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A deep water towed body for upfacing echo sounding from a small boat

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A DEEP WATER TOWED BODY FOR UPFACING ECHO SOUNDING FROM A SMALL BOAT

by

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ABSTRACT

Enzenhofer, H.J., and J.M.B. Hume. 1992. A Deep Water Towed Body For Upfacing Echo Sounding From a Small Boat. Can. Tech. Rep. Fish. Aquat. Sci. 1880: 14p.

We have designed a towed body that can be deployed to depths of 50 m or more and will carry an echosounder transducer facing upwards towards the surface. This paper describes the design and construction of the towed body. The main body was made from fiberglassed plywood with attached steel fins and towing bracket. A discus shaped weight hanging from below the towed body provided stability. The towed body required about 100 m of cable to send it down to 40 m of water when moving at 1.3 m/sec. One person easily handled the 9.3 kg towed body from the side of a small (7 m) boat. We demonstrate that under some conditions an upward facing transducer will detect fish targets not insonified by a more traditional downward facing transducer.

RÉSUMÉ

Enzenhofer, H.J., and J.M.B. Hume. 1992. A Deep Water Towed Body For Upfacing Echo Sounding From a Small Boat. Can. Tech. Rep. Fish. Aquat. Sci. 1880: 14p.

Nous avons conçu un corps remorqué pouvant servir à 50 m ou plus de profondeur pour traîner un transducteur orienté vers la surface. Ce document décrit la conception et la construction du corps remorqué. Celui-ci est fait de contreplaqué recouvert de fibre de verre, auquel ont été fixées des ailettes en acier et une patte de remorquage. Un lest en forme de disque est attaché sous le corps remorqué pour en assurer la stabilité. Il faut environ 100 m de câble pour que le corps pénètre jusqu'à 40 m de profondeur à une vitesse de déplacement de 1,3 m/s. Une seule personne peut facilement manier le corps, pesant 9,3 kg, sur la côté d'une petite enbarcation (7 m). Nous démontrons que, dans certaines circonstances, un transducteur orienté vers la surface peut permettre de relever la présence de poissons indécelables au moyen d'un transducteur plus classique, orienté vers le fond.

INTRODUCTION.

Population estimates of pelagic fish rearing in lakes are routinely done using hydroacoustics (Burzcynski 1979, Thorne 1983), which has been shown to be a cost effective method of obtaining distributional patterns of fish throughout a lake (Burzcynski et al 1987). Traditional methods house a downward facing transducer in a towed body or fin, suspended one or two meters below the water surface, while being towed alongside a surveying boat (Dahm et al 1985, Burzcynski and Johnson 1986).

Whether the density estimate is done by echo-integration (Traynor et al 1990), duration-in-beam (Nunnallee 1973, Thorne 1988), or echo counting, all rely on fish being within the detectable region of the echo sounding system. This region is mainly dependent upon the specifications inherent with the echo-sounding system and behaviour of the targeted fish. Transducer frequency, beam dimension, blanking distance, and effective range of the time varied gain (TVG), play a role in the system's ability to detect targets.

In many cases fish can occur in the "shadow zone" of the transducer (Olsen 1990). When the transducer depth is added to the blanking distance inherent within the system (generally 1 m in a Biosonics 105 echosounder), the top several meters are undetectable by the sounder. Moreover, with the narrowest portion of the beam near the transducer, fish that occur in low densities near the surface are detected less frequently. Hyatt et al (1989) found that fish occupying the upper 10 m of the water column (due to glacial turbidity or behaviour) are frequently not accessible to the acoustic beam. Thus when large quantities of fish occupy the surface layers as occurs in some sockeye (*Oncorhynchus nerka*) lakes (Hyatt et al 1989, Levy, 1990), reliable population estimates can not be made with traditional gear.

These factors show the need for an alternate approach to sounding with a downward facing surface towed transducer. Aiming the transducer towards the surface and towing it below the depth of interest may eliminate this problem (Miller 1979, Levy et al 1991). We therefore developed a towed body that housed a 6 degree 420 kHz upward facing transducer that could be towed at a depth of 40 m. The narrow beam width in conjunction with a short pulse length and high frequency allowed for acoustic sampling of the upper 10 m.

This report describes the construction and dimensions of the towed body (nicknamed "The Enzenducer") along with some of the implications and uses for it. The towed body was easy to deploy, inexpensive to build, and tracked stably at depth. Although this is not a new concept, most existing towed bodies and armoured cables are bulky, expensive, and not easily used on small boats, already encumbered with trawling gear.

CONSTRUCTION

The main body was cut from 20 mm fiberglassed plywood. Areas where the fins and the tow bridle platform were attached were recessed to produce a flush finish (Fig. 1). The fins were 3 mm stainless steel and were attached by countersunk screws. The tow bridle platform was cut from 6 mm steel plate. The tow bridle included a horizontally movable tow point to enable levelling adjustments during field testing. The tow point was made from a 115 mm stainless steel hinge that acted as a gimbal joint so that the towed body would plane horizontally during changes in boat direction. We felt that without this flexibility any resulting tilt would give an incorrect aspect from the transducer face to any targets. Holes in the tow platform and main body allowed passage of the acoustic cable to the transducer. Since this version of the towed body was a prototype, future versions could be made entirely from metal or fibreglass.

A 5.5 kg discus shaped lead weight with a stainless steel fin was suspended by a 4.8 mm cable from two points on the bottom of the towed body (Fig 2). This locally made downrigger weight is commercially available. We chose this shape of weight because we felt it would make the towed body track straighter. The combined weight of the towed body (9.3 kg) and lead weight enabled the towed body to drop to the desired depth. All cable connection points were made with galvanized swivel connectors and hand swaged loop ends.

A transducer mounting was cut from a 9 mm thick steel pipe with the same inside diameter as the transducer. A flange was welded to the bottom of the mounting for securing to the underside of the towed body. The top portion of the brace was just small enough to pass through the hole made for the transducer cable. A hose clamp secured the transducer to its mounting.

DEPLOYMENT

The towed body was attached to the boat by 160 m of 4.8-mm galvanized aircraft cable (7 X 19 construction). The entire transducer cable (150 m) was attached every 2 m by electrician's tape to the tow cable except for the portion fed through the towed body. The transducer cable was attached so that strain under tow was taken by the tow cable. The cables passed through a 100 mm snatch block attached to a 3.5 m outrigger pole on the side of the boat. The outrigger pole was used to reduce the possibility of fish avoidance of the boat and to keep the transducer out of the propeller wash. Excessive surface noise was observed when the transducer was towed directly behind the boat. A portable garden hose reel held all the cables and worked well when deploying or retrieving the towed body. The transducer cable was disconnected from the sounder to prevent twisting whenever cables were let out or brought in.

Once the towed body was submerged, and still within sight, it was checked for its horizontal positioning and tracking. Adjustments were made by changing the pivot points from the tow cable to the tow bridle plate. The transducer and towed body were then lowered to depth and connected to the echo sounder. With a transect speed of 1.3 m/second, 100 meters of cable was needed to attain a depth of 40 m, approximately 90 m behind the towboat. Chart recorder records showed the towed body dropped 4 m during gradual turns but quickly returned to depth once under straight tow.

USE

We tested the upward facing transducer on diel migrating juvenile sockeye salmon in Quesnel lake, British Columbia. School size, the timing of school formation and breakup were simultaneously observed with downward and upward facing transducers operated by two boats in the same area of the lake. One boat used a Biosonics "2-Foot Towed Body", with a 420 kHz 6/15° dual beam transducer. The second boat used the upward facing towed body with a 420 kHz 6° narrow beam transducer. Both systems used the Biosonics dual beam/echo integration system for data acquisition and processing, including; a model 105 echo sounder, a model 171 tape recorder interface, a model 115 chart recorder, a model 121 digital echo integrator, and a Sony TCD-D10 digital audio tape recorder for recording and playback. The narrow beam data from both systems were integrated with the water column divided into 2 m intervals to the maximum depth of interest. The integrator averaged echo returns in one minute outputs of the 20 Log R TVG collected data.

We collected echograms at dusk, as the fish were rising in schools towards the surface, with the upward and downward facing transducers (Fig. 3). The upward facing echogram shows fish targets from about 15 m to the surface boundary, while the downward facing echogram showed almost no visible targets in the upper 8 m's of water. Echo integrated outputs for the same time periods shows that many portions of the downward collected data in the 0 - 8 m range had no measurable voltages (Table 1). The upward collected data contained measurable voltages over the entire time period at these depth ranges. The actual voltages produced by the two systems cannot be directly compared as the power produced by the two sounders was different. However, the data does show that the upward facing transducer detected integrated voltage consistently as opposed to the more intermittent detection by the more conventional downward facing design.

IMPLICATIONS

With the ability to insonify the upper 10 meters a hydroacoustic fish density estimate of this layer is possible. Hyatt et al (1989) described the problems encountered for acoustic and trawl surveys on a glacially turbid lake in which fish occupied the non-insonifiable surface strata. They approached the problem by using an acoustic estimate based on echo counting (Thorne 1983). The acoustic estimate for the surface layer was calibrated by trawling at the surface and at depths where the sounder was known to be accurate. Traces made with an upward facing transducer, in conjunction with trawling, would provide a direct measure of density in the surface layer.

Other acoustic estimation techniques would also benefit from or could be used with an upward facing transducer. The duration-in-beam technique, used alone or in conjunction with echo integration (Traynor et al 1990), requires an estimation of the beam dimension through the average insonifications/fish/depth stratum as the beam passes over. The minimum times a fish can be insonified is once (Nunnallee 1973). This causes a small portion of the conical beam to approach that of a cylinder producing a bias in beam dimension calculations for the shallower depths. This bias becomes significant when fish are insonified on less than 3 successive echoes (Thorne 1988), typically at depths less than 8 m when moving at 2 m/sec, using our equipment. The effect of this is to overestimate the beam volume for the top 10 m and underestimate fish density. If the same process was reversed with an upward facing transducer, fish that were near the surface would then be in the far field of the beam. A more accurate estimate of the beam volume could then be made since the surface fish would be insonified more times. In situ target strength estimations, either by dual beam (Ehrenberg 1983) or single beam (Lindem 1983), are also possible with the upward facing transducer.

There are a few circumstances that limit the use of an upward facing towed body. The first and most obvious is water depth. Shallow areas close to shore could not be surveyed. We also found that noise created by wave action during rough weather masked the acoustic signal of fish near the surface. As well, we had considerable difficulty in deploying the towed body during rough weather.

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LITERATURE CITED

Burczynski, J.J. 1979. Introduction to the use of sonar systems for estimating fish biomass. FAO Fish. Tech. Pap. (191) 89p.

Burczynski, J.J. and R.L. Johnson. 1986. Application of dual-beam acoustic survey techniques to limnetic populations of juvenile sockeye salmon *Oncorhynchus nerka*. Can. J. Fish. Aquat. Sci. 43:1776-1788.

Burczynski, J.J., P.H. Michaletz, and G.M. Marrone. 1987. Hydroacoustic assessment of the abundance and distribution of rainbow smelt in Lake Oahe. North American Journal of Fisheries Management 7:106-116.

Dahm, E, J. Hartmann, T. Lindem, and H. Loffler. 1985. EIFAC (European Inland Fisheries Advisory Commission) Occasional paper 15.

Ehrenberg, J.E., 1983. A review of in situ target strength estimation techniques, p.85-90. In: O. Nakken and S.C. Venema (ed.) Selected papers of the ICES/FAO Symposium on Fisheries acoustics. FAO Fish. Rep. 300:331p.

Hyatt, K.D., D.P. Rankin and E. Rome. 1989. Acoustic Census of limnetic fish in a glacially turbid lake. Proceedings of the Institute of Acoustics. Volume 11 Pt3 1989.

Levy D. A. 1990. Sensory mechanism and selective advantage for diel vertical migration in juvenile sockeye salmon, *Oncorhynchus nerka*. Can. J. Fish. Aquat. Sci. 47:1796-1802.

Levy, D., B. Ransom and J. Burczynski. 1991. Hydroacoustic estimation of sockeye abundance and distribution in the Straight of Georgia, 1986. Pacific Salmon Comm. Tech. Rep. No. 2:45p.

Lindem, T. 1983. Successes with conventional in situ determination of fish target strength. FAO Fish. Rep., (300):104-11

Miller, D.S. 1979. Hydroacoustic Assessment of Capelin (*Mallotus villosus*) stocks in the Newfoundland and Labrador areas. Meeting on hydroacoustical methods for the estimation of marine fish populations, 27-29 June 1979. II: Contributed papers, discussion, and comments. 1981 p. 837-845

Nunnallee, E.P. 1973. A hydroacoustic data acquisition and digital analysis system for the assessment of fish stock abundance. University of Washington Fisheries Research Institute, Circular 73-3, Seattle.

Olsen, K. 1990. Fish behaviour and acoustic sampling. -Rapp. P. - v. Reun. Const. Int. Explor. Mer, 189: 147-158

Thorne, R.E. 1983. Hydroacoustics, p.239-259. In L.A. Nielson and D.L. Johnson (ed.). Fisheries Techniques. Bethesda, Maryland. Am. Fish. Soc. 469p.

Thorne, R.E. 1988. An empirical evaluation of the duration-in-beam technique for hydroacoustic estimation. Can. J. Fish. Aquat. Sci. 45: 1244-1248.

Traynor, J.J., N.J. Williamson, and W.A. Karp. 1990. A consideration of the accuracy and precision of fish- abundance estimates derived from echo-integration surveys. -Rapp. P. -v. Reun. Const. Int. Explorn. Mer., 189: 101-111

Table 1. Comparison of integrator output (% of total for time interval) from downward and upward facing transducers operating at the same time and in the same area of Quesnel Lake, near dusk, on August 14, 1991. Data is from same time period as Figure 1.

Depth (M)	Time 20:15	20:16	20:17	20:18	20:19	20:20	20:21
DOWNWARD FACING TRANSDUCER							
2 - 4	4.769	1.289	0.062	0	0.401	3.437	3.164
4 - 6	0	0	0	0	0	0.050	0.537
6 - 8	0	56.256	0.124	0	0.714	0.082	2.980
8 - 10	0.156	9.769	9.523	65.878	13.206	18.454	56.393
10 - 12	11.294	22.531	80.839	34.122	47.016	70.043	20.155
12 - 14	50.806	10.156	3.921	0	20.106	7.581	0.724
14 - 16	32.974	0	5.531	0	15.285	0	0.222
16 - 18	0	0	0	0	3.037	0.149	15.825
18 - 20	0	0	0	0	0	0	0
20 - 22	0	0	0	0	0	0	0
22 - 24	0	0	0	0	0	0	0
24 - 26	0	0	0	0	0.236	0	0
26 - 28	0	0	0	0	0	0.204	0
28 - 30	0	0	0	0	0	0	0
30 - 32	0	0	0	0	0	0	0
32 - 34	0	0	0	0	0	0	0
34 - 36	0	0	0	0	0	0	0
36 - 38	0	0	0	0	0	0	0
38 - 40	0	0	0	0	0	0	0

UPWARD FACING TRANSDUCER

Depth (M)	20:15	20:16	20:17	20:18	20:19	20:20	20:21
			Time				
2 - 4	2.861	0.105	21.507	1.960	0.395	1.370	6.828
4 - 6	27.495	0.167	13.430	5.825	2.176	1.251	8.785
6 - 8	32.882	45.467	27.992	74.615	0.355	1.421	14.264
8 - 10	4.498	53.176	35.936	3.200	2.643	0.390	13.205
10 - 12	19.970	1.070	0.879	4.927	1.689	48.649	51.461
12 - 14	0.794	0.004	0.202	5.370	0.089	46.751	5.293
14 - 16	5.454	0.010	0.033	4.071	0.020	0.155	0.039
16 - 18	3.200	0.001	0	0.032	40.234	0	0
18 - 20	0	0	0	0	0.005	0	0.078
20 - 22	0	0	0.021	0	0	0.013	0.012
22 - 24	0	0	0	0	0.010	0	0.035
24 - 26	0	0	0	0	15.203	0	0
26 - 28	0	0	0	0	37.182	0	0
28 - 30	0	0	0	0	0	0	0
30 - 32	0	0	0	0	0	0	0
32 - 34	0	0	0	0	0	0	0
34 - 36	0	0	0	0	0	0	0
36 - 38	0	0	0	0	0	0	0
38 - 40	2.845	0	0	0	0	0	0

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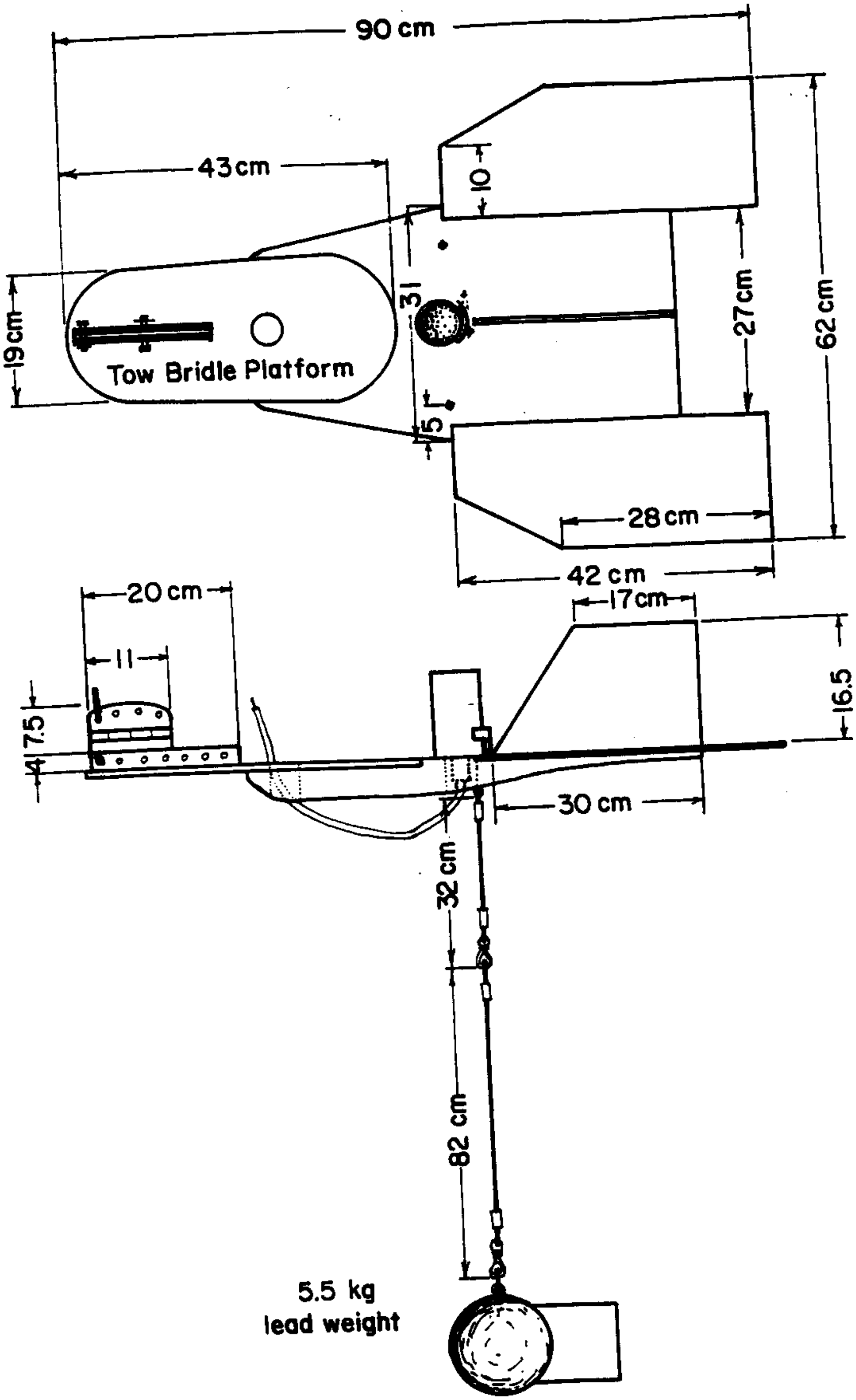
Fig. 2. Perspective drawing of the upward facing towed body.

Fig 3. Simultaneous echograms of juvenile sockeye salmon in Quesnel Lake, B.C. Fish are in schools, rising towards the surface at dusk from their daytime depths of around 60 m. Vertical lines indicate 1 minute intervals.



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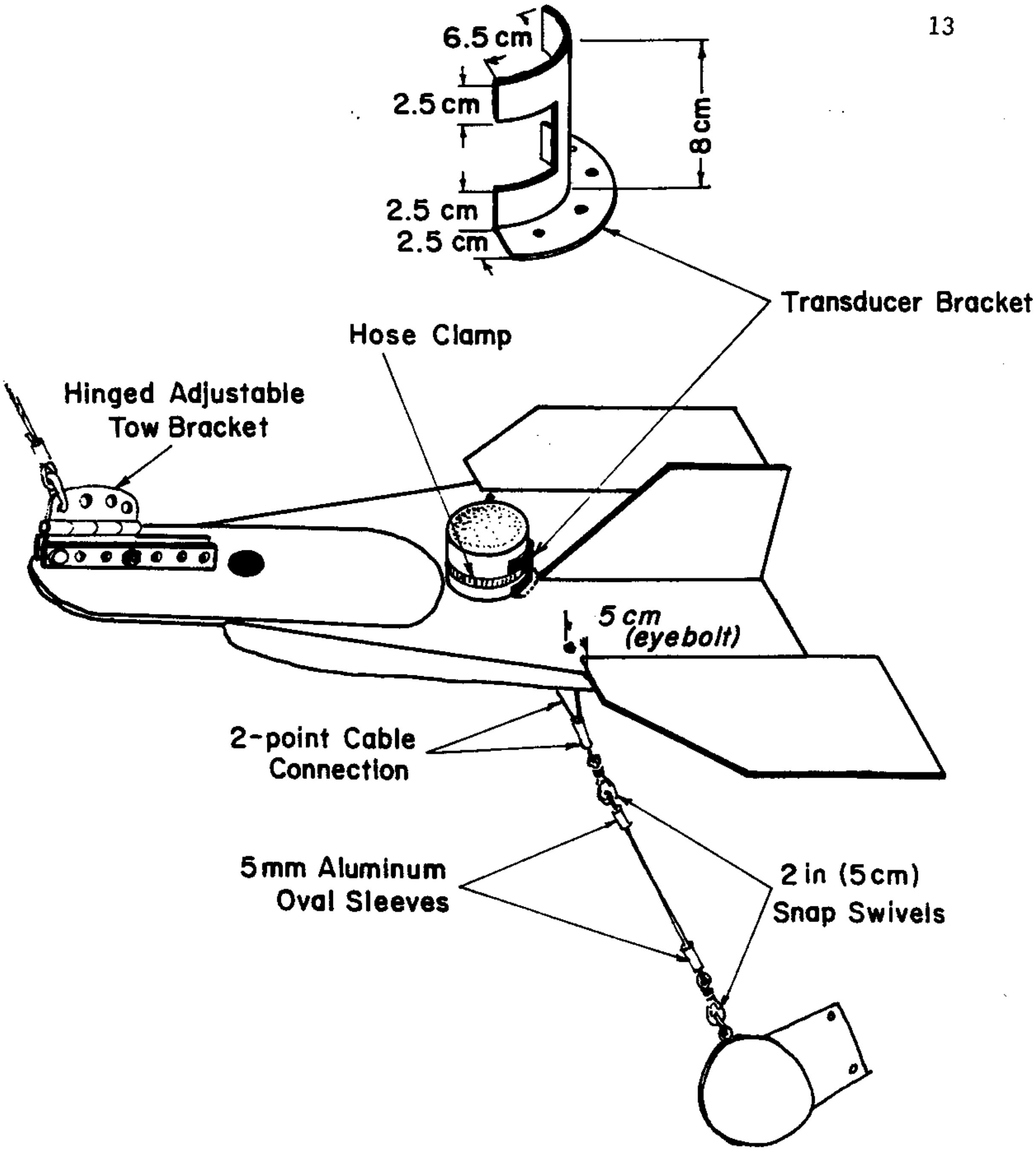

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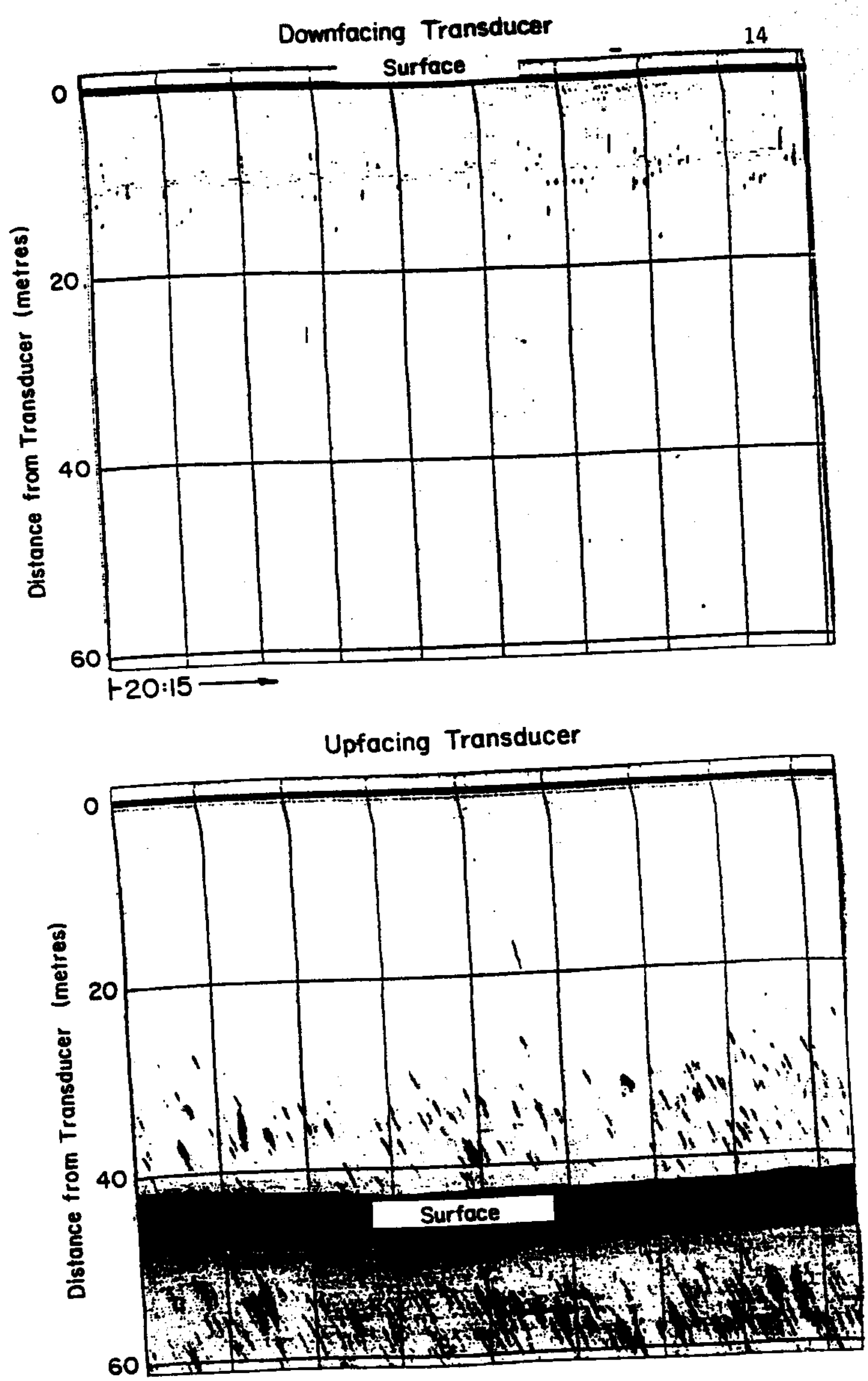

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