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Mesh Size Assessment for Cod in Subarea 1

by

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Introduction

The present paper estimates the effect of a stepwise increase in mesh size for bottom trawl from the present minimumum of 120 mm for trawls of synthetic materials (equivalent to 130 mm manila) to 200 mm on yield of cod in NAFO Subarea 1.

Material

The mean weight by age and the length/weight curve for cod is taken from Horsted, 1980, i.e. based on samples from 1979.

The recruitment pattern is assumed to be 60% for age 3, 72% for age 4 and 90% for age 5 as previously estimated for Subarea 1 cod, but not corresponding with those used most recently (Horsted, 1980, Schumacher et al., 1980).

The selection curve used derives from H. Bohl, 1967, and the curve chosen is that for the polyethylene monofilament material, for which the calculated selection factor was 3.40.

Methods

The weight/length relation for cod in 1979 is estimated to be

$$w = 0.0126 \times \ell^{2.944}$$

as shown in Fig. 1.

The growth curve (Fig. 2) is estimated from the mean weight by age, and the Bertalanffy's parameters are found to be

$$L_\infty = 119.866 \text{ cm} \qquad W_\infty = 16.598 \text{ kg}$$

$$K = 0.152 \qquad t_o = 0.584$$

From the selection factor of 3.40 and the growth curve the 50% retention length (l_c) and the corresponding ages (t_c) are calculated for mesh sizes from 120 mm to 200 mm (Table 1).

The selection pattern for each age group and each mesh size given in Table 2 is estimated from Bohl's original curve by parallel displacement.

To estimate the maximum yield per recruit for each mesh size, when selection takes place over a range of age groups, a Y/R model is used, where the natural mortality, the emigration "mortality", the relative fishing mortality and the weight for each age group are taken into account. The emigration coefficient is treated as a natural mortality and added to this from age 6 and onwards with a value of 0.05 for Subarea 1 and 0.15 for Div. 1E and 1F. The relative F is estimated from the recruitment pattern and the mesh selection as the product of these two curves for each age group. All the input parameters for Y/R calculation are given in Table 3.

The calculation of the effect of the increase of mesh size is based on a forecast analysis. The starting stocks are taken as those achieved by a stable recruitment and with a mesh size of 120 mm, a fishing mortality of F = 0.3, emigration mortalities of 0.05 and 0.15 (see section above), and the natural mortality is M = 0.2. The forecasts for these starting stocks with a constant recruitment of 1000 are running over a period of 13 years, corresponding to the number of age groups involved in the fishery.

Results and Discussion

The results of the calculations of the yield by weight per recruit for different mesh sizes are given in Table 4A and B for Div. 1E-1F and Subarea 1, respectively. In all the yield-per-recruit assessments it is assumed that cod enter the fishery at the beginning of its fourth year (age 3). In Subarea 1 the F_{max} increases evenly with increasing mesh size, whereas in Div. 1E-1F the F_{max} increases very rapidly with the increasing mesh size due to the emigration coefficient of 0.15 from age 6 in that area.

Figure 3 shows the Y/R as a function of the values of t_c corresponding to mesh sizes 120-200 mm with constant F-values (0.2-0.5). These yield-per-recruit figures are shown for Subarea 1 and Div. 1E-1F separately. The figures show big differences between the two areas. For Div. 1E-1F the maximum yield in the range of F-values used is achieved from mesh sizes of 140-170 mm, whereas for Subarea 1 as a whole (Table 4B and Fig. 3) the yield per recruit seems to increase continuously with increasing F and mesh sizes for the range of F-values and mesh sizes considered. The difference might as mentioned be due to differences in emigration patterns.

The cod fishery at West Greenland depends both on the incoming year-classes from East Greenland-Iceland and on West Greenland year-classes. Since East and West Greenland cod have different Y/R curves it seems reasonable to assess the increase of mesh sizes over the range from 120 mm to between 140 and 180 mm.

The long-term effects of increasing mesh sizes as mentioned is shown in Table 5. The long-term effect is expressed as percentages of the yield taken with 120 mm meshes by various F-values (0.2-0.5). In Subarea 1 the long-term yeild increases with mesh sizes and with F-values inside the range analyzed, whereas in Div. 1E-1F the Y/R is at its maximum at relatively lower mesh sizes for each of the F-values considered. By F-values of 0.2-0.4 the maximum Y/R for Div. 1E-1F is achieved by mesh sizes of 140-160 mm.

The short- and long-term changes in Y/R from 120 mm mesh size to 140-180 mm meshes are estimated with a constant F = 0.3 and over a period of 13 years roughly corresponding to the number of year-classes in the fishery. The losses and gains are expressed as percentages of the yield per recruit in weight taken with 120 mm meshes. The effect of the changes is given for both areas in Fig. 4. As shown in that figure the immediate losses in Subarea 1 (Fig. 4 curve B) are from 7.5 to 32.0%, increasing with the mesh sizes, and the negative effect will phase out over 4-5 years after changing the mesh size. In Div. 1E-1F (Fig. 4 curve A) the immediate loss per recruit will be from 6 to 37%, increasing with the mesh size. The negative effect for a change to 140 mm mesh size is phased out over four years whereas for the 180 mm mesh size the yield per recruit will continue to be below that of the 120 mm meshes.

The effect on the cod spawning stock in Subarea 1 of the changes in mesh sizes is given in Table 6. These figures are derived from the Y/R model, and show an increase of the spawning stock with increasing mesh sizes with a constant F in the range of 0.2-0.5. This increase of the spawning stock could give a better recruitment, which would take place approximately 4-5 years after the introduction of a larger mesh size, if spawning biomass were the only factor to determine recruitment.

Comparison of the increase in Y/R for Subarea 1 as a whole and Div. 1E-1F separately with the corresponding increase in the spawning biomass per recruit, shows that an increase in mesh size from the present 120 mm to mesh sizes between 140 and 160 mm seems reasonable. Such mesh sizes would give a long-term gain for fishing mortalities of 0.3-0.5 of 4-12% in yield per recruit in Subarea 1 and of 2-8% in Div. 1E-1F. The gain on the spawning biomass per recruit would be between 13 and 40%. The immediate loss would amount to 7-17% (Subarea 1) and 6-20% (Div. 1E-1F).

In 1979 about 60% of the cod landed by Greenland fishermen were caught in pound nets. This is a gear nearly without mesh selection for cod. The only selection which takes place in that fishery is the fishermen's sorting to the local minimum size of 40 cm for cod landed. If the minimum size has to follow the mesh sizes in the bottom trawl, then the minimum size of cod landed has to increase to 47-50 cm (l_c for mesh sizes 140 and 160 mm) should trawls be regulated to any of these mesh sizes. Such increase in minimum size of fish would have a strong effect on the pound-net fishery, because many cod of that size would have migrated from the fiords to the banks.

The effect of the increase in mesh sizes on the redfish fishery is difficult to calculate. The size of the redfish (Sebastes marinus) caught in West Greenland waters is smaller than those caught in ICES Subareas XIV and V. Therefore a reduction in the catches of redfish by mesh sizes of 140-160 mm would likely occur compared to catches taken with the present mesh size of 120 mm. On the other hand there is a heavy meshing problem with redfish, and that could reduce the effect of an increase in mesh size.

References

Bohl, H. 1967. Selection of cod by bottom trawl codends in southwest Greenland waters. ICNAF Redbook 1967, Part III: 75-87.

Horsted, Sv. Aa. 1980. Subarea 1 cod: data for 1979 and early 1980, and estimates of stock yield 1980-82. NAFO SCR Doc. 80/VI/72, Serial No. N124.

Schumacher, A., J. Messtorff, Sv. Aa. Horsted, and P. Kanneworff. Some further analyses of Subarea 1 cod. NAFO SCR Doc. 80/VI/113, Serial No. N169.

Table 1: The retention lengh (lc) and age (tc) estimated for meshsizes from 120 to 200 mm. The selection factor is 3.40.

Meshsize mm	50% length (lc) cm	retention age (tc) year
120	40.8	3.3
130	44.2	3.6
140	47.6	3.9
150	51.0	4.2
160	54.4	4.6
170	57.8	4.9
180	61.2	5.3
190	64.6	5.7
200	68.0	6.1

Table 2: The selection for meshsizes from 120 to 200 mm for age grop.

	Meshsize in mm								
Age year	120	130	140	150	160	170	180	190	200
3	.23	.90	.01	0	0	0	0	0	0
4	.96	.84	.55	.32	.15	.04	0	0	0
5	1.0	1.0	1.0	.91	.82	.57	.26	.14	.02
6	1.0	1.0	1.0	1.0	1.0	.98	.87	.70	.36
7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.99	.88

Table 3. The input parameters for the yield per recruit for meshsizes from 120 to 200 mm

Age	Weight kilo	Natural and emigration mortality		Relative F for each meshsize									Fishing mortality
				120	130	140	150	160	170	180	190	200	F
3	.72	.20	.20	.14	.05	.01	0	0	0	0	0	0	0.05-1.0
4	1.23	.20	.20	.69	.60	.40	.23	.11	.03	0	0	0	-
5	2.02	.20	.20	.90	.90	.90	.82	.74	.51	.23	.13	.02	-
6	2.71	.25	.35	1.0	1.0	1.0	1.0	1.0	.99	.87	.70	.36	-
7	3.78	.25	.35	-	-	-	-	-	1.0	1.0	.99	.88	-
8	4.90	.25	.35	-	-	-	-	-	-	-	1.0	1.0	-
9	6.40	.25	.35	-	-	-	-	-	-	-	-	-	-
10	7.80	.25	.35	-	-	-	-	-	-	-	-	-	-
11	9.00	.25	.35	-	-	-	-	-	-	-	-	-	-
12	9.70	.25	.35	-	-	-	-	-	-	-	-	-	-
13	10.20	.25	.35	-	-	-	-	-	-	-	-	-	-
14	10.40	.25	.35	-	-	-	-	-	-	-	-	-	-
15	10.50	.25	.35	-	-	-	-	-	-	-	-	-	-

Table 4: The yield per recruit at age 3 given for meshsizes from 120 to 200 mm and for F from 0.05 to 1.00.
The emigration mortality is from age 6 0.15. (A) and 0.05 (B)
The maximum yields are underlined.

A — Y/R in gram for meshsizes from 120 to 200, Div. 1E - 1F

F	120	130	140	150	160	170	180	190	200
0.05	397	394	388	380	374	361	343	330	304
0.10	646	643	638	628	620	603	576	557	517
0.15	804	804	802	794	787	769	739	717	670
0.20	906	910	912	908	903	886	857	834	784
0.25	972	981	988	987	985	971	943	920	870
0.30	1015	1028	1040	1043	1044	1033	1008	986	937
0.35	1043	1059	1076	1084	1087	1080	1057	1037	989
0.40	1059	1080	1101	1113	1119	1115	1095	1076	1030
0.45	1069	1093	1118	1134	1143	1142	1125	1108	1064
0.50	1073	1101	1130	1149	1161	1163	1149	1133	1091
0.55	1075	1105	1138	1161	1175	1180	1169	1153	1114
0.60	1073	1107	1143	1169	1186	1193	1185	1170	1133
0.65	1070	1106	1146	1174	1194	1204	1198	1185	1149
0.70	1066	1104	1147	1178	1200	1213	1209	1197	1163
0.75	1061	1102	1147	1181	1205	1220	1218	1207	1175
0.80	1055	1098	1146	1182	1208	1225	1226	1215	1185
0.85	1050	1094	1144	1183	1211	1230	1232	1223	1194
0.90	1043	1090	1142	1183	1213	1234	1238	1230	1202
0.95	1037	1085	1139	1183	1214	1237	1243	1235	1210
1.00	1031	1081	1137	1182	1215	1240	1248	1240	1216

B — Y/R in gram for meshsizes from 120 to 200, Subarea 1

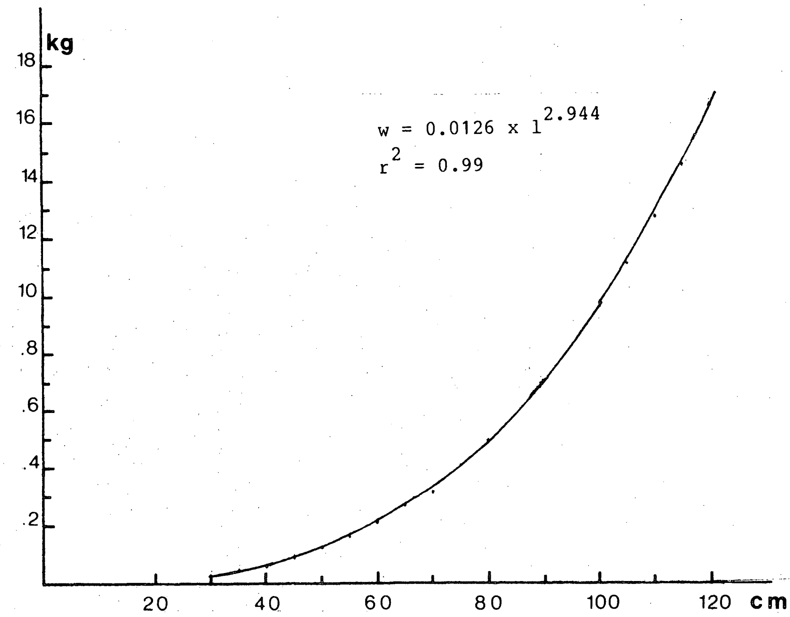
0.05	558	556	553	547	542	532	517	506	483
0.10	858	860	859	856	852	842	825	812	783
0.15	1022	1028	1034	1036	1036	1030	1016	1005	977
0.20	1110	1122	1135	1142	1146	1146	1138	1130	1107
0.25	1156	1173	1192	1205	1214	1219	1218	1212	1196
0.30	1177	1199	1224	1242	1255	1265	1270	1268	1258
0.35	1184	1210	1240	1263	1279	1295	1305	1306	1302
0.40	1182	1212	1246	1274	1293	1313	1328	1332	1333
0.45	1175	1208	1246	1278	1300	1323	1343	1349	1356
0.50	1165	1201	1243	1278	1303	1329	1352	1361	1373
0.55	1153	1192	1237	1275	1303	1332	1358	1369	1385
0.60	1141	1182	1230	1271	1301	1333	1362	1374	1394
0.65	1129	1172	1223	1266	1298	1332	1364	1377	1400
0.70	1117	1162	1215	1260	1295	1331	1364	1379	1405
0.75	1105	1152	1207	1255	1290	1328	1364	1380	1408
0.80	1094	1143	1200	1249	1286	1326	1363	1380	1410
0.85	1083	1133	1192	1243	1282	1323	1362	1379	1412
0.90	1073	1124	1185	1237	1278	1320	1361	1378	1413
0.95	1063	1116	1178	1232	1273	1317	1359	1377	1413
1.00	1053	1107	1171	1226	1269	1314	1357	1376	1414

Table 5: The long term yield with meshsizes from 140 to 180 mm expressed as percentage of the yield for 120 mm meshsizes. The figures are given for various F values for Subarea 1 and Div. 1E - 1F respectively.

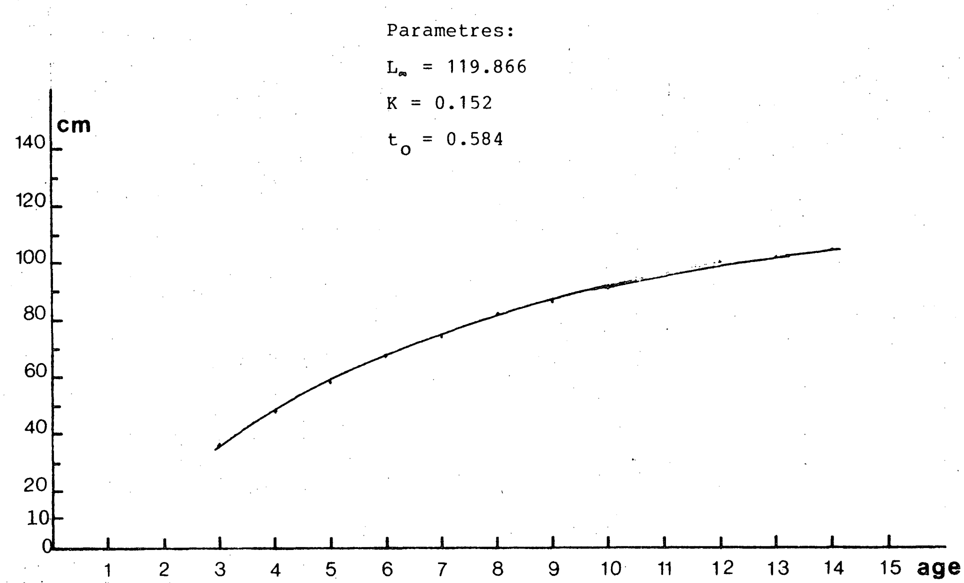
	F	Y/R gram 120 mm Meshes	Long term yield in % 140mm	150mm	160mm	170mm	180mm
	0.2	1110	102.3	102.9	103.2	103.2	102.5
	0.3	1177	104.0	105.5	106.6	107.5	107.9
Subarea 1	0.4	1182	105.4	107.8	109.4	111.0	112.4
	0.5	1165	106.7	109.7	111.8	114.1	116.1
	0.2	906	100.7	100.2	99.7	97.8	94.6
	0.3	1015	102.5	102.8	102.9	101.8	99.3
Div. 1E	0.4	1059	104.0	105.1	105.7	105.3	103.4
and 1F	0.5	1073	105.3	107.1	108.2	108.4	107.1

Table 6: The effect on the spawning stock per recruit gram subarea 1 of the increase of the meshsizes. The figures are given for various F-values, and the figures in brackets are percentages.

	Meshsizes in mm.					
F	120	140	150	160	170	180
0.2	5004 (100.0)	5443 (108.8)	5733 (114.6)	5967 (119.2)	6359 (127.1)	6895 (137.8)
0.3	3289 (100.0)	3730 (113.4)	4033 (122.6)	4282 (130.2)	4710 (143.2)	5307 (161.4)
0.4	2275 (100.0)	2692 (118.3)	2987 (131.3)	3235 (142.2)	3672 (161.4)	4295 (188.8)
0.5	1635 (100.0)	2017 (123.4)	2297 (140.5)	2538 (155.2)	2973 (181.8)	3604 (220.4)



Figur1: The weight lenght relation for cod in Subarea 1, 1979



Figur2: The growth curve for cod in Subarea 1. 1979

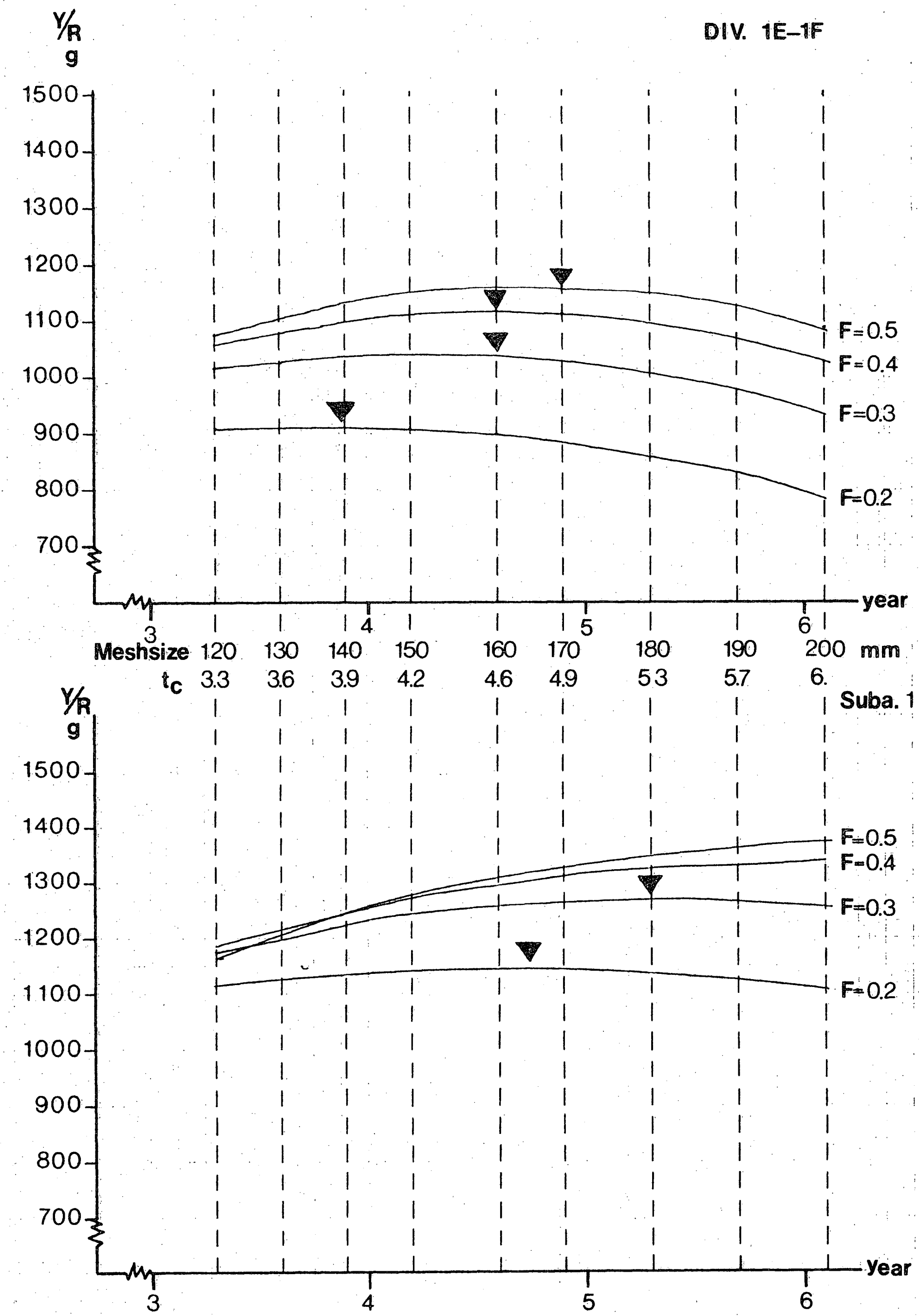
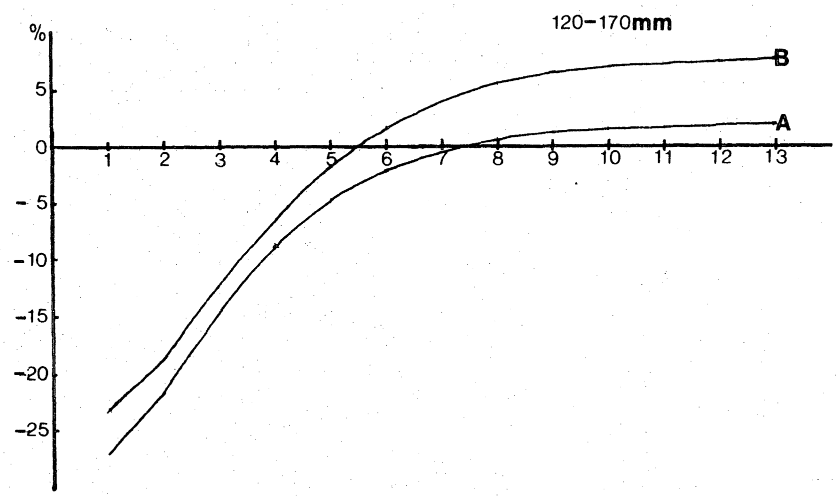


Fig. 3: The yield per recruit for various tc, which correspond to meshsizes from 120mm to 200mm, with F-values from 0.2 to 0.5. Upper figure: Div. 1E-1F, lower figure: Subarea 1.



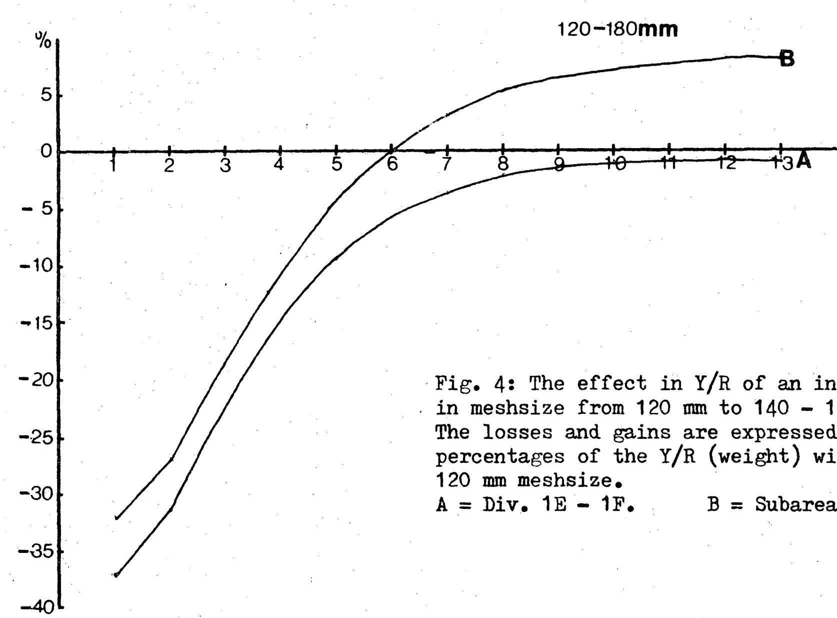


Fig. 4: The effect in Y/R of an increase in meshsize from 120 mm to 140 - 180 mm. The losses and gains are expressed as percentages of the Y/R (weight) with 120 mm meshsize.
A = Div. 1E - 1F.   B = Subarea 1.

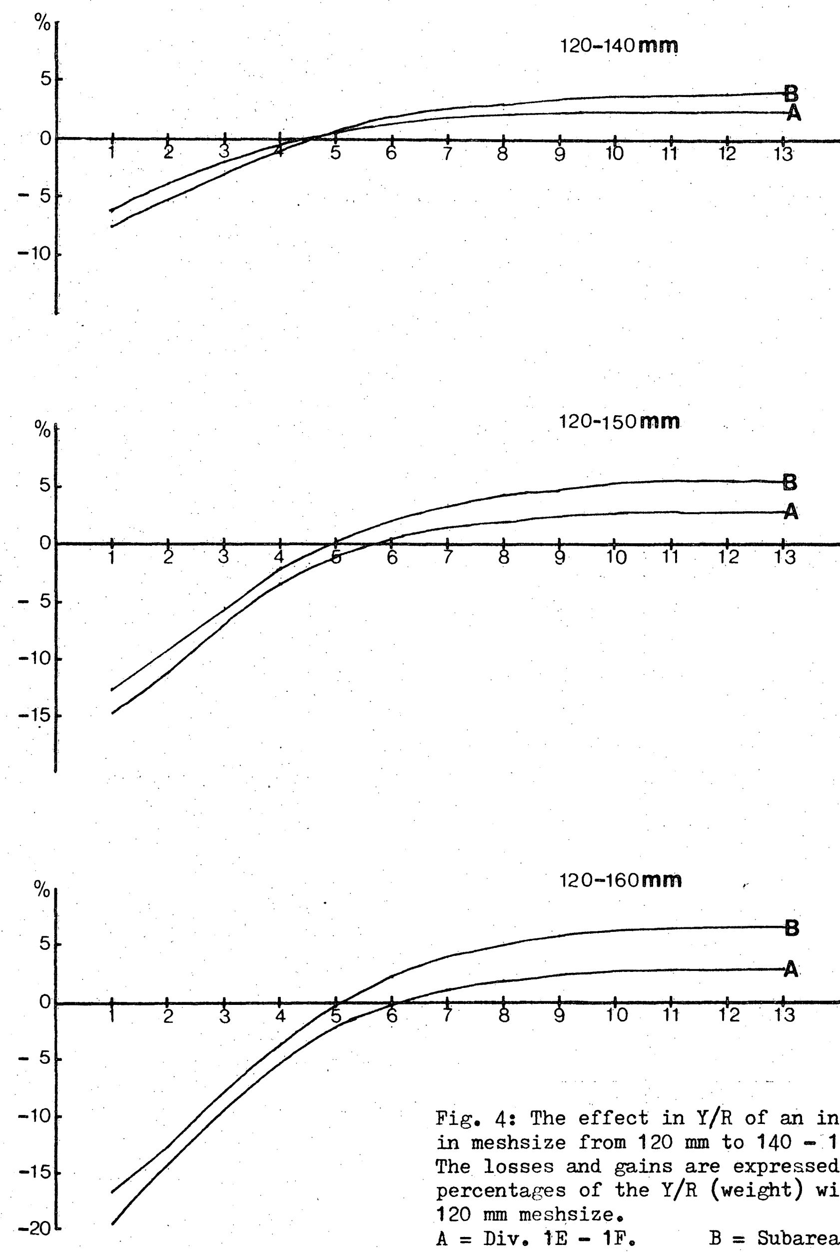


Fig. 4: The effect in Y/R of an increase in meshsize from 120 mm to 140 - 180 mm. The losses and gains are expressed as percentages of the Y/R (weight) with 120 mm meshsize.
A = Div. 1E - 1F. B = Subarea 1.

Figure 4 continued