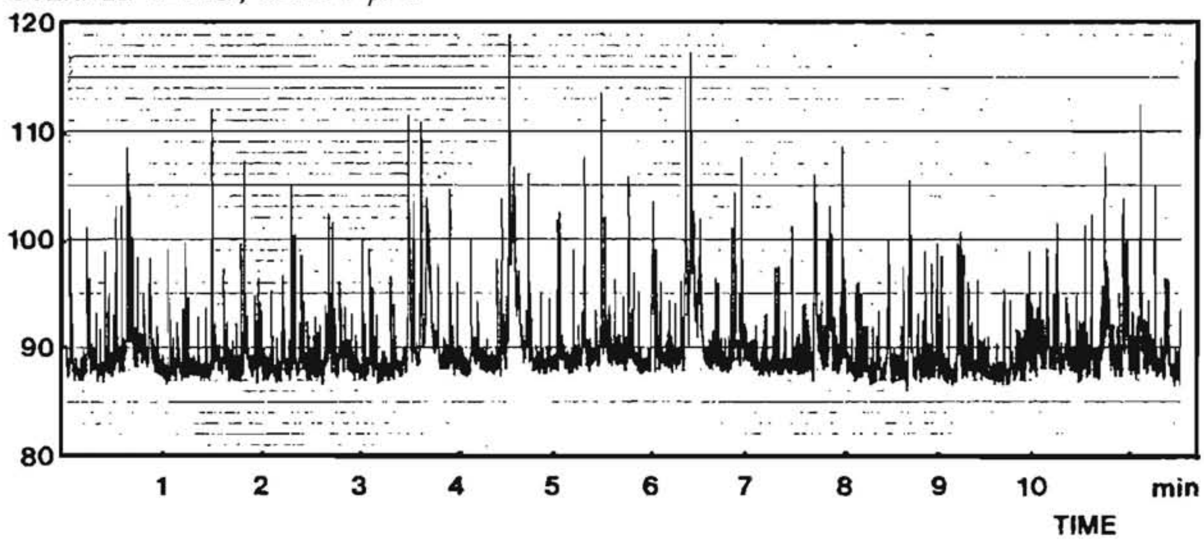
Measuring position: C   Water depth: 200 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency Hz	L_1 dB	L_{50} dB	L_{99} dB
31.5	80	61	56
63.0	85	64	60
125	84	62	58
250	80	57	54
500	71	52	49
1000	63	47	44
2000	56	45	44
4000	50	43	42

OVERALL LEVEL, dB re 1 μPa



Wind: Zero

Temperature: -24°C   Weather conditions: Clear, sunshine

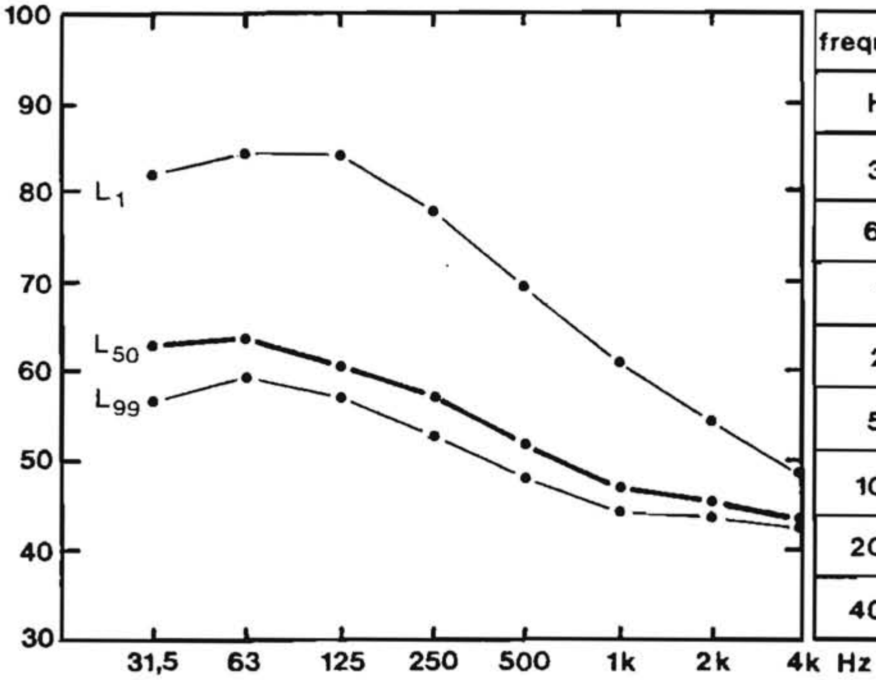
C 23

Recording no.: 23

Date: 21st April, 1982 Time: 09.55-10.15

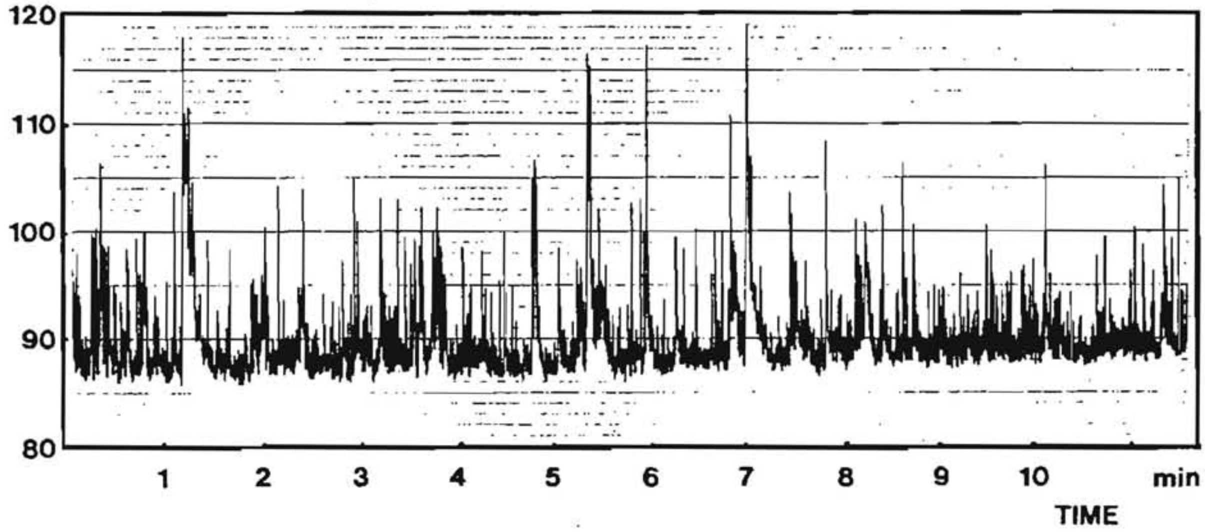
Measuring position: C Water depth: 200 m

SPECTRUM LEVEL, dB re 1 $\mu Pa/\sqrt{Hz}$



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	82	63	57
63.0	84	64	59
125	84	61	57
250	78	57	53
500	70	52	48
1000	61	47	44
2000	55	46	44
4000	48	43	42

OVERALL LEVEL, dB re 1 μPa



Wind: Zero

Temperature: -22°C Weather conditions: Clear, sunshine

Recording no.: 24

C 24

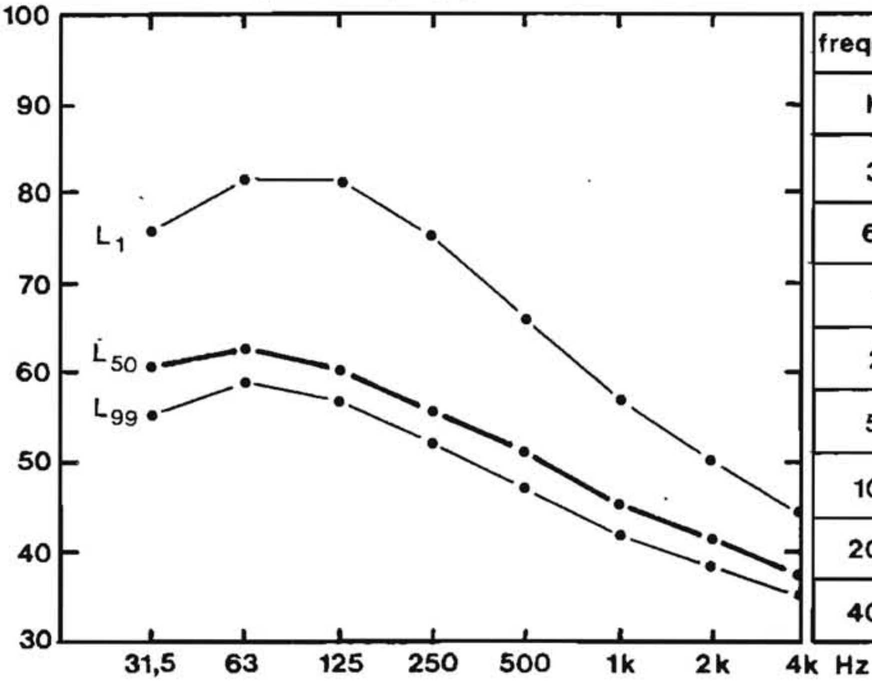
Date: 21st April, 1982

Time: 12.10-12.32

Measuring position: C

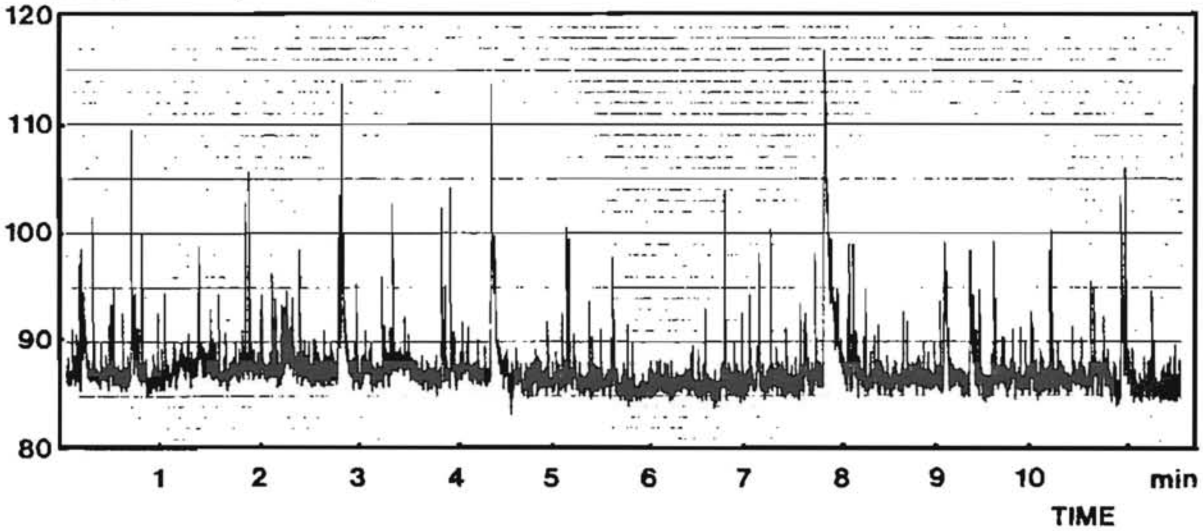
Water depth: 200 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	76	61	56
63.0	82	63	59
125	82	61	57
250	76	56	53
500	66	52	48
1000	58	46	42
2000	52	42	39
4000	45	37	35

OVERALL LEVEL, dB re 1 μPa



Wind: 3.2 m/s

Wind direction: East

Temperature: -21°C

Weather conditions: Clear, sunshine

Remarks: A little snow drifting over the ice.

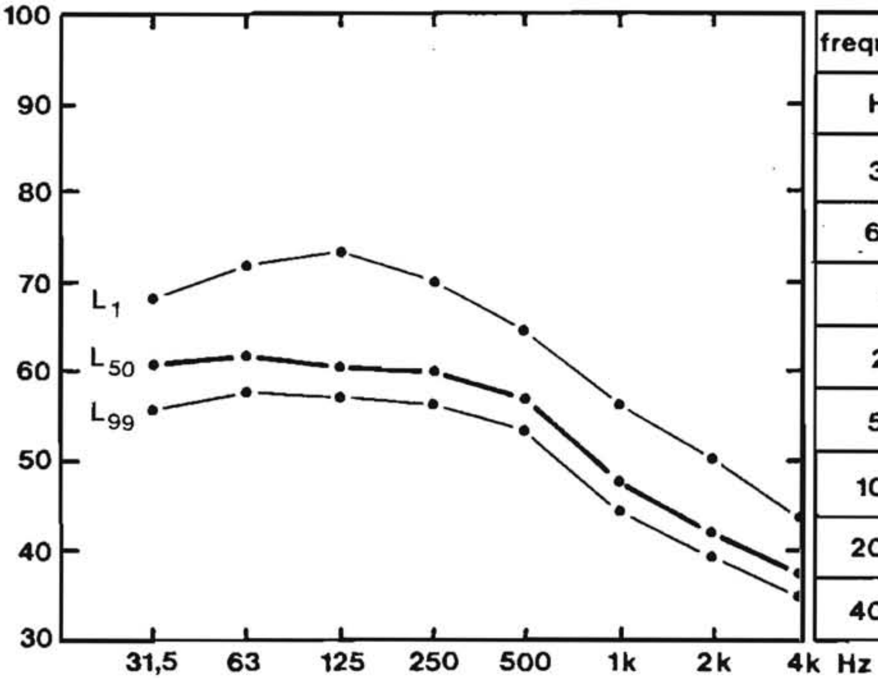
C 25

Recording no.: 25

Date: 21st April, 1982 | Time: 14.05-14.30

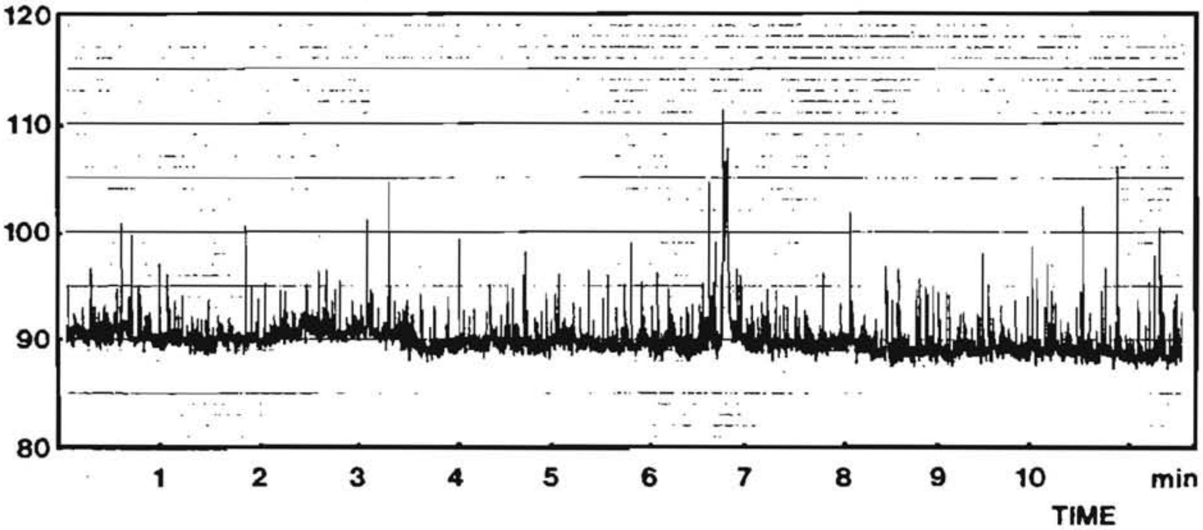
Measuring position: C | Water depth: 200 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	69	61	56
63.0	72	62	58
125	74	61	57
250	70	60	57
500	65	58	54
1000	57	48	45
2000	51	43	39
4000	44	38	35

OVERALL LEVEL, dB re 1 μPa



Wind: 4.3 m/s | Wind direction: East

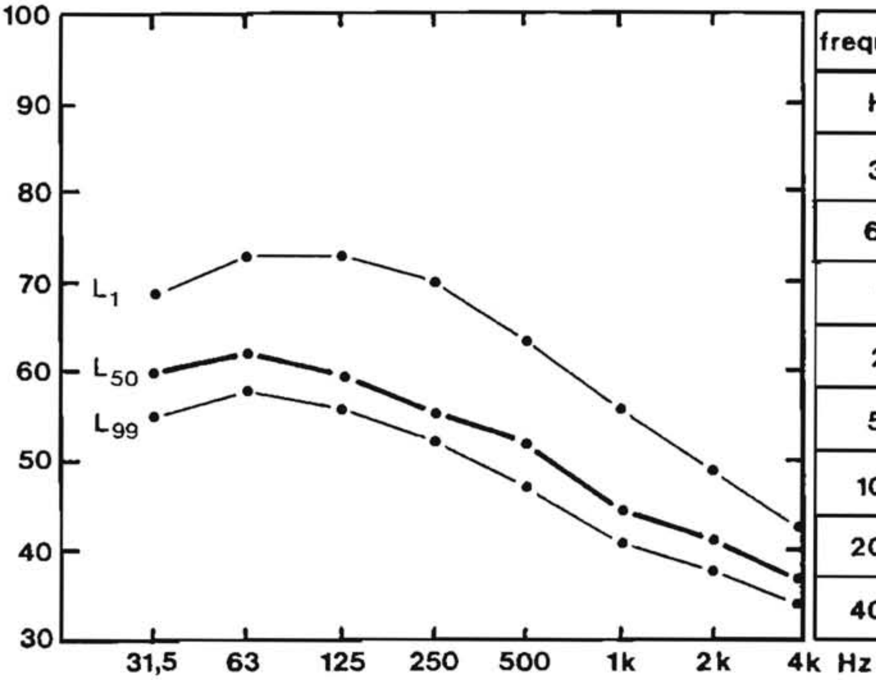
Temperature: -20°C | Weather conditions: Clear, sunshine

Recording no.: 26

Date: 21st April, 1982 Time: 16.06-16.30

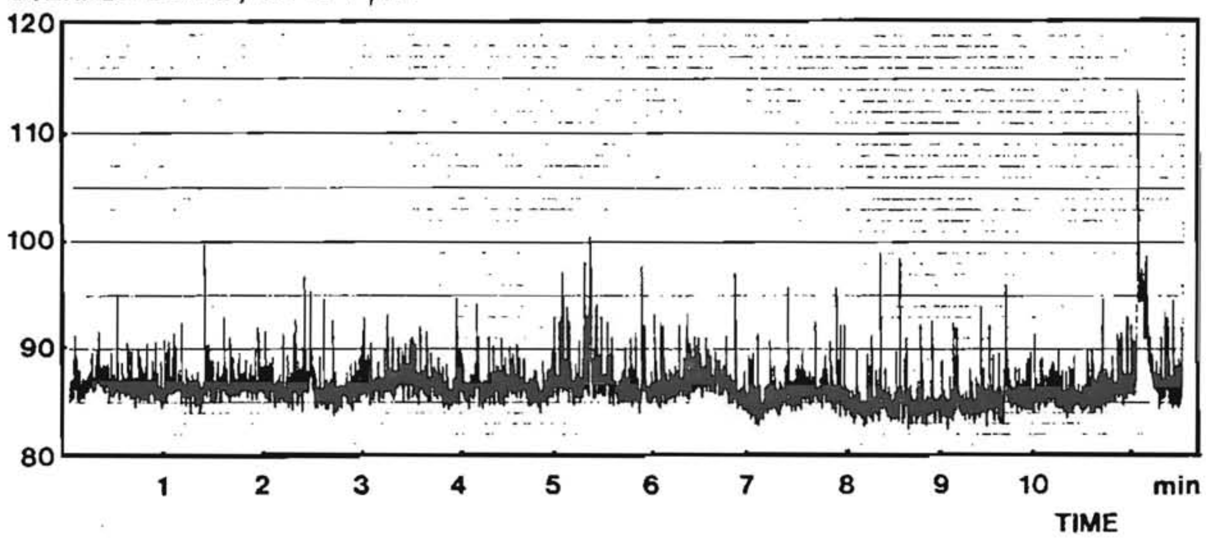
Measuring position: C Water depth: 200 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	69	60	55
63.0	73	62	58
125	73	60	56
250	70	56	53
500	64	53	48
1000	57	45	41
2000	51	42	38
4000	43	37	34

OVERALL LEVEL, dB re 1 μPa



Wind: 0-3 m/s Wind direction: Shifting

Temperature: -19°C Weather conditions: Misty, sunshine

Remarks: A little snow drifting over the ice at times.

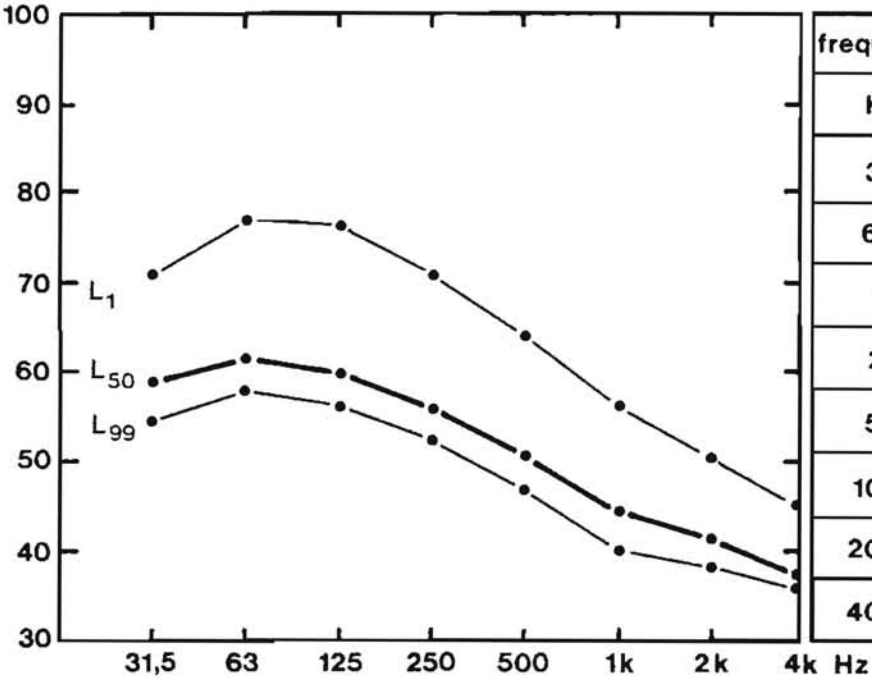
C 27

Recording no.: 27

Date: 21st April, 1982 Time: 17.59-18.22

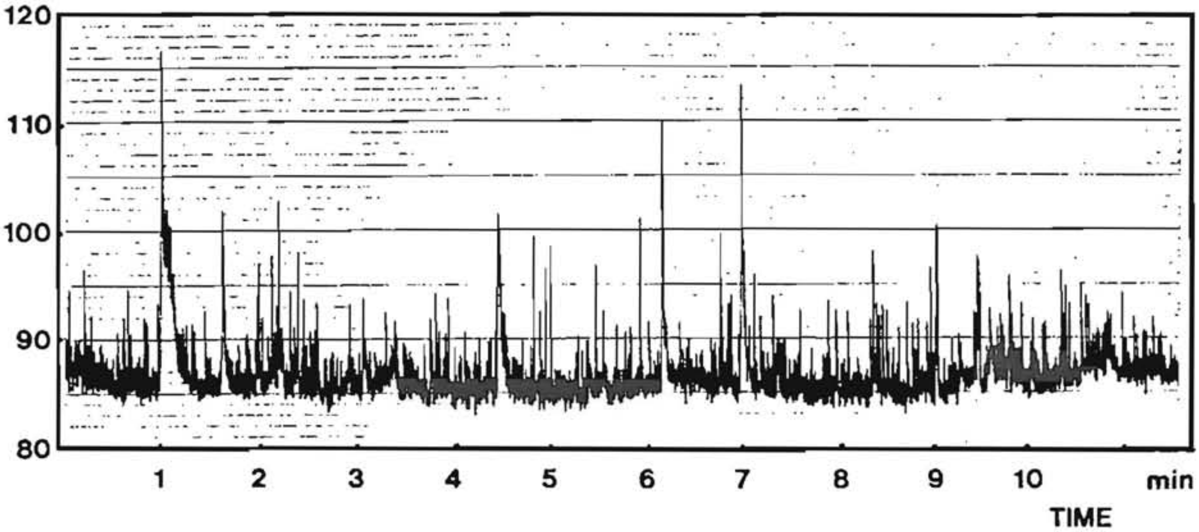
Measuring position: C Water depth: 200 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	71	59	54
63.0	77	62	58
125	76	60	56
250	71	56	53
500	65	51	47
1000	57	45	41
2000	51	42	38
4000	45	37	34

OVERALL LEVEL, dB re 1 μPa



Wind: Zero

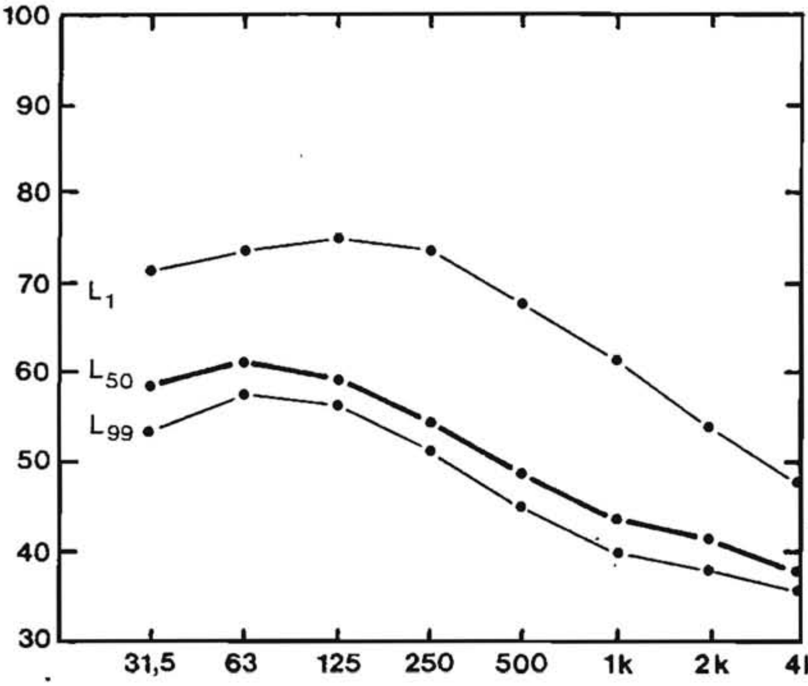
Temperature: -20°C Weather conditions: Clear, sunshine

Recording no.: 28

Date: 21st April, 1982 Time: 19.57-20.19

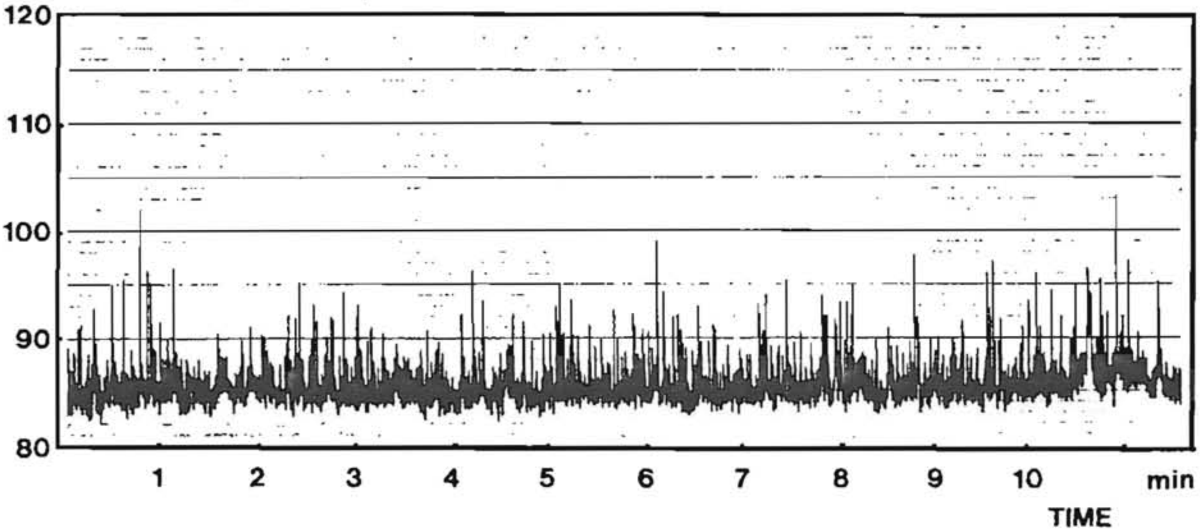
Measuring position: C Water depth: 200 m

SPECTRUM LEVEL, dB re 1 μPa/√Hz



frequency	L_1	L_{50}	L_{99}
Hz	dB	dB	dB
31.5	71	59	54
63.0	74	62	58
125	75	59	57
250	74	55	52
500	68	49	46
1000	62	44	40
2000	55	42	38
4000	48	37	35

OVERALL LEVEL, dB re 1 μPa



Wind: Zero

Temperature: -21°C Weather conditions: Clear, sunshine

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