サケマス流網の素材の超音波反射指向性の測定

Measurement of Directivity of supersonic wave reflection from elements of salmon gillnet

畠 山 良 己・石 井 憲

Yoshimi Hatakeyama and Ken Ishii

水 産 工 学 研 究 所

National Research Institute of Fisheries Engineering

1985年 3月

March, 1985

水 産 庁

Fisheries Agency of Japan

この文書を引用する場合は下記による：
畠山良己・石井　憲　1985
サケマス流網の素材の超音波反射指向性の測定　水産庁
北太平洋漁業国際委員会海産哺乳動物特別小委員会
科学分科会　1985年3月　東京　提出文書

サケマス流網の素材の超音波反射指向性の測定

Measurement of Directivity of supersonic wave reflection
from elements of salmon gillnet

水産工学研究所　畠　山　良　己
石　井　　　憲

1983年度の報告[1)]のようにサケマス流網を構成する素材のうちで浮子、沈子、ロープは大きな反射波を生じ、その反射損失が小さい。イシイルカが遠くから流網に接近する場合、エコーロケーションビームの角度を10°とすると、30 *m*以上の距離ではビーム直径が6 *m*以上となり、流網全体から反射波を受ける。従ってイシイルカは素材の総合反射波により、まず流網全体の存在を知り、更に近づいて個々の素材の配置を認識する筈である。イシイルカが流網に対し直角に接近する場合一番反射波が大きく、イシイルかの検知可能最大距離（Ｒｄ）は前年度報告の値となるが、斜めに接近する場合、流網の素材の反射指向性によりＲｄは減少する。

今回、浮子、沈子、ロープの反射指向性をイシイルカのクリックスの周波数に近い50、100ｋＨｚについて測定したのでここに報告する。

1．測　定　方　法

図１に示した魚体のターゲットストレングス（ＴＳ）を測定する装置[2)]を使い、図２の配置により反射体の角度（θ）を変えて反射指向性を測定した。ＴＳと反射損失（ＲＬ）の間には、ＲＬ＝－ＴＳの関係がある。

図３のように、指向性を測定する反射体の長軸（Ｈ）に垂直な方向（Ｖ）を０°とし、時計回り方向をマイナス、反時計方向をプラスとして１°間隔で－50°～＋50°の範囲を測定している。図１の魚体回転機構は魚のように密度が水と余り異ならない物の回転には都合が良いが、軽い物や重い物は重量バランスをとる必要があった。即ち、浮力がある物には錘を付け、沈む物には浮きを付けてから長軸が水平になるように糸を調節した。

測定試料は前年度に反射損失を測定したものと同じであり、その寸法、材質を表１に示した。

浮子については長軸（Ｈ）方向を０°とする測定も行ったので、前述の方向の測定には“Ｖ”、長軸方向の測定には“Ｈ”を付けて区別した。

2. 測定結果・考察

浮子、沈子、ロープの反射指向性の測定結果を図4～7に示した。測定は静岡県伊豆半島の戸田港内に筏を浮かべて行ったので、漁船と観光船の通過や強い風によって波が発生する度に筏の下に吊り下げられた反射体と送波器がゆれて、角度（ θ ）が変動した。従って角度の設定精度は水槽実験のように正確でなく、本来時計方向と反時計方向で測定値が対称である筈なのに非対称となっている。しかし、流網の素材の反射指向性を大まかに理解し、イルカが斜め方向から流網に接近する時の検知状況を推察するのに役立つ。

ＴＳの最大値（ＴＳmax）とそれより６ｄＢ小さくなる角度巾（ α ）を求め、表２に示した。一番右の欄には前年度に143ｋＨｚについて測定したＴＳを参考として記入した。各反射体とも、周波数が高くなり、波長が短かくなるにつれて、また反射体の寸法が長くなるにつれて、指向性は鋭くなっている。浮子、ロープは大きい反射波を発生するが、 α は10°内外であり、それ以上の角度では急に反射波が小さくなり、斜方向から検知しにくくなっている。

前年度の報告のように、イシイルカのエコーロケーションクリックスの周波数を145ＫＨＺ、送波レベルを68ｄＢ、パルス巾を50 μ Ｓ、パルス周期を100ｍＳとして、エコーレベルがイシイルカの補正聴覚閾値と同じになる距離を検知可能最大距離（Ｒｄ）とし、色々な値のＴＳについてＲｄを計算し図８に示した。

吸収損失が無視できるような近距離では、ＴＳが△ＴＳ（ｄＢ）だけ変化したことによりＲｄがＲｄ′になったとすると

$$Rd' = Rd \times 10^{\frac{\Delta TS}{40}}$$

の関係がある。

イシイルカの推定聴覚閾値[3)]は50～100ｋＨｚで約－51ｄＢであり、145ｋＨｚの時より６ｄＢ感度が良い。聴覚閾値のみ変え他は同じ条件で50～100ｋＨｚの時のＲｄを求め、図８に示しておいた。例として、図４と６の100ｋＨｚの浮子と沈子の反射指向性で、縦軸を検知可能最大距離に変換して図９に示した。浮子では角度が０°から40°に変化すると、検知可能最大距離は40 *m* から６ *m* に急激に減少している。

今回は、サケマス流網の素材一つずつについて指向性を測定したが、一定間隔でそれらの素材が多数付いている流網全体の反射指向性についても今後検討していく必要がある。流網に色々な反射物を取り付けて、イルカに認知し易くしイルカの羅網状況を調べる実験を計画しているが、反射物のターゲットストレングスと指向性を考慮し、その形状と配置を決めなければならない。

References

1) Hatakeyama, Y. 1984 : On Reflection Loss of Gillnet and Maximum Datectable Range of Dall's Porpoise. Document submitted to the meeting of the Scientific Subcommittee of the Ad Hoc Committee on Marine Mammals, INPFC Tokyo, Japan. March, 1984.

2) Research Department, Fishery Agency of Japan, 1984 : 1982 Report on Actual Measurement and Investigation for Quick Assessment (in Japanese).

3) Awbrey, F. T. et al. 1979 : The bioacoustics of the Dall's porpoise-salmon driftnet interaction. H/SWRI Technical Report 79-120, Nov. 1979, Hubbs/Sea World Research Institute.

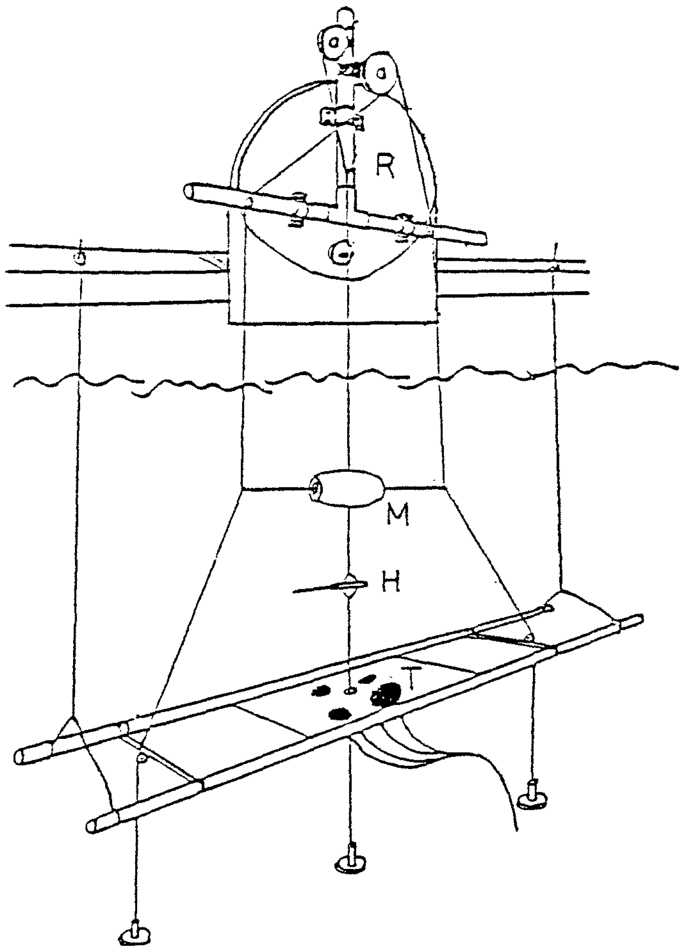
Table 1. Configuration and size of measured samples

Measured samples	Configuration and size
Lead	weight=75g, d_1=21mm, d_2=10mm, l=31mm
Float(vinyl chloride)	weight=50g, max d_1=46mm, d_2=9mm, l=154mm
Rope of lead line(Poli propilene)	l=69cm, d_1=7mm

l = lenght, d_1 = outer diameter, d_2 = inner diameter

Table 2. Maximum target strength (TS_{max}) and 6 dB down angle (α^o)

Samples \ Frequency		50 KHZ	100 KHZ	143 KHZ
Float(V)	TS_{max}(dB)	-27	-27	-25
	α(°)	9	5	
Float(H)	TS_{max}(dB)	-38	-33	
	α(°)	67	39	
Lead	TS_{max}(dB)	-38	-35	-39
	α(°)	64	60	
Rope	TS_{max}(dB)	-27	-32	-33
	α(°)	14	9	



R ----Rotation system H ----Hydrophone
M ----Measured sample T ----Transmitter

Fig. 1 Measuring system for target strength

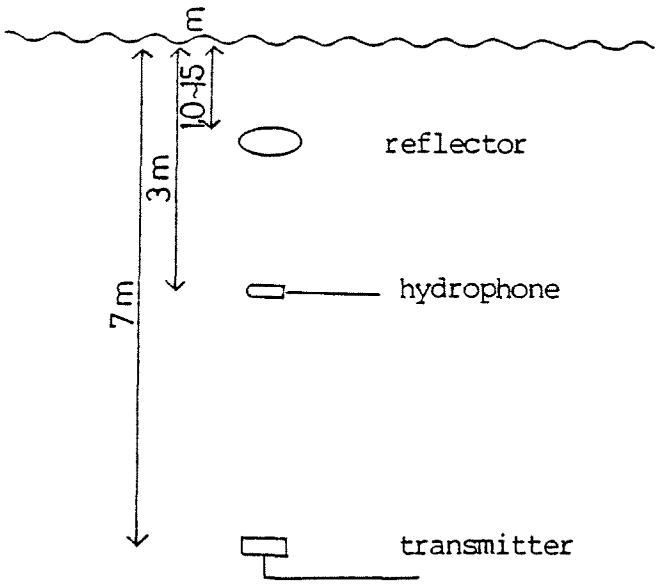


Fig. 2 Arrangement of measuring equipments

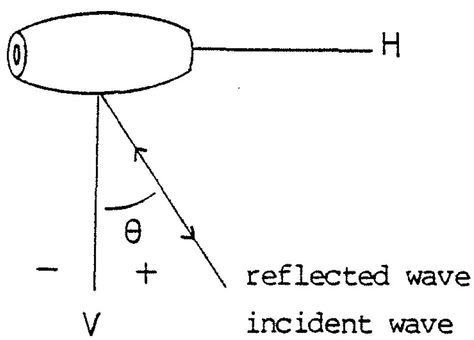
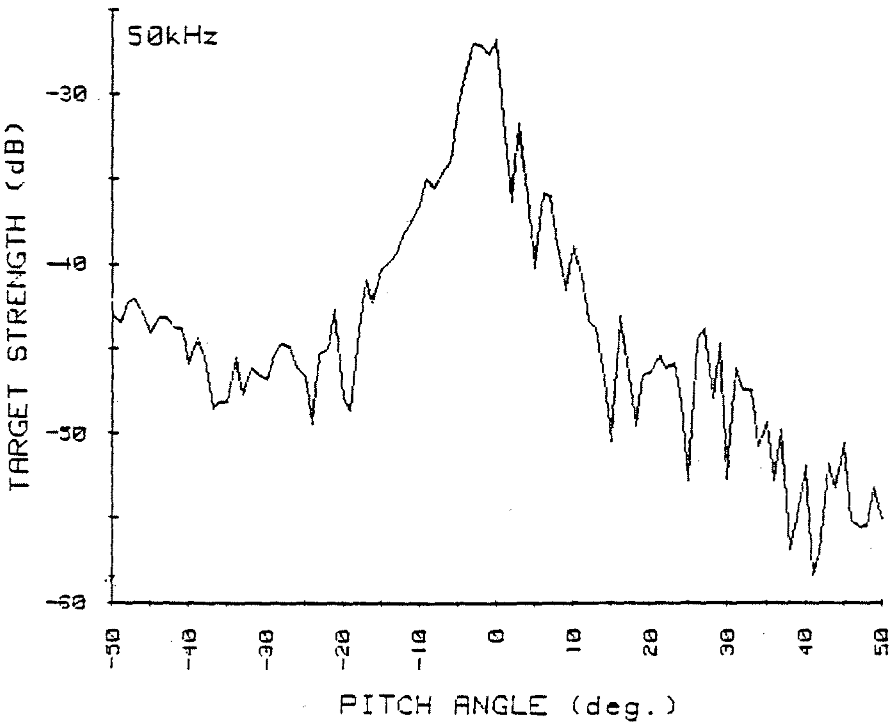


Fig. 3 Determination of angle



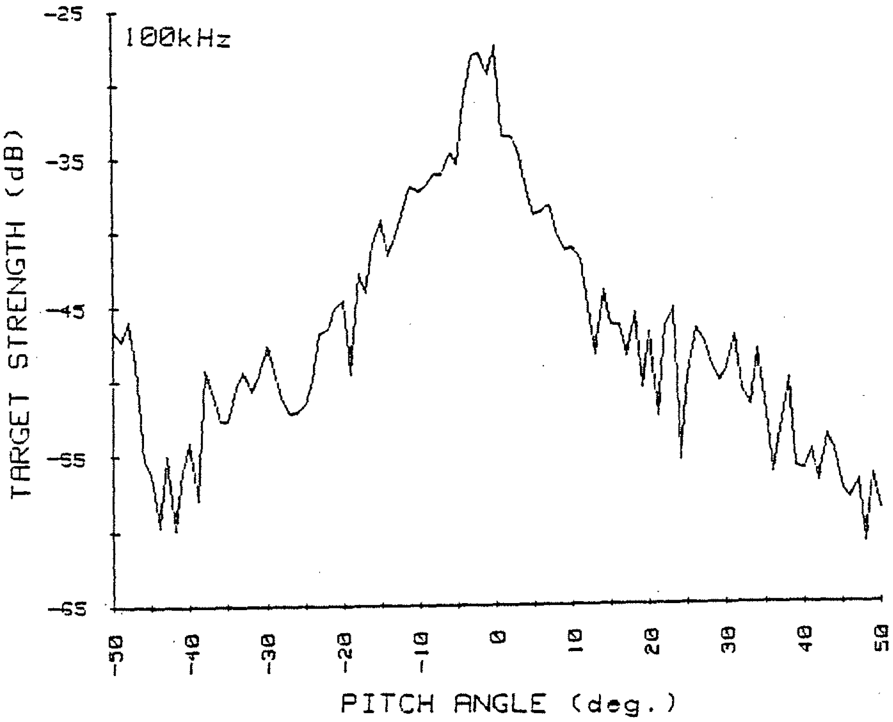


Fig. 4 Directivity of reflection from float(V direction)

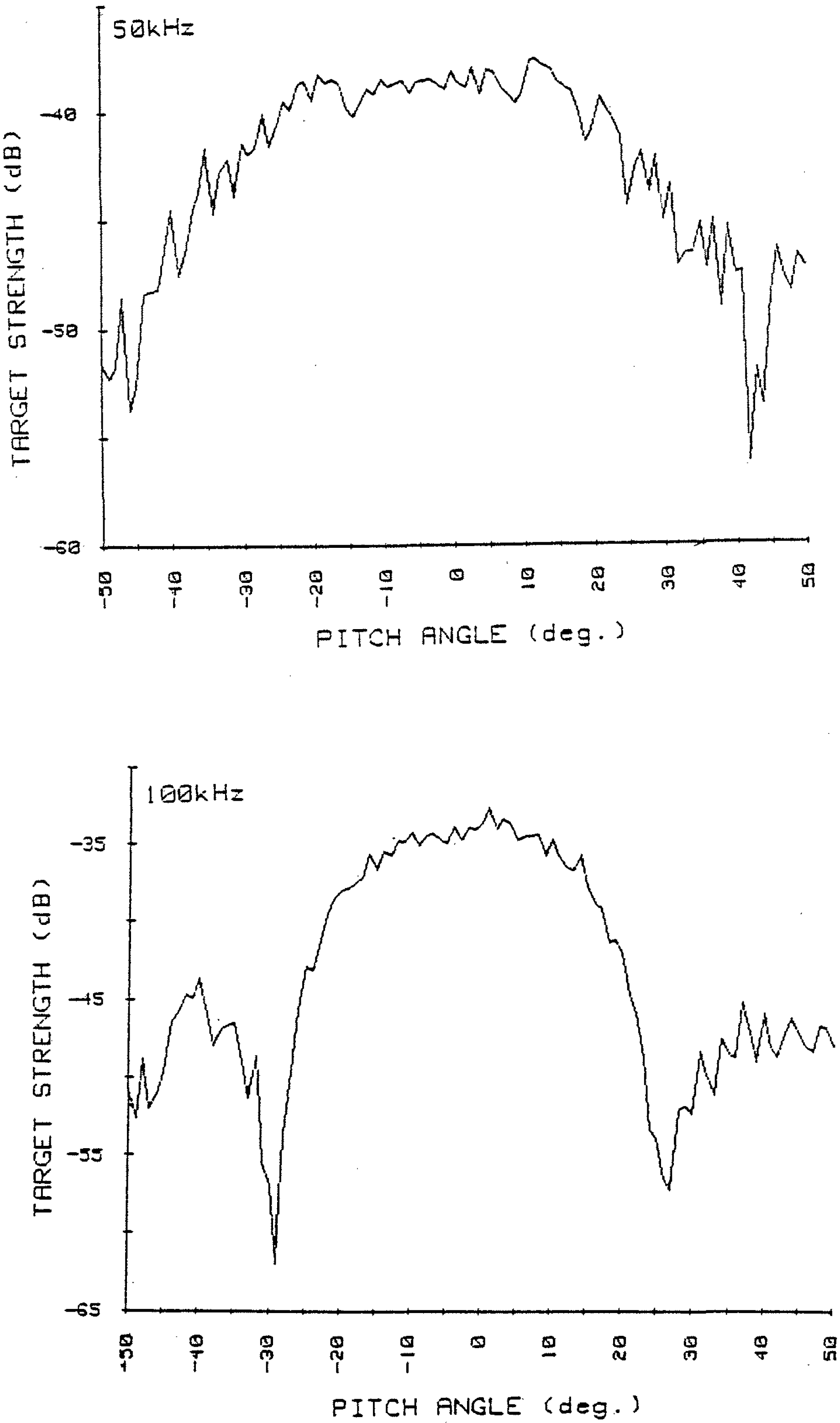
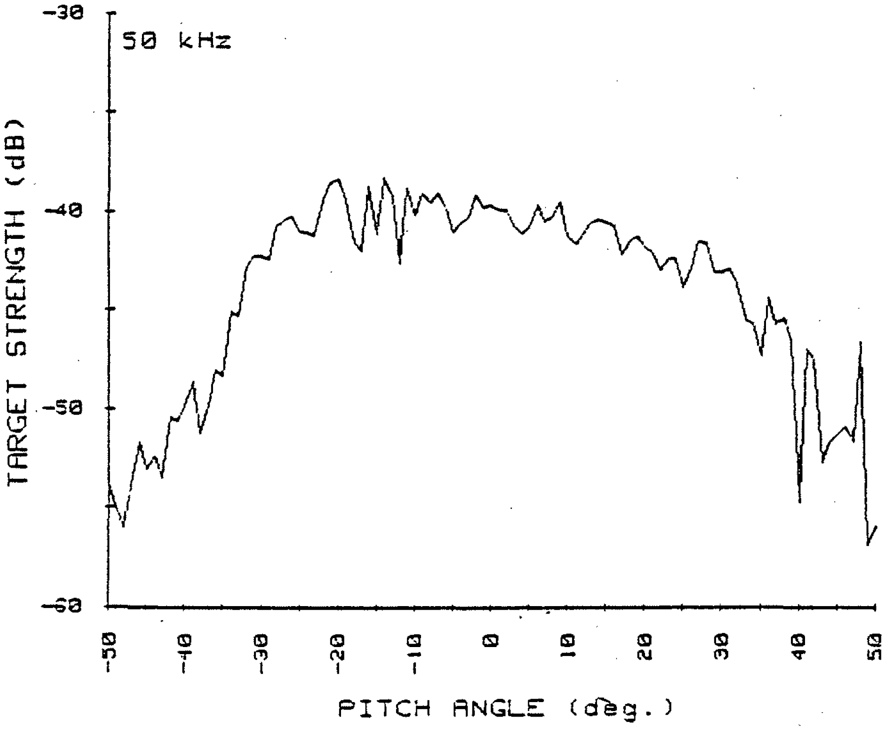


Fig. 5 Directivity of reflection from float(H direction)



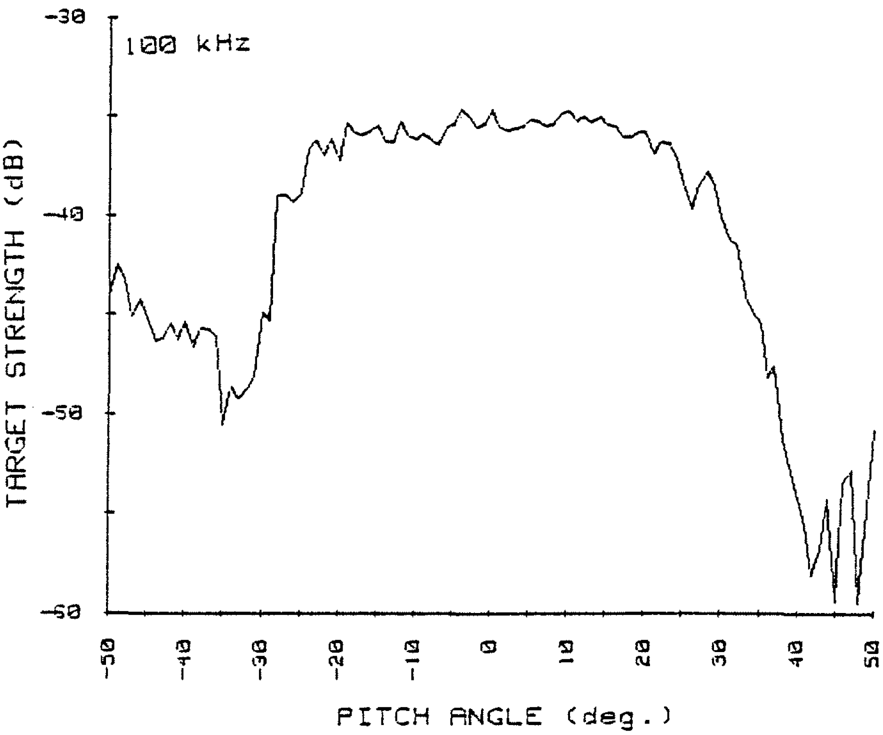


Fig. 6 Directivity of reflection from lead

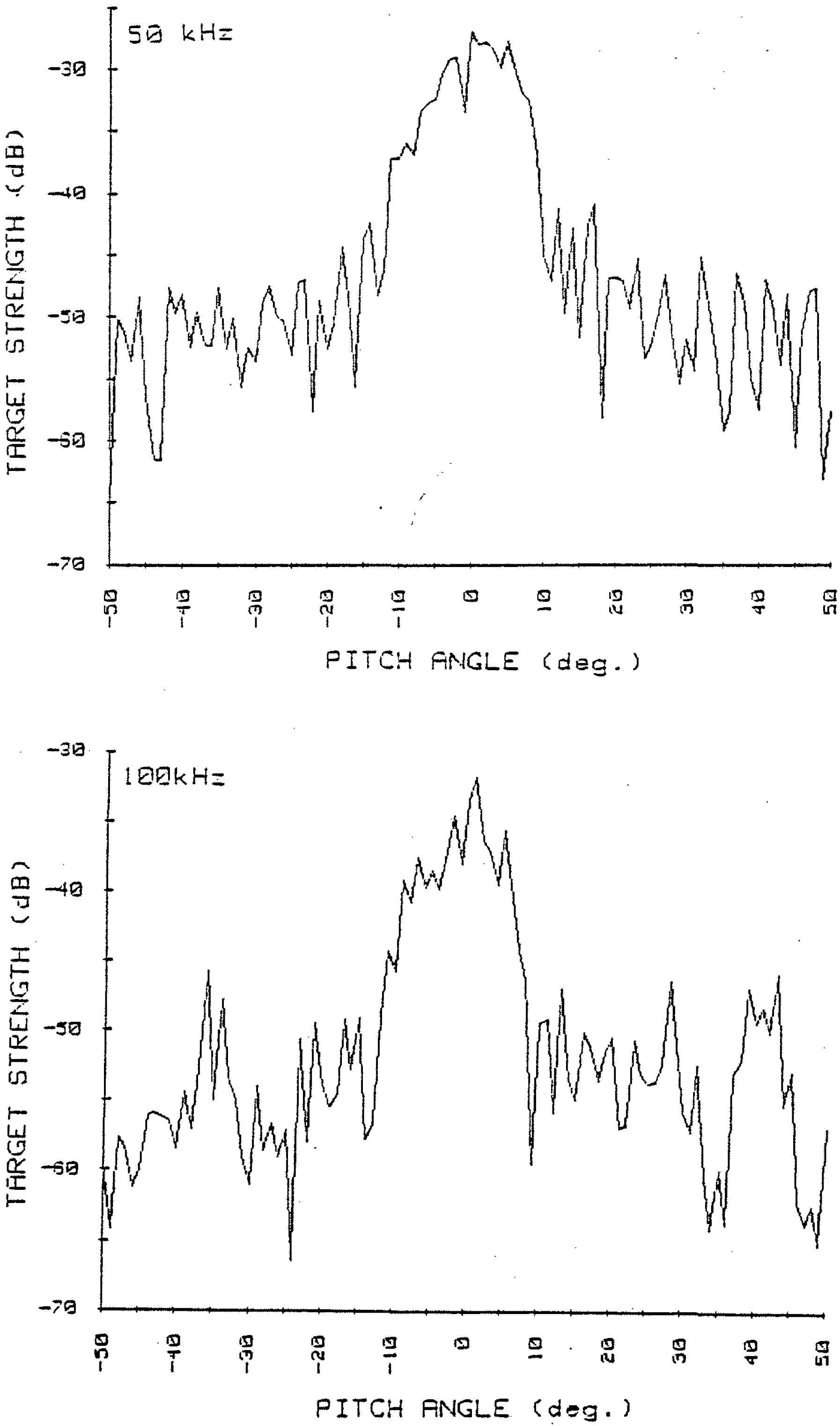


Fig. 7 Directivity of reflection from rope

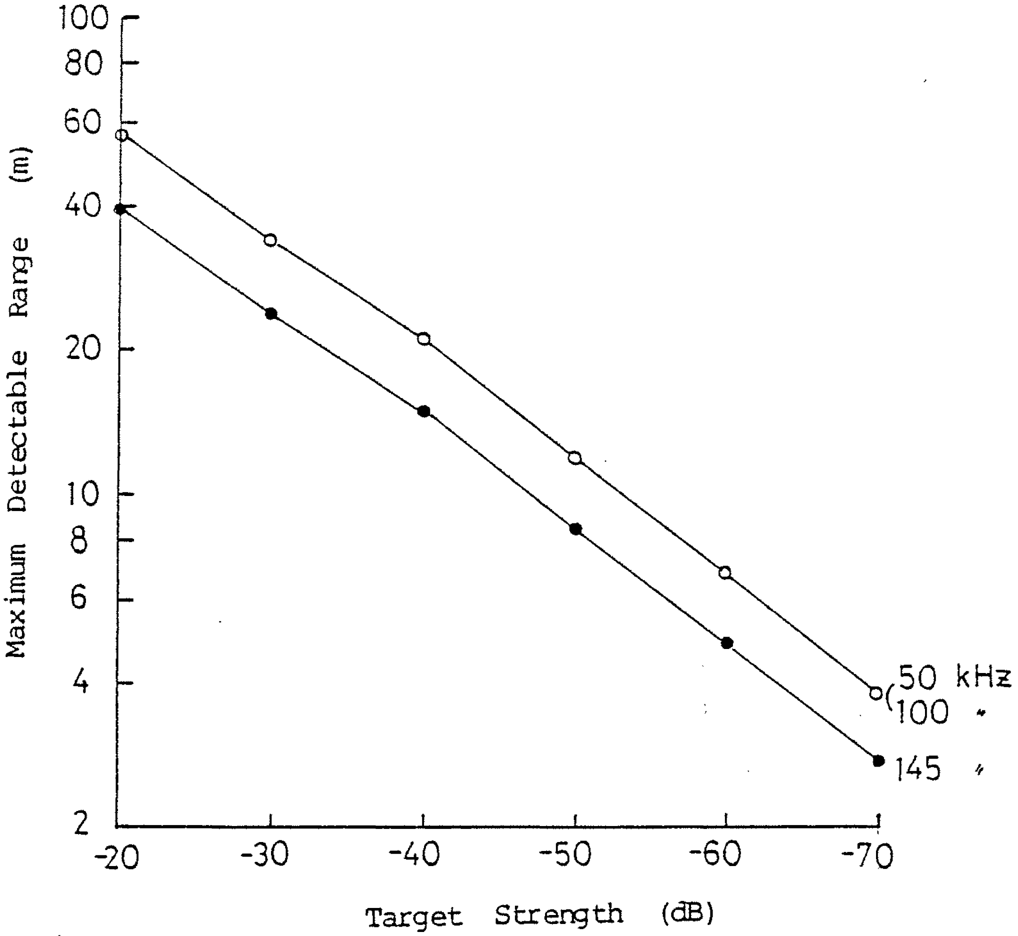
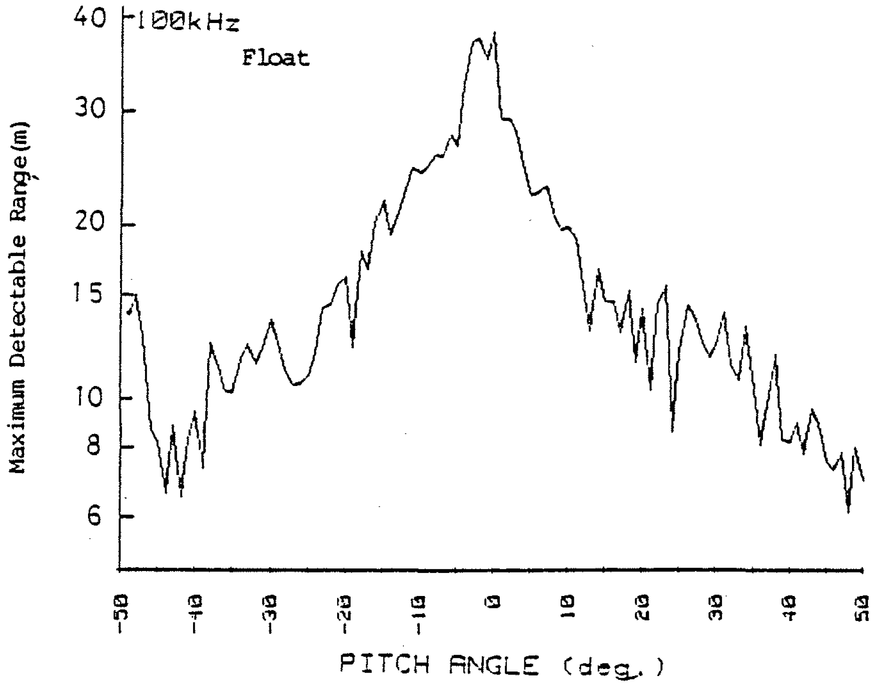


Fig. 8 Maximum detectable range calculated from target strength



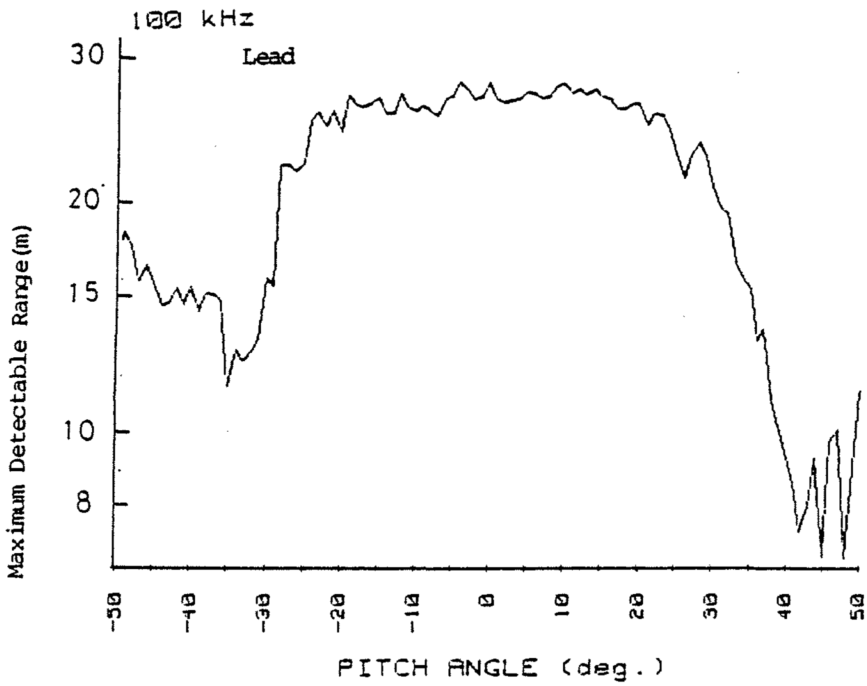


Fig.9 Maximum detectable range at each angle

Not to be cited by
INPFC Document Number

INPFC
Doc. 2858

TRANSLATION

MEASUREMENT OF DIRECTIVITY OF SUPERSONIC WAVE REFLECTION FROM ELEMENTS OF SALMON GILLNETS

Yoshimi Hatakeyama and Kenichi Ishii
National Research Institute of Fisheries Engineering
Tokyo, Japan

1985 January

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
Hatakeyama, Yoshimi, and Kenichi Ishii. 1985.
Measurement of directivity of supersonic wave reflection from elements of salmon gillnets.
(Document submitted to the International North Pacific Fisheries Commission, 1985 January.) 5 p.
Fishery Agency of Japan, Tokyo, Japan.

Introduction

As reported in 1983[1], among materials which comprise the salmon gillnet, the floats, leads, and ropes show strong reflection of sonic waves and small reflection loss. When a Dall's porpoise approaches the net from a distance, the diameter of its echolocation beam at the net (assuming its angle is 10°) is 6 m or greater when the porpoise is more than 30 m away from the net. It means the porpoise receives reflected waves from all portions of the net. Therefore, the Dall's porpoise should first recognize the existence of the whole net then, as it comes closer to the net, recognize the position of each material.

The porpoise receives the strongest reflected waves when they swim towards the net at right angles and the value of the Maximum Detectable Range (Rd) is as reported in the previous year. The Rd value would be reduced when the porpoise approaches diagonally because of difference in reflection directivity.

The reflection directivity for floats, leads, and ropes was measured using supersonic waves of 50 kHz and 100 kHz which are similar to the clicks of Dall's porpoise. The results are reported here.

1. Methods

The device used was the same as that used to measure target strength (TS) of a fish body (Fig. 1)[2]. Measuring equipments were placed as shown in Fig. 2 and the reflection directivity was measured with changing angles (θ) of the reflector. The relationship between the target strength (TS) and reflection loss (RL) is RL = -TS.

As shown in Fig. 3, direction which is perpendicular to the long axis (H) of the reflector to be measured is set as 0° with the clockwise side as minus and the anticlockwise side as plus. The reflection was measured between +50° and -50° at 1° intervals. The revolving mechanism was originally designed for reflectors with density similar to water and therefore it was necessary when using light objects to add weight and for heavy objects to add floats so that the long axis was horizontal in water.

The samples used were the same as those used in measurements of reflection loss in the previous year and their size and materials are shown in Table 1.

For the floats, a measurement setting the long axis as 0° was also made. Therefore, we designated vertical measurements (V) for the former and horizontal measurement (H) for the latter.

2. Results and discussion

The results are shown in Figs. 4 to 7. As shown in these figures, measured values are not symmetrical between the clockwise and anti-clockwise sides while these should be symmetrical. The reason is that the measurements were conducted on a raft in Toda Port on the coast of the Izu Peninsula in Shizuoka Prefecture. Therefore, the measurement system was occasionally affected by waves caused by fishing boats passing by or by strong winds. The results are not as accurate as those obtained in a water tank experiment. However, the results still give a rough understanding of reflection directivity of materials used in the salmon gillnets and are useful to infer how the porpoises are detecting the net which they are approaching.

The maximum TS values (TS max) and the angles (α) at which the TS values become 6 dB smaller than TS max were obtained and are shown in Table 2. The TS values obtained in the previous experiment, using 143 kHz supersonic waves, are also shown in the righthand column of the table. The directivity became sharper as the frequency became higher (wave length is shorter) and the length of the reflector increased for each material. The reflection of the floats and ropes is strong but α values are around 10°. Where the angle becomes more than 10° for these materials, the reflection decreases rapidly which means these are rather difficult to detect from slanted directions.

Rd values were calculated for various TS values and are shown in Fig. 8. As in the previous report, Rd value is defined as the distance of echo level equal to corrected auditory threshold of Dall's porpoise, assuming that frequency are 145 kHz, source level is 68 dB, pulse width is 50 μs, and pulse periods are 100 ms.

At close distance when the absorption loss can be ignored, where TS changes by ΔTS (dB), and Rd becomes Rd', the relationship is --

$$Rd' = Rd \times 10^{\left(\frac{\Delta TS}{40}\right)}$$

The estimated auditory threshold value for Dall's porpoise[3)] is about -5 dB for frequency range of 50 kHz to 100 kHz or 6 dB better than the case of 145 kHz.

Using the same conditions as mentioned before, except for the threshold value, the Rd values were calculated for 50 kHz to 100kHz waves and the results are shown in Fig. 8. Fig. 9 shows the change in Rd values by angle for float and lead at 100 kHz. The figure was constructed by changing the vertical axes of Figs. 4 and 6 from target strength to Rd value (the Maximum Detectable Range).

As for the float in this figure, when the angle changes from 0° to 40°, the Rd value decreases substantially from 40 m to 6 m.

TABLES 1 AND 2 AND FIGS. 1 TO 9 ARE IN THE JAPANESE DOCUMENT