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THE INFLUENCE OF TRAWL GEOMETRY AND PERFORMANCE AND FISH VERTICAL DISTRIBUTION ON FISH SAMPLING WITH BOTTOM TRAWL.

By

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ABSTRACT

The Institute of Marine Research, Bergen has carried out bottom trawl and acoustic surveys for cod and haddock in the Barents Sea since 1981. These investigations have revealed several problems:

- considerable discrepencies between the acoustic and bottom trawl estimates
- underestimation of young fish
- different catching efficiency of the gear from ship to ship

In 1984 a programme was started with the aim of improving the reliability of the surveys.

This paper presents measurements of the sampling trawl´s geometry during fishing operation and acoustic recordings of fish densities and vertical distributions in the sampling area.

The observations revealed several aspects of geometry and performance of the gear that could have reduced its efficiency for sampling different species and size groups, and further explained some of the ship to ship differences. The recordings of fish densities and vertical distributions indicated that the fish density has a decisive influence on the correlation between trawl and acoustic abundance estimates. Further, a day-night discrepancy of integrated acoustic fish abundance is indicated.

SPECIAL SESSION ON BIOLOGICAL SURVEYS

INTRODUCTION

The Institute of Marine Research, Bergen-Norway, has carried out combined bottom trawl and acoustic surveys for cod and haddock in the Barents Sea and the Svalbard area since 1981(Fig. 1)

The results show that the trawl catches did not accurately reflect the true age structure of the cod in the survey area, with fish less than four years old being progressively underrepresented in the trawl catches. In addition, there were large discrepancies between the stock size esimates prepared from results from the two types of survey(Hylen and Nakken 1983, Hylen, Nakken and Sunnanå 1985), the estimates based on trawl survey results consistently being much lower than those based on acoustic data. The trawl survey have also showed that the catching efficiency of the gear is different from ship to ship(Godø 1984).

In 1984 the Institute of Marine Reseach and the Institute of Fishery Technology Research, Division of Fishing Gear and Methods(FTFI), initated a cooperative research program to improve the reliability of the survey results.

The first efforts in the programme were to measure the sampling trawl´s geometry during fishing operations, as the shape and motions of the trawl, doors, and the bridles influences the efficiency and selectivity of the gear. Results from a preliminary experiment(Engås and West 1985) identified gear performance characteristics that might have influenced the sampling efficiency of the gear.

This paper presents the results from a later experiment where particular interest was afforded to the evaluation of the effects on gear geometry caused by the use of different designs and sizes of trawl doors. The various vessels participating in the surveys use the same standard trawl and rigging, but four different doors.

In addition, acoustic investigations were carried out with the aim of isolating effects on abundance estimation by variation in fish vertical distribution and density.

MATERIALS AND METHODS

Measurements of gear dimensions and acoustic investigations were carried out in a limited area of the Barents Sea aboard the research vessel R/V "G. O. Sars", January 18-26, 1985(Fig. 1).

Gear

The trawl used was the standard Norwegian sampling trawl for bottom fish and shrimp in the Barents Sea and the Svalbard areas, the Campel 1800 (Fig 2b). Bridle and rigging arrangements used are illustrated in Figure 2a. The surveys in the Barents Sea and Svalbard areas are carried out with bridle lenghts of 40 and 80 m, respectively. Both these lenghts were used in the experiments.

The three following doors used on survey vessels were tested: 7.5 sq. m Waco-doors (3.25x2.25 m,1750 kg), 6 sq. m Waco-doors (3.00x2.04 m, 1500 kg) and 6.4 sq. m Vee-doors (3.65x2.02 m, 1750 kg). (The fourth type of doors, 8 sq. m Waco, was tested by Engås and West (1985)).

Duration of a tow was 1 hour made at a speed of 1.5 m/s(Doppler-log). To avoid effects of current, the vessel turned 180 degrees after a tow and a new trawl tow was repeated in the opposite direction. After each tow the doors were examined for mud deposits to determine whether they had fallen down during the tow.

The gear dimensions, i.e. headline height, wingspread, and distance between the doors were measured with acoustic trawl instruments(SCANMAR). Wingspread measurements were obtained by attaching the instruments to the upper bridle, approximately 0.25 cm ahead of the wingends. When measuring door spreads the instruments were attached to the upper backstrops about 2.5 m behind the doors. All three gear parameters were measured simultaneously throughout each individual tow.

Acoustics

The acoustic results were obtained with Simrad Ek-400 38 khz echo sounder in conjunction with an echo integrator developed by the Institute of Marine Research, Bergen, Norway(Blindheim et. al. 1982). The instrument settings were the standar ones used during all routine surveys for cod and haddock in the Barents Sea. The only exception was that the bottom channel (an integration area of specific thicness following the bottom contour) was 4 m during the greater part of the cruise instead of the standard 10 m. Recordings above the bottom channel is in this paper called pelagic recordings.

Methods for judging and sampling for acoustic abundance estimation were used as discribed by Dalen and Nakken (1983). The notation, "integrator value", is referred to as the output figures from the integrator obtained from recordings judged as cod/haddock registration. The judging is based on the character of registration and the species composition of the trawl catches. Also during the routine cruises cod and haddock are considered as one category, and determination of the abundance of the two species is based on their specific importance in trawl catches.

The daytime was in this connection defined as the period 0730-1330, GMT, (includes to some extent dawn and dusk).

The results from 23 catches are included in the catch data.

RESULTS

Trawldimensions.

Observations were made during 28 bottom trawl tows with the three different doors and these are summarzed in Table 1.

The direction of the tow did not seem to have any influence on the trawldimension.

Waco-door, 7.5 sq. m

Observations were made during 8 bottom trawl tows. During the five first tows the rigging of the doors was as normally used on the survey vessel. The measurements showed vertical openings from 3.5 to 3.9 m and wingspreads beetween 19 and 20.5 m. Door spreads were relativly stable, varying from 63 to 68 m with 40 m bridles and from 81 to 89 m with 80 m bridles. The bridle angles calculated from these figures are about 25 and 21 degrees, respectively. The difference between these two bridle angles, did not, however, effect the headline height and wingspread of the trawl.

In the three last tows the rigging of the doors was changed to minimize the angles of attack of the doors. No effect was recorded, indicating that the spread of these doors is too large for the sampling trawl in use.

Waco-door, 6 sq. m

Observation were made during 14 tows with these doors. During the 8 first tows the rigging of the doors was as normally used on the survey vessel.

Higher vertical openings were measured with these doors, from 3.8 to 4.2 m as the door spread and the wingspread is reduced to 51-58 m and 17.5-18.5 m, respectively (40 m bridle, bridle angle about 20 degress).

From tow no 17 the doors were rigged to minimize the angle of attack of the doors. No effect on wingspread or door spread was recorded.

With 80 m bridle(tows nos 21 and 22) the bridle angle was reduced to about 18 degrees without showing any differences in vertical opening and wingspread.

Tows in deeper waters indicated a slight increase in wingspread and door spread.

Vee-doors

The doors were rigged with minimum angles of attack as normally used aboard the reseach vessel. The three gear parameters were measured only during one tow, because of problems with the instruments. The parameters measured were about the same as with 6 sq. m Waco-doors in this tow and during the following tows only two dimensions were measured.

Acoustics and catch

The cruise was run in a rather small geographic area(Fig. 1). Most of the data were collected in depths between 100 and 200 m where the type of recordings and species composition, as well as the size composition of cod and haddock, were relatively homogeneous. Cod and haddock were mainly recorded from bottom and up to 50 m and with highest consentration towards the bottom. The cod were mainly between 35 and 55 cm, while the great bulk of the haddock were 25-45 cm. When not specified, the presented acoustic results are from this specific depth area, the rest beeing collected between 200 and 300 m. At these depths the recordings were generally closer to the bottom and the fish somewhat bigger.

Day night variations.

The relative amount of the total integrator value obtained in the bottom channel is assumed to reflect the vertical distribution of the fish. In Fig. 3 the percentage of the integrator values in the bottom channel is presented on time axis(GMT) together with the catch results of cod and haddock. There is a slight tendency of consentration of fish recordings in the 4 m channel during the day. The 10 m bottom channel observations are fewer and more difficult to interprete.

A greater variation in catch size through day and night was observed (Fig. 3). The cod catches were biggest at dawn and early day. The haddock catches had a less prominent top right before day break. There is no significant connection between a high relative contribution of the integrator value from the bottom channel, and size of the catch.

During the cruise two short experimental surveys were conducted - one during night (GMT 22.07-04.00) and one at day (GMT 07.30-12.15). The cruise lines were roughly the same during day and night(Fig. 4). The depth of the covered area was mainly between 100 and 200 m. In Fig. 4 are also indicated the integrator values from the two surveys which show that all the day values except two were larger than the corresponding night values. The mean day value was 2.8 times grater than the mean night value. A similar tendency was found when considering all data as presented in the following text table.

	Mean integrator value		Number of observations	
Depth	Day	Night	Day	Night
100 - 200 m	189	37	55	189
200 - 300 m	34	28	14	31

In depths between 100 and 200 m the results indicate the same as observed in the mini surveys - the mean day value being about five times higher than the corresponding night value. There is no noteworthy day-night difference at 200-300 m´s depth. The data from 100-200 m depth are also presented on a time scale in Fig. 5 with the standard deviation indicated. The increase and decrease in morning and afternoon is clearly demonstrated. However, the figure also show high standard deviation.

In Fig. 6 is shown the total integrator value against the pelagic integrator values (4 m bottom channel). The observations are found along a line which by linear regression are defind by the formula

$$y=0.9x - 3.9 \quad r=0.95$$

A similar regression was calculated from the results obtained with 10 m bottom channel ($y=0.7x - 1.8$ $r=0.96$). The data include both day and night values. The single observation are rather consentrated along the line while dispersion is expected if a pronounced vertical day-night migration occured.

Vertical distribution and fish density

The main information from the above commented Fig. 6 is the linear relationship between the pelagic integrator value and the total integrator value, i.e. the amount of pelagically distributed cod and haddock seem to be dependent on the total density of those species. This impression is further supported by Fig. 7, showing the relative part of the integrator value in the bottom channel against the total integrator value. The frequency of high percentages decrease with increasing integrator values.

It is further shown in Fig. 8 that there is only a slight tendency that the frequency of high integrator values in the bottom channel increases with increasing total integrator value.

DISCUSSION

Trawldimensions

The trawl performance observations revealed several aspects of the geometry and performance of the gear that could have reduced its efficiency for sampling different species and size groups, and further explained some of the ship to ship differences.

Vertical opening

Most of the time, the trawl´s vertical opening was between 3.8-4.2 m. These values are well below the operating height of 6 m assumed by the Institute of Marine Research(Hylen and Nakken 1983).

There was a marginal difference(0.30 m) in vertical opening despite the difference in wingspreads(3-3.5 m) between the doors used. What effect this would have on the efficiency of the gear is unknown.

The relative low opening might however have reduced the efficiency of the trawl in situations where concentrations of fish extended several meters up into the water column. Different vertical reactions of cod and haddock in the catching zone of a trawl might also effect the species composition. Haddock is observed to rise and enter the trawl at a higher level than cod, and possibly escape above the headline(Main and Sangster 1981).

Wingspreads

The wingspread measurements with 7.5 sq. m Waco-doors(20 m) gave a rather large spread for a trawl with a headrope only 29 m long, suggesting that the gear may have been overspread. This conclusion is supported by the measurements made while the trawl was settling to the bottom. Ordinarily, bottom trawl wingspreads are rather low during this settling phase, roughly half of the headrope lenght (Wathne 1977). This is because the trawl doors cannot fully spread the gear on basis of their hydrodynamic force alone, but need the additional spreading force contributed by ground friction as they shear along the bottom. During a typical tow with 7.5 sq. m Waco-doors and 8 sq m Waco-doors(Engås and West 1985) the wingspread quickly rose to 20 m well before the gear had reached the bottom. However, with 6 sq. m Waco-doors and 6.4 sq. m Vee-doors the wingspread during the settling period was 11 to 15 m, rising to 17-18 m when the gear reached the bottom.

Beside the effect different wingspread could have on catching efficiency, the question araised is the bottom contact of the bobbins effected by overspreading the trawl ?. On a well-tuned bottom trawl most of the towing strain is taken by the headrope, allowing the groundrope to be somewhat slack. This allows the bobbins to make good contact with the bottom. However, when a trawl is grossly overspread it is likely that the groundrope is too taut to make good bottom contact along its entire lenght. This may provide avenues of escape below the bobbins for fish of those species that tend to escape downwards, such as cod and flatfishes(Main and Sangster, 1981b, Harden Jones <u>et. al.</u> 1977, Korotkov 1984).

Door spreads and bridle angles

The high door spread/wingspread ratio with 7.5 sq m Waco-doors and 40 m bridle resulted in very high bridle angles(about 25 degrees). At such high angles the herding efficiency of the bridles is reduced and may results in a strong size selection effect(Carrothers 1981, Wardle 1977, 1983).

In addition, with such high angles it is most probable that the sand clouds pass well outside the wingend of the trawl, thus reducing the powerful effects of herding by sand clouds(Main and Sangster 1981a, b, 1983, Korotkov 1984).

The reduction in bridle angles with the two other doors and espesially with 80 m bridle might result in higher sand clouds and better bridle herding efficiencies.

Identifications of "bad" tows

During 5 of the 28 tows, measurements obtained suggested that the gear was not fully spread or it was not at bottom for a substantial part of the tow. Trawl measurements made during normal sampling tows at the survey stations showed about the same frequency as mentioned above(Engås and West 1985). Without instruments these would have been considered as "normal" tows and used in the calculations without special treatment.

Acoustics and catch

The acoustic recordings were made under rather favourable conditions. The catches were mainly made up of cod, haddock and flatfishes, and the problem of separating cod/haddock recordings from other fish traces was small, and if occuring, assumed to be of limited effect on the results. The bottom channel was set to 4 m which was measured to be the maximum hight of the trawl during the first tows.

A prominent vertical day - night migration may influence the bottom trawl catch results and hence the cod - haddock estimates in the Barents Sea, from both the acoustic and the bottom trawl surveys. During this cruise no prominent vertical migration was observed. It must be stressed, however, that the day length and also other environmental factors change very much during the year at these latitudes, and, consequently, the behaviour may vary seasonally.

Both the cod and haddock catches (kg/hour) had a top at dawn or early day. This could not be linked to a corresponding increase in acoustic abundance at the bottom, but may be a result of a considerable variation in catchability during day and night. This may have an effect on the results of trawl surveys and should be further investigated.

The most prominent and surprising day - night difference was the great discrepancy between day and night indicator values at 100 - 200 m depth (Fig. 5). The two night figures which were higher than the corresponding at day during the minisurveys (Fig. 4), were on cruise lines covering an area with depths approaching 300 m. This may explain the two exceptions in the minisurveys. As the phenomenon was observed in the in the shallower areas only, an explanation may be that the fish at these depths has a ship avoidance reaction during night (light influenced ?) decreasing its target strength. Sound induced ship avoidance effects is observed by Olsen et.al. (1983). A considerable part of the acoustic data were obtained under slow ship speed while trawling. Ship influence on fish may therefore be stronger than under cruising speed. The day-night effect on acoustic estimates of cod and haddock in shallower waters is, however, obvious, and the problem should be further investigated.

The results from the acoustic investigations clearly showed that the vertical distribution of cod and haddock is dependent on the total density of the two species (Fig. 5-6). Under low densities most of the cod and haddock will be consentrated close to the bottom and thus, probably a greater proportion of the stocks will be available to the bottom trawl than at high densities. The indices from stratified bottom trawl surveys at high fish densities will consequently probably be too low compared to estimates obtained at low fish densities.

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Table 1. Results of trawl performance observations.

TOW NO.	DEPTH (m)	WARP (m)	BRIDLE (m)	HEIGHT (m)	WINGSPR. (m)	DOORSPR. (m)	COMMENTS
1	"	450	40	3,5-3,9	19-20.5	-	Waco, 7.5 sq m
2	180	"	"	"	"	64-68	
3	160	"	"	"	"	63-66	
4	"	"	80	"	"	81-88	
5	150	"	"	"	"	81-89	
6	"	"	"	"	"	"	Change the rigging of the doors.
7	"	"	40	"	"	63-67	
8	190	"	"	"	"	64-67	
9	155	"	"	3,9-4,2	17.5-18.5	54-57	Waco, 6 sq m
10	140	"	"	3,8-4,2	"	52-58	
11	"	"	"	"	"	51-57	Mud on bracket of starboard door.
12	"	"	"	"	"	54-58	Probable bad bottom contact.
13	300	800	"	3.7-4.0	18-19	54-62	
14	"	"	"	-	-	-	Mud on bracket of starboard door.
15	"	"		3,6-4.0	18-19	57-61	Probable bad bottom contact
16	250	700	"	3.7-4.3	-	53-60	
17	300	800	"	3,6-4,2	18-19	57-60	Change the rigging of the doors.
18	280	750	"	3,9-4,2	-	52-60	Probable bad bottom contact
19	"	750	"	ca 3.8	17.5-18.5	52-56	
20	150	450	"	3,9-4,2	"	48-56	
21	"	"	80	3.7-3.9	17.5-18.5	68-75	
22	"	"	"	3,8-4,1	17-18.5	70-75	
23	"	450	80	3,8-4,2	"	68-77	Vee-doors
24	"	"	"	-	-	-	
25	"	"	"	3.7-4.1	17-18.5	-	
26	"	"	"	"	-	68-73	
27	"	"	40	3,7-4.0	17-18	-	
28	135	"	"	3.9-4.1	-	-	

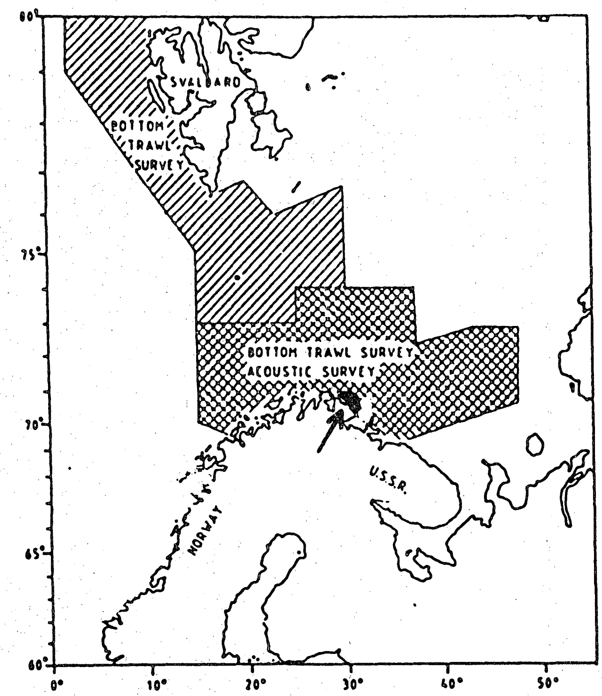
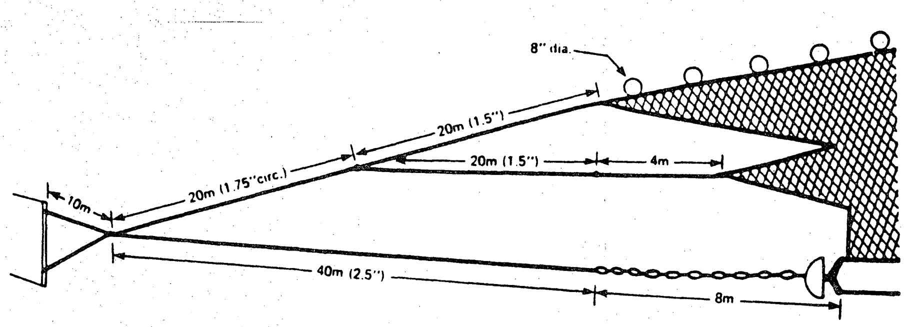


Fig. 1. The area covered by cod and haddock surveys (hatched and doublehatched). The trawl experiment area is indicated (black area pointed out by an arrow).

Headline floats 90 x 8''



Footrope bobbins - all rubber
Bosom: 3 x 18'' cylindrical and 1 x 18'' half shape at ends
Wings: 6 x 18'' half shape and 4 x 14'' half shape at ends

Fig. 2a. Rigging specification of Campel 1800/96.

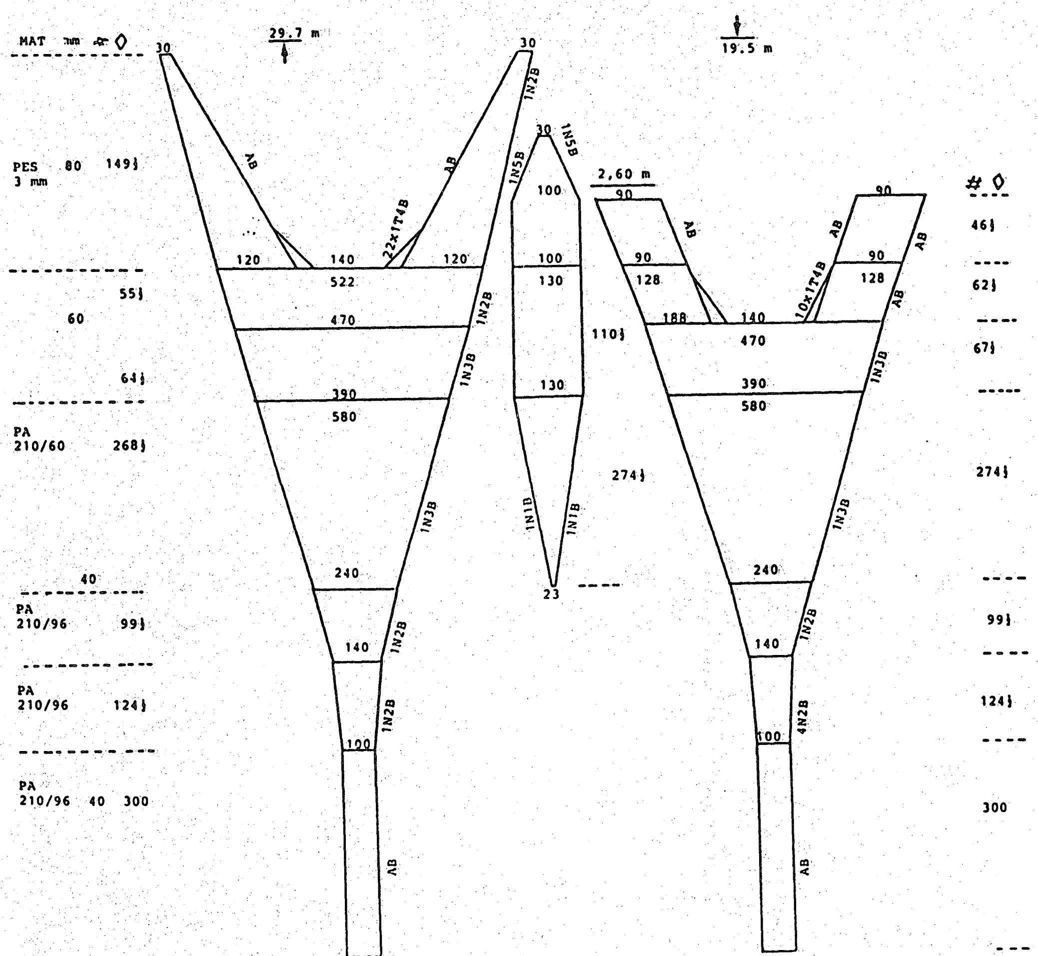


Fig. 2b. Bottom survey trawl Campel 1800/96.

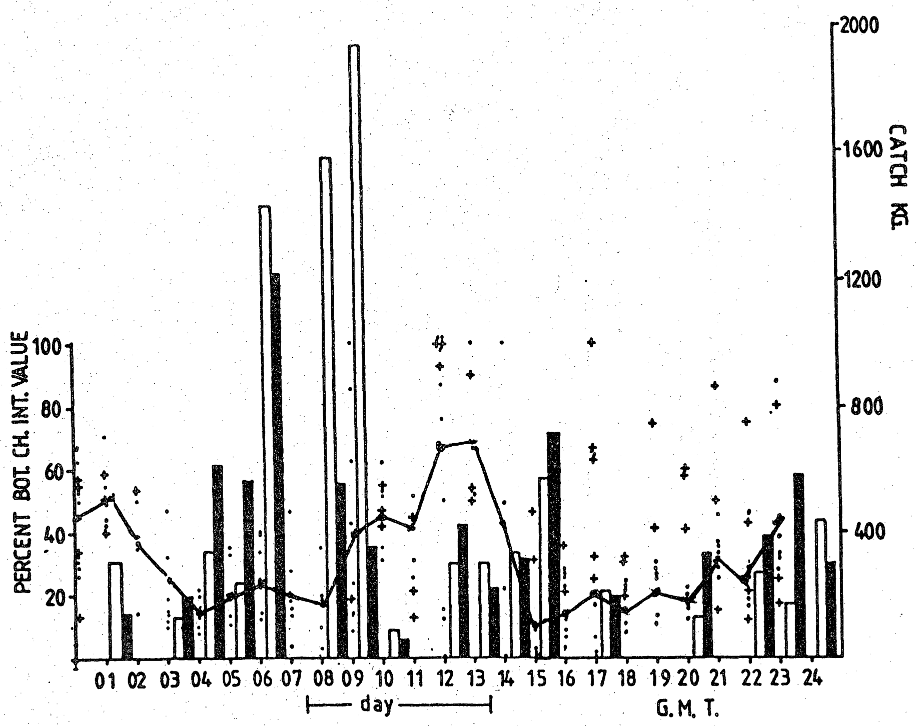


Fig. 3. Variation in the percentage of the total integrator value found in the bottom channel(4m) against time [line]. Single observations with 4 m [.] and 10 m [+] bottom channel. Catch of cod [open columns] and haddock [black columns] against time. GMT is greenwich mean time.

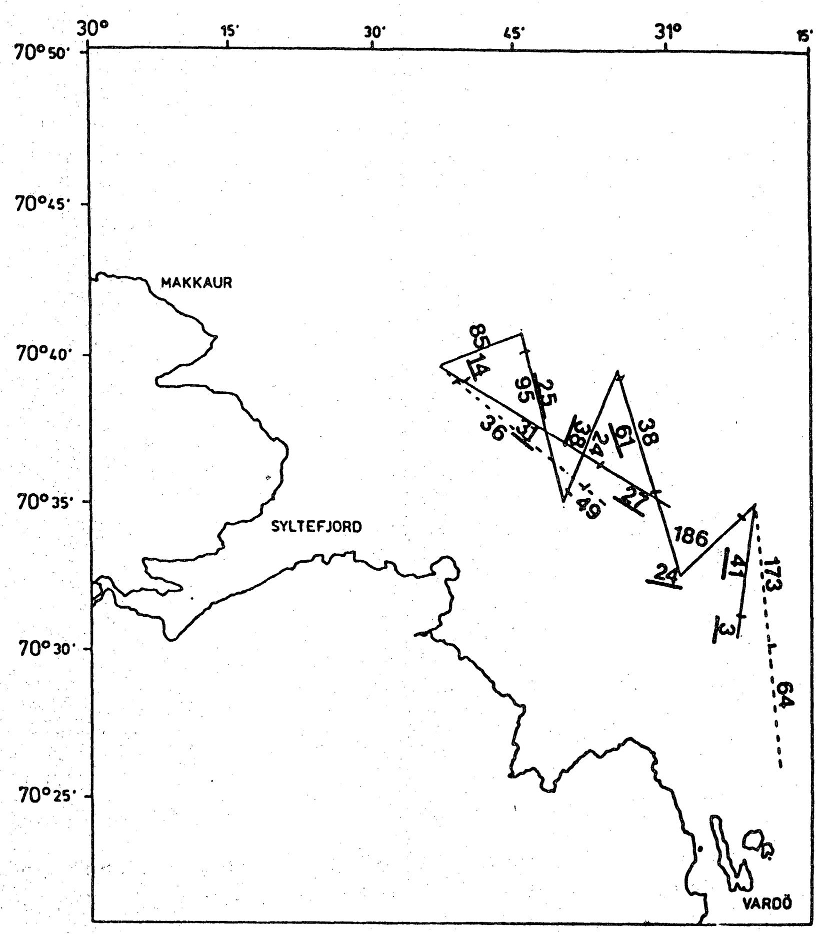


Fig. 4. Cruise tracks and integrator values during the mini surveys. Night values are underlined and the broken lines indicate the day surveys deviance from the nigth survey.

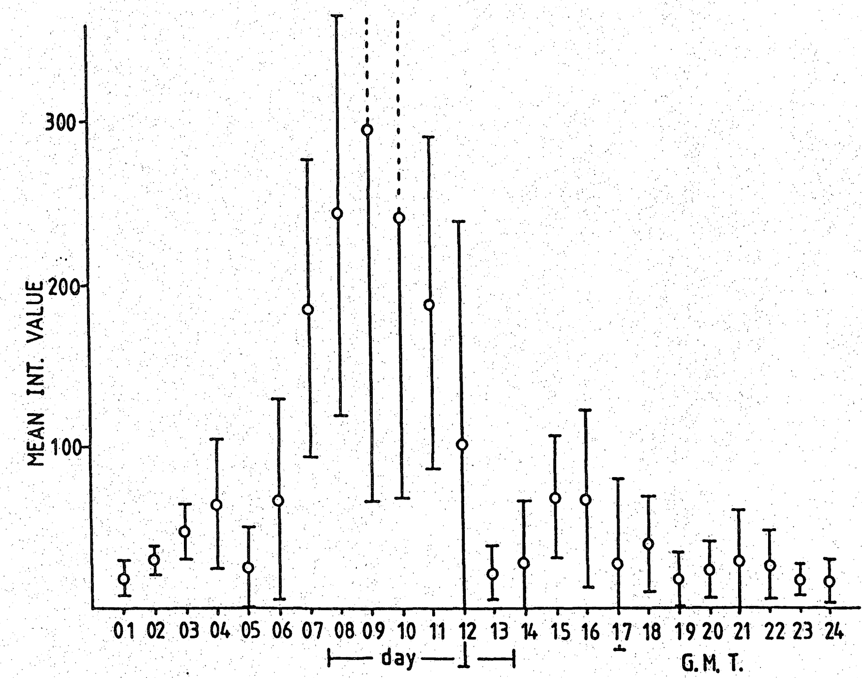


Fig. 5. Mean integrator values against time. Standard deviation is indicated.

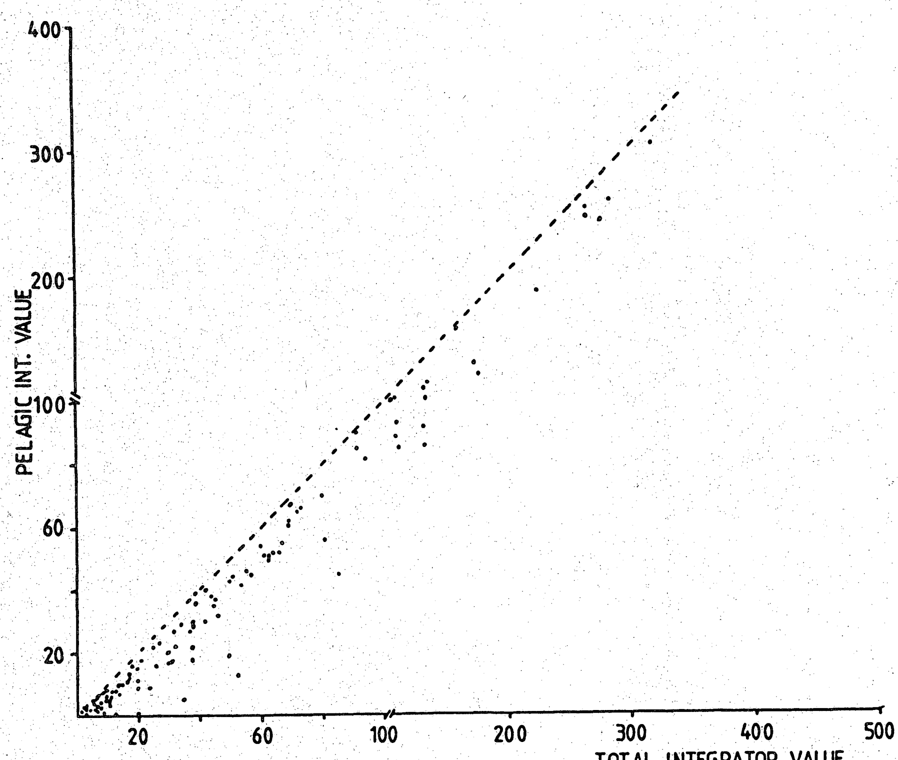


Fig. 6. Pelagic integrator values against total integrator values. Observations with 4 m bottom channel. The y=x line is indicated.

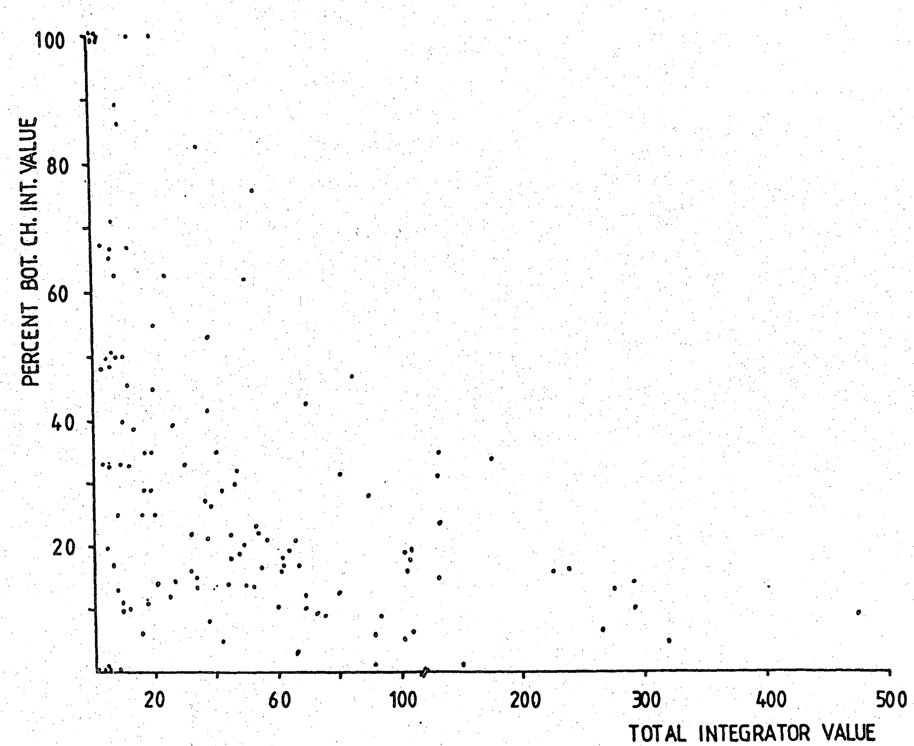


Fig. 7. Percent of the total integrator values recorded in the bottom channel(4m) against the total integrator value.

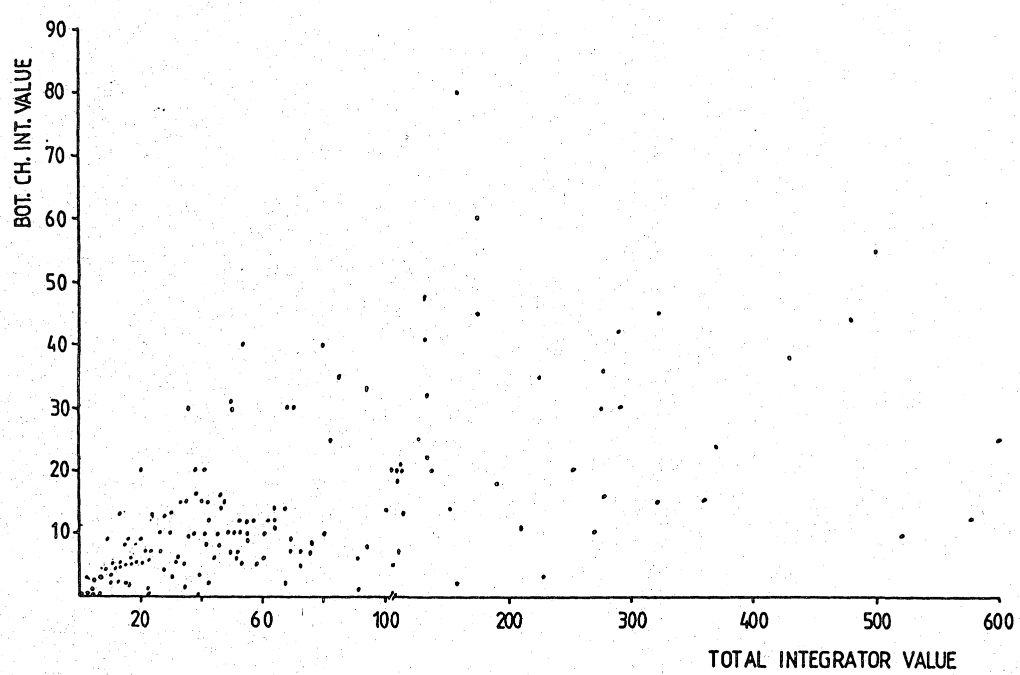


Fig. 8. Bottom channel(4m) values against total integrator values.