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THE EFFECT OF DIFFERENT SWEEP LENGTHS ON LENGTH COMPOSITION OF BOTTOM SAMPLING TRAWL CATCHES

by*

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ABSTRACT

Abundance estimates of North-east Arctic cod and haddock are given annually on the basis of combined bottom trawl and acoustic surveys. Both survey methods use data from bottom trawl catches in the calculations. The surveys are conducted in the Barents Sea and the Svalbard area with the same bottom trawl, but with different sweep wire length. The bottom trawl indices are calculated for both areas assuming an effective path width of 25 m.

In this paper results from parallel trawling experiments with the standard sampling trawl equipped with different sweep lengths are analyzed. These show that the total catch increases with increasing sweep length. Small fish are relatively underestimated by the trawl with the longer sweeps, but no species selection was observed. It is concluded that combining survey results without compensating for the effect of using different sweep length will bias the estimates. The variability in the presented results demonstrates the complexity of combining data from trawl surveys conducted with different sweep lengths on the bottom trawl.

INTRODUCTION

Bottom trawl surveys in the Barents Sea and Svalbard areas are carried out annually, and abundance indices of cod and haddock are computed. In addition species and length composition from bottom trawl catches are used in converting echo abundance to fish density in the acoustic surveys. The stock assessments of North east Arctic cod and haddock are partly based on the survey results. Hylen, Nakken and Sunnanå (1986) have shown that errors in the bottom trawl sampling cause small fish to be grossly underestimated as compared to larger fish in the bottom trawl survey. The acoustic abundance estimates are affected in the same way as the bottom trawl survey indices by the sampling errors.

Engås and Godø (1987) show that underestimation of small fish can partly be explained by escapement under the fishing line.

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Bottom trawl surveys in the Barents Sea and Svalbard areas are carried out with the same trawl, but with sweep lengths of 40 m and 80 m, respectively. The indices of abundance are computed assuming that the trawl has an effective fishing width of 25 m for the whole length range of both species for both sweep lengths. Investigations on commercial bottom trawls have shown that catch size increases with increasing sweep lengths (Strange 1984). Information on the effect of using different sweep length on size and species composition is, however, limited.

The aim of this paper is to test the validity of the assumptions used in the index calculation mentioned above. In particular, we want to focus on length and species selection.

MATERIAL AND METHODS

The trawling experiments comparing different sweep length were carried out off the coast of Finnmark, Norway, in 1982, 1985 and 1987. The standard Norwegian sampling trawl for bottom fish and shrimp (Fig. 1), and 6.4 m Vee-doors (3.65*2.02 m, 1750 kg) were used. The scope-to-depth ratio was 2.5. Table 1 gives a overview of the experiments.

The standard rigging of the survey trawl with 40 m sweep wire is shown in Figure 1. Experiments with 80 m and 120 m sweeps were run with the same rigging except from single sweep extensions of 40 m and 80 m respectively. The rigging during the experiments with 20 m sweeps are shown in Figure 1. To compensate for the effects of shorter sweeps, heavy chains were used in part of the lower sweep during these hauls.

Gear geometry (i.e., headline height, wing spread and door spread) were measured with acoustic trawl instruments (SCANMAR) in 1985 and 1987 on both vessels.

All results are from parallel fishing with the vessels approximately 2 cables apart. The duration of a tow was 1/2 hr in 1985 and 1987 and 1 hr in 1982 at a speed of 3 knots (Doppler-log). Tows were made throughout day and night.

Sampling and measurements of the trawl catches were performed as during routine surveys in the Barents Sea, i.e., the species composition and length distribution were determined by sorting/measuring either the total catch or a representative sample. The fish length was measured to the nearest centimeter below.

The statistical comparisons between long/short sweeps are done according to the method proposed by Gulland (1967) on pooled size groups: small fish ($\leq$ 29.5 cm) and large fish (> 29.5 cm).

RESULTS

Trawl dimensions

The gear measurements obtained by parallel towing vessels during one experiment were fairly similar. However, a considerable descrepancy between experiments with 40 m and 80 m sweeps in 1985

and 1987 were observed, especially on the door spread (Table 2). The door spread measurements with 120 m sweeps varied considerably during each haul, probably due to digging of the wire.

Despite the difference in sweep angle with varying sweep length, the differences in trawl height and wing-spread are small.

The door spread ratio of the different sweep comparisons are given below.

80m/40m	sweep	(1985):	1.3
120m/40m	"	:	1.6
80m/40m	"	(1987):	1.4
40m/20m	"	:	1.6

Catch comparison

In all the 5 comparisons (Table 1), the trawl with the longer sweeps gave the highest pooled catch of cod and haddock (Tables 3 - 4). Exceptions were recorded in 7 out of the 124 possible incidents (62 hauls x 2 species), distributed over both species, all years and all sweep lengths.

The catch ratios for cod and haddock on each 5 cm group (catch long sweep/catch short sweep, Table 5 - 6), generally increase with increasing length in all comparisons except those including experiments with 20 m sweeps. In contrast to the catch ratios for small fish ($\leq$ 29.5 cm), the catch ratios for large fish (> 29.5 cm) are significantly higher than 1 (Table 7 - 8). In the experiments comparing 40 m and 20 m sweeps, no specific length dependent trend is found. The catch ratios for both small and large fish are higher than 1, but for small cod these are not significantly different from 1.

No significant change in the relationship between cod and haddock in the catches is observed with changing sweep length (Tables 3-4).

The catch ratios for large fish (Table 7 - 8) were higher than the corresponding door spread ratios (text table pp 3) in 1985 while the opposite occurred in 1987.

DISCUSSION

The results from these experiments confirm the conclusions of Strange (1984): Trawl catches increase with increasing sweep length. Earlier experiments have, however, been carried out with commercial fishing trawls, which have considerable mesh selection. In contrast to the current data, the recruiting year classes were therefore sparse in formerly analyzed material. Our data show that small fish are relatively underestimated when the sweep length is increased. Catch ratios below 1 are commonly found among the lower length groups (Table 5-6), which indicates that the catches of small fish may even decrease with increasing sweep length. The tendency is most prominent for 120 m sweeps, possibly because small fish need stronger herding stimuli (door noise, sand cloud, sweep wire) and have lower swimming capacity than larger fish. We think that two effects are responsible for most of the small fish -large fish descrepancy in catch ratio:

1) Door stimulus effect will to a greater extent herd large fish directly into the trawl path than small fish.
2)An important stimulus like sand cloud intensity will decrease in front of the trawl with increasing sweep length. Direct observations have indicated that the distance between the wing tip and the sand cloud increase with increasing sweep length. If the sand cloud is a dominant herding stimulus, the possibility of small fish escaping in front of the wing tips will increase with increasing sweep length.

The 20 - 40 m sweep comparison shows that small fish have catch ratios above 1. This might be a result of herding from both door and sand cloud stimuli, which fits the above hypothesis.

The gear parameters measured in 1985 and 1987 were rather different. The variation is supposed to reflect what is occurring during a standard survey when depth and bottom stratum changes. An important question is to what extent the observed difference in gear geometry may explain the lack of correspondence between catch ratios and door spread ratios obtained in 1985 and 1987. If the above reasoning is correct, it is plausible that the catch ratios will decrease with increasing sweep angle, as was also observed.

Engås and Godø (1987) have shown that small fish, to a great extent escape under the standard bottom trawl. To avoid variability in the results caused by under-trawl escapement, the experiments should have been carried out with a rockhopper ground gear which minimizes the problem (Engås and Godø 1987). Such experiments were planned for the 1987 cruise, but for practical reasons were not possible to carry out.

The results demonstrate that the indices computed from the bottom trawl surveys in the Barent Sea and the Svalbard area are not fully comparable without compensating for the difference in employed sweep length. The following rough age-length relation for cod is used to indicate sweep length effects on recruiting age groups: length groups 9.5-19.5, length groups 24.5-29.5 and length groups 34.5-39.5 include fish of age 1, 2 and 3 respectively.

	1985			1987		
Age	80	40	80/40	80	40	80/40
1	7	17	0.41	19	42	0.45
2	111	81	1.37	196	249	0.79
3	70	52	1.35	922	753	1.22

The results show that by combining data from the two surveys, the recruiting year classes of cod in the Svalbard area will be relatively underestimated. The tendency of the data on haddock is similar. There is a considerable difference between catch ratios from 1985 and 1987 especially on age 2 cod (the 1982 material contain few young fish). As discussed above the between- year discrepancy in catch ratios might partly be a result of the observed differences in the gear geometry. However, considerable variation in gear geometry will occur during a bottom trawl survey (Engås and Godø 1986), which adds complexity to the comparison of survey data from bottom trawls with different sweep lengths.

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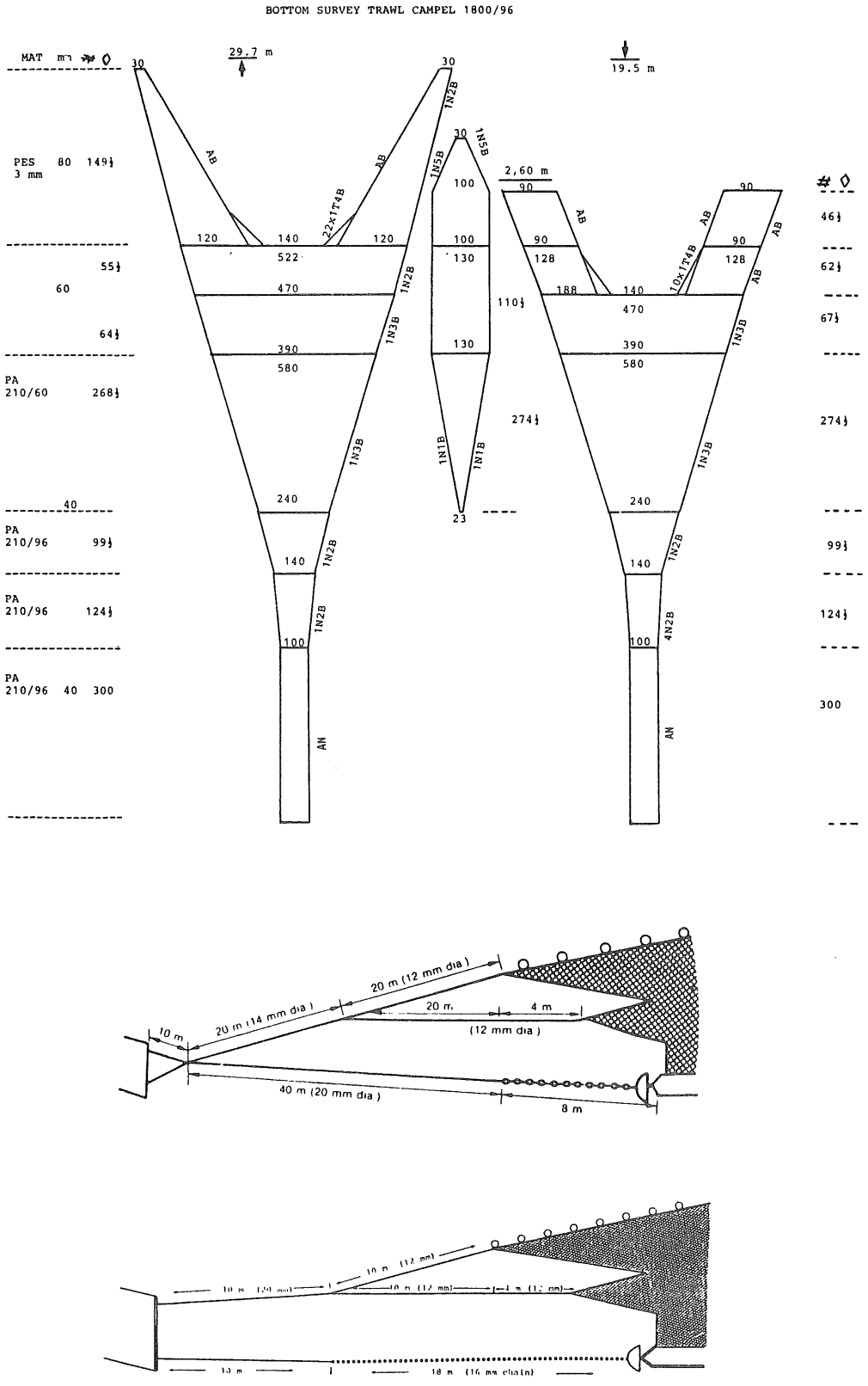

Fig. 1. Standard survey bottom trawl. Rigging with 40 m and 20 m sweeps.

Table 1. Overview of the experiments. Figures in brackets are the sweep length.

Year	Time of year	Vessels	Sweeps	Number of haul	Depth
1982	Feb.-Mars	Masi Vikheim	40m-80m	9(40)-10(80) 10(40)-9(40)	310m
1985	September	Eldjarn Raiti	40m-80m	3(40)-3(80) 3(40)-3(80)	280m
1985	September	Eldjarn Raiti	40m-120m	7(40)-3(120) 3(40)-7(120)	280m
1987	February	G.O. Sars Masi	40m-80m	8(40)-7(80) 7(40)-8(80)	340m
1987	February	G.O.Sars Masi	20m-40m	7(20)-6(40) 6(20)-7(40)	340m

Table 2. Measurements of trawl height, wing-spread and door-spread during the 1985 and 1987 experiments, with calculated mean sweep angle.

Year	Sweep m	Height m	Wing-spread m	Door-spread m	Sweep angle
1985	40	3.7-4.1	18.5-19.5	50-54	19.3
"	80	3.8-4.2	18-19	64-69	15.6
"	120	3.9-4.3	17.5-18.5	75-92	14.8
1987	40	3.3-4.3	19-21	60-67	24.8
"	80	3.2-3.8	19-20.5	78-95	22.8
"	20	3.3-3.5	20-21	37-42	28.5

Table 3. Sweep length comparison. Catch of cod in numbers by length.

	1982		1985				1987			
Sweep length(m)	80	40	120	40	80	40	80	40	40	20
Length group										
9,5			4	6	2	4		1		
14,5			6	6	2	5		1		
19,5		2	15	23	3	8	19	40	9	7
24,5			67	51	38	28	101	135	77	55
29,5	3	2	113	91	73	53	95	114	53	43
34,5	14	9	75	63	38	38	261	246	178	158
39,5	86	65	37	42	32	14	661	507	453	332
44,5	172	119	61	37	40	18	815	604	487	369
49,5	347	224	109	61	70	28	389	268	225	190
54,4	565	304	181	80	95	51	136	106	50	56
59,5	660	391	179	66	86	43	66	37	27	23
64,5	721	396	63	32	33	14	45	34	18	19
69,5	493	303	56	27	24	10	19	11	14	12
74,5	186	111	25	13	9	5	8	8	7	2
79,5	59	28	6	11	3	2	8	6	1	1
84,5	17	13	9	3	3		3	-	0	0
89,5	2	2	5	3	2		2	-	0	0
94,5	-	4	3	1	2			-	0	0
99,5		1	3	-	-			2	0	1
104,5			2	-	-				0	2
109,5									0	0
Total	3325	1974	1019	616	545	321	2628	2120	1599	1270

Table 4. Sweep length comparison. Catch of haddock in numbers by length.

	1982		1985				1987			
Sweep length(m)	80	40	120	40	80	40	80	40	40	20
Length group										
9,5		5	80	271	10	20				
14,5		-	412	1080	134	167	18	14	31	11
19,5	2	2	1579	2433	1065	1079	30	32	22	16
24,5	3	-	1631	1384	1270	832	189	221	108	71
29,5	5	3	2103	1457	1474	867	1045	810	603	369
34,5	11	10	881	536	620	368	3120	2292	1475	922
39,5	26	21	446	272	352	200	4080	2763	1653	1041
44,5	73	40	642	336	422	215	2416	1586	1015	633
49,5	181	99	312	149	176	86	1626	933	753	437
54,5	236	130	55	22	47	11	224	128	102	67
59,5	152	112	14	9	14	9	27	12	3	3
64,5	34	18	11	3	3	2				
69,5	3	1	7	1	3	2			1	
74,5	1	1	4	1	3	4				
Total	727	442	8177	7954	5593	3862	12775	8791	5766	3570

Table 5. Sweep length comparison. Catch ratios (catch with long sweep/catch with short sweep) of cod by length and experiment.

	1982	1985		1987	
Length group	80/40	120/40	80/40	80/40	40/20
14.5		0.83			
19.5		0.65	0.41	0.45	1.29
24.5		1.31	1.36	0.75	1.40
29.5		1.24	1.38	0.83	1.23
34.5	1.31	1.19	1.00	1.06	1.13
39.5	1.32	0.88	2.29	1.30	1.36
44.5	1.45	1.65	2.22	1.35	1.32
49.5	1.55	1.79	2.50	1.45	1.12
54.5	1.86	2.26	1.86	1.28	0.89
59.5	1.69	2.71	2.00	1.78	1.17
64.5	1.82	1.97	2.36	1.32	0.94
69.5	1.63	2.07	2.40	1.72	1.17
74.5	1.68	1.92	2.71(+)	1.31(+)	1.33(+)
79.5	2.11	1.56(+)			
84.5	0.95(+)				
Total catch ratio	1.68	1.65	1.70	1.24	1.26

Table 6. Sweep length comparison. Catch ratios (catch with long sweep/catch with short sweep) of haddock by length and experiment.

	1982	1985		1987	
Length group	80/40	120/40	80/40	80/40	40/20
9.5		0.29	0.50		
14.5		0.38	0.80	1.28	2.82
19.5		0.65	0.99	0.93	1.38
24.5		1.18	1.53	0.86	1.52
29.5	1.00	1.44	1.70	1.29	1.63
34.5	1.10	1.64	1.68	1.36	1.60
39.5	1.24	1.64	1.76	1.48	1.59
44.5	1.83	1.91	1.96	1.52	1.60
49.5	1.83	2.09	2.05	1.74	1.72
54.5	1.82	2.50	4.27	1.75	1.47(+)
59.5	1.36	2.57(+)	1.28(+)	2.25	
64.5	1.95(+)				
69.5					
74.5					
Total catch ratio	1.64	1.03	1.45	1.45	1.62

Table 7. Catch ratios for small (≤ 29.5cm) and large (> 29.5 cm) cod with 95% confidence limits.

		Small fish		Large fish	
Year	Sweeps	Ratio	95% conf.lim.	Ratio	95% conf.lim.
1982	80/40	-		1.68	(1.46 - 1.94)
1985	120/40	1.16	(0.86 - 1.54)	1.85	(1.49 - 2.31)
1985	80/40	1.20	(0.66 - 2.20)	1.95	(1.56 - 2.35)
1987	80/40	0.74	(0.51 - 1.09)	1.32	(1.12 - 1.85)
1987	40/20	1.32	(1.18 - 1.48)	1.25	(1.07 - 1.46)

Table 8. Catch ratios for small (≤ 29.5 cm) and large (> 29.5 cm) haddock with 95% confidence limits.

		Small fish		Large fish	
Year	Sweeps	Ratio	95% conf.lim.	Ratio	95% conf.lim.
1982	80/40	-		1.65	(1.34 - 2.04)
1985	120/40	0.88	(0.64 - 1.20)	1.79	(1.58 - 2.01)
1985	80/40	1.33	(0.97 - 1.83)	1.83	(1.61 - 2.08)
1987	80/40	1.19	(0.82 - 1.49)	1.49	(1.31 - 1.71)
1987	40/20	1.63	(1.22 - 2.17)	1.61	(1.40 - 1.85)