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SWEPT AREA VARIATION WITH DEPTH AND ITS INFLUENCE ON STRATIFIED TRAWL SURVEYS INDICES ON ARCTO-NORWGIAN COD

by

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ABSTRACT

Stratified trawl surveys have been carried out in the Barents Sea and the Svalbard areas since 1981. Based on the assumption of a constant area swept by the trawl during a standard trawl haul at any depth, swept area abundance indices have been presented for both areas. The results have been used in the management of the Arcto-Norwegian cod stock.

In this paper results from measurements of trawl geometry during trawling operation during a standard stratified trawl survey in the Svalbard area in September-October 1985 are presented and the implication on the trawl indices of these results are discussed.

A considerable depth - and also to some extent area/bottom stratum - dependency of wingspread was recorded. Assuming that

the swept area is lineary related to the wingspread, it was found that the currently applied method relatively underestimates the younger ages of cod (1-3 years) in the Svalbard area. Further, if the depth dependency of the wingspread is taken into account, the Svalbard indices should be raised by about 20% to be related to indices from roughly the same depths as found in the Barents Sea survey. The use of instruments for measuring trawl geometry during all tows may diminish variability in bottom trawl survey indices.

INTRODUCTION

Stratified bottom trawl surveys have been carried out in the Barents Sea and the Svalbard area since 1981 (Hylen, Nakken and Sunnanå, 1986, and Godø and Nedreaas, 1986). Based on the assumption of a constant area swept by the trawl during a standard trawl haul at any depth (Hylen, Nakken and Sunnanå, 1986), swept area abundance indices have been calculated for the two areas. The two sets of indices have been combined and used in the management of the Arcto-Norwegian cod stock (Hylen and Nakken, 1985).

The surveyed areas of the Barents Sea vary little in depth; 250m $\pm$ 50m (Jacobsen, 1986). The Svalbard area, however, is characterized by depth variation from about 40m to 600m, which is the depth limits of the survey. Survey stratification follows depth contours. It is known that the area swept by a trawl increases with depth as a result of increasing warp length (Carrothers, 1981). According to previous Svalbard survey results, it is also known that many of the groundfish species migrate from shallow nursery areas towards deeper water with increasing age (Godø and Nedreaas, 1986). Thus, without adjustments for the effects of depth on area swept and size/age distribution, the estimated indices of the different age groups may be significantly biased.

In the 1985 Svalbard survey wingspread of the trawl was observed during trawling operations. In this paper the results from these observations are presented and discussed. Further the influence of wingspread variation on trawl indices is estimated and discussed in relation to the calculated standard Svalbard indices (Godø and Nedreaas, 1986).

MATERIALS AND METHODS

The survey

The material was collected during the 1985 standard Svalbard survey (Godø and Nedreaas, 1986). During the stratified random trawl survey a total of 202 trawl stations were occupied. Of these 94 were by the R/V "Eldjarn" (60.3 m LOA-3400 HP) and 108 by the M/T "Raiti" (46.7 m LOA-1200 HP). Observations of trawl height and wingspread were made on 131 hauls (Table 1).

Fishing gear and instrumentation

The standard bottom sampling trawl of the survey was a Campelen 1800/40 shrimp trawl (Fig.1). R/V "Eldjarn" was equipped with 6m^2 Waco doors (3.00 x 2.04 m), 1500 kg, while M/T "Raiti" used 6.4m^2 Vee-doors (3.65 x 2.02 m), 1750 kg. Warp lengths of 2-3 times the depth were used, depending on depth. All observations of trawl geometry were done with SCANMAR instrumentation. A height sensor was mounted on the trawl headline while sensors for measuring distance were hung on the sweep wires 20cm in front of the headline wingtips. Stable readings of trawl height and wingspread were recorded from the SCANMAR digital display every five minutes during the haul . Bottom contact observations were obtained from the height sensor (Engås and Godø, 1986).

Calculation

The indices (I) are calculated according to the following equation:

$$I = \bar{X}_{st} \cdot A \cdot 10^{-6} / SA$$

where $\bar{X}_{st}$ is the stratified mean catch (numbers) in a strata with area A, (Hylen, Nakken and Sunnanå, 1986). Standard swept area (SA) is calculated as the area covered by a trawl tow of 3n.m. and catching width of 25m. It is assumed that the corrected swept area (SA_{co}) is lineary related to the measured wingspread (WS) at all depths;

$$SA_{co} = a \cdot WS \cdot 3n.m.$$

where a is a constant. To study the effect on the indices at different depths by introducing variation in WS, a mean corrected swept area within each specific depth zone (Table 3) is used. The calculations are done under three options: Standard swept area (3n.m. x 25m) is valid in reference depths (rd) 50-100m, 200-300m and 400-500m. Thus a is calculated from the equation above with input of WS figures from reference depths.

RESULTS

Wingspread

The measurements of wingspread from R/V "Eldjarn" and M/T "Raiti" are shown in Fig.2. A logarithmic fitting of the "Eldjarn" values is indicated in Fig.2 and is given by the equation:

$$WS = 2.9 + 2.47 \cdot \ln D$$

where WS is wingspread and D is depth.

The wingspread varies from about 11m at 50m to close to 19m in the deepest depths (more than 400m). The variation within a given depth interval is considerable. There is, however, a reasonable consistency between the two vessels.

In Fig.3 the results from "Eldjarn" is presented for two areas - the area west of Spitsbergen and the Bear Island area. The points seem to fit different curves.

Towed distance

Several hauls onboard "Eldjarn" showed considerable disagreement between time of bottom contact as recorded by the SCANMAR instruments and the time determined in conventional way by the officer on watch. In deep waters the discrepancy might be up to 10 minutes. The same problem was not observed onboard "Raiti". Onboard "Eldjarn" the towed distance was determined by the the SCANMAR instrument readings when available.

Geometry of trawl opening and quality of haul

The measurements of trawl height versus wingspread are presented in Fig.4. Linear regression gave the line

$$TH = 9.21 - 0.27WS \qquad r = 0.90$$

where TH is trawl height and WS is wingspread.

Instruments readings in disagreement with this relationship for a conciderable period of time (more than one minute), indicated either bad bottom contact or a fallen door (indicated by scratches and mud deposits after haulback). Examples are given by the encircled points in Fig.5, which are not included in the linear regression. Problems of this kind were observed on several occasions onboard "Eldjarn" and were corrected during the haul. Onboard "Raiti" no such problems were recorded.

A schematic presentation of the trawl opening at 50m and 450m depth is given in Fig.5. The trawl opening (WS x TH) covers an area of about $72m^2$. Only $48m^2$ is covered in the same part of the water column at the two depths.

Abundance indices

Standard abundance indices are presented in Table 3 (from Godø and Nedreaas, 1986). In Table 2 results from abundance indices calculated with varying swept area are presented together with the deviation (%) from the standard. Figures for the different ages and for three reference depths (0-100m, 200-300m and

400-500m) are calculated. The total indices vary from -9% to +34% of the standard.

DISCUSSION

Engås and Godø (1986) studied the trawl geometry of the Campelen 1800/40 shrimp trawl used with various doors. The two sets of doors applied in this survey, were found to give relatively equal trawl geometry. The present results confirms this, but it is indicated that the Waco doors are more difficult to operate; i.e. are more unstable and implies difficulties in estimating exact time of the bottom contact. This may affect the area swept by the trawl and thus the indices. The variability is a serious problem in bottom trawl surveys (Carrothers, 1981; Byrne, Azarovitz and Sissenwine, 1981). The effect of using instruments to determine exact time of bottom contact was not estimated, however, such procedures may help decrease the sources of variability of bottom trawl survey indices.

A main source of variation in swept area was found to be the wingspread variation with depth (Fig.2 and 3). A relationship was estimated, although there appears to be a considerable amount of residual variability. The variation from haul to haul or from area to area is thought to be caused by the bottom conditions and currents. The wingspread variation may partly be overcome by shooting extra warp lenght in the shallow areas. Direct observations of trawl geometry under all tows seem to be the best way of controlling the swept area in bottom trawl surveys.

The results additionally show a close relationship between trawl height and wingspread as expected. The recorded large difference in trawl opening (Fig.5) at different depth, probably affects the catchability of target species; although, to what extent and in what way is unknown.

The Svalbard area is characterized by large variations in depth, and the main target species are distributed from the

shallowest banks and towards the deepest areas (Godø and Nedreaas, 1986). Further, most of the commercial exploited species have a size (age) dependent depth distribution. The calculations (Table 2) show that the effects of swept area variation on the abundance estimates of cod is considerable. The calculated age distributions also change markedly compared to the standard. Most interesting is the estimate based on reference depth 200-300m, which is most comparable with the Barents Sea survey. Taking into account variation in swept area only, it was found that the Svalbard swept area indices must be increased 22% to be comparable with the Barents Sea figures. It must be stressed that there are several other factors confounding the comparison of Svalbard and Barents Sea estimates. For instance, coverage during different periods of the year and different length of sweep wires (Hylen, Nakken and Sunnanå, 1986). The results in this paper, however, clearly demonstrate the necessity of a better control of the trawl performance in the Svalbard bottom trawl survey.

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Table 1. Number of observations of wingspread (WS) and trawl hight (TH) on R/V "Eldjarn" and M/T "Raiti".

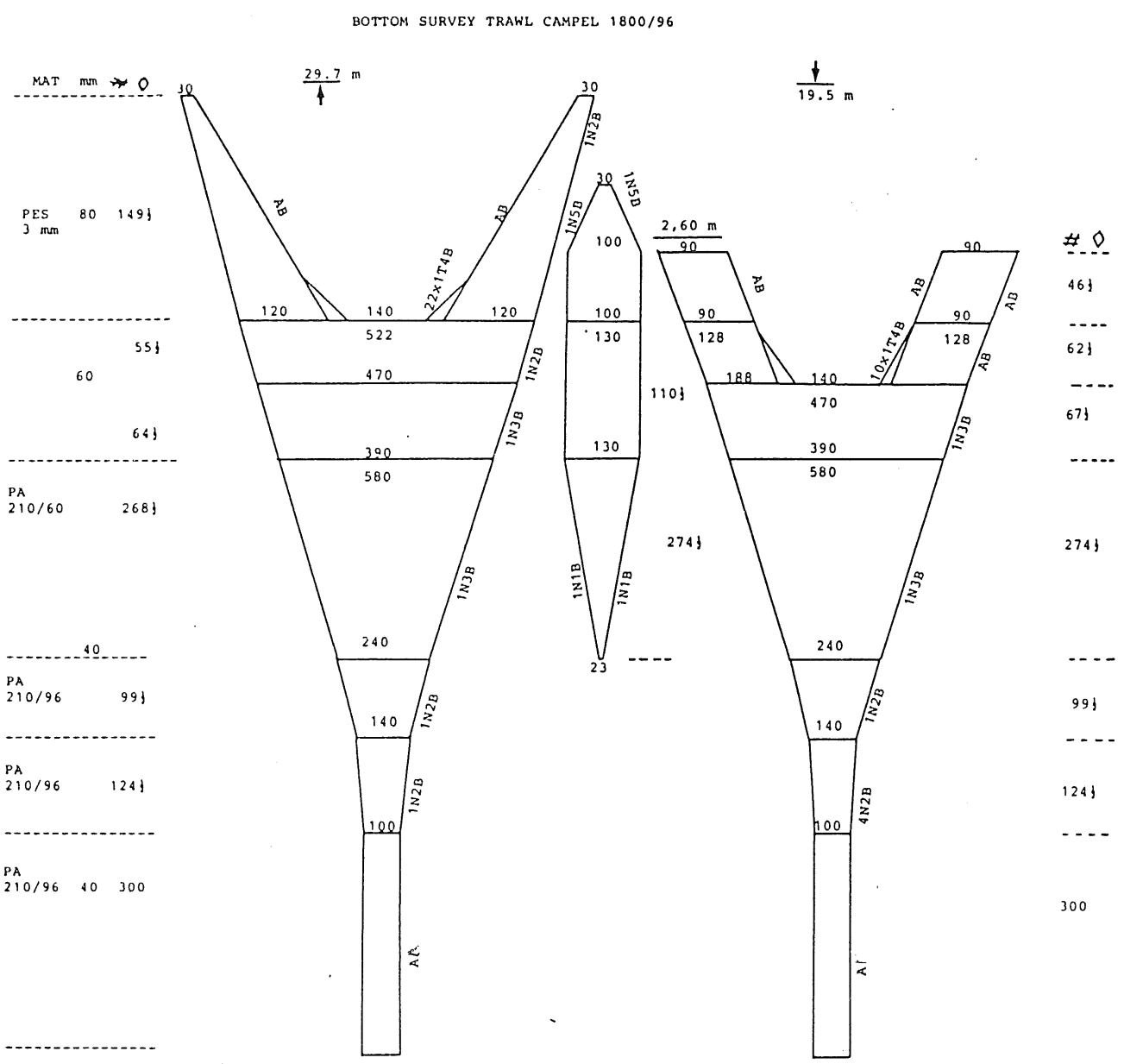
	WS	TH	WS + TH
"ELDJARN"	40	86	30
"RAITI"	35	34	34

Table 2. Variation of abundance indices of numbers at age by varying reference depth. I is the index and % D is percent diviation from the standard figures (Table 3).

	AGE													
	1		2		3		4		5		6+		TOTAL	
Ref. depth	I	%D	I	%D	I	%D	I	%D	I	%D	I	%D	I	%D
STAND	27.0		133.1		74.3		27.9		6.5		10.9		280.6	
0-100	24.3	-10	122.0	- 8	70.2	- 6	24.7	-11	5.4	-18	8.2	-25	255.8	- 9
100-200	32.7	+21	162.5	+23	94.0	+27	21.1	+24	6.9	+ 7	11.0	+ 1	341.2	+22
400-500	35.7	+32	179.4	+35	100.3	+39	36.3	+30	7.8	+19	11.9	+ 9	375.2	+34

Table 3. Stratified indices of numbers at age by different strata.

	Depth	Age										
		1	2	3	4	5	6	7	8	9	10+	Total
North of 76°N	0-100	11.4±17.4	27.7±27.5	5.5±6.0	1.0±0.4	0.2±0.2	+	+	0	0	0	45.8±43.7
	100-200	6.3±3.8	13.2± 7.2	6.5±3.3	3.1±2.7	0.7±1.1	0.7±0.1	0.2±0.2	+	0	+	30.9±27.7
	200-300	0.8±0.3	2.1±2.2	0.9±0.9	0.4±0.2	0.2±0.1	0.3±0.2	0.1±0.1	+	0	+	4.7±3.1
	300-400	+	+	+	0.2±0.1	0.2±0.1	0.4±0.1	0.1±0.1	+	0	+	1.0±0.4
	>400	+	+	+	0.1±0.1	0.1±0.1	0.1±0.1	+	+	0	+	0.4±0.3
	Total	18.5±17.5	43.0±27.8	12.9±1.6	4.8±1.6	1.4±0.6	1.5±0.7	0.3±0.1	+	0	+	82.8±51.8
South of 76°N	0-100	1.5±1.0	52.2±29.4	49.4±32.7	13.1±9.9	1.6±1.2	0.8±0.6	0.1±0.1	+	+	+	119.5±66.9
	100-200	4.1±1.6	18.1±5.2	6.3±2.9	3.4±1.1	0.8±0.2	0.8±0.2	0.1±0.1	0.1±0	+	0.1±0	34.8±9.1
	200-300	2.6±1.6	15.5±10.7	3.1±2.9	2.9±1.1	1.1±0.4	1.6±0.9	0.2±0.1	0.1±0.1	+	0.1±0.1	127.9±17.0
	300-400	0.3±0.2	2.3±0.9	1.6±1.0	2.4±0.7	1.0±0.2	1.5±0.7	0.3±0.1	0.1±0.1	+	+	9.6±2.8
	>400	0.1±0.1	1.0±0.8	1.0±0.5	1.4±0.9	0.7±0.4	1.4±0.7	0.3±0.2	0.1±0.1	+	+	6.0±3.1
	Total	8.5±2.4	90.0±31.7	61.4±33.1	23.1±10.1	5.1±1.3	6.2±1.5	1.1±0.2	1.1±0.2	0.1±0	0.2±0	197.7±65.0
Total all areas		27.0±17.7	133.1±17.7	74.3±33.8	27.9±10.2	6.5±1.4	7.7±1.6	1.4±0.3	1.4±0.3	0.1±0	0.3±0	280.6±83.2



Headline floats 90 x 200 mm

Footrope bobbins - all rubber

Bosom: 3 x 457 mm cylindrical and 1 x 457 mm half shape at ends

Wings: 6 x 457 mm half shape and 4 x 356 mm half shape at ends

Fig. 1. Campelen 1800/40 sampling trawl.

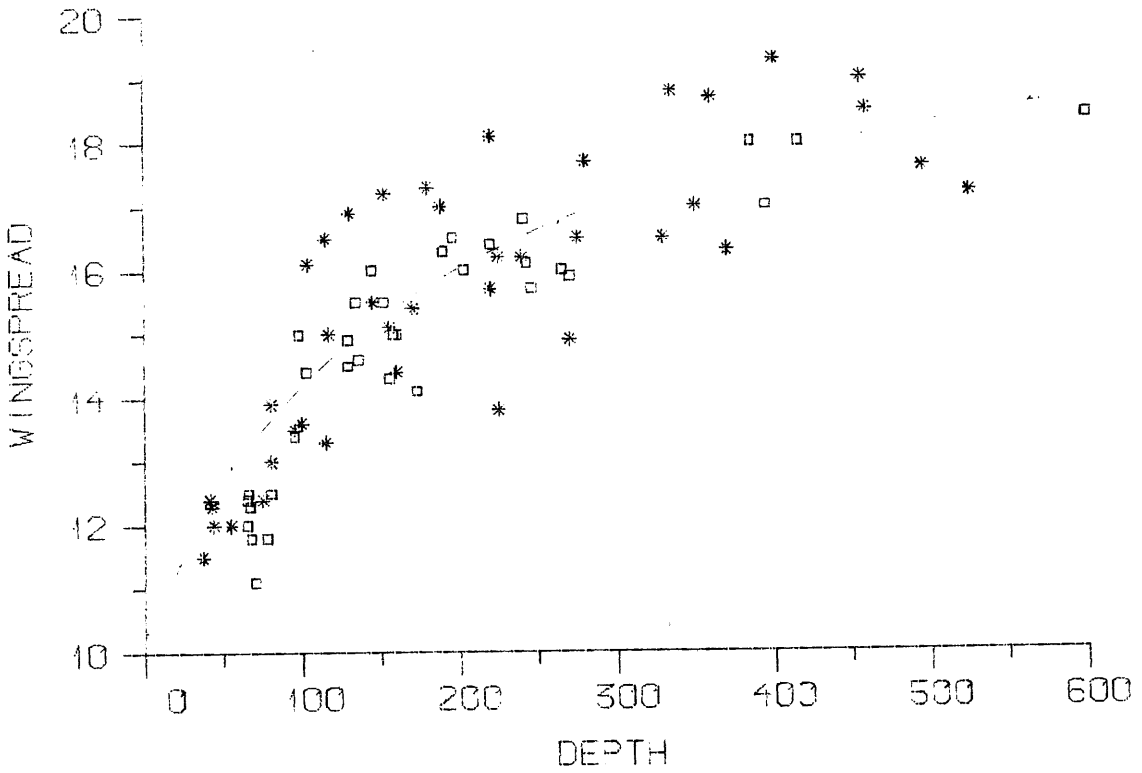


Fig. 2. Wingspread (m) by depth (m). Measurements from "Eldjarn" (*) and "Raiti" (□). A logarithmic fitting of the "Eldjarn" points is indicated.

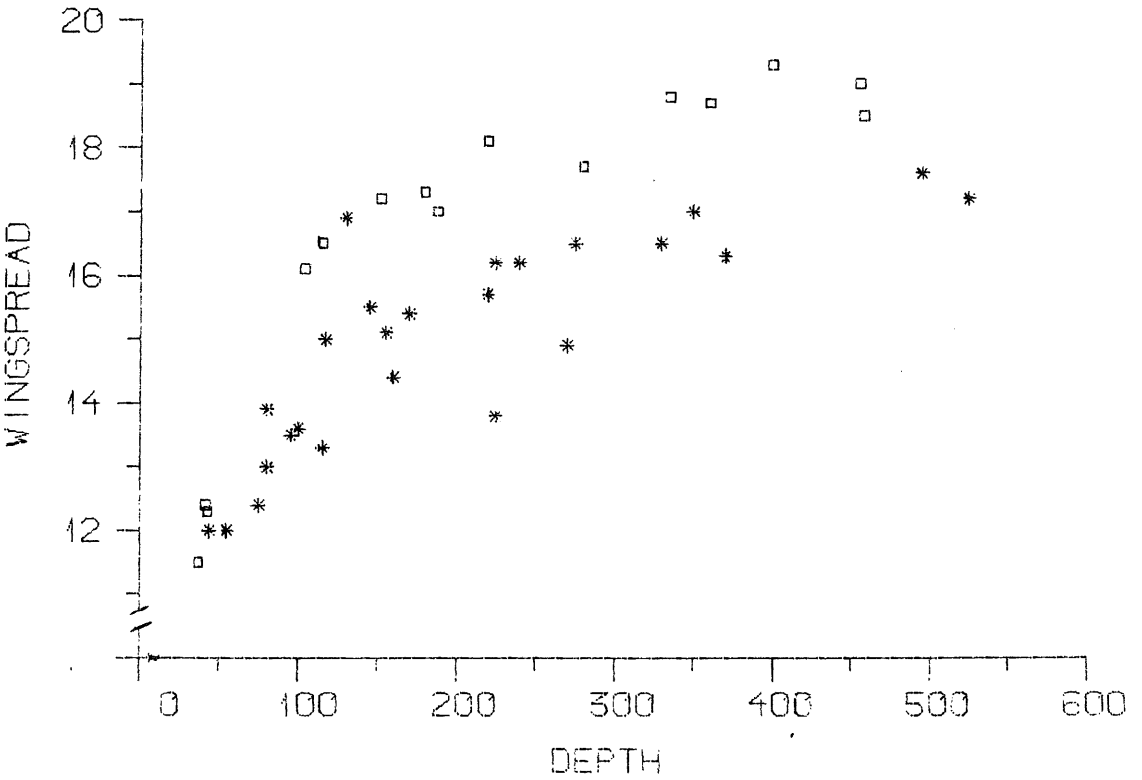


Fig. 3. Wingspread (m) by depth (m). Measurements from the Bear Island area (□) and west of Spitsbergen (*).

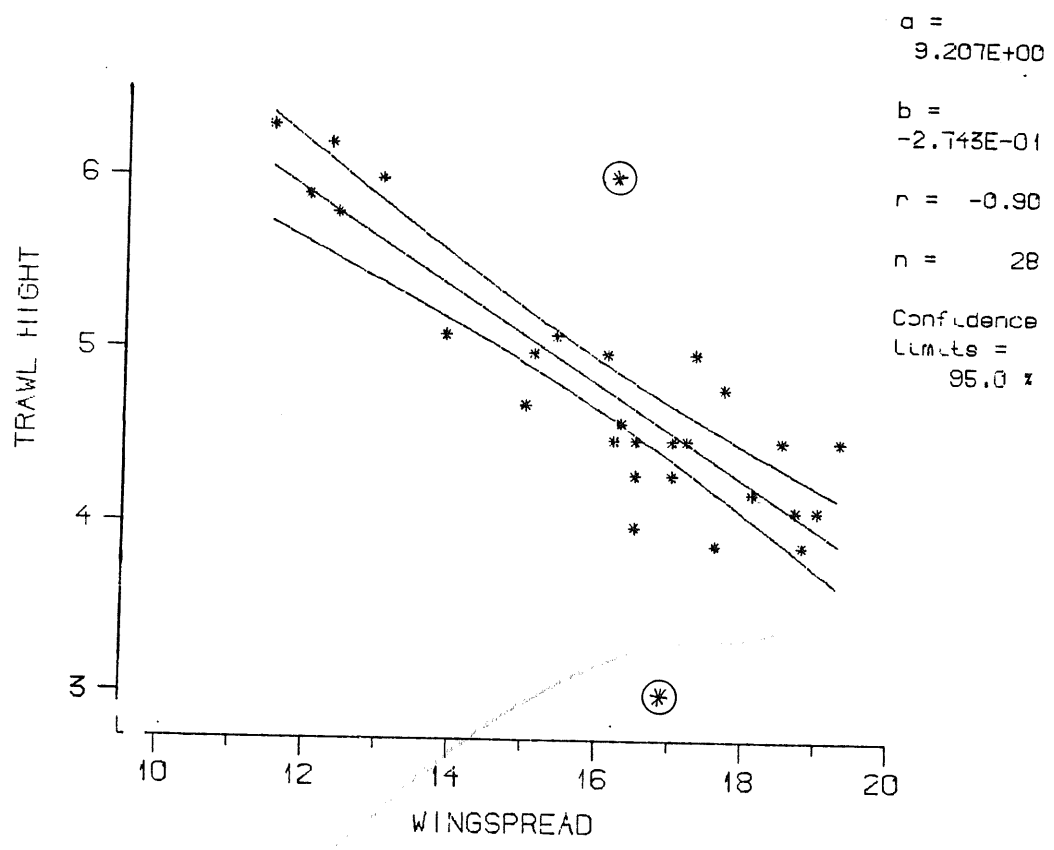


Fig. 4. Trawl height (m) by Wingspread (m). Measurements from "Eldjarn". Linear regression is indicated. Encircled points are not included in the regression.

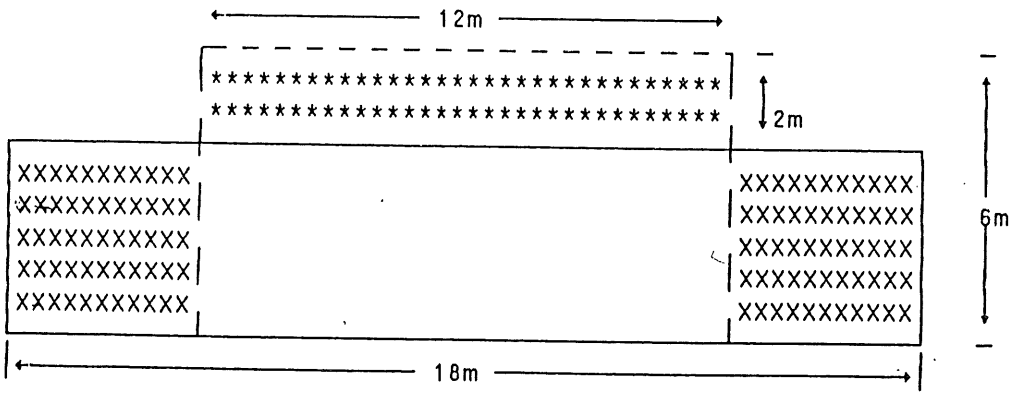


Fig. 5. A schematic presentation of the trawl opening at 50 m (broken line) and 450 m (solid line). The difference in covered area is indicated by (x) and (*).