International Council for the
Exploration of the Sea

C.M.1980/B:8
Fish Capture Committee
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Selection of cod by bottom trawl cod-ends in the central Baltic (German experiments 1978)

by

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Abstract

In continuation of a series of German mesh selection experiments on Baltic cod, the escape of fish from single-braided polyamide bottom trawl cod-ends was once more studied by means of the covered cod-end technique in September 1978. In the course of this experiment which was carried out on board the FRV "Solea" in subdivision 25, three different cover types were used, viz. the "normal" topside cover of ICES specification, a complete cover, and a combination of upper and lower cover. The results obtained show that the selective action of the cod-end is influenced by the construction of the cover. However, the data collected do not indicate any clear relationship between the selectivity on the one hand and catch size, towing speed, and duration of tow on the other. The selection factors found in 1978 are compared with those

reported from previous experiments in the central Baltic. The technical IBSFC regulations actually in force in the Baltic cod fishery as well as those recommended for the future by the ICES Advisory Committee on Fishery Management (ACFM) are discussed with regard to their efficiency and expedience.

Introduction

The technical regulations established for the Baltic cod fishery are still a matter for discussion. This is closely connected with the fact that the selection experiments conducted in the seventies led to extremely inconsistent results. Since it is difficult or even impossible to assess which of the results is most realistic, the question remains open what minimum mesh size is needed to produce a certain biologically desirable length at first capture. In order to improve the scientific basis for an effective mesh regulation, the Institut für Fangtechnik continued its series of trawl mesh selection trials within the central Baltic during the second half of September 1978.

Material and methods

In the course of the experiment 45 hauls of 1-2 hours duration were made with a cod bottom trawl of 526 meshes of 160 mm mesh length around the net mouth. The groundrope was mounted with rubber disks. The gear which did not differ from that used in 1974 (BOHL and VALENCIA, 1976) was again towed by FRV "Solea", a diesel-mechanically driven stern trawler (without ramp) of 35.4 m length o.a. and 337 gross tons, capable of developing 879 h.p.e. at 900 r.p.m.

Three single-braided polyamide cod-ends with mean mesh openings of approximately 98 mm, 102 mm, and 108 mm were used. Detailed information about these cod-ends and their netting yarns is given at the top of Table 1. The netting yarns were identical with those used in the German experiments 1972 (BOHL and v.SEYDLITZ, 1972)

and 1974 (BOHL and VALENCIA, 1976).

The selectivity of the cod-end meshes was investigated by means of the covered cod-end technique. In contrast to the previous trials, this time not only the "normal" topside covers of ICES specification (ICES, 1964 and 1965) but also two other cover constructions were applied, viz. a) a combination of top and bottom cover, and b) a complete cover enveloping the whole cod-end.

In the case of construction a), two covers were attached to the cod-end in such a way that one of them surrounded the upper cod-end panel whilst the other wrapped the lower cod-end panel. Both top cover and bottom cover were in accordance with the ICES specification, i.e. each cover extended about 1.5 m beyond the end of the cod-end, and each cover was one and a half as wide as the cod-end when stretched crosswise. The two covers differed from each other in one respect only (comp. Table 1): To counteract wear and tear on the sea bottom, the lower cover was made of somewhat stronger netting yarn (23tex x11x3) than the upper cover (23tex x8x3).

In order to contrive the cover construction b), the construction a) had to be changed by detaching the lateral connections between cod-end and covers and by subsequent joining the free cover edges. These changes led to a complete cover which enveloped the whole cod-end, although the hindmost part of the cover still consisted of two bags with separate codlines.

Mesh measurements were made immediately after each haul by means of an ICES gauge exerting a pressure of 4 kg. The number of measurements varied in dependence on the type of cover used. When using the top cover, one marked row of consecutive meshes running the full length of the cod-end was measured in the middle of the upper panel. However, when using the complete cover or the combination of upper and lower cover, an additional row of meshes

was measured in the middle of the lower cod-end panel.

The length composition of the cod-end and cover catches was ascertained separately by measuring the total length of cod to the centimeter below. During the experiment a total of 69871 cod passed the measuring boards.

To study the girth/length relationship, the unconstricted maximum body girth of 375 cod was measured by means of a length of netting yarn to the nearest millimeter.

Results

The experiment was carried out within sub-division 25 on two neighbouring fishing grounds: Eighteen hauls were made between Bornholm and Christiansö (central position 55°15'N, 15°06'E; ICES statistical rectangle 39/G5), and further 27 hauls were conducted between Utklippan and Mittelbank (central position 55°48'N, 16°14'E; ICES statistical rectangle 40/G6).

Fig.1 shows the relative length composition of the total cod catches for each cod-end/cover combination and working area separately. It becomes obvious that the cod caught between Bornholm and Christiansö were considerably smaller than those caught between Utklippan and Mittelbank. In the former area the length frequency distributions revealed pronounced maxima at 20.5 cm and less distinct secondary maxima at 24.5 ,and 25.5 cm respectively, while in the latter the fish lengths 26.5 and 27.5 cm were clearly most abundant.

The working areas differed also with regard to the size and composition of the catches: Off Bornholm the total catches (cod-end plus cover) ranged from 1 3/4 to 7 1/2 baskets (i.e. about 105 - 450 kg) per 1-2 hours fishing. They consisted almost entirely of cod. Off Utklippan, however, the catches varied between 4 1/2 and 18 1/2 baskets (i.e. about 270-1110 kg) per 1-2 hours fishing.

They were mixed up with herring, but cod was nearly always the clearly prevailing species (Tables 4 - 8).

The selction data obtained from the grouped hauls of each cod-end/cover combination are compiled in Table 2 for Bornholm/Christiansö and in Table 3 for Utklippan/Mittelbank . The corresponding selection curves, being smoothed by using three-point moving averages and fitted by eye, are shown in Figures 2 and 3.

The use of the "normal" topside cover led to the following selection factors:

2.84, Cod-end S-5, 107.9 mm, Bornholm/Christiansö,
2.91, Cod-end S-3, 97.9 mm, Bornholm/Christiansö,
2.93, Cod-end S-3, 97.9 mm, Utklippan/Mittelbank.

The last two factors indicate that the different conditions on the fishing grounds had little or no influence on the selective action of the trawl.

It is worth mentioning that the above three selction factors tally with those found during the "Solea" experiment 1974 (BOHL and VALENCIA, 1976) and that they are rather similar to those published by STRZYZEWSKI et al. (1973), but that they are not at all in line with the selection factors reported by BAGGE (1978) as well as OLOFSSON and OTTERLIND (1978) (comp. Table 11). From the fact that the last-mentioned Scandinavian workers have used complete covers, it was concluded that the inconsistency of the results obtained in the seventies might be attributed in whole or in part to the different cover constructions applied. The following proves this assumption to be correct.

The combination of upper and lower cover rigged to cod-end S-4 (102 mm) was used on both fishing grounds, but only on one of them (Utklippan/Mittelbank) the collection of data resulted in a reliable selection factor. Off Bornholm, the cod caught were too small (see dotted line at the top of Fig.1) or the cod-end meshes used too

large, to enable the upper branch of the selection curve to be drawn with sufficient accuracy. Off Utklippan, the top/bottom cover design yielded a selection factor of 3.10. This value exceeds the factors derived from the topside cover experiments by 6-9 per cent.

On the same fishing ground and with the same cod-end, an even better selectivity could be achieved by using the complete cover. In this case the selection factor was found to be 3.23 which corresponds to a 10-14 per cent increase compared with the factors 2.84-2.93 mentioned above. Hence, there is every appearance that the small-meshed netting attached to the inner underside of the cod-ends S-3 and S-5 has impeded the selective process by reducing the available area of escape. Moreover, it is obvious that the selectivity was also hampered to some degree by the lateral junctions between the cod-end S-4 and each of the two (i.e. top and bottom) covers rigged to it.

The use of the upper/lower cover combination enabled some observations to be made on the behaviour pattern of the cod accumulated in the cod-end: As shown in Table 10, the number of cod escaping through the upper and lower panel of the cod-end S-4 was about the same. This is rather surprising, although "estimates of the proportion of all escapes that occur through the underside have been variable, e.g. TRESCHEV (unpubl.) 3 % for cod in Arctic trawls, CIEGLEWICZ and STRZYZEWSKI (1958) 17-72 (?) % for cod in Baltic trawls, GILIS (unpubl.) 33-52 % for soles and 5-13 % for whiting in Southern North Sea trawls" (cited from ICES, 1964). CLARK (1963) concluded from his trials in the Northwest Atlantic the following: "Although haddock do not appear, from indirect reasoning, to utilize the lower side of the cod-end for escapement, more direct evidence available indicates that about one-fifth of the silver hake escapement takes place there". So the behaviour patterns seem to differ considerably from species to species and from area to area.

As to the length compositions of the cover catches, Table 10 shows that on both fishing grounds the mean length of the cod in the lower cover was somewhat greater than that of the cod caught in the upper cover. These small, but statistically significant differences which are also reflected in different catch weights, cannot be attributed to diverging mesh openings in the upper and lower cod-end panel; the meshes were practically of the same size.

Fig.4 demonstrates that within the 0-100 % selection range of the cod-end S-4 the larger-sized fishes did preferably escape through the underside, whilst the smaller-sized ones did so through the topside. This phenomenon is also clearly illustrated in Fig.5, where the selection ogives calculated for each of the two covers are shown separately. It can be seen that these ogives intersect at a length of 26.5 cm; cod larger than 26.5 cm in length were caught more frequently in the lower cover, and cod smaller than 26.5 cm in length were caught more frequently in the upper cover. The selection factors derived from the curves in Fig.5 were 2.85 (top cover only) and 2.90 (bottom cover only). These factors are similar to those obtained from the experiments with topside covers and underside blinders (2.84-2.93).

To answer the question whether and to what extent the selectivity was influenced by factors other than mesh size (e.g. catch size, towing speed, duration of tow), the experimental data had to be analysed on a haul-by-haul basis. The results of this analysis are compiled in Tables 4-8. Since cod were sufficiently numerous in most of the catches, reliable selection factors could be obtained from 34 hauls. Five hauls allowed to be used for a rough estimate of the selection factors (queried in Tables 4-8), and two hauls (nos. 10 and 21) did not yield any selection data. The group of hauls (nos. 30-33) carried out with the upper/lower cover combination between Bornholm and Christiansö had to be completely omitted from the analysis due to reasons mentioned at the bottom of page 5.

Unfortunately, no new knowledge could be derived from the haul-by-

haul analysis: The individual selection factors have been plotted against many parameters which are thought to be relevant to the selective action of the cod-end, but none of these plots revealed a clear relationship. At the best, there is sporadically some vague indication that the selection factors tend to increase with increasing towing time (Table 6) and to decrease with increasing towing speed. As to the catch sizes, conflicting results were obtained. In one group of hauls (Table 8), the selectivity was found to be negatively correlated with the size of the cod-end catch, while in another group (Table 5) this correlation was found to be positive.

In Table 9, the unweighted means calculated from individual selection fectors are compared with the selection factors calculated from combined hauls. For each cod-end/cover combination and working area separately, it can be seen that the factors evaluated by employing two different methods do not vary to any appreciable extent.

The results of the girth measurements carried out on both fishing grounds are shown in Fig. 6. The relationship between average maximum body girth (G) and total length of fish (L) is described by the regression equations $G = 0{,}491\ L + 0{,}016$ cm for Bornholm/Christiansö, and $G = 0{,}514\ L - 0{,}365$ cm for Utklippan/Mittelbank. Since the measurements conducted in September 1974 within the same area, have led to a very similar equation, viz. $G = 0{,}512\ L - 0{,}766$ cm (BOHL and VALENCIA, 1976), there is every indication that the girth/length relationship was almost identical in both experiments.

Discussion

For reasons which have not to be discussed here, three years ago the Liaison Committee recommended

"to increase the average length at first capture for cod from 30 cm to 35 cm by the introduction of a minimum mesh size of 110 mm (stretched diagonally between knots) in the cod fisheries throughout the entire IBSFC Area accompanied by a minimum landing size for cod of 33 cm" (ICES, 1978).

There were no objections whatever to this recommendation, because it was in full accord with the data available by that time. - One year later when the paper by BAGGE (1978), and by OLOFSSON and OTTERLIND (1978) had been published, the relevant paragraphs of the ACFM report read as follows:

"Mesh selection experiments cited in the 1977 report showed that a 50 % retention length of 35 cm corresponded to a mesh size of 110 mm. Minimum landing and mesh sizes were recommended accordingly. - Recent Swedish and Danish data presented at the meeting were quite different. The mesh size corresponding to a l_c of 35 cm in these experiments is about 95 mm. The ACFM still feel that a minimum landing size for cod of 35 cm would be advisable but not beeing able to evaluate which of the selection experiments best represents the conditions of the commercial fishery, it is recommended that as a first step a minimum landing size for cod of 33 cm and a minimum mesh size of 100 mm should be introduced" (ICES, 1979).

Again one year later, the ACFM advocated a slightly different opinion. This is illustrated by the following quotation from the latest ACFM report:

"The results of more recent Swedish and Danish mesh selection experiments showed that the mesh opening corresponding to a 50 % retention length of 35 cm is about 95 mm .... The 50 % retention length for an 100 mm mesh size is about 38 cm;" (note the conflict between the last two sentences!), "but fixing the minimum landing size at that level would result in considerable discarding. ACFM accordingly recommends that a 100 mm mesh size and a 35 cm minimum landing size be introduced in all cod fisheries of the Baltic" (ICES, 1980).

These quotations give the impression that ACFM attaches more credit to the results of the Scandinavian experiments than to those of the Polish and German trials. This arbitrary weighting of the results could easily be attended with grave consequences to the Baltic cod fisheries: Put the case that a) the most recent ACFM proposal (viz. 100 mm mesh and 35 cm landing size) comes into force and that b) the selection factors are in practice not nearly as high as suggested by the Swedish workers, then a tidy discarding would be inevitable. To reduce this destruction of undersized fish, it would either be necessary to decrease the minimum landing size or, if this is not desirable, to increase the minimum mesh opening.

The magnitude of these changes merely depends on a profound knowledge of the trawl selectivety which does not exist.

The selection factors recently obtained within the central Baltic (including those given in this paper) cover a wide range, viz. from 2.82 to 3.84. Since the crucial question which of these factors is most realistic, cannot be answered, the only alternative is to give the same weight to each of them. - ACFM obviously considers the 35 cm minimum landing size to be prerequisite for a rational exploitation of the cod stocks. Hence, the 50 % retention length (= l_c) of the corresponding minimum mesh opening should be about 38 cm*. This requirement is met by an 135 mm mesh (when using a selection factor of 2.82) as well as by a 99 mm mesh (when using a selection factor of 3.84).

The experiments dealt with in this paper have shown that some of the difference between the Scandinavian and Polish/German results is due to the design of the covers used. The remaining difference, however, is not easily explained. Neither the catch size nor the towing speed nor the duration of tow was found to influence the cod-end selectivity to a measurable extent. - There is no point in enumerating all the factors which might have been responsible for the different results, but some of them should be mentioned:

The season: The "Solea" experiments 1974 and 1978 were carried out in September, while all the other trials compiled in Table 11 took place between January and April. So it is possible that seasonal differences in the behaviour pattern, maturity, girth/length relationship etc. have led to diverging selection results.

The presence of jelly-fish in the catch: Jelly-fish which annually occur in crowds in the Baltic from June to October, may have impeded the selectivity of the "Solea" trawl to some degree, al-

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* In order to avoid unnecessary discarding, three centimeters have been added to the minimum landing size.

though the grounds fished were not heavily infested at the time of the investigations.

The length composition of the cod catch: The cod caught during the "Solea" trials were markedly smaller than those caught during the other trials. It is possible that the relative physical weakness of young cod which is accompanied by a lack of swimming power, has reduced the escapement from the "Solea" trawl.

The vessels: Among the research vessels listed in Table 11, the "Solea" is the only stern trawler. - When hauling the net, a stern trawler is always steaming slowly ahead, in order to avoid gear damage caused by the propeller. Consequently, the trawl is permanently under tow. - A side trawler, however, is stopping at the end of hauling; in this phase the netting of the trawls slackens, and this may have a positive effect on the selectivity.

Finally, some comments on the reliability of the selection factors obtained from the experiments carried out in the seventies in the central Baltic: The results derived from trials conducted with complete covers involve the danger of overestimating the cod-end selectivity. This is so, because the fishermen are commonly using worn netting to protect the underside of the bottom trawl cod-ends against abrasion. This chafing gear which obstructs the meshes to some extent, is thought to handicap the selectivity to a similar degree as underside blinders do, when topside covers are applied.

There are still many gaps in the knowledge of trawl selectivity. These should be filled as soon as possible by further experiments in order to enable IBSFC to take exactly those regulatory measures which are essential to an optimum utilization of the Baltic cod stocks.

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Table 1: Information about cod-ends, covers, and netting yarns used

Cod-end designation	S-3, S-4, S-5
Net material and type of fibre	PA multifilament
Construction of netting yarn	Twisted
of cod-end	Single braided
Method of manufacture of cod-end	Hand-made
Treatment of netting yarn	Thermo-fixed
of netting	Untreated
Age of cod-end (fishing hours): S-3	19.5
S-4	0
S-5	44
Trade number	Nt 3/600
Rtex (g/1000 m)	4895
Runnage (m/kg)	204
Diameter (mm)	2.65
Direction of twist	S
Amount of twist in turns per meter (t/m)	88
Twist factor = α tex = t/m $\sqrt{\text{Rtex}/1000}$	196
Breaking length, dry (km)	54.1
wet (km)	49.0
Weaver's knot breaking length, wet, 1/2 (km)	21.6
Weaver's knot breaking load, wet (kp)	211
Breaking load without knot, dry (kp)	265
wet (kp)	240
Elongation, wet (%) at loads, of	
3 kp	0.9
6 kp	2.5
12 kp	5.3
30 kp	9.9
60 kp	13.8
106 kp (1/2 knot breaking load, wet)	17.3
Flexibility*, wet (g)	60
Cover material and type of fibre	PA multifilament
Construction of netting yarn	Twisted
of cover	Single braided
Method of manufacture of cover	Machine-made
Linear density of netting yarn	
of top cover and upper half of full cover	23 tex x 8 x 3
of bottom cover and lower half of full cover	23 tex x11 x 3
Nominal mesh length (mm)	40

* The flexibility (resistance against deformation) has been determined by means of the "Lötzener Methode" described by v. Brandt and Carrothers (1964).

Table 2: Cod selection data for grouped hauls from the area between Bornholm and Christiansö

Cod-end designation	S-5	S-3	S-4
Type of cover (comp. text)	Top	Top	Top & bottom
Number of hauls	5	9	4
Duration of tow			
- average (minutes)	102	117	105
- range (minutes)	60-120	90-120	90-120
Av.towing speed (knots)*	3.8	3.8	3.8
Depth range (m)	72-77	72-76	74
Av.quantity of cod/haul			
- cod-end (baskets**)	2	2	3/4
- cover (baskets**)	3	2	1 3/4
Av.quantity of by-catch***/haul			
- cod-end (baskets)	+	+	+
- cover (baskets)	1/2	1/4	+
Range of total catches/haul			
- cod-end (baskets)	1 1/2-2 1/2	1 -2 1/2	3/4-1 1/4
- cover (baskets)	2 1/2-5	3/4-3 1/4	1 1/2-2 3/4
Total number of cod caught			
- cod-end	1884	3571	892
- cover	8459	10221	4220
25-75% selection range (mm)	80	56	?
No. of cod in selection range			
- cod-end	784	1579	?
- cover	1099	2105	?
Cod-end mesh opening			
- mean ± standard error(mm)	107.9±0.16	97.9±0.16	102.3±0.15
- range (mm)	103-114	89-107	95-111
- no. of measurements	225(=5x45)	450(=9x50)	376(=4x94)
50% retention length (mm)	306	285	?
Selection factor	2.84	2.91	?

* The towing speed was derived from the distance between the Decca positions of shooting and hauling.

** The net weight of one basket filled with cod was about 60 kg.

*** Mainly herring; small quantities of whiting, plaice, flounder, and Enchelyopus (Onos) cimbrius; sparadically sprat, eel, and turbot.

Table 3: Cod selection data for grouped hauls from the area between Utklippan and Mittelbank

Cod-end designation	S-3	S-4	S-4
Type of cover (comp. text)	Top	Top & bottom	Complete
Number of hauls	14	5	8
Duration of tow			
- average (minutes)	90	60	60
- range (minutes)	60-120	-	-
Av.towing speed (knots)*	3.7	3.7	3.7
Depth range (m)	60-68	61-62	61
Av.quantity of cod/haul			
- cod-end (baskets**)	6	4 3/4	3 1/3
- cover (baskets**)	1 3/4	4 1/2	2 3/4
Av.quantity of by-catch***/haul			
- cod-end (baskets)	1/4	+	+
- cover (baskets)	2 1/4	1 1/4	1
Range of total catches/haul			
- cod-end (baskets)	3 1/2-11 1/4	2 1/2-6 1/2	2 -5 3/4
- cover (baskets)	1 - 7 1/4	3 3/4-7 1/4	2 1/4-6 1/4
Total number of cod caught			
- cod-end	11115	4051	3353
- cover	8350	7129	6626
25-75% selection range (mm)	111	73	76
No. of cod in selection range			
- cod-end	5761	2198	1648
- cover	6568	2911	2019
Cod-end mesh opening			
- mean ± standard error (mm)	97.9±0.13	101.7±0.12	101.1±0.10
- range (mm)	91-107	94-110	94-109
- no. of measurements	700(=14x50)	470(=5x94)	752(=8x94)
50% retention length (mm)	287	315	327
Selection factor	2.93	3.10	3.23

* Comp. footnote to Table 2

** Comp. footnote to Table 2

*** Almost entirely herring; very few specimens of plaice, flounder and sprat.

Table 4: Cod selection data for individual hauls; cod-end S-5 with topside cover;

Bornholm/Christiansö

Haul No.	Duration of tow (min.)	Mesh size (mm)	50%-length (mm)	Sel. factor	Sel. range (mm)	No. of cod in selection range cod-end	cover	Total no. of cod caught cod-end	cover	Quantity (baskets) of cod cod-end	cover	of by-catch cod-end	cover
2	60	107.7	300	2.79	77	132	171	267	1197	1 1/2	2 1/4	+	1/4
3	90	108.2	325	3.00	58	59	73	238	1503	1 1/2	2 3/4	+	1/4
4	120	107.8	294	2.73	75	225	334	490	1649	2 1/3	3	+	1/4
5	120	108.0	291	2.69	53	164	214	408	1832	2 1/4	3 1/4	+	1/4
6	120	107.9	336?	3.11?	?	?	?	481	2278	2 1/2	4	+	1

Table 5: Cod selection data for individual hauls; cod-end S-3 with topside cover;

Bornholm/Christiansö

Haul No.	Duration of tow (min.)	Mesh size (mm)	50%-length (mm)	Sel. factor	Sel. range (mm)	No. of cod in selection range cod-end	cover	Total no. of cod caught cod-end	cover	Quantity (baskets) of cod cod-end	cover	of by-catch cod-end	cover
7	120	97.8	288	2.94	60	201	234	497	1152	2 1/2	2	+	1/3
8	120	98.0	298	3.04	52	142	190	414	1736	2 1/2	3	+	1/4
9	120	97.8	302	3.09	37	104	135	372	1663	2 1/2	3 1/4	+	+
10	120	97.7	?	?	?	?	?	345	357	1	3/4	+	+
11	120	97.9	272	2.78	52	216	271	425	646	2 1/2	1 1/4	+	+
12	120	98.0	285	2.91	48	174	234	414	1221	1 3/4	2 1/4	+	+
13	120	97.9	266	2.72	51	208	246	389	620	1 1/4	1 1/4	+	+
28	90	97.9	286	2.92	52	107	157	239	1364	1 1/4	2 1/2	+	1/4
29	120	98.4	276	2.80	45	162	204	476	1462	1 3/4	2 1/2	+	3/4

Table 6: Cod selection data for individual hauls; cod-end S-3 with topside cover;

Utklippan/Mittelbank

Haul No.	Duration of tow (min.)	Mesh size (mm)	50%-length (mm)	Sel. factor	Sel. range (mm)	No. of cod in selection range cod-end	cover	Total no. of cod caught cod-end	cover	Quantity (baskets) of cod cod-end	cover	of by-catch cod-end	cover
14	60	97.7	265	2.71	68	121	111	352	220	3 1/2	1/2	+	2 1/4
15	60	97.6	229	2.35	83	437	315	1200	475	7 1/4	1 1/4	1	5
16	90	98.0	304	3.10	81	138	207	446	740	4	1 1/2	1/4	3
17	120	98.0	271	2.77	86	367	435	791	682	6 3/4	1 1/2	3/4	5 1/4
18	120	97.6	308	3.16	53	109	130	446	347	5	1	+	+
19	120	97.9	311	3.18	60	459	621	1378	1581	11	4 1/4	1/4	3
20	90	97.8	287?	2.93?	?	?	?	725	484	5 1/4	1 1/2	+	+
21	120	98.2	?	?	?	?	?	832	346	5 3/4	1 1/4	+	+
22	90	97.8	306	3.13	75?	223?	256?	485	421	3 3/4	1 3/4	+	+
23	60	97.8	289	2.96	89	684	763	1269	1008	7 1/2	3 1/4	+	1
24	60	98.1	287	2.93	79	214	259	589	392	5 1/4	1	1/3	2 1/4
25	90	97.8	226	2.31	?	?	?	518	220	3 3/4	1/2	1	6 1/2
26	90	98.0	304	3.10	54	125	147	597	433	6 1/2	1 1/4	1/4	3
27	90	97.8	265	2.71	140?	1016?	851?	1487	1001	9	3 1/2	+	3/4

Table 7: Cod selection data for individual hauls; cod-end S-4 with top and bottom cover;

Utklippan/Mittelbank

Haul No.	Duration of tow (min.)	Mesh size (mm)	50%-length (mm)	Sel. factor	Sel. range (mm)	No. of cod in selection range cod-end	covers	Total no. of cod caught cod-end	covers	Quantity (baskets) of cod cod-end	covers	of by-catch cod-end	covers
34	60	101.7	307	3.02	94	416	484	624	922	3 1/2	3	+	2 3/4
35	60	101.8	329	3.23	57	150	185	345	891	2 1/2	2 3/4	+	1
36	60	101.8	311	3.06	64	476	601	968	1722	6	5	+	1 1/4
37	60	101.6	311	3.06	81	730	947	1182	1851	6 1/2	6 1/4	+	1
38	60	101.6	317	3.12	58	398	508	932	1743	5 1/2	5 1/4	+	+

Table 8: Cod selection data for individual hauls; cod-end S-4 with complete cover;

Utklippan/Mittelbank

Haul No.	Duration of tow (min.)	Mesh size (mm)	50%-length (mm)	Sel. factor	Sel. range (mm)	No. of cod in selection range cod-end	cover	Total no. of cod caught cod-end	cover	Quantity (baskets) of cod cod-end	cover	of by-catch cod-end	cover
39	60	101.1	322	3.18	58	253	260	515	1146	3 1/2	3 2/3	+	1 1/2
40	60	101.2	338?	3.34?	?	?	?	230	602	2 1/4	2 1/4	+	+
41	60	101.2	331	3.27	57	214	267	495	1114	4	3 3/4	+	1/2
42	60	101.1	332	3.28	57	152	176	355	777	2 3/4	2 3/4	+	1/2
43	60	101.2	310	3.06	59	205	232	544	753	4	2 1/4	+	1 1/2
44	60	101.2	298	2.94	60	301	349	685	989	5 3/4	2 3/4	+	3 1/2
45	60	100.8	345?	3.42?	?	?	?	267	692	2	2 3/4	+	1/4
46	60	101.1	345?	3.41?	?	?	?	262	553	2 1/4	2	+	2

Table 9: Selection factors for grouped hauls compared with mean selection factors calculated from individual hauls

	Bornholm/Christiansö		Utklippan/Mittelbank		
Cod-end designation Type of cover	S-5 Top	S-3 Top	S-3 Top	S-4 Top & bottom	S-4 Complete
Selection factor based on grouped hauls Number of hauls	2.84 5	2.91 9	2.93 14	3.10 5	3.23 8
Unweighted mean selection factor ± s.e. based on single hauls Range of selction factors Number of hauls	2.86±0.08 2.69-3.11 5	2.90±0.05 2.72-3.09 8	2.87±0.08 2.31-3.18 13	3.10±0.04 3.02-3.23 5	3.24±0.06 2.94±3.42 8

Table 10: Comparison between the cod catches of the upper and lower cover

	Bornholm/ Christiansö	Utklippan/ Mittelbank
Number of hauls	4	5
Mean mesh opening of cod-end S-4		
- upper panel (mm)	102.4	101.8
- lower panel (mm)	102.3	101.7
Mean length of cod caught		
- upper cover (cm)	21.53 ± 0.07	26.90 ± 0.06
- lower cover (cm)	22.23 ± 0.08	27.52 ± 0.06
Total number of cod caught		
- upper cover	2169 = 51.4 %	3447 = 48.4 %
- lower cover	2051 = 48.6 %	3682 = 51.6 %
Total weight of cod caught		
- upper cover (kg)	199 = 47.5 %	606.5 = 46.3 %
- lower cover (kg)	220 = 52.5 %	702.5 = 53.7 %

Table 11: Synopsis of cod selection data recently collected in the central Baltic

Source	Research vessel	Time	Type of cover	Mesh opening* (mm)	Selection factor
Bohl and v. Seydlitz (1972)	"Anton Dohrn"	IV'72	Top	89.3	3.20
			Top	104.6	3.43
Strzyzewski et al. (1973)	"Dr. Lubecki"	II-IV'72	Top	102.0	3.00
			Top	116.1	3.04
		III-IV'73	Top	114.1	3.23
			Top	98.8	3.25
Bohl and Valencia (1976)	"Solea"	IX'74	Top	91.7	2.82
			Top	102.6	2.96
Bagge (1978)	"Dana"	IV'75	Complete	88	3.38
Olofsson and Otterlind (1978)	"Thetis"	I-II'78	Complete	88.5	3.69
			Complete	100.5	3.84
Bohl (this paper)	"Solea"	IX'78	Top	97.9	2.91
			Top	97.9	2.93
			Top	107.9	2.84
			Top & bottom	101.7	3.10
			Complete	101.1	3.23

* Polyamide cod-ends, single braided

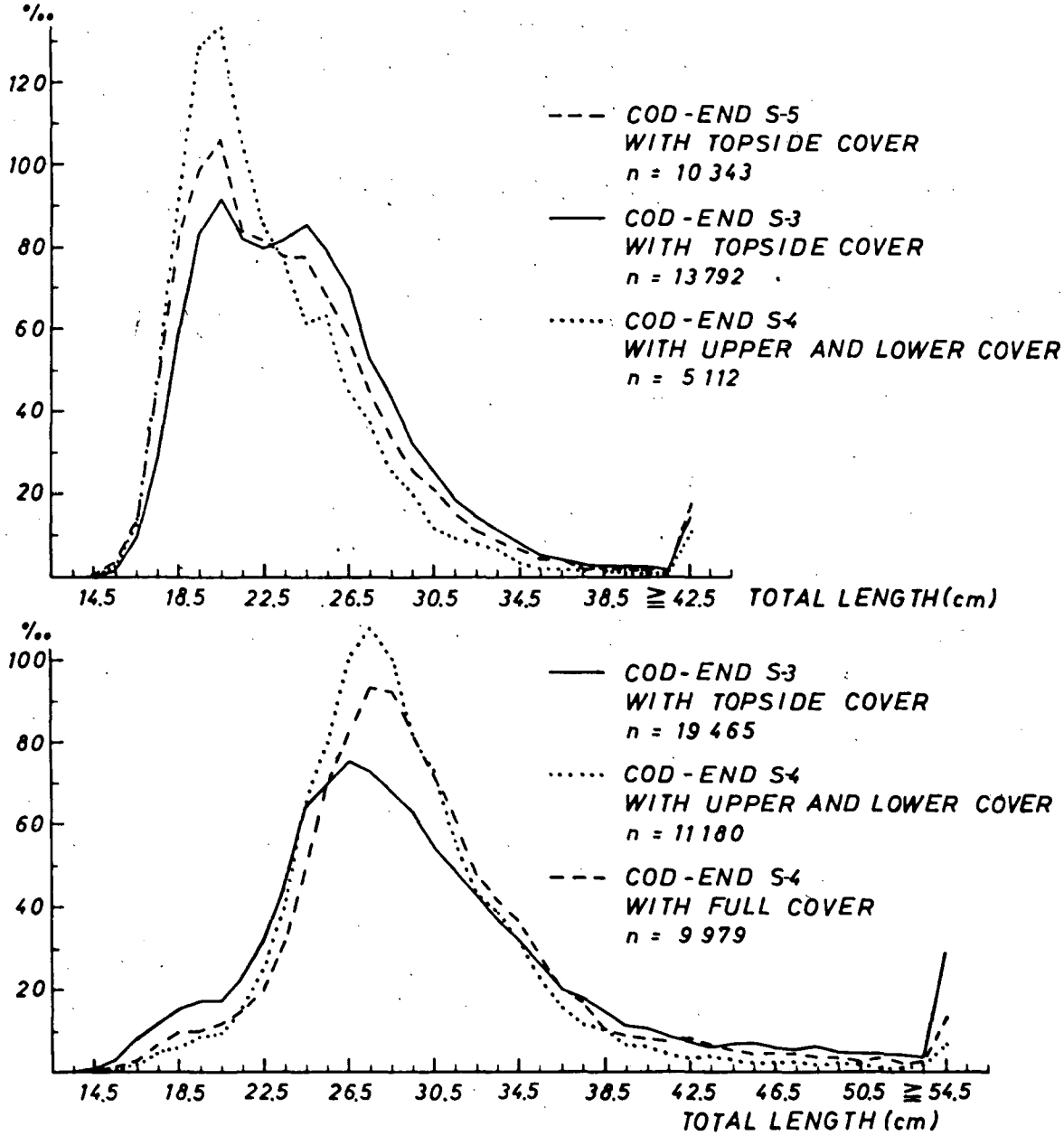

FIG.1 : RELATIVE LENGTH COMPOSITION OF TOTAL COD CATCHES (COD-END PLUS COVER).

ABOVE: BETWEEN BORNHOLM AND CHRISTIANSÖ
BELOW: BETWEEN UTKLIPPAN AND MITTELBANK

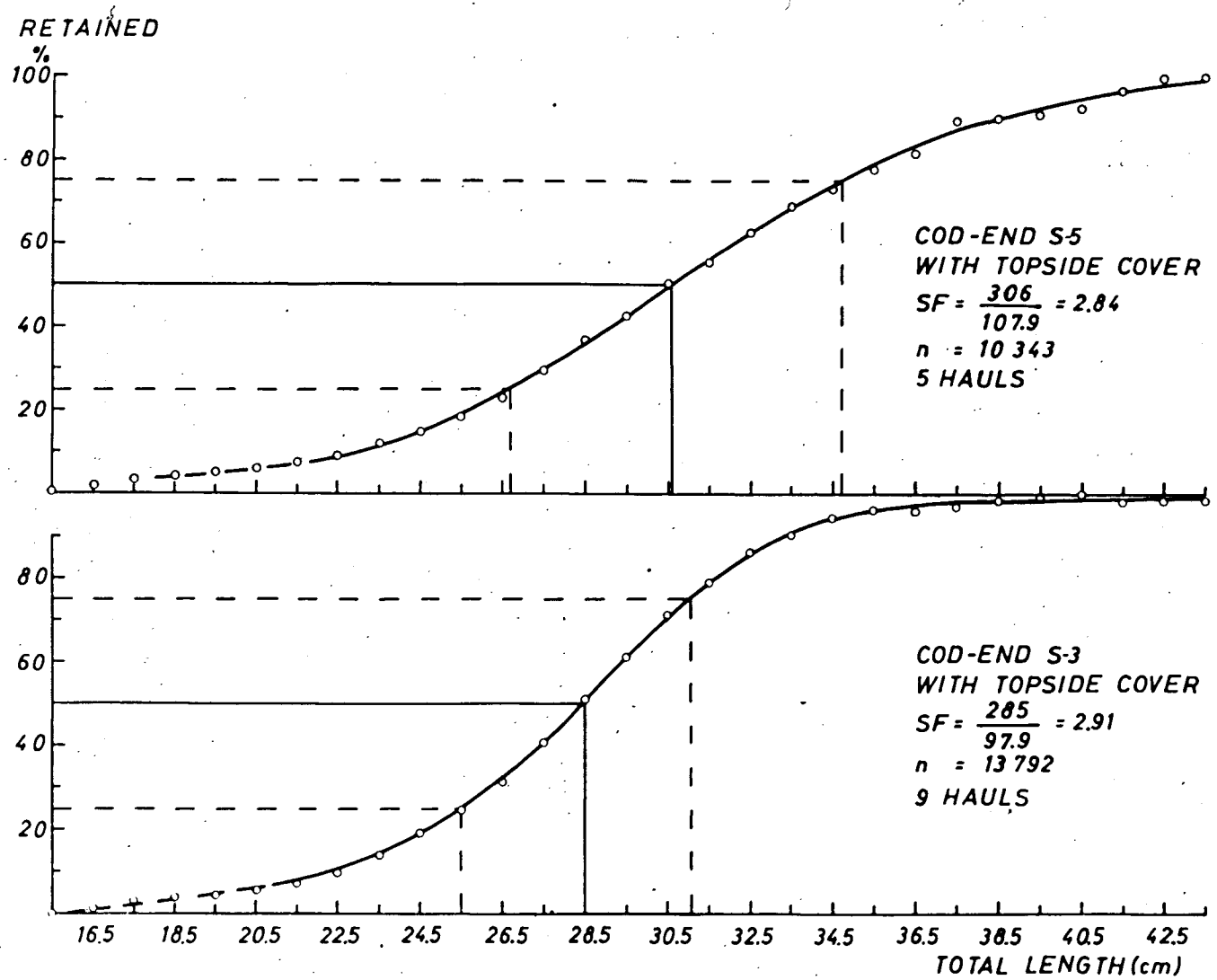

FIG.2: SELECTION CURVES FOR COD CAUGHT BETWEEN BORNHOLM AND CHRISTIANSÖ

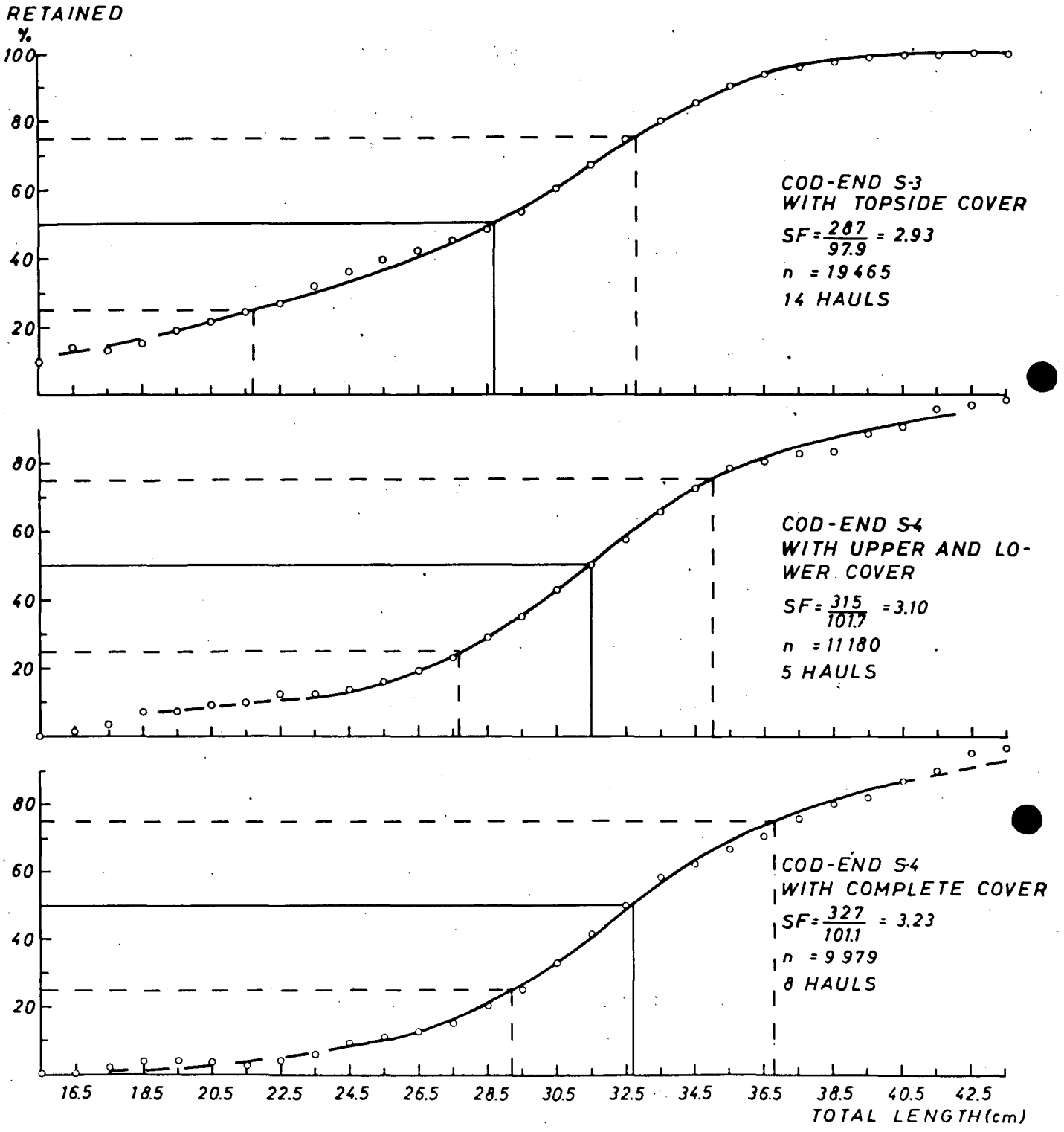

FIG. 3: SELECTION CURVES FOR COD CAUGHT BETWEEN UTKLIPPAN AND MITTELBANK

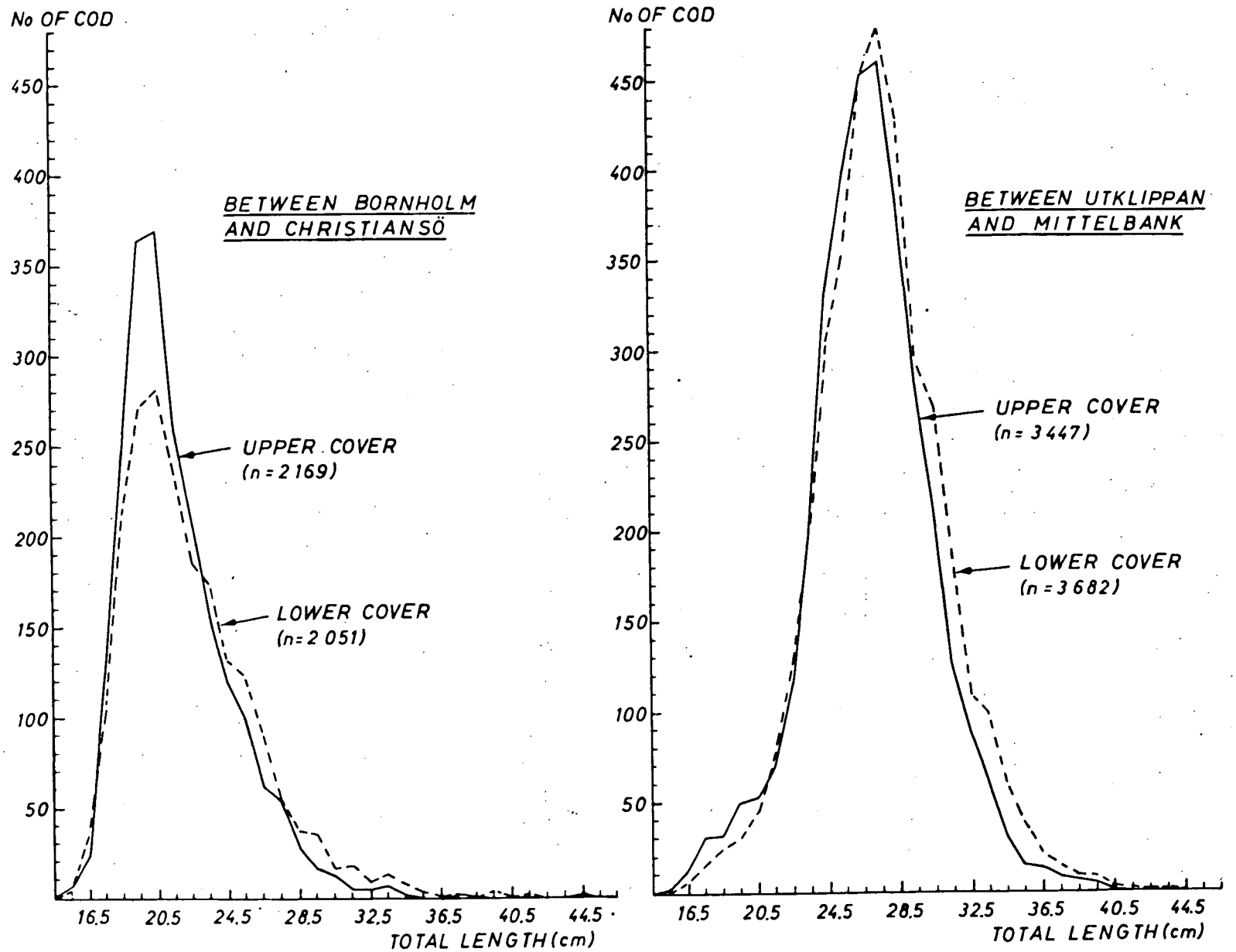

FIG. 4: LENGTH FREQUENCY OF COD CATCHES IN UPPER AND LOWER COVER RIGGED TO COD-END S4

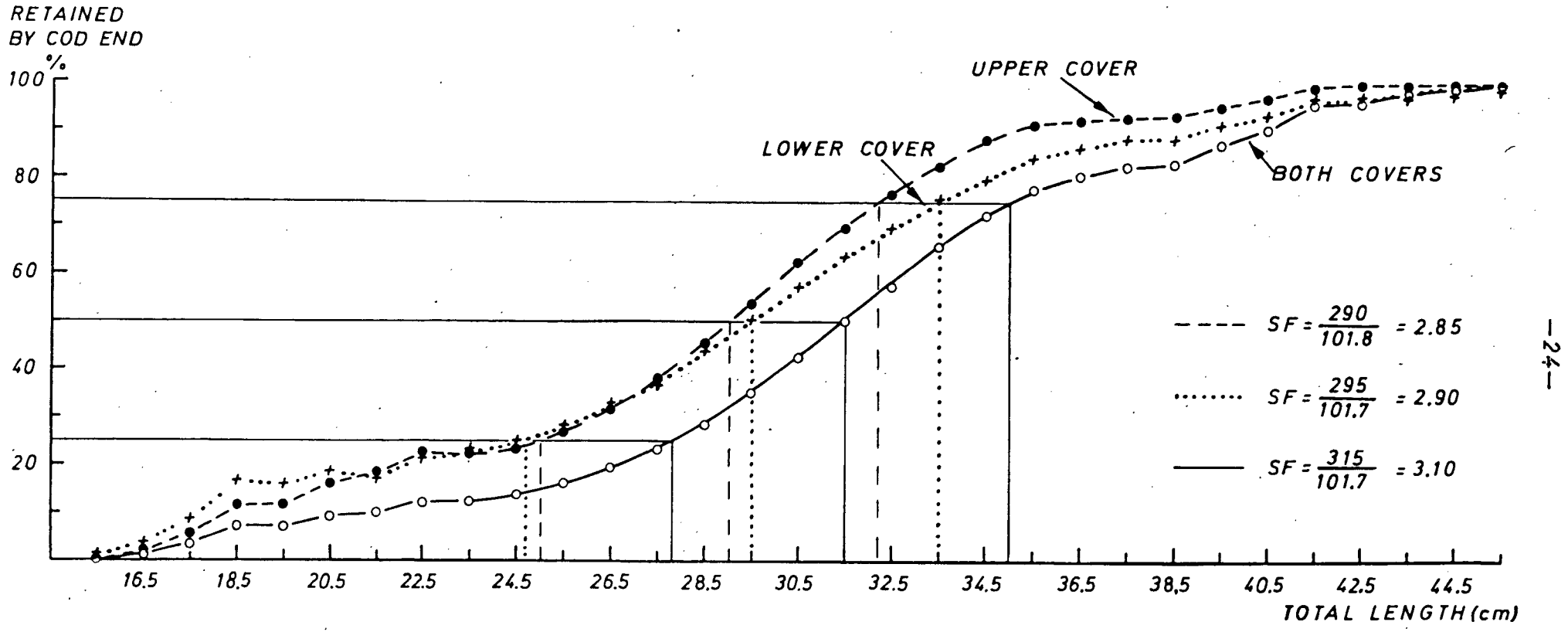

FIG.5: COD SELECTION CURVES FOR COD-END S-4 (UTKLIPPAN/MITTELBANK)

BASED ON UPPER COVER ONLY
BASED ON LOWER COVER ONLY
BASED ON BOTH COVERS COMBINED

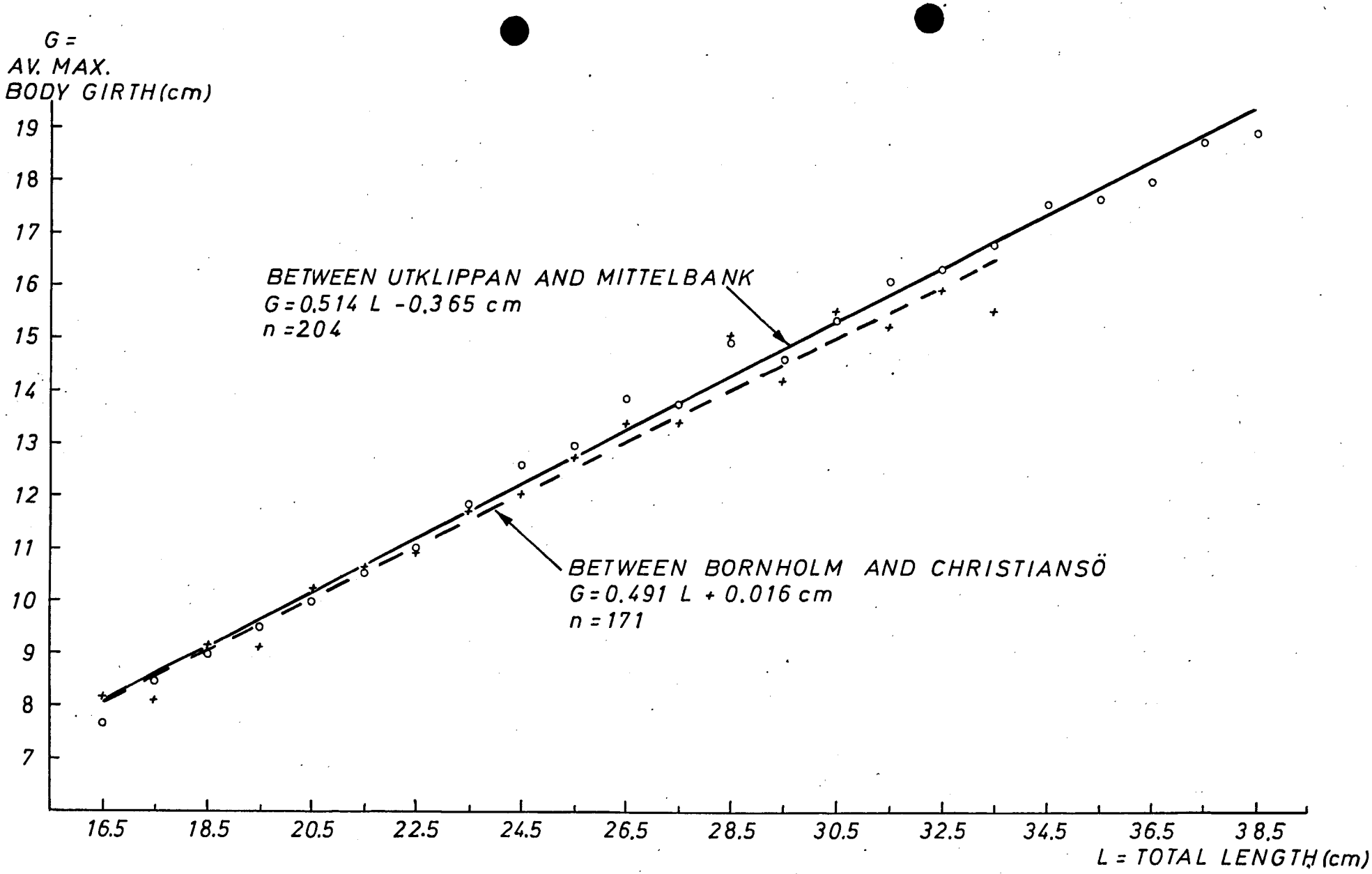

FIG. 6 : COD GIRTH/LENGTH RELATIONSHIP