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The Use of Hydroacostics for the Enumeration of Redfish - Preliminary Investigations in NAFO Divisions 4RS

by

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Abstract

In 1980 the Newfondland Region of Fisheries and Oceans initiated investigations into the use of hydroacoustics for the enumeration of redfish. The study area chosen was the northern Gulf of St. Lawrence. The 1980 survey indicated the feasibility of towing the transducer at a speed of 8 knots up to 200 m below the surface and that clear return echos could be received from redfish under these conditions. The 1981 survey, conducted in the same area resulted in a biomass estimate very close to that of a trawl survey conducted at approximately the same time.

Introduction

Commercial fishermen have successfully utilized hydroacoustic techniques for over 40 years in order to improve their catches. After World War II, the use of these techniques was expanded to incorporate fish resource surveys (Hodson and Fredriksson 1955). Since then the use of hydroacoustic techniques for fisheries research has been described by many workers (see Forbes and Nakken 1973, Burczynski 1979, Suamola 1981). Investigations have been carried out on a wide variety of pelagic and demersal fish species but very little work has been directed toward redfish (Sebastes sp.). On the west coast of North America hydroacoustic techniques have been applied to rockfish and biomass estimates obtained (see Marine Fisheries Review 42: 1980, Taylor and Kieser MS 1980, MS 1981). The target strength used in the latter studies are described but those of the former are not.

In the mid-to-late 1970's some work was carried out on redfish in the Hermitage Bay area of Newfoundland (McKone pers. comm.) but was discontinued without completion of data analyses.

In 1980 studies were again initiated by the Newfoundland Region of Fisheries and Oceans to investigate the utilization of hydroacoustic techniques for the enumeration of redfish in the Northwest Atlantic. Surveys were conducted in NAFO Div. 4RS in August-September of 1980 and 1981. The purpose of this paper is to outline the techniques used and the preliminary results of research in this area.

Methods and Results

Acoustic system

In 1980 the hardware used was the same as that used in the Canadian computerized echo counting system (C.E.C.S.) (Shotton and Dowd MS 1975). Miller (1981) has described the modified system (C.E.I.S.) and its use in the Newfoundland Region.

In 1981, a new data aquisition system (H.Y.D.A.S.) developed at the Northwest Atlantic Fisheries Centre, St. John's, Newfoundland was used (Stevens MS 1982). Analysis of the data was as described by Miller (MS 1982).

Study area

In the selection of a study area, the physical limitations of the system already in place had to be considered. Since the transducers in use are certified to a maximum depth of 200 m and assuming that they could be effectively and practically towed at this depth, the maximum working depth of the system would be 400-450 m since for reasonable target resolution the transducer should be no more than 200-250 m from the bottom (Simrad Scales A or B) (Stevens pers. comm.).

Redfish inhabit depths of 150-600 + m so no one area could be examined in its entirety unless the maximum depth did not exceed 450 m (unless considerable funds were made available for new equipment). In addition, it was deemed desirable to examine an area where standard trawl surveys were being conducted at approximately the same time. The northern Gulf of St. Lawrence (NAFO Div. 4RS north of 49°00'N and east of 64°00'W, Zones 1 and 2 of Fig. 1) satisfied both of these criteria. The maximum depth is only slightly over 400 m and annual trawl surveys were being conducted throughout the area in July-August. Another advantage of working in this area at depths greater than 140 m was that the main fish species encountered is redfish, with other species only being present in minor amounts. (It should be noted that a possible disadvantage is the presence of shrimp and euphausiids in commercial quantities). With these in mind it was decided in late 1979 to conduct initial investigations in this area.

The surveys

The acoustic surveys were carried out on the charter vessel, M.V. Gadus Atlantica. In 1980 the cruise track (Fig. 2) was laid out in a zig zag pattern. No attention was paid to basing this track on statistical theory as the primary objective was to test the equipment and the feasibility of working within practical bounds at the required depths. This track covered a distance of approximately 2000 km and required 8¼ days (including 18 sets). The towed body was maintained at distances between 80 and 140 m from the bottom with an overall average of 95 m. The area encompassed by the survey was 26,287 sq km and with a beam angle of 12° (-10dB), the area sampled was 40 sq km or 0.15% of the total (based on mean height of the towed body above the bottom).

The towed body functioned well to a depth of 200 m (maximum tested) at towing speeds up to 8.5 knots, with sharp signals being returned devoid of interference. Although no meter block was available, it was estimated that approximately 1500 m of cable (unfared) were required when the towed body was at 200 m.

In 1981 the cruise track was designed differently. Again a zig zag pattern was employed (Fig. 3) but this design was based on a series of 'blocks' with all transects within each block being of equal length. This procedure enables the calculation of variance associated with the estimates (Kimura and Lemberg 1981, Nakashima MS 1981).

The area covered by this survey was 27,318 sq km. The average distance of the towed body from bottom was 113 m, usually being between 90 and 150 m. Again the towing speed was maintained at about 8 knots. The cruise track covered a distance of 1937 km and again 0.15% of the total area was surveyed. A meter block was available during the cruise so the relationship between towed body depth and cable (unfared) length could be determined (Fig. 4). The survey required 8½ days although only 8 fishing sets were done since problems with the magnetic tape drive necessitated repeating a number of transects.

Target strength estimates

A great deal of work has been done on the target strengths (TS) of fish species (eg. McCartney and Stubbs 1971, Forbes 1975, Anon MS 1977, Goddard and Welsby 1977, Naklen and Olsen 1977, and Buerkle and Sreedharan 1981) but little if anything has been done on redfish. Taylor and Kieser (MS 1980, MS 1981) in work on Pacific redfish, used the relationship

$$TS=23.5 \log_{10} l - 3.5 \log_{10}\lambda - 29.5$$

l = fish length in m

λ = wavelength in m

as derived for gadoids by Forbes (1975). They converted the derived TS at length to TS/kg using the relationship.

$$TS/kg = 10 \log_{10} \frac{10^{\frac{TS_L}{10}}}{WT_L}$$

where TS_L is the TS at length and WT_L is the weight in kg at length. They derived a TS/kg of -34.8dB for 50 cm rockfish.

Traynor (in Anon MS 1977) noted that in 1976-77, dual beam data indicated an average target strength of -38dB/kg for walleye pollock and yellowtail rockfish from 40-60 cm in length.

At the same meeting of target strength experts (Anon MS 1977) it was tentatively concluded that all fish with swimbladders could be grouped as one class with respect to target strength. It was noted that although absolute values of TS differed greatly between workers, the best values to use until better data are available were those of Nakken and Olsen (1977) as follows[a]:

Length/Species	Cod	Saithe	Herring	Mackerel
10 cm	-29.0dB	-29.0dB	-30.0dB	
30 cm	-33.5dB	-33.0dB	-33.0dB	
35 cm				-45.0dB
50 cm	-34.5dB	-34.0dB		

[a]Expected values of TS/kg from Norwegian data (In Anon MS 1977, based on Nakken and Olsen 1977).

Based on the above, a TS of -33.0dB/kg was selected as an initial input value.

Biomass estimates

Estimates from the 1980 data were not calculated for a number of reasons. The Simrad time varied gain (TVG) was known to be incorrect but had not been examined and therefore could not be corrected. The old Honeywell computer system was suspected of causing problems but 'where, why, or how' was unknown. It was felt that with a new system in place in 1981, it would be better to wait until this time to initialize a time series of data. Finally, since the 1980 survey design made it extremely difficult to obtain estimates of variance, it was felt that including these data in a time series would only complicate the situation further.

Biomass estimates were obtained from the 1981 survey with an input TS of -33dB. These are shown in Table 1A. Known aggregations of pelagics (suspected to be capelin and/or herring) have been removed but no adjustment has been made for the occurrence of shrimp or euphausiids. Block K (227.2 sq km) was removed from the analysis because a considerable amount of propeller noise was present and the estimated density (0.163 kg/sq. metre) was considered to be unreal. It can be seen that the estimated biomass is 119,697 t with upper and lower 95% confidence limits of 138,679 t and 100,175 t respectively.

The results of the summer random stratified survey in Zones 1 and 2 (Fig. 1) are shown in Table 1B. The estimate is 127,604 t with 95% confidence limits of 178,352 t and 76,856 t respectively.

Discussion

The results of the 1980 survey indicated that the acoustic hardware presently in use by the Newfoundland Region can be utilized at practical towing speeds to work in depths down to 450 m (below surface). Although a great deal of cable (1500 m unfared) was required to place the towed body down to a depth of 200 m, this did not present any problems.

The results from the 1981 survey indicate that the biomass estimate obtained is in very close agreement with that obtained from the summer trawl survey (-6.2%) but has a much tighter 95% confidence interval. Although this is encouraging, it should be viewed with extreme caution. The trawl surveys only yield a 'minimum trawlable biomass'. One of the reasons for examining the use of hydroacoustics for redfish was that the estimates from trawl surveys had always been suspect. Although the problems with diel movement were not encountered during the trawl survey since fishing was done during daylight only, the known clumping of redfish and the resulting skewed distribution of catches could still result in erroneous estimates when working with means.

The target strength used in the acoustic estimate is one derived for gadoids. Although it has been shown that TS/kg is more stable with changing length than TS/l, it can be seen from the results of Nakken and Olsen (1977) that the TS/kg changes from 3-4dB between lengths of 10 and 30 cm and thus this appears to be a critical range. With the occurence of a new strong year-class, as was noted during the 1981 summer trawl survey, the weighted mean length may decrease considerably resulting in a greater TS/kg and a related decrease in the biomass estimate. Similarly, the formulae used by Taylor and Kieser (MS 1980) resulted in a TS/kg of -32dB for a 30 cm fish and -29dB for a 10 cm fish, again suggesting a lower estimate of biomass.

Countering a possible lowering of the estimate is the 'in situ' work of Traynor (Anon MS 1977). He found a mean target strength of -38dB/kg for fish between 40 and 60 cm (compared with -34dB for 50 cm fish by the method of Taylor and Kieser). Although the mean length of redfish in the Gulf of St. Lawrence is much less than 40 cm (26 cm in 1980), if his results are considered realistic, the TS/kg for the redfish in the Gulf may be close to or above -33dB resulting in the same or an increased biomass estimate. Mamylov and Sergeeva (MS 1982) found that Barents Sea redfish 26 to 34 cm had target strengths ranging between -43 dB and -39 dB. Applying these values in the present study would result in a much higher estimate. Orlowski (MS 1982) working with Sebastes sp. on the west coast of Canada arrived at an estimate of -32.3 ± 1.4 dB/kg when the echointegrator was calibrated with bottom trawling results. Based on this and assuming similar catchabilities the results of the present study should be minimum estimates and comparable with the trawl survey results.

In addition to the above, although pelagic capelin and herring have been removed from the estimates, the effects of shrimp and euphausiids have not been considered as to date the response of those invertebrates to the frequency used has not been examined. Undoubtedly their consideration will result in a lowering of the biomass estimate but the extent is unknown at present.

Therefore, in summary, it can be said that although the work to date is encouraging, there are still a number of important questions to be answered particularly with regard to target strength. The biomass estimate presented here should be considered as a point estimate only with many uncertainties associated with it. Hopefully, these will be resolved in the future.

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Table 1a. Biomass estimate of redfish from 1981 hydroacoustic survey in NAFO Div. 4RS (zones 1 and 2).

BLOCK	# OF TRANSECTS	AREA(SQ.KM)	BIOMASS/ SQ.M(KG)	VARIANCE	COEFF. OF VARIATION	BIOMASS (TONS)	95% CONF. INTERVAL
A	3	4153.75	.00218	.469D-06	.31419	9055.	+- 5576.
B	4	2867.13	.00582	.485D-05	.37846	16687.	+- 12378.
C	8	3074.57	.00663	.597D-06	.11653	20384.	+- 4656.
D	2	488.04	.00977	.468D-05	.22152	4768.	+- 2070.
E	3	493.39	.00535	.323D-05	.33618	2640.	+- 1739.
F	6	2923.92	.00360	.487D-06	.19386	10526.	+- 3999.
G	4	2114.84	.00526	.177D-05	.25302	11124.	+- 5517.
H	6	5376.44	.00413	.741D-06	.20842	22205.	+- 9071.
I	6	2387.83	.00352	.342D-06	.16611	8405.	+- 2737.
J	8	3210.89	.00433	.273D-06	.12078	13903.	+- 3291.
TOTAL	50	27090.80	.00442	.128D-06		119697.	+- 18982.

Table 1b. Biomass estimate of redfish from 1981 trawl survey in NAFO Div. 4R$ (zones 1 and 2).

WEIGHTS (kg)

STRATUM	NO.SETS	TOTAL	AV./SET	UNITS	TOTAL	VAR.
112	2	190.10	95.05	30575.	2906127.	11235.00
113	5	560.65	112.13	60570.	6791755.	12005.56
114	2	320.05	160.02	30922.	4948316.	965.80
122	6	1342.50	223.75	90798.	20315968.	121695.94
123	8	2286.42	285.80	99368.	28399536.	66540.75
124	3	449.80	149.93	53043.	7952833.	17355.84
213	4	472.70	118.17	61844.	7308453.	3884.12
214	8	716.45	89.56	128553.	11512703.	3573.59
221	3	429.30	143.10	50147.	7176058.	24014.86
223	3	102.00	34.00	44936.	1527809.	1298.25
224	2	21.90	10.95	28143.	308162.	163.81
500	2	150.00	75.00	25942.	1945663.	4014.08
501	5	934.49	186.90	134807.	25195024.	67606.00
510	6	80.50	13.42	98094.	1316092.	299.74

TOTAL	TOTAL UPPER	TOTAL LOWER	AVERAGE MEAN	AVERAGE UPPER	AVERAGE LOWER
127604384.	178352336.	76856432.	136.08	190.19	81.96

EFFECTIVE DEGREES OF FREEDOM= 14
STUDENTS T-VALUE= 2.14 ALPHA=0.05

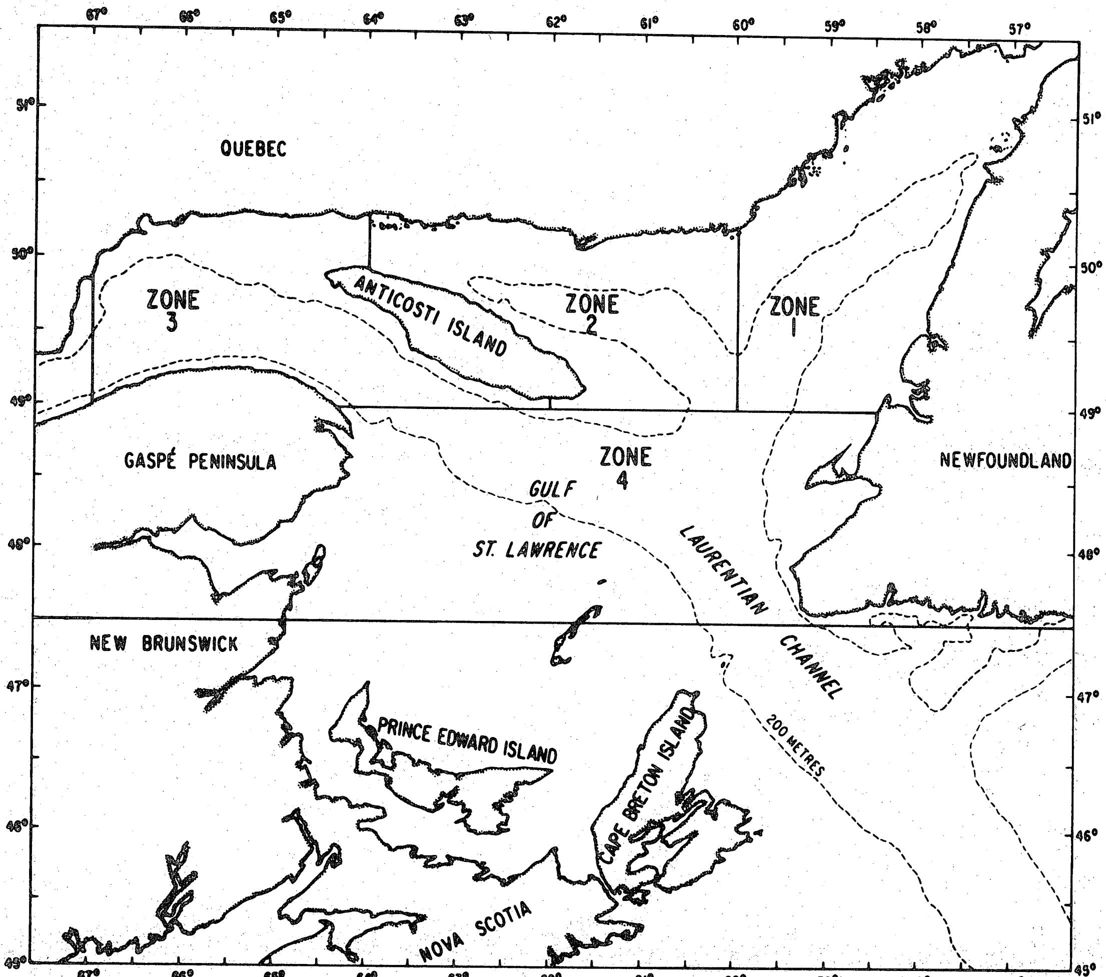

Fig. 1. Gulf of St. Lawrence showing zone divisions used in stratified surveys.

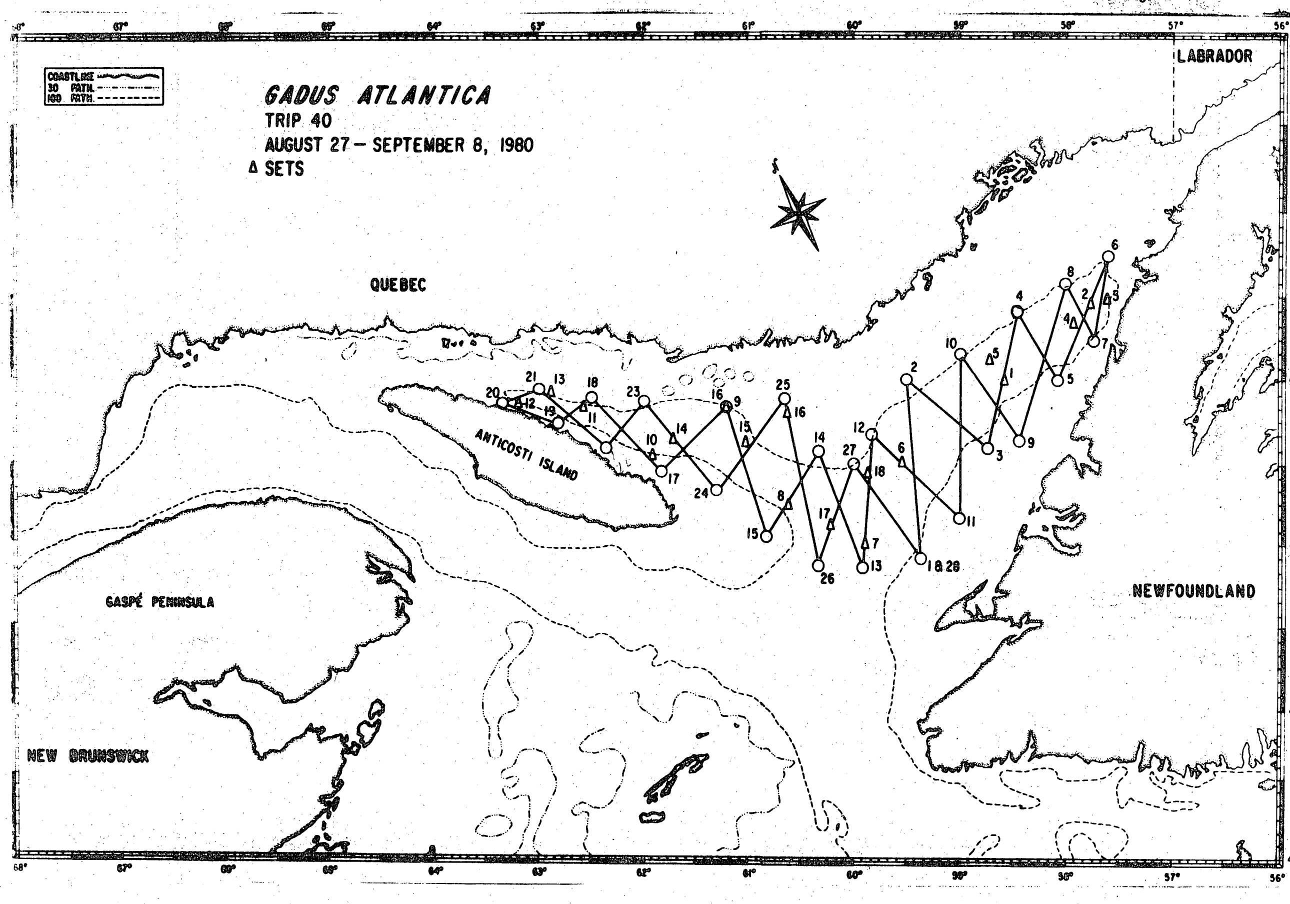

Fig. 2. 1980 redfish hydroacoustic cruise track NAFO Div. 4RS.

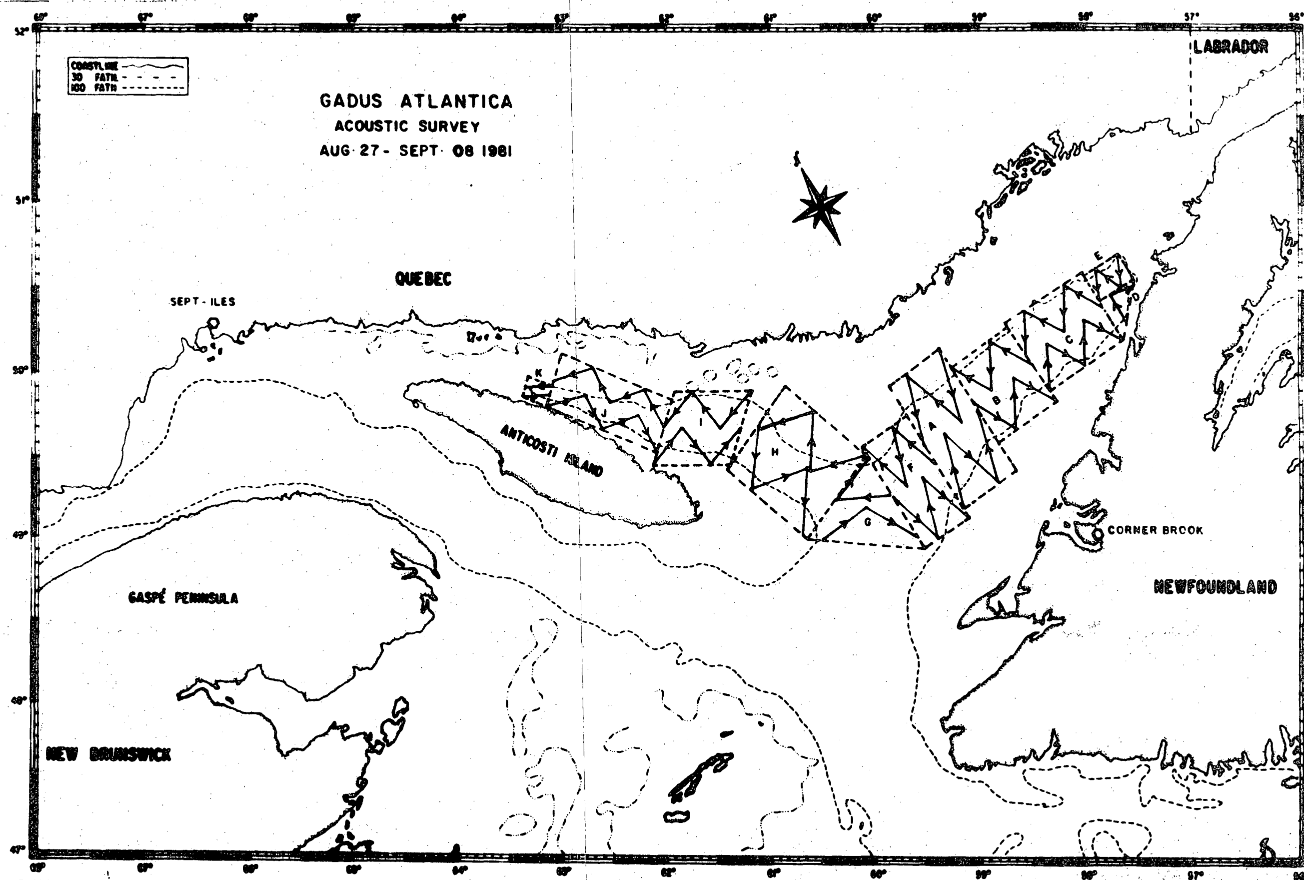

Fig. 3. 1981 redfish hydroacoustic cruise track NAFO Div. 4RS showing blocks used for variance determinations.

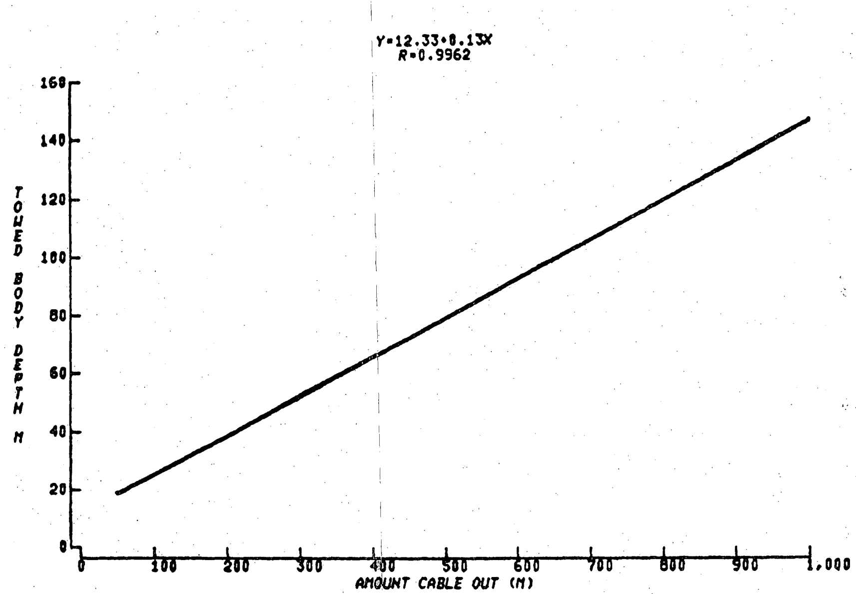

FIG 4 : RELATIONSHIP BETWEEN TOWED BODY DEPTH (M) AND AMOUNT OF CABLE OUT (M) AT TOWING SPEED OF 8 N.