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CHANGE IN LENGTH COMPOSITION OF DIFFERENT SPECIES WITH THE DOORS AND SWEEPS ON AND OFF BOTTOM

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INTRODUCTION

Abundance estimates from bottom trawl surveys are in most cases based on the assumption that the effective fishing width is the same for the whole length range of all species. Compared to the great effort in carring out bottom trawl survey and calculation of abundance estimates little attention is payed to the above assumption which indubitably is wrong in most cases.

To get closer to reality, it is necessary to separate the biases that are due to door and sweep herding, and due to net escapement.

Various experiments have been carried out trying to understand the effect of door and sweeps.

Comparisons of various sweep versus no sweep for gadoids all showing a catch loss much more than the loss of swept area when the sweeps are dispenced with (Bagenal 1958, and some old Scots unpublished reports). On the other hand, two quite separate comparisons of long versus quite short sweeps have shown the short sweep gear to be rather more efficient in relation to the total area swept (Dickson, 1988). The disparity between the results by the two methods called for a different approach to the problem of resolving door and sweep efficiency. Having the doors off and on bottom with the net itself firmly on the bottom in both cases seemed worth a try.

MATERIALS AND METHODS

The experiments were carried out off the coast of Finnmark, Norway, 12. - 13. October 1988, at depths of 250 m with M/Tr "Anny Kræmer". The standard Norwegian sampling trawl for demersal fish and shrimp in northern areas, the Campelen 1800/96 was used, Fig. 1. The trawl was equipped with 40 m sweeps, rockhopper ground gear and 6.4 m^2 V-doors (1750 kg).

To set the doors a fixed height above bottom, a Scanmar height sensor were mounted on the backstrops of the door. It was not found difficult to keep the otterboards within 2 to 6 m off bottom. To be sure that the trawl had bottom contact especially with the doors off bottom a Scanmar height sensor was used on the headline on every haul. Wingspread or doorspread were also measured.

In order to make sure that the net firmly maintained bottom contact with the doors off bottom, 550 kg of chain was attached at each wing end. The reduction in net spread and otterboard spread due to this was rather more than anticipated, and to keep things about the same, the heavy bunch of chain was also used with the doors on bottom. With the doors off bottom the lower sweep was increased by approximately 20 cm. The warp to depth ratio with doors off bottom was approx. 1.6, and approx. 2.2 with the doors on bottom. The following gear dimensions were obtained as in Table 1.

Table 1. Operating dimensions.

Otterboard spread m	Net spread m	Headline height m	Sweep angle
Otterboard on bottom:			
38	11.5	5.7	17.1°
Otterboard off bottom:			
31	9.5	5.9	13.8°

The experiments were carried out by alternating between trawl hauls with the doors on bottom and doors off bottom. The two hauls which are compared were taken within a short time interval and the catch worked up before a new comparison was carried out. Table 2 gives an overview of the experiments. Paired hauls 3, 4 and 5 are called night hauls. The duration of a tow was 1/2 hour at a speed of 3 knots.

Table 2. Overview of experiments.

Paired hauls (ON+OFF) Haul no.	Time interval (GMT)
1	13.33 - 15.00
2	16.22 - 17.55
3	18.50 - 20.25
4	22.00 - 23.33
5	00.41 - 02.07
6	10.33 - 12.03
7	13.27 - 15.03

RESULTS

Tables 3, 4, 5 and 6 give the raw data for cod, haddock, redfish and flatfish (mostly long rough dab). So far only the data for cod and haddock are worked up.

Table 3. Raw data cod.

	OFF							ON							DAY			NIGHT			TOTAL		
Haul No.	1	2	3	4	5	6	7	1	2	3	4	5	6	7	OFF	ON	OFF/ON	OFF	ON	OFF/ON	OFF	ON	OFF/ON
Length group																							
10-14																							
15-19					1	1	1					1	1	2	2	3	0.67	1	1	1.0	3	4	0.75
20-24	2	2	1	1	3	2	3		2	3		2	4	8	9	14	0.64	5	5	1.0	14	19	0.74
25-29	1	1	2	1	1	2	1	2	1	2	1	2	3	8	5	14	0.36	4	5	0.8	9	19	0.47
30-34	2	2		1	2	2	1	4	3	2	2	2	5	7	7	19	0.37	3	6	0.5	10	25	0.4
35-39	2			3	1	2		7	7	2	2	3		2	4	16	0.25	4	7	0.57	8	23	0.35
40-44			1	3	2		1	1	3	3	2	5	3		1	6	0.17	6	10	0.60	7	16	0.44
45-49	2	1	1	2	3	2		7	3	1	6	2			5	10	0.5	6	9	0.67	11	19	0.58
50-54	2	1	2	3	4	3	3	5	6	5	6	5	9	4	9	24	0.38	9	16	0.56	18	40	0.45
55-59	2	2	1	2	4		1	3	1	1	6	3	11	3	5	18	0.28	7	10	0.70	13	28	0.46
60-64		3	3	2	1			1	3	1	1	2	2	3	3	9	0.33	6	4	1.5	9	13	0.69
> 65				1	2	1		1			2	3	2		1	3	0.33	3	5	0.6	4	8	0.5
Sum	13	12	11	19	24	15	11	31	29	20	28	30	40	37	51	136	0.38	54	78	0.69	106	214	0.49

Table 4. Raw data haddock.

	OFF							ON							DAY			NIGHT			TOTAL		
Haul No.	1	2	3	4	5	6	7	1	2	3	4	5	6	7	OFF	ON	OFF/ON	OFF	ON	OFF/ON	OFF	ON	OFF/ON
Length group																							
10-14	14	13	4	2	2	21	16	32	3		1	2	56	29	64	120	0.53	8	3	0.92	72	123	0.59
15-19	21	10	6	4	7	12	4	24	17	11	9	4	24	27	47	92	0.51	17	24		64	116	0.55
20-24	3	5	3	3	3	6	2	6	11	4	3	7	7	5	16	29	0.55	9	14	0.64	25	43	0.58
25-29	2	3	3	3	3	4	5	12	13	9	4	4	4	2	14	31	0.45	9	17	0.53	23	48	0.42
30-34	2	6	4	6	6	4	2	9	22	11	15	9	8	6	14	45	0.31	16	35	0.46	30	80	0.38
35-39	1	7	6	5	5	5	5	13	19	15	17	8	4	10	18	46	0.39	16	40	0.4	34	86	0.39
40-44	3	8	7	9	5	5	-	10	15	9	18	17	8	15	16	48	0.30	21	44	0.47	37	92	0.40
45-49	9	4	8	22	16	4	1	15	19	13	41	25	13	13	18	60	0.33	46	79	0.58	64	139	0.46
50-54	9	6	5	15	9	4	4	16	9	12	36	23	16	20	21	61	0.38	29	71	0.41	50	132	0.38
> 55	2	1	3	6	4	4	3	7	-	6	7	12	10	10	9	27	0.33	13	27	0.48	22	54	0.38
Sum	66	63	49	75	60	68	42	144	128	90	151	111	150	137	237	559	0.42	184	354	0.52	421	913	0.46

Table 5. Raw data flatfish.

Haul No.	OFF 1	OFF 2	OFF 3	OFF 4	OFF 5	OFF 6	OFF 7	ON 1	ON 2	ON 3	ON 4	ON 5	ON 6	ON 7	DAY OFF	DAY ON	DAY OFF/ON	NIGHT OFF	NIGHT ON	NIGHT OFF/ON	TOTAL OFF	TOTAL ON	TOTAL OFF/ON
Length group																							
10-14	1	1	1	2	1	-	1				1	2	9	2	3	11	0.28	4	3	1.33	7	14	0.5
15-19	-	3	1	-	1	-	2	3	8	1	2	2	8	4	5	23	0.21	2	5	0.4	7	28	0.25
20-24	1	4	6	8	5	7	3	7	10	9	5	7	18	9	15	44	0.34	19	21	0.9	34	65	0.52
25-29	2	1	8	10	8	7	2	7	5	3	2	6	12	9	12	33	0.36	26	11	2.36	38	44	0.86
30-34	1	4	2	2	1	3	1	4	3	7	3	4	2	3	9	12	0.6	5	14	0.36	14	26	0.54
35-39			1	1				1	1	-	1	1		1	-	3		2	2	1.00	2	5	0.4
>40																							
Sum	5	13	19	23	16	17	9	22	27	20	14	22	49	28	44	126	0.35	58	56	1.04	102	182	0.56

Table 6. Raw data redfish.

Haul No.	OFF 1	OFF 2	OFF 3	OFF 4	OFF 5	OFF 6	OFF 7	ON 1	ON 2	ON 3	ON 4	ON 5	ON 6	ON 7	DAY OFF	DAY ON	DAY OFF/ON	NIGHT OFF	NIGHT ON	NIGHT OFF/ON	TOTAL OFF	TOTAL ON	TOTAL OFF/ON
Length group																							
<10	-	1	-			1	2					1	2		4	2	1.0	0	1	0.77	4	3	0.85
10-14	1	4	-	2	3	4	5	1		1	6	5	7	4	10	12		10	12		19	24	
15-19	-	2	2	4	1	5	1	4	4	-	3	4	6	7	9	21	0.43	7	7	1.0	15	28	0.54
20-24	2	13	8	18	5	13	6	12	12	7	8	10	34	30	34	88	0.39	31	25	1.24	65	113	0.58
25-29	7	5	25	27	22	36	5	99	38	5	43	29	66	22	53	225	0.24	74	77	0.96	127	302	0.42
30-34	3	7	7	18	16	28	2	146	59	12	52	47	54	7	40	266	0.15	41	111	0.37	81	377	0.21
35-39	2	2	3	7	2	5		55	15	1	23	23	14	2	9	86	0.11	12	47	0.26	21	133	0.16
>40	1	-	2	4	2	1		3	8		29	4	5		2	16	0.13	8	31	0.26	10	49	0.20
Sum	16	34	47	80	51	93	21	320	136	26	164	123	188	72	161	716	0.22	183	311	0.59	342	1029	0.33

The cod catch ratio for doors OFF/ON is shown in Figure 2 for both day and night plotted by 5 cm length group. The less the herding by the ON bottom gear, the more nearly does the OFF/ON plot approach 1.0 would seem to be the most likely explanation. How much herding is due to otterboards and how much due to sweeps and sandclouds is not clear. The general conclusions would seem to be:

1. Distinctly more herding of cod by day.
2. Less herding of small cod than bigger ones, and a flattening off of herding effect above 40 cm both by day and night.
3. Very little or no herding of small cod by night (but the numbers were few).

A similar plot for haddock in Figure 3 shows the same general trend, but the daytime trend is flatter. The day and night plots are closer together over most of the range.

Again the OFF/ON ratio appears a little higher at night.

RESULT ANALYSIS

Previous experiments with bags underneath the net were conducted on different grounds so that it was not possible to deduce from them any differences in the efficiency of the net itself by day and by night (Engås & Godø, 1989). To do this remains a prime requirement, because establishing net efficiency is a key to establishing sweep efficiency, also overall gear efficiency, and because survey trawling is done by night and day and at times of the year which include all light and nearly all dark. From the data in this experiment, it has not been possible to resolve day and night net efficiencies.

The starting point in this analysis is, according to the paper given to ICES last year (Dickson, 1988), where the effective pathwidth for any length group is given by:

$$Y_e = f_n(Y_n + f_s(Y_b - Y_n - R_{bo} - R_{bi})(Y_b - R_{bo})/(Y_b - R_{bo} - R_{bi})$$

where

Y_e = effective pathwidth
f_n = net efficiency
f_s = sweep efficiency
Y_N = net spread
Y_b = otterboard spread
R_{bo}= Path width loss due to negative effect of otterboards
R_{bi}= pathwidth of otterboard herding effect

Since then the program has been modified so that R_{bi} can be given a range of values, generally bigger for bigger fish. The previous results for net efficiency, the effective path width and sweep efficiency, were composite day and night values. Now using last years derived values for net and sweep efficiency with rockhopper gear together with the much reduced spread values, the following Table 7 emerges. In this table it is taken for a start that otterboard and sweep effect for the OFF gear should be zero.

Table 7. Composite day and night gear efficiencies and effective pathwidths, cod.

COD			GEAR1	OFF		GEAR2	ON		
			YN1	9.5m		YN2	11.5m		
			YB1	31m		YB2	38m		
			RBO1	0m		RBO2	5m		
FS GIVEN									
Length	RBI1	FN1	FS1	YE1	YE1/YE2	RBI2	FN2	FS2	YE2
10-19	0	0.61	0	5.80	0.48	5	0.61	0.33	12.2
20-29	0	0.67	0	6.37	0.42	6	0.67	0.46	15.3
30-39	0	0.71	0	6.75	0.39	7	0.71	0.55	17.5
40-49	0	0.75	0	7.13	0.35	8	0.75	0.68	20.5
50-59	0	0.79	0	7.51	0.34	9	0.79	0.73	22.4
60-69	0	0.80	0	7.76	0.32	10	0.80	0.75	23.1

The actual values of YE1/YE2, i.e. OFF/ON, for the cod length range 10 to 69 cm, obtained from the catches were

10/19	20/29	30/39	40/49	50/59	60/69		
0.75	0.60	0.38	0.51	0.46	0.61		Composite day and night
-	0.60	0.52	0.50	0.50	0.50	smoothed	

These values are higher than those obtained in Table 7, so something in Table 7 has to be adjusted. A few runs establish YE1/YE2 is not particularly sensative to changes in RBI2. So long as the net and board spreads are similar, YE1/YE2 is little sensative to change of FN1 and FN2 so long as FN1=FN2. With similar net spreads and heavy weights at the wing end, these seems good reason for FN1 = FN2. Introduction of residual values for FS1 brings YE1/YE2 fairly close to the smoothed results. So with other values as in Table 7, there comes out:

Length	FS1	YE1	YE1/YE2
10/19	0.18	8.2	0.65
20/29	0.19	9.1	0.59
30/39	0.20	9.8	0.56
40/49	0.21	10.5	0.52
50/59	0.22	11.2	0.52
60/69	0.23	11.6	0.50

With quite a length of the sweep wire near ground at the net end when the doors are 3-4m off bottom, a residual sweep effect seems quite acceptable.

For haddock the OFF/ON ratio by 10 cm length groups is as follows:

10/19	20/29	30/39	40/49	50/59		
0.57	0.53	0.39	0.44	0.39		Composite day and night
0.6	0.48	0.42	0.40	0.40	smoothed	

The same argument gives Table 8.

Table 8. Composite day and night gear efficiencies and effective pathwidths, haddock.

HADDOCK		GEAR1	ON			GEAR2	OFF		
		YN1	9.5m			YN2	11.5m		
		YB1	31m			YB2	38m		
		RBO1	0m			RBO2	5m		
FS GIVEN									
Length	RBI1	FN1	FS1	YE1	YE1/YE2	RBI2	FN2	FS2	YE2
10-19	0	0.61	0.03	6.19	0.60	5	0.61	0.18	10.40
20-29	0	0.79	0.03	8.01	0.49	6	0.79	0.36	16.49
30-39	0	0.9	0.04	9.32	0.42	7	0.9	0.54	22.08
40-49	0	0.92	0.07	10.12	0.40	8	0.92	0.69	25.28
50-59	0	0.9	0.10	10.49	0.40	9	0.90	0.78	26.30

Values from Tables 7 and 8 are plotted in Figures 4 and 5.

In drawing up Tables 7 and 8 and Figures 4 and 5, also the same constraints as mentioned last year have to be observed. With net spreads fairly much the same for the two gears and heavy weights at the wing end, the net efficiencies should be equal to each other at each fish length. The new doors off bottom gear should give either zero sweep efficiency or a residual one.

DISCUSSION

It may be noted how much flatter the effective spread and overall efficiency curves are for the doors OFF bottom rig. In other words, it is a less biassed sampling trawl. This suggests the use of the doors OFF bottom rig with bigger lighter pelagic otterboards, which will spread the necessarily wing end weights to a decent extent, as being worth testing. The experiment is worth while in that being able to substantially reduce sweep effect (the residual being estimated), a lot of the biassed sampling occurring with the standard survey rig can be eliminated. The bias remaining due to escapes at the groundrope was already substantially reduced by introducing rockhoppers. Another encouraging feature is that last years estimates of sweep and net efficiency have been used in this analysis together with this years new data without noticable discrepancies arising, which does not of course prove the previous estimates as being true, but is supportive.

The contention that the sweeps are more effective by day is supported. The other part of Bridger´s (1967) contention, that the net itself is more efficient by night, could not be demonstrated from this experiment, but neither could it be demonstrated as improbable.

One should use sampling gear which is unbiassed enough to give a decent sample over the size range required, but it is not necessary (not even possible) to use completely unbiassed sampling gear. It is necessary to know what the remaining biasses are.

To obtain a "true" or at least much truer estimate of the population distributions, it is necessary to divide the numbers caught at each length group by the appropriate effective swept area for that length group, and then calculate the length frequency composition. The appropriate swept area in this case is represented by the effective pathwidth YE1 and YE2, as in the Table 7 and 8 for each lengthgroup. If the estimates of YE1 and YE2 are good, then the "true" length frequency composition derived from the catches taken by each gear should coincide.

CONCLUSIONS

1. The otterboards OFF bottom rig gives a less biassed sample of the fish distribution, that is its effective spread is more nearly constant with increasing fish length. While the otterboards OFF bottom rig has at the moment an inadequate spread because of the necessary heavy weights at the wing end, this could be corrected by the use of larger and lighter pelagic otterboards.

2. Making gear which substantially reduces sweep effect and which with rockhoppers has in any case considerably less bias in efficiency at the net, has made it possible to better understand and estimate the biasses occurring with standard sampling gear. This OFF bottom otterboard gear is not recommended as a sampling gear, but has been a useful step.

3. It would appear that for both cod and haddock there is a small residual sweep effect with the doors OFF bottom.

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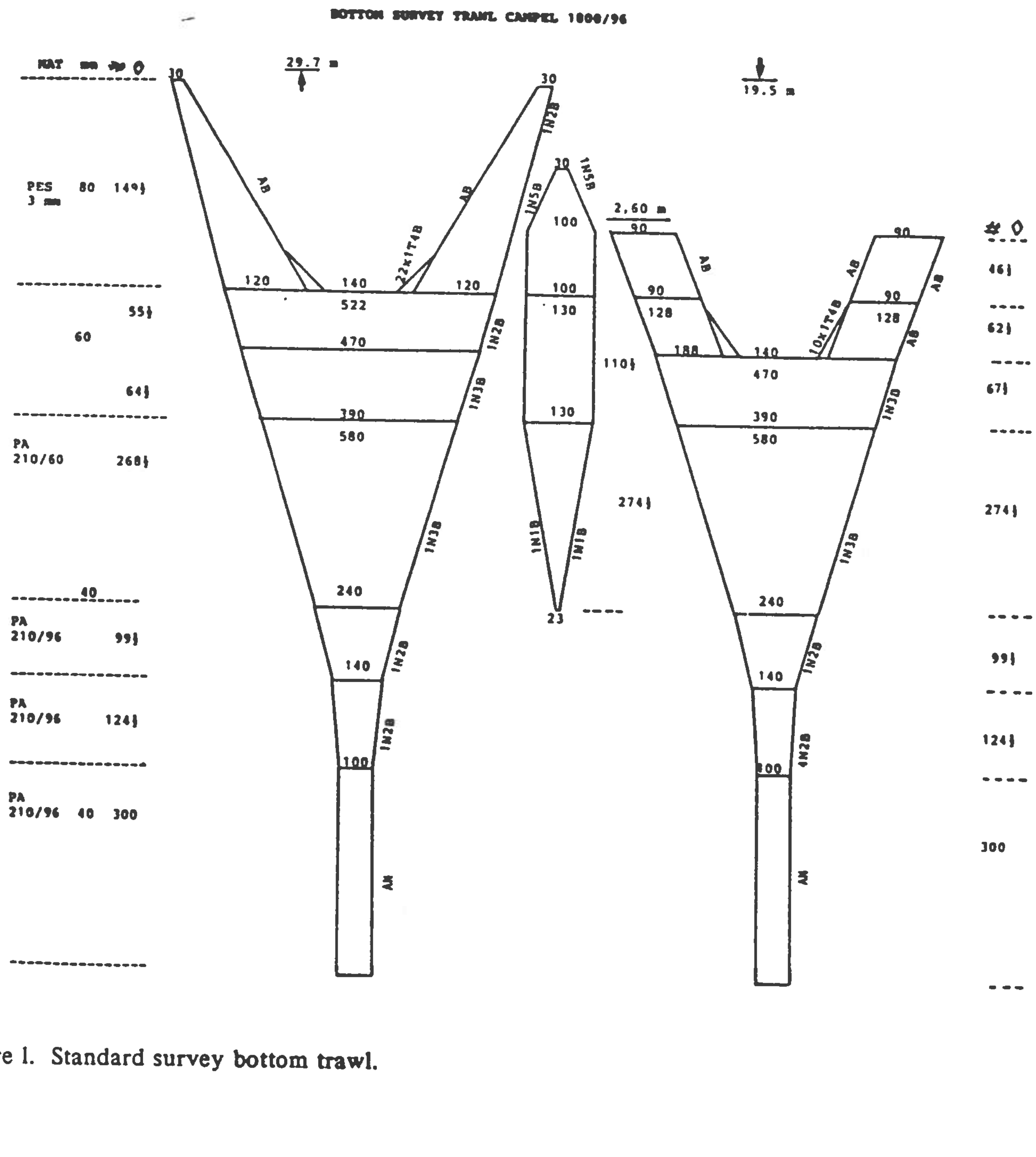

Figure 1. Standard survey bottom trawl.

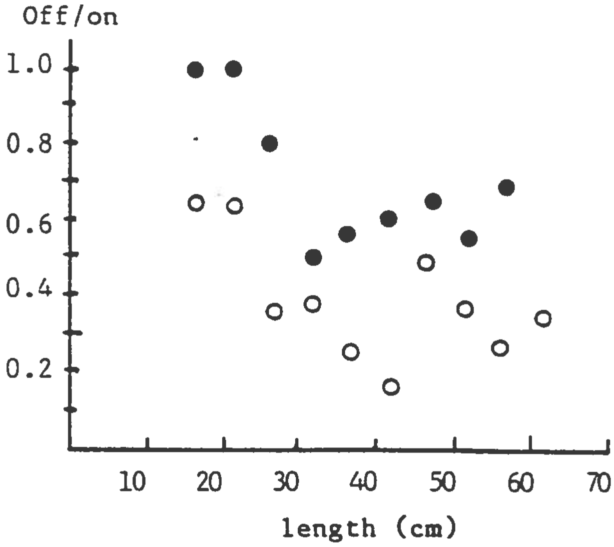

Fig. 2 COD, catch ratio by length group with otterboards OFF and ON bottom, by day (○) and by night (●).

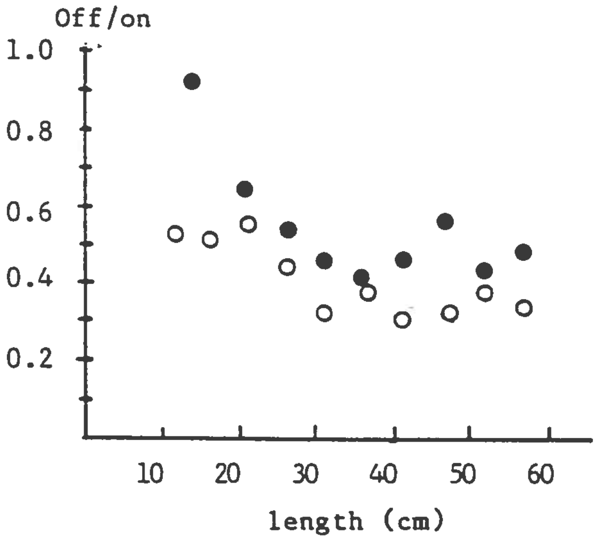

Fig. 3 HADDOCK, catch ratio by lenth with otterboards OFF and ON bottom, by day (○) and by night (●).

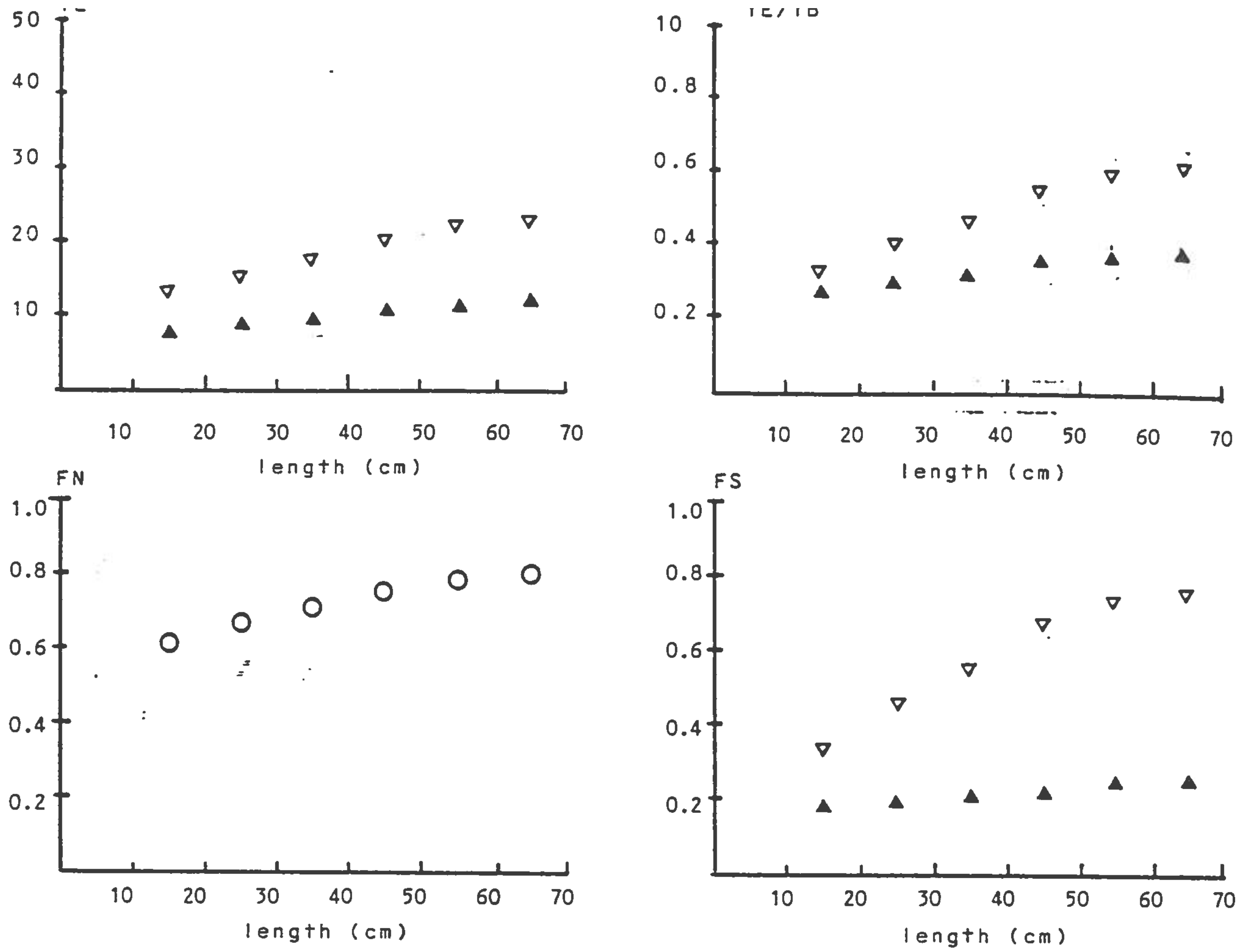

Fig. 4 COD, gear efficiencies and effective pathwidth.
(▽ on, ▲ off, O on-off)

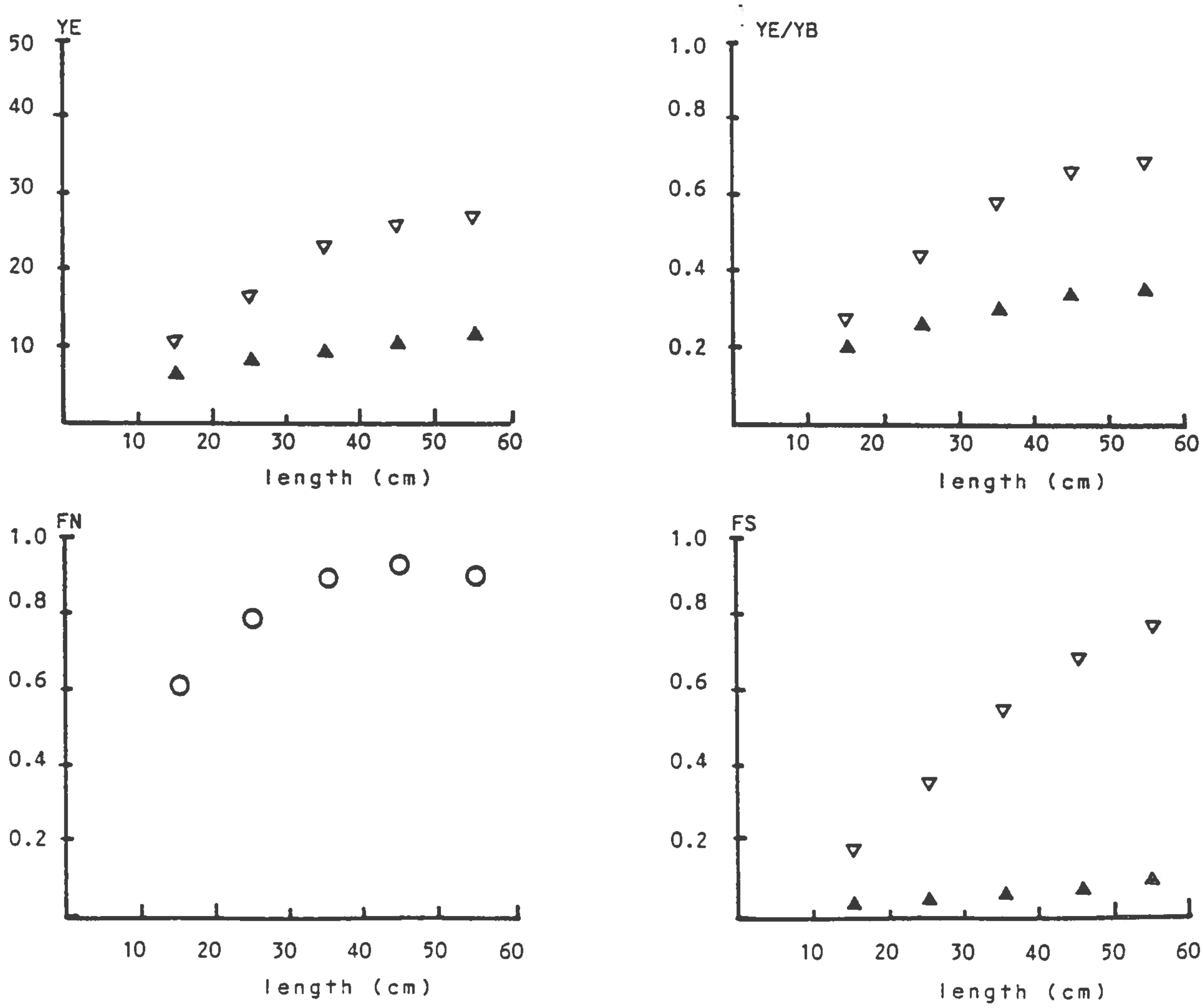

Fig. 5 HADDOCK ,gear efficiencies and effective pathwidth.
(▽ on, ▲ off, O on-off)