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Effects of Mesh Size Changes in the Flemish Cap Cod Fisheries

by

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1. Introduction

Cod on Flemish Cap (NAFO Div. 3M) is fished by several fleets using trawls, gillnets and long lines. Altogether seven fleets were identified by gear (trawl/mesh size, gill net, long line) and by flag.

This paper investigates the effects from enforcing a 130 mm stretched effective mesh throughout Division 3M for all trawlers flying flags of NAFO member countries. Non NAFO member fleets are expected to continue the fishery with the same exploitation pattern as has been used hitherto. The effects are calculated by fleet category.

The relative effort exerted on Flemish Cap by different fleets varies with the stock situation and since the effort distribution effects the results of a mesh change, particularly the effort of the non-member fleets, a simulation varying the effort level for that fleet is presented.

2. Data and Material

Total Catch, catch in numbers and mean weight at age by age groups for 1991

The total catch estimate for cod on Flemish Cap for 1991 is disputed, (Anon 1992). For the purpose of this paper, we have

- 1) applied a guess of about 10,000 tons for the 1991 catch
- 2) allocated this catch to fleets as given in table 1
- 3) converted this into catch in numbers by age group based on available sampling. Further we had to make assumptions about similarities between trawler fleets where no samples were available. For long liners the age compositions is constructed from a selection pattern constructed on 1990 data (Reinert 1991) applied to the 1991 survey results.
- 4) Constructed a set of mean weights-at-age from the available sampling for 1991. The sum-of-product calculated from total catch in number by age and the mean weight-at-age is 9624 tons for 1991. This figure is below the higher scenario discussed in Anon 1992 of app. 11,000 tons. The catch in numbers by age group is given in table 2.

Catch at age for each fleet

During 1991, there were seven identifiable fleets catching cod in Division 3M. The mean weight per specimen, the percentage of the total cod catch taken in 1991 and the estimated effective mesh size are given in table 1 by fleet. Some sampling were done in 1991 and these data were used to convert in catch-at-age in numbers (Anon 1992). Fig.1 shows the length compositions by fleet. The length compositions were used to judge the effective mesh size difference between fleets.

The production done on board determine the minimum size of cod which is of interest. Freezers use cod of any size, while filleting or salting requires 35-40 cm cod as minimum.

1. The Spanish pair-trawler fleet mainly directs its effort towards cod, which is salted on board. The trawlers belong to the PTB-4 and PTB-5 categories, see NAFO Statistical Yearbook for definition of vessel categories. The effective mesh size of 100 - 110 mm is probably effected by the long hauling time (12 hours) which may reduce the selectivity of the legal 120/130 mm mesh-sizes.

2. The Spanish freezers vessels are otterboard trawlers of the OTB-4 category and this fleet mainly directs its effort to flatfish. There is a relatively large by-catch of cod in these catches. This fleet freezes the catch on board.

3. The Portuguese freezers are also otterboard trawlers, category OTB-6 vessels and this fleet is directing its effort to redfish, the cod by-catch is between 5 and 10%. These vessels freeze the catch on board.

4. The Portuguese gillnetters catch the larger fish, they are directed for cod and they process the catch by freezing or salting on board.

5. The longliners are mainly from the Faroe Islands, although one Norwegian ship also worked in this area during 1991. Their target species is cod and the catch is processed on board as salted fillets. They fish cod with a average size between that of the Spanish pair trawlers and Portuguese gillnetters. There are no length distributions for 1991 available but Reinert (1991) provides length and age distributions for this fleet in 1990. The mean weight was 2.3 Kg for that year. Applying this length distribution to the catch of 1991 however produces an age composition which suggests that long liners have deliberately avoided fish of the 1986 yearclass as opposed to all other fleets fishing Flemish Cap in 1991 and this result is not considered to reflect the actual situation in the fishery. Instead the long liner age composition for 1990 was compared with the EEC survey results for July 1990. The comparison indicate that age group 4+ is fully recruited to the long lines. The age composition for long liners applied in the subsequent calculations is constructed from the selection pattern derived for 1990 and the survey results for 1991. This selection is multiplied with the survey stock composition and adjusted so that the sum over all age-groups of the product between catch in numbers by age and the mean weight at age match the reported 1991 catch for these two fleets. The selection pattern for long liners were set to 0 for age groups 11+. This procedure, at least accounts for the 1986 yearclass which is considered to be the most important age group in the fishery in 1991.

6. Other NAFO member countries freezers are otterboard trawlers from Germany, Russia and Japan. They fish for redfish and take a small by-catch of cod. No data on length or age were available. It is assumed that their length distribution is similar to that of Portuguese freezers.

7. Non-NAFO members trawlers flying the flag of Panama or South Korea. The Panama fleet consists of pair trawlers with characteristics similar to Spanish pair trawlers. The South Korean fleet is otterboard trawlers (freezers) comparable to Spanish freezers fishing with a app. 60 mm effective mesh size.

The fleets are grouped into 6 categories

- Spanish Freezers, fishing with an effective mesh size of 60 mm stretched and affected by an introduction of an enforced legal 130 mm mesh
- Non NAFO member trawlers from South Korea fishing with an effective mesh size of 60 mm stretched. These vessels are not supposed to alter their fishing pattern due to a change in the enforcement scheme
- Non NAFO member trawlers from Panama fishing with an effective mesh size of 100 mm stretched. These vessels are not supposed to alter their fishing pattern due to a change in the enforcement scheme
- NAFO member trawlers fishing with an effective mesh size of 100 mm stretched. These vessels will be affected by a mesh size regulation
- Portuguese Gillnetters
- Faroese and Norwegian long liners

The total catch in numbers by age and fleet category is presented in table 2.

Mortalities by age and Exploitation pattern

The most recent analytical assessment for this stock is from 1984 (Wells et al. 1984). The overall Partial Recruitment (PR) estimated in 1984 includes age groups 3 to 12 and is given below as 1983 Partial Recruitment. The ratio between the catches in July 1991 and the EEC survey also conducted in July provides an estimate of 1991 PR, which can be compared with the 1983 estimate. The 1983 PR was derived using a similar method. The PR for age group 6 has for both series been adjusted to 1.

Age	3	4	5	6	7	8	9	10+
1983 Partial Recruitment	0.55	0.75	0.90	1.00	0.95	0.75	0.55	0.40
1991 Partial Recruitment	0.58	1.00	0.56	1.00	1.24	---	---	---
Actual Partial Recruitment	0.57	0.80	1.00	1.00	1.00	0.56	0.37	0.37

The estimate for 1991 PR for 7+ cod are based on very few fish and was discarded. The two estimates available, the 1983 PR and the 1991 PR show some similarity but the value obtained for the 1991 PR for age group 5 appears out of line. This value is probably not reflecting the fishery and instead the PR for these age groups 4 to 7 were all set to 1.00.

Fishing mortality of an age group is equal to the ratio between the total catch in numbers by age and the annual average stock size and this estimate was used by Wells et al (1984). Assuming that the EEC survey in July 1991 (Vazquez, 1992) represents the annual average stock composition, fishing mortalities can be obtained for age groups 1 - 7. Older age groups are too scarce in the data material to provide even estimates within order of magnitude. However the catchability of the survey gear is not known and the estimates could well be off by a factor of 2 or more. It is assumed that the catchability is independent of size to provide a partial recruitment pattern, also this assumption is often found not to be fulfilled in trawl surveys.

For the study of the effects of a mesh change a $F(5-7) = 0.5$ was applied. Values of $F = 0.3$ for age group 8 and $F = 0.2$ for age groups 9+ were applied. This together with the value for $F = 0.313$ applied for age group 3 generate the Actual Partial Recruitment presented in the text table above. The 1991 Partial recruitment can be extended to include age group 1 and 2 and the estimates are for age group 1 $PR = 0.0003$ and $PR = 0.04$ for age group 2. This indicates that in spite of the rather small

effective mesh (60 - 70 mm stretched) used by some fleets on Flemish Cap these two age group are almost not recruited to the fisheries.

Since the actual level of fishing mortality is not known the values were halved and multiplied by 1.5 and the simulations were repeated.

This fishing pattern raised to fishing mortalities for 1991 were broken down into fleet contributions by age group using the catch at age for 1991.

The 1983 assessment (Wells et a. 1984) applied $M = 0.2$ per year throughout the calculations and this value was taken over to this work. The age compositions from the sampled catches span between age 1 and age 17. This range was truncated to the age groups 1 to age 11+ in the calculations.

The effects of introducing a 130 mm effective mesh size are investigated using selectivity data from Halliday and White (1989). The proportions retained for a 60 mm, 100 mm and a 130 mm mesh size are given by age group in table 4 and by length in fig. 2.

3. Scenarios investigated

Two stock scenarios were investigated

- The 1991 average age composition as derived from the EEC survey 1991 (Vazquez 1992)
- The equilibrium age composition derived from the fishing pattern by fleet category for 1991. When effects of an effort change is studied, simple proportionality between fishing mortality and effort is assumed.

The cod fishery on Flemish Cap is opportunistic and effort levels vary with the stock situation. This opportunistic behaviour cannot be regulated for the Non NAFO member fleets and therefore the assumption that the Non NAFO member fleets double their effort while the others fleets remain at the 1991 level were investigated.

There are thus three scenarios presented in the result section

- The NAFO member trawler fleets increase their mesh size to 130 mm stretched and the non NAFO member fleets maintain their mesh sizes and effort level.
- The NAFO member trawler fleets maintain their current mesh sizes and effort levels while the non NAFO member fleets double their effort.
- The NAFO member trawler fleets increase their mesh size to 130 mm stretched and the non NAFO member fleets maintain their mesh size and double their effort.

The gillnet and long line fisheries are in are three scenarios kept at the 1991 level both with respect to selective properties and effort level.

4. Results

The results for all three scenarios are given in table 5. The calculations presented are based on the input data given in table 3. Simulations using a catchability in the EEC survey gear of 0.5 ($F(4-7) = 0.25$) and 1.5 ($F(4-7) = 0.75$) gives slightly different results but do not change any of the general conclusions.

Introducing a 130 mm mesh with no effort change will in the short run, the 1991 situation, have little effect on fleets not directly affected by the mesh size i.e. Non NAFO member trawler fleets, gillnetters and longliners. The NAFO member trawl fleets fishing with 100 mm effective stretched mesh size loose app. 30 % of their catches while the trawler fleet fishing with 60 mm stretched loses virtually all cod catches. The long term

(equilibrium) situation is characterized by older fish in the population and the longliners and gillnetters will gain app. 30 % with an overall increase in total landings of 14 %. The average size of the fish caught will increase. Also the spawning stock biomass would benefit from the introduction and enforcing a 130 mm legal mesh regulation.

An increase in effort by Non - NAFO member Trawler Fleets will generate a short term gain to these two fleets and minor loses to the other fleets in the short term. However in the long term perspective overall a decrease is expected. Combining the mesh increase with an effort increase indicate that the potential gain from an increase in mesh size by the NAFO member trawler fleet can totally disappear, if the non NAFO member fleets increase their effort. Since these Non NAFO member fleets are opportunistic in behaviour and since the increase of the effective mesh size should improve the stock situation on Flemish Cap, an effort increase is not unlikely.

5. References

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6. Tables and Figures

Table 1 Mean weight of a cod specimen (kg) by fleet and the relative catch of cod by fleet in 1991 for Division 3M, together with the assumed effective mesh size used.

<u>Fleet</u>	<u>Mean weight of cod</u> kg	<u>% of cod catch</u> 1991	<u>Effective Mesh size</u> mm
Spanish Pair Trawlers	1.3	23	100
Spanish Freezers	0.4	1	60
Portuguese Freezers	0.9	4	100
Portuguese gillnetters	2.5	23	-
Longliners	2.3	27	-
Other Freezers	-	1	100
Non-NAFO member trawlers			
Panama	-	12	100
South Korea	-	9	60
Total		100	

Table 2 Catch in number by fleet category (Tr: Trawlers)

Age	60 mm Tr	100 mm Tr	60 mm Tr	100 mm Tr	Gillnet	Long Line	Total
	Non NAFO Members		NAFO Members				
1	26754	13	3864	996			31627
2	600605	25365	86754	95056	189	11126	819095
3	1501707	407466	216913	1000455	2174	1718835	4847550
4	18611	167130	2688	356699	6804	213189	765121
5	388	256904	56	597450	323401	690643	1868842
6		85458		195256	437281	192092	910087
7		10903		21842	138641	27759	199145
8		252		958	20130	1110	22450
9		126		236	6521	4441	11324
10		50		1066	6615	1110	8841
11+					3310		3310
Total	2148065	953667	310276	2270014	945066	2860305	9487393

Table 3 Stock estimates by age group for Cod in Division 3M from EEC July 1991 survey, total catch in numbers and F-at-age used in the calculations. Mean weight-at-age (kg) used in the calculations

Age	Stock '000000	Total Catch '000000	Total catch/ Survey F-at-age	Mean weight kg
1	137.8	0.032	0.00023	0.1
2	25.6	0.819	0.032	0.23
3	15.5	4.848	0.313	0.50
4	1.9	1.031	0.537	0.72
5	6.2	1.869	0.300	1.70
6	1.7	0.910	0.535	2.35
7	0.3	0.199	0.664	3.20
8				4.5
9				7.7
10				9.0
11+				13.7
		Mean F (4-7)	0.509	

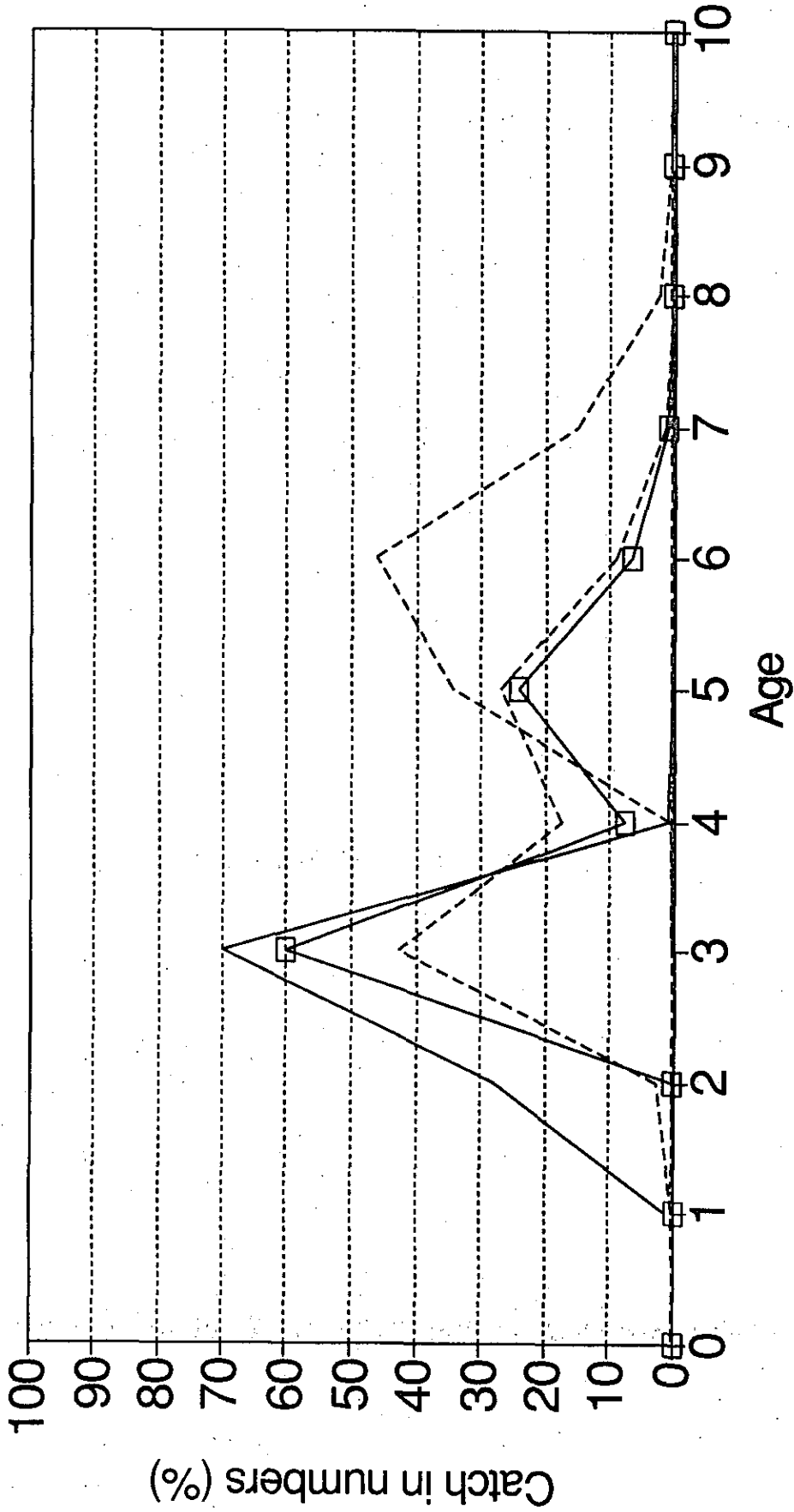
Table 4 Selection pattern by age group applied in the calculations, based on selection factor SF = 3.7 and selection range L75 - L50 = 4 cm, from Halliday and White (1989).

Age(years)	Length(cm)	Mesh Size (mm stretched)		
		60	100	130
1	21.5	0.455	0.014	0.0007
2	28.4	0.847	0.087	0.0045
3	36.8	0.982	0.489	0.043
4	41.6	0.995	0.780	0.144
5	55.4	1	0.994	0.881
6	61.7	1	0.999	0.977
7	68.4	1	1	0.996
8	76.6	1	1	0.999
9	91.7	1	1	1
10	96.5	1	1	1
11+	111.1	1	1	1

Table 5. Effect of mesh and effort changes in per cent of yield of a fishery conducted with a fishing pattern as in 1991. The 1991 column is based on the 1991 stock situation as estimated by the EEC survey (Vazquez 1992) while Equilibrium is the stable (long term) effect.

	130 mm		No effort change		Effort change		No mesh change		Effort + mesh change	
	1991	Equilibrium	1991	Equilibrium	1991	Equilibrium	1991	Equilibrium	1991	Equilibrium
Total fishery	- 8	+ 10	+ 16	- 16	+ 9	- 3	+ 9	- 3	+ 9	- 3
NAFO member Trawlers 60 mm	- 96	- 94	- 4	- 13	- 96	- 95	- 96	- 95	- 96	- 95
- Spanish Freezers										
Non NAFO member Trawlers	+ 3	+ 4	+ 91	+ 74	+ 96	+ 92	+ 96	+ 92	+ 96	+ 92
- Korea	+ 2	+ 19	+ 94	+ 41	+ 96	+ 86	+ 96	+ 86	+ 96	+ 86
- Panama										
NAFO member Trawlers 100 mm	- 29	- 23	- 3	- 11	- 31	- 42	- 31	- 42	- 31	- 42
- Spanish Pair Trawlers										
- Portuguese Freezers										
- Other Trawlers										
Gillnetters	0	+ 26	- 2	- 39	- 2	- 14	- 2	- 14	- 2	- 14
- Portuguese gillnetters										
Longliners	+ 1	+ 19	- 3	- 30	- 2	- 7	- 2	- 7	- 2	- 7
- Faroese Longliners										
- Norway Longliners										

Rel. age distribution of catch by fleet category



— 60 mm Trawl - - - - 100 mm Trawl - - - - Gill netters - □ - Long Liners

Fig.1 Length compositions by fleets for 1991 for cod in Div 3M. Data presented to NAFO Scientific Council June 1992. The legends: Sp. Fr. is Spanish Freezers, PTr is Pair Trawlers, P.Fr. is Portuguese Freezers.

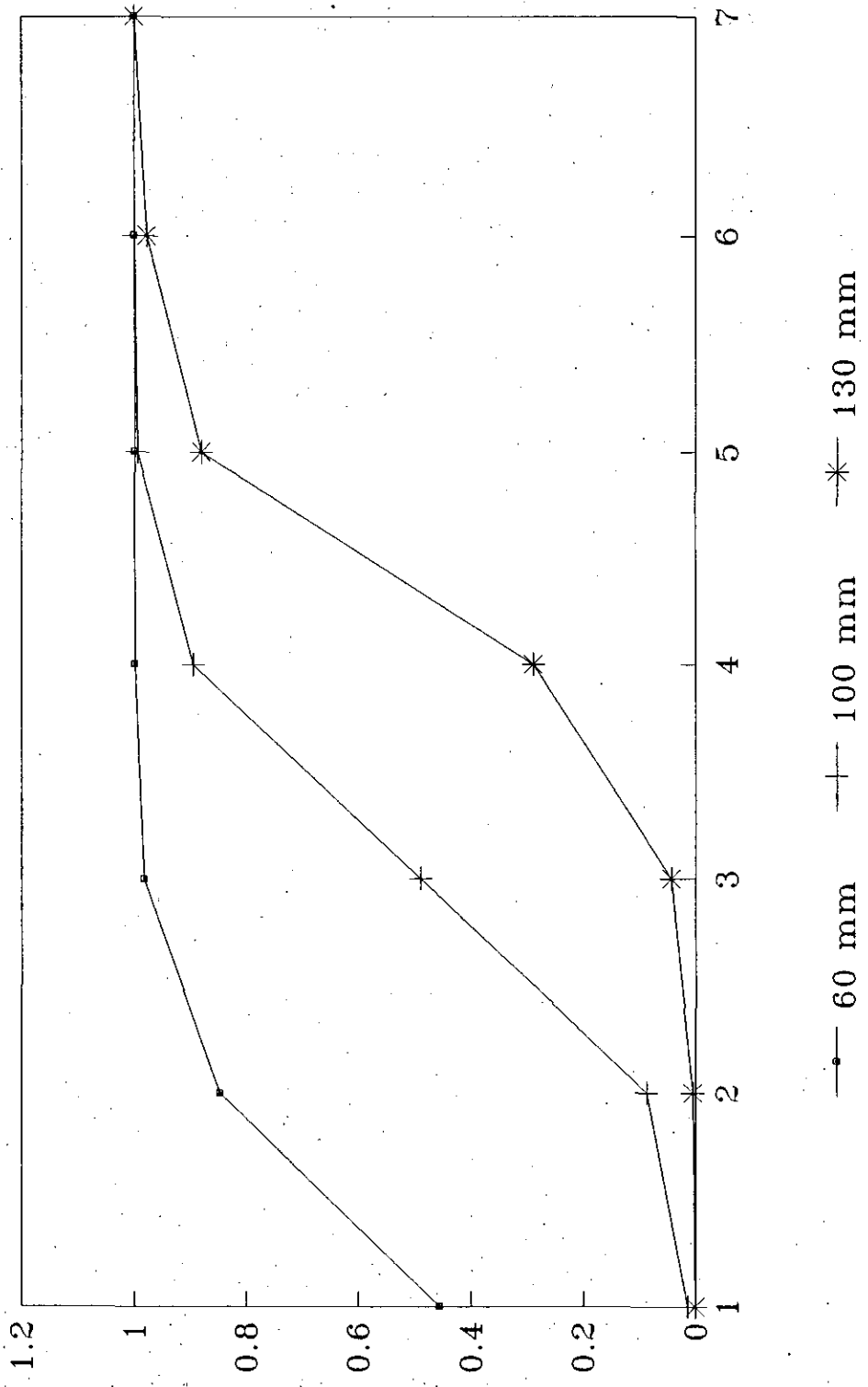


Fig. 2 Selection curves for 60 mm, 100 and 130 mm effective stretched mesh size based on data from Halliday and White (1989).