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HULL MOUNTED, PROTRUDING TRANSDUCER FOR IMPROVING ECHO INTEGRATION IN BAD WEATHER

by

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Abstract

A 38 kHz split beam survey transducer has been mounted on the tip of a 4 m vertical protrusile stabilizing keel of the United States NOAA fishery research vessel R/V Miller Freeman. Air blocking problems, generally observable on all hull mounted transducers, were reduced substantially, and excellent acoustic conditions were achieved with the new mounting for wind speeds up to 35 knots (19 m/s). The improvements are demonstrated through comparative, sequential echo integration of the air close to the transducer with the keel in retracted and extended positions, and through echo recordings on fish. Empirical functions for residual air bubble corrections of echo integration data will presumably work well up to wind speeds where target identification by trawl is problematic because of safety.

INTRODUCTION

In most commercial and research vessels, hull-mounting of acoustic transducers is regarded as an acceptable means of balancing concerns about performance in bad weather with costs of installation. In research vessels, however, severe problems are encountered during collection of acoustic data from hull-mounted transducers in bad weather. Consequently most modern fishery research vessels also carry towed transducer systems for standard data collection or as an alternative for use during inclement weather. By deploying the transducer below the depth of entrained air bubbles, acoustic data quality can generally be improved to a substantial degree.

Most acoustic survey designs incorporate frequent trawl sampling. When using a towed transducer, the time required for transducer and cable handling before and after fishing and the time required for transducer stabilization after deployment can lead to significant loss of transect data.

On commercial vessels, trials with towed transducers for use in bad weather have met with little success, mainly because of the complicated handling procedures required and the need to tow the transducer at speeds greater than those required for trawling in order to stabilize the towed fin (G. Vestnes, pers. comm). Protruding transducers are common in commercial sonar installations and in the deployment of bottom mapping equipment; thus the improvements in performance obtained by extending transducers below the hull are well known.

In this paper we describe improvements in echo integration data quality obtained with a conventional acoustic transducer mounted in a structure protruding 4 m below the keel of a 215 feet (65 m) research vessel.

MATERIAL & METHODS

A Simrad EK-500, 38 kHz split beam transducer was mounted at the end of the stabilizing keel, or "centerboard" of the US research vessel R/V Miller Freeman (Fig. 1). The centerboard can, from an upper position when the tip is flush with the keel, be hydraulically lowered about 4 m. The transducer blister extends another 30 cm on the end of the centerboard, leaving only the blister exposed when the centerboard is pulled to the upper position.

To examine the improved acoustic conditions, and air blocking characteristics of the centerboard installation, integration data were collected from several narrow layers from 2-15 m depth. The first layer (2-3 m) included some energy from the last decay of the transmit pulse. The integrator outputs were set to 6 min representing about one nautical mile transecting distance. In this analysis, made during a period when the average wind speed was 23 -

30 knots (12.5 - 16 m/s), the data set consists of 50 outputs -- 23 outputs with the centerboard in the upper position, and 27 with the centerboard in the normal, lowered position.

The average vessel speed was 11.0 ±1.4 knots (6.16 m/s), and the average wave height 6-8 feet (1.8 - 2.4 m). The weather information is based on the ships deck log, weather observation sheet, updated each hour, and the Marine Operations Abstract (MOA), updated each half hour, and at the position of each significant event. The data were collected in late February, 1990 in an area just south of Chirikof Island, Gulf of Alaska (about 55°45' N, 155°47' E), over bottom depths ranging from 100 - 250 m.

RESULTS

Three examples for the depth range extending from the transmit pulse to 15 m are shown in Fig. 2. Even with the centerboard in the lowered position, there is a consistent ringing out to about 3.5 meters below the transducer surface. Beyond this range, there is a low intensity back radiation, presumably from the vessel hull and horizontal plates inside the hull. This back radiation represents a constant volume back scattering strength of about -49 dB in the layer from 2-3 m, and -66 dB in the layer from 3-5 m.

Air blocking was absent when the centerboard was in the lowered position (Fig. 2A). With the centerboard retracted, examples of moderate (Fig. 2B), and severe (Fig. 2C) air blocking were observed. In these examples, air blocking appears as dark vertical stripes extending from the transmit pulse. The three observations were made within 25 minutes at a wind speed of 23 knots (12.5 m/s), with the vessel traveling into the wind.

The effect of the centerboard deployment on the echo registrations, and acoustic returns from fish is clearly seen in Fig. 3. With the centerboard down, the echoes from the fish layer appear normal. As soon as the centerboard is raised, the effect of air blocking can be observed. The vertical white lines through the fish layer are caused by total or partial air blocking. The transmitted signal is attenuated substantially as it passes through the entrained air and the returned echoes are weak. Often, even the bottom echo is lacking.

The results of sequential echo integration of the air below the transducer in the 2-3 m depth range are illustrated in Fig. 4. Each series of observations with the centerboard lowered was followed by a series of observations with it retracted. Sufficient time was allowed for the transducer to stabilize after each lowering and retraction. The first two series of data were collected as the vessel surveyed with the wind and the last three with the ship heading into the wind.

With the centerboard lowered, air blocking was nearly absent at this wind speed (23-30 kts). With the board in the upper position, however, the average volume back scattering strength in the 2-3 m layer increases more than 13 dB, or more than 20 times compared to the level when the board is extended. At the upper position, air bubbles are also present 3-5 meters in front of the transducer. When the area back scattering coefficient in the 2-3 m layer exceeds 900, significant amounts of air also appear in the 3-5 m layer (Fig. 5). Most of the return in the 3-5 m layer occurs between three and four meters.

By comparing the average backscattering coefficient with the centerboard in the lowered and the retracted position, it can be seen that the return in the 2-3 m layer was very low during data collection with the centerboard in the extended mode (Fig. 6). Even when the centerboard was retracted, very little back scattering was observed from depths greater than 5 m below the transducer.

DISCUSSION

The study shows that excellent acoustic recordings and data can be obtained by extending the transducer outside the main bubble layer created by the interaction of the vessel and wave action. For the Miller Freeman, it appears that an extension of about 4 m from the vessel hull places the transducer below nearly all of the air that is entrapped below the vessel due to wave action or wave-vessel interaction. The main problem of air blocking is not due to a wind-generated bubble layer, but rather due to the vessel itself, which traps air underneath the hull, and leads it backwards over the transducer surface. However, in some situations, the wave action also probably entraps air below the transducer depth. In some cases, air trapping rings at the edge of the transducer blister have been used to split the air bubble layer generated by vessel motion and reduce the amount of air bubbles coming in direct contact with the transducer face. Moderate improvements have also been observed by mounting the transducer blister on the vessel keel rather than a conventional mounting. The mounting with the centerboard retracted on the Miller Freeman is similar to a keel mount and should already exhibit improved performance compared to conventional mounts.

By examining wind conditions typical for the Gulf of Alaska in the winter, the potential impact of air-blocking on a survey becomes apparent (Fig. 7). This data is derived from hourly observations of wind speed made during a portion of the spawning pollock survey in the Gulf of Alaska during March, 1990. Over one-third of the observations of wind speed exceeded 23 knots. Above this wind speed, with the centerboard retracted, the effect of air blocking on echo returns from fish targets is significant (Fig. 3). These data indicate that, if we had used a conventional hull-mounted transducer on the Miller Freeman, it would have been difficult to complete a successful survey of this spawning stock.

When the problem of total air blocking is removed by lowering the centerboard, the correction factor for air bubble attenuation, caused by residual air bubbles in front of the transducer is reduced. The correction factor presented in Dalen & Lovik (1981) and Berg et al. (1983), is based on measurements of bottom echo statistics, and measurements of bubble attenuation in front of the transducer. However, the total accumulated integral is used in the correction. Their estimated correction factor is reduced by a factor of two when only the echoes with little or no air blocking are used in the averaging algorithm. The selection for valid and non-valid transmissions is made on the basis of a threshold voltage on the received bottom echo (Ona & Mamylov, 1988). An indicator of air blocking problems is the percentage of non-valid transmissions in an output interval. This has been a standard output when using an ND-10 echo integrator at the Institute of Marine Research in Bergen. This percentage is a stable (but vessel dependent) index for bubble attenuation. Simultaneous data from towed and hull mounted transducers can be used to establish the bubble attenuation corrections for a hull-mounted system (Ona & Mamylov, 1988).

A similar approach, where the whole array of data from a bad transmission is discarded is implemented in the EK-500, but the fraction of lost transmissions is not reported. Algorithms for air bubble attenuation corrections, based on echo integration measurements of the amount of air in front of the transducer should provide a more stable indication of air blocking than that based on the strength of the returning bottom echo. Studies to elucidate the utility of such measurements should now be given more attention.

For commercial fisherman, identifying fish on the basis of visual examination of the echo recordings, a protruding transducer mounting like the one described here would also improve operational capabilities.

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Ona,E. and Mamylov, V. 1988. Scientific report from the planning group for the joint Norwegian - USSR multispecies survey 1988. Internal report PINRO-IMR, May 1988.

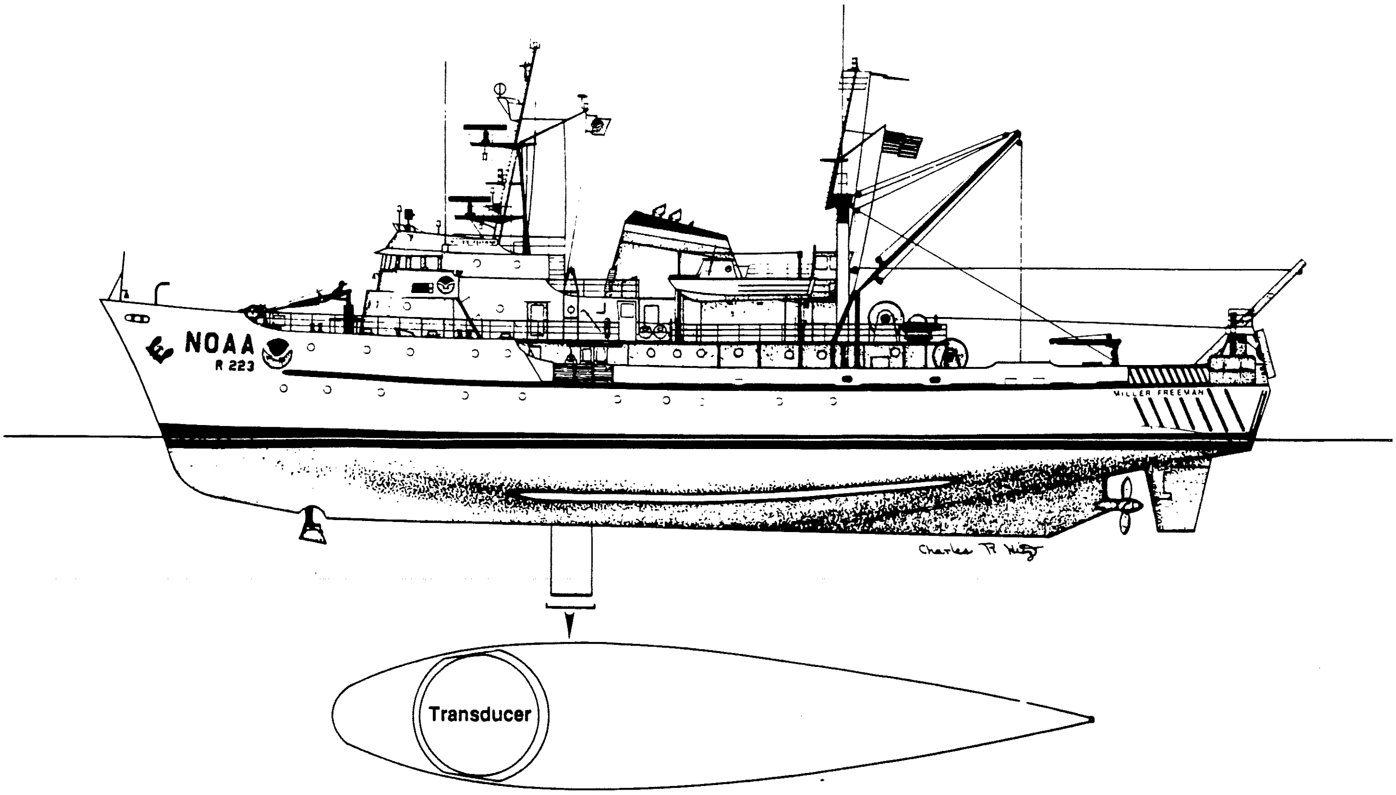

Fig. 1. Diagram of NOAA research vessel <u>Miller Freeman</u> showing location of retractable centerboard and position of EK500 transducer.

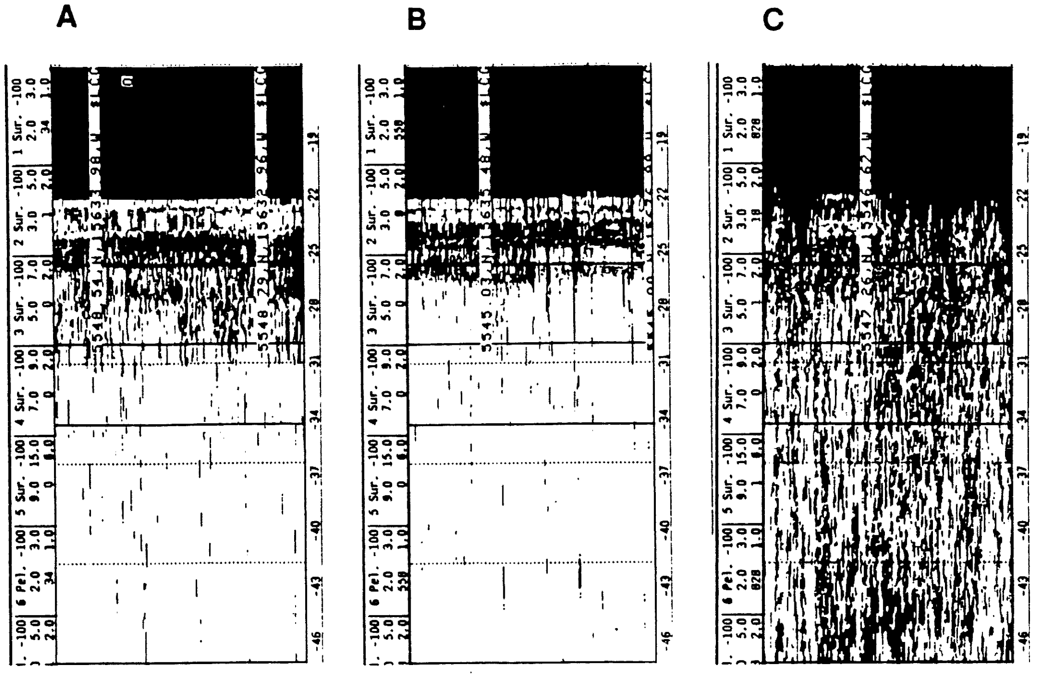

Fig. 2. Three examples of air blocking in the region from 0-15 m below the EK500 transducer: A) centerboard in the lowered position showing little air blocking, B) centerboard in the retracted position, showing moderate air blocking, and C) centerboard in the retracted position, exhibiting severe air blocking.

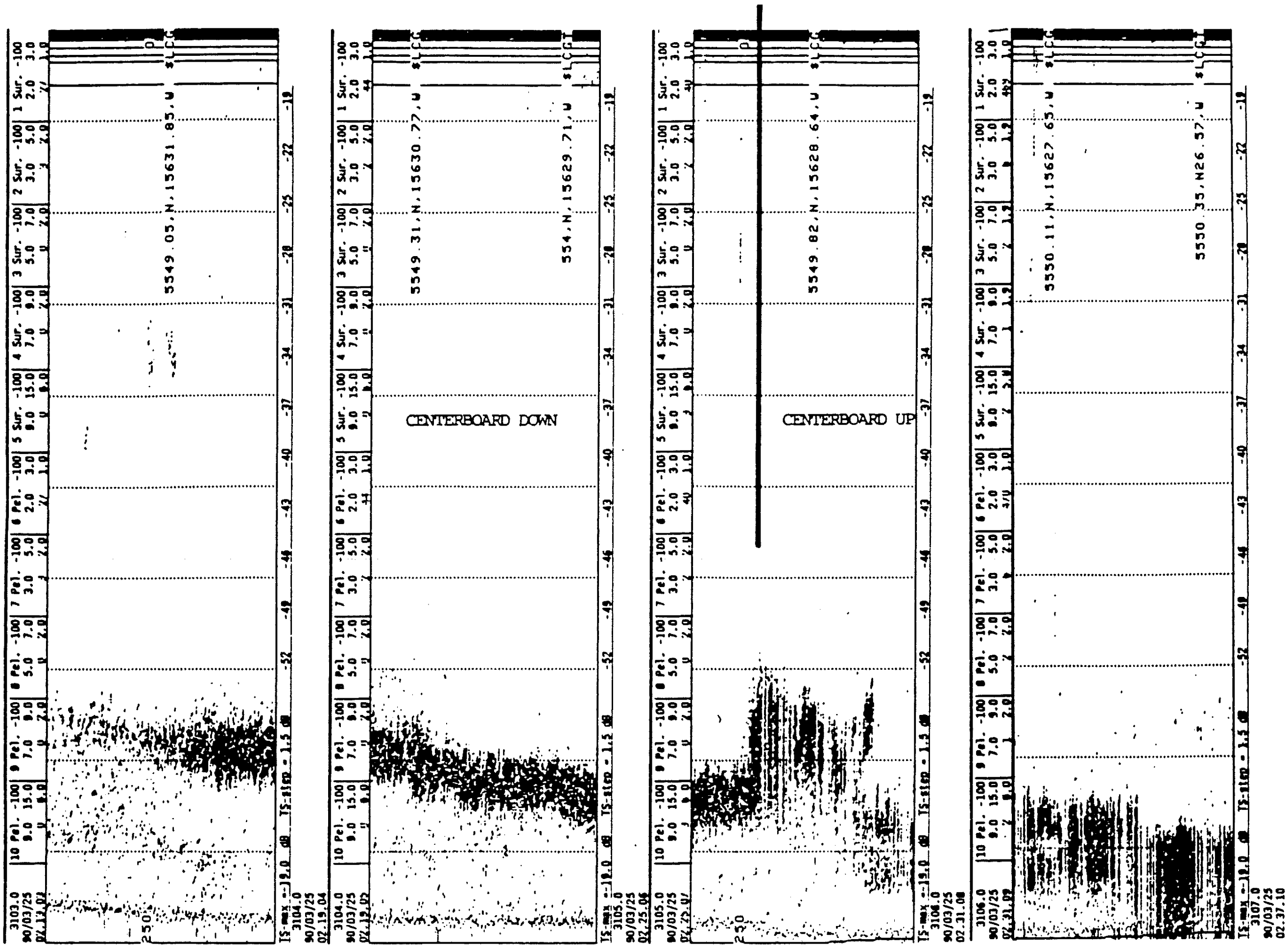

Fig. 3. Echograms of walleye pollock showing the effect of air blocking on the echo return from fish targets. The vertical line indicates the position at which the centerboard was moved from the extended to the retracted position.

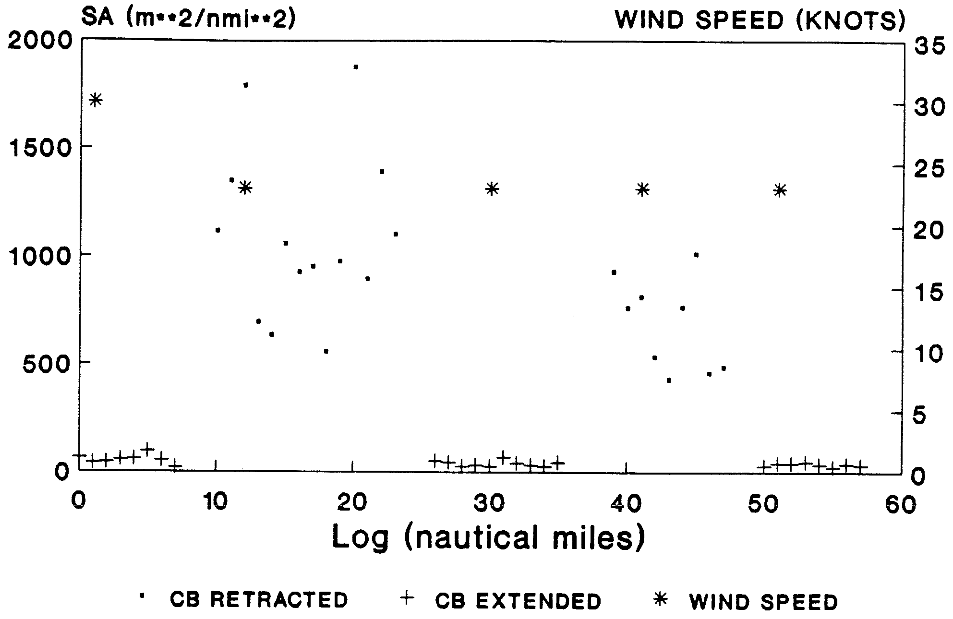

Fig. 4. Echo integration of the air below the transducer in the 2-3 m depth range.

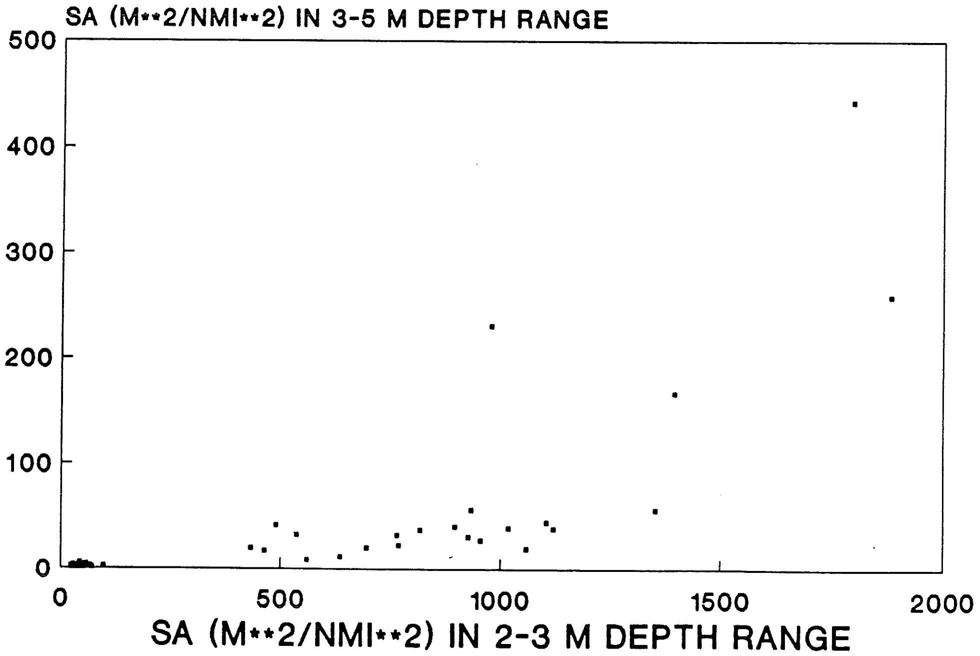

Fig. 5. Comparison of the area back scattering coefficient (SA) for the 2-3 m depth range with that for the 3-5 m depth range.

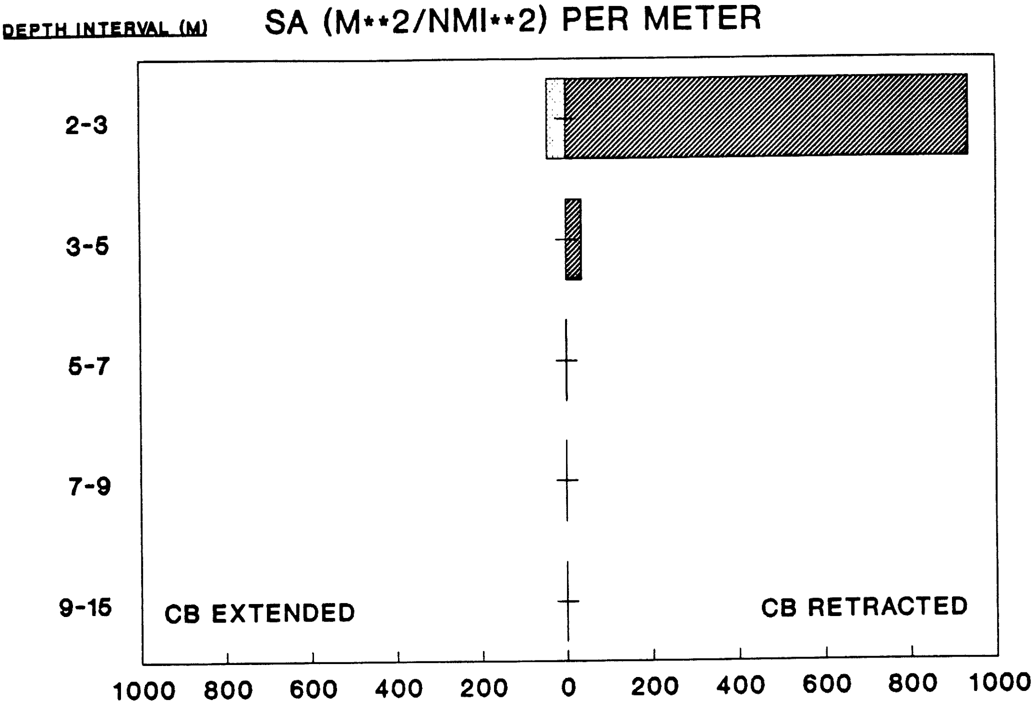

Fig. 6. Comparison of the area back scattering coefficient (SA) per meter with the centerboard extended and retracted. A threshold of SV = -80 dB was used.

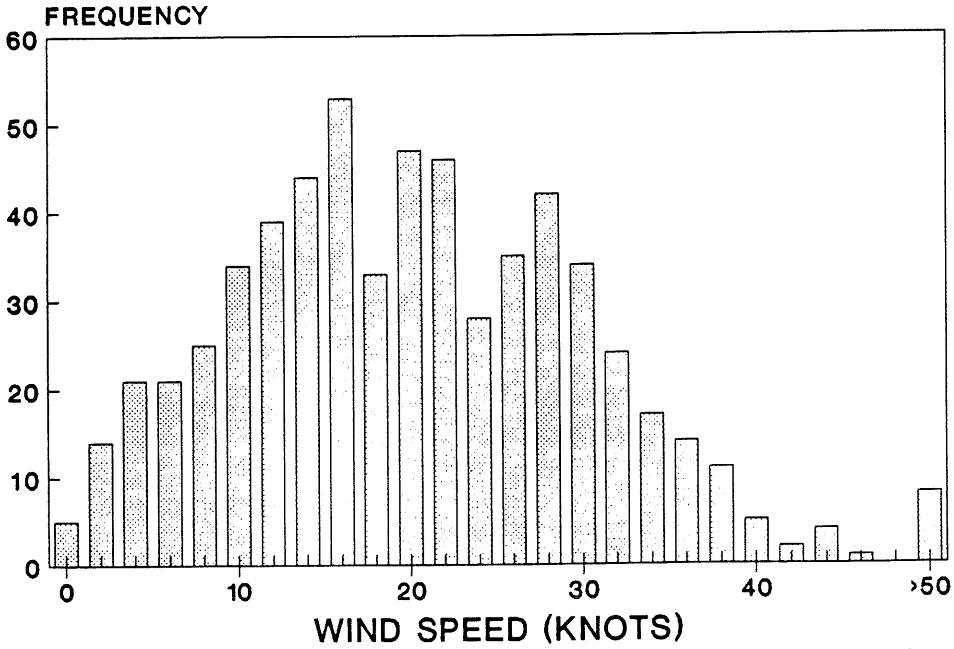

Fig. 7. Histogram of hourly wind speed measurements observed during spawning pollock survey in the Gulf of Alaska, USA in the month of March, 1990.