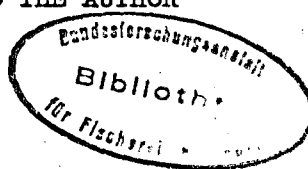


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CM 1975/K:30
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A YIELD ASSESSMENT OF IRISH SEA NEPHROPS AND THE EFFECT OF A MESH CHANGE

by

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INTRODUCTION

A number of recent studies have examined the problem of by-catches, particularly of whiting, in the small mesh fisheries of the Irish Sea (Anon, 1973; Watson and Parsons, 1974; Hillis, 1974). Small mesh cod ends are used in the industrial fisheries and in the fishery for Nephrops norvegicus (L) by Northern Irish, Irish and French vessels. The N. Irish and Irish fisheries are mainly Nephrops - directed although there is some by-catch of Nephrops from the whitefish fisheries. The French fishery is by "semi-industrial" trawlers, also using <50 mm cod ends, but mainly directed at whitefish species (Anon, 1975). In 1973 there was no recorded French catch of Nephrops in the Irish Sea.

The studies cited above give estimates of the total instantaneous mortality rate on prerecruit whiting of 2-2.5, of which a large component is due to small mesh fisheries. The yield per recruit of whiting would be expected to increase by 50-70% following an increase in mesh size from 45 mm to 70 mm at current levels of fishing mortality. Cod is the second most important by-catch species in the small mesh fisheries.

Some recent work on the growth rate of Irish Sea Nephrops by Farmer (1973) and Hillis (1972), as well as unpublished information on gear efficiency and selection and an excellent review of the data on selection by Garrod (unpublished), enable an assessment of the effect on Nephrops catches of a change in mesh size to be made.

GROWTH

The growth curves of Farmer (1973) and Hillis (1972) and carapace length/tail weight relationship of Garrod (unpublished) have been used to determine the weight at age (tail weight) for males and females (Table 1 and Figure 1). Farmer gives mean lengths for ages up to 7 yr and Hillis has calculated asymptotic lengths of 51.4 and 62.4 mm carapace length, which agree "moderately well" with maximum sizes observed.

SELECTION

Data on mesh selection of Nephrops were reviewed by Garrod in 1964 (unpublished) and he came to the following conclusions:

- (a) Selection varies with mesh size throughout the trawl.
- (b) Diurnal and seasonal factors affect selection characteristics

(c) The length range over which selection occurs is wide and the proportion retained at different lengths varies. This makes conventional assessment of the effect of a change in mesh size difficult.

Even the largest mesh in use will retain some small Nephrops.

(d) One may reasonably establish carapace lengths above which escape is impossible (ie 100% selection points) for different mesh sizes.

The 100% point for 27 mm carapace length occurs with a uniform 45 mm mesh. Thus a trawl containing any meshes exceeding 45 mm will release some Nephrops of up to 27 mm carapace length.

(e) Comparative fishing trials must be carried out using the parallel haul technique.

As a result of this review, a series of trials was carried out using two very similar trawlers fishing different gears in parallel and switching gear during the experiment. The results of two of these comparisons are given in Table 2. A similar series of trials has recently been carried out by Mr P S Watson* to compare (a) a Prawn Trawl of 40 mm mesh throughout with a Dual Purpose Trawl with 40 mm cod end and (b) a Dual Purpose Trawl with 40 mm cod end with a Dual Purpose Trawl with 70 mm cod end. Both series of trials gave the non-uniform mesh gear with 40 mm cod end an advantage in catch rate over the uniform 40 mm Prawn Trawl, although this was very slight in the later series. The catch rate of marketable prawns (>30 mm in this case) using a trawl with 70 mm cod end was 25% lower than that taken with a 40 mm cod end in the recent series and 27% in the earlier series. These results are consistent with the analysis of selection and fishing power by Garrod and also with the differences in mean catch rate between "whitefish" and "prawn" trawlers between 1968 and 1972 (Watson, 1973).

There is no doubt that the catch rate of Nephrops is reduced by increasing the mesh size from 40 mm to 70 mm, but there is considerable doubt as to whether and how the selection characteristics of the gear are changed. The analysis below will therefore consider the changes expected in the fishery (a) if the only effect is to reduce the catch rate and hence the effective fishing effort and (b) if the change in catch rate includes a change in the length selection.

Figure 2 shows the selection lines derived by Garrod for 40 mm and 70 mm mesh, uniform throughout the trawl (lines a & b). Case (a) above is indicated by line c, which shows no change in selection with length between the two mesh sizes, but a 25% reduction in catch rate at all sizes. Taking 27 mm carapace length as the minimum marketable size, the difference between case (a) and case (b) is given by the difference between the areas marked d_1 and d_2 in the figure.

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YIELD ASSESSMENT

Starting with a population of 1000 at age 1, one can calculate the population numbers and catch weights for different levels of M and F for different mesh sizes. The calculations have been made for males and females separately and taking values of $M = 0.1, 0.2$ and $F = 0.1, 0.2, 0.4$ and 0.6 .

Case (a) - No selection:

The yield curves for 40 mm mesh, with recruitment at 1 year old and no selection, are shown in Figure 3. The maximum occurs at an F value of between 0.15 and 0.25 and, if the actual value of F is more than 25% above this, then the yield would be improved by implementing a 70 mm mesh regulation. This will of course act as an effort limitation and, if there really is no selection in the Nephrops fishery, then it will be far more efficient to limit the effort in some other way and allow the use of small mesh gear. In fact, Hillis (1975) suggests that the current level of total mortality is close to 1.0 in the Irish Sea, so that a reduction in effort is needed.

Case (b) - selection:

Table 3 gives the yield per recruit for 40 mm and 70 mm mesh at different levels of natural and fishing mortality, and the yield curves, with selection taking place (for males and females separately), are shown in Figure 4. At all levels of fishing mortality above 0.1 the yields are higher with the 70 mm mesh than with the 40 mm. The maximum sustainable yields (MSY) for both sexes at both levels of natural mortality are higher by 20-30% using a 70 mm mesh. The mean ages and mean carapace lengths of male and female Nephrops in the catch at MSY are also given in Table 3. This is important because larger Nephrops are more valuable per unit weight than smaller ones.

SOURCES OF ERROR

A possible source of error in the yield assessments is that the growth curves have been extrapolated for ages for which data are not available. The effect of this has been investigated only in a cursory way by looking at the changes which would result if growth, in fact, stopped at age 7. The effect is greatest at low levels of natural mortality and the absolute value of yield per recruit at MSY is reduced by about 14%. The level of fishing mortality needed to obtain MSY is increased very slightly, but the relative positions of the various curves remain almost the same. The effects of such differences in growth data are very easily investigated by changing the values in the weight at age column in Table 4. Similarly one could calculate the effect of higher natural mortality on older prawns or even their complete disappearance by truncating the age range.

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TABLE 1. Irish Sea Nephrops: Selection by 40 mm and 70 mm mesh and growth rates

Age (years)	1	2	3	4	5	6	7	8	9	10
Carapace length ♂	14.0	21.0	26.0	31.0	34.0	38.0	41.0	(45)	(48)	(50)
mm ♀	14.0	21.0	23.0	25.0	27.0	30.0	32.0	(34)	(36)	(38)
Tail weight ♂	0.7	2.0	3.4	5.5	8.3	11.7	15.0	18.0	20.6	22.5
g ♀	0.3	1.2	2.2	3.2	4.4	5.7	6.9	8.1	9.0	9.6
% retained ♂	70.0	91.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
40 mm ♀	70.0	91.0	97.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% retained ♂	12.0	33.0	48.0	60.0	72.0	83.0	93.0	100.0	100.0	100.0
70 mm ♀	12.0	33.0	39.0	45.0	51.0	60.0	66.0	72.0	77.0	82.0

TABLE 2. BONNIE LES/HARVEST MORN: Parallel haul trials

Carapace length (mm)	Total numbers		Total numbers			Total weight (g)		
	40 mm P.T.	40 mm Gundry	40 mm Gundry	70 mm Gundry	70/40	40 mm Gundry	70 mm Gundry	70/40
12-14			16	12	0.75	10.4	7.8	
15-17	32	34	15	29	1.93	15	29	
18-20	650	850	239	172	0.72	368	265	
21-23	2 179	3 185	1 243	618	0.50	2 847	1 415	
24-26	1 809	2 872	1 148	604	0.53	3 800	1 999	
27-29	1 049	1 672	538	267	0.43	2 496	1 239	
30-32	529	803	313	136	0.43	1 981	861	
33-35	255	408	129	88	0.68	1 085	740	
36-38	106	216	73	63	0.86	799	689	
39-41	30	72	45	55	1.22	629	768	
42-44	38	50	20	24	1.20	351	421	
45-47	13	6	12	10	0.83	261	217	
48-50			7	7	1.00	186	186	
Total	6 589	10 080	3 785	2 058	0.54	14 828	8 837	0.60
Total >30	712	1 190	463	322	0.69	5 292	3 882	0.73

P.T.: Uniform 40 mm prawn trawl made by Gourock.

Gundry: Standard Gundry prawn trawl, 20 fm courlene, wings 89 mm, belly + batings 56 mm.

TABLE 3. Yield of Nephrops in gms per recruit for 40 mm & 70 mm mesh and no selection at different levels of natural (M) & fishing mortality (F) and mean age and length at MSY

Sex	Mesh Size	M								F	Age in years	Carapace length in mm
		0.05	0.15	0.25	0.35	0.45	0.65	0.85	1.05			
♂	40	{ 0.1	3.7228	4.6337	4.0296	3.3687	2.8408	2.1422	1.7357	1.4813	4.436	33
		{ 0.2	1.4863	2.3276	2.3179	2.1300	1.9278	1.6029	1.3827	1.2299	3.561	29
		{ 0.4	0.4302	0.8484	0.9971	1.0390	1.0371	0.9918	0.9380	0.8901	2.107	22
	70	{ 0.1	3.8590	5.6532	5.6249	5.2395	4.8100	4.0723	3.5282	3.1289	6.080	38
		{ 0.2	1.4200	2.5632	2.8657	2.8886	2.8126	2.5902	2.3788	2.2026	4.117	32
		{ 0.4	0.3387	0.7449	0.9570	1.0721	1.1353	1.1862	1.1930	1.1833	3.594	29
	No selection	{ 0.1	3.6683	4.4205	3.7357	3.0475	2.5183	1.8445	1.4694	1.2438	4.149	32
		{ 0.2	1.4735	2.2414	2.1768	1.9587	1.7426	1.4140	1.2021	1.0623	3.283	28
		{ 0.4	0.4354	0.8394	0.9681	0.9932	0.9789	0.9192	0.8600	0.8115	1.894	20
♀	40	{ 0.1	1.7067	2.2304	2.0268	1.7582	1.5262	1.1916	0.9761	0.8294	4.448	26
		{ 0.2	0.7135	1.1678	1.2069	1.1417	1.0553	0.8967	0.7749	0.6832	3.567	24
		{ 0.4	0.2230	0.4527	0.5435	0.5742	0.5777	0.5536	0.5187	0.4846	1.950	21
	70	{ 0.1	1.4954	2.4656	2.6459	2.6114	2.5033	2.2509	2.0252	1.8397	5.574	28
		{ 0.2	0.5430	1.0883	1.3111	1.3980	1.4218	1.3924	1.3303	1.2638	3.922	25
		{ 0.4	0.1346	0.3204	0.4374	0.5137	0.5648	0.6232	0.6497	0.6601	2.438	22
	No selection	{ 0.1	1.6823	2.1254	1.8737	1.5824	1.3418	1.0088	0.8041	0.6706	4.149	25
		{ 0.2	0.7085	1.1242	1.1303	1.0436	0.9444	0.7755	0.6538	0.5667	3.283	24
		{ 0.4	0.2261	0.4473	0.5247	0.5432	0.5369	0.4999	0.4588	0.4227	1.894	20

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TABLE 4

7A NEPHROPS F

M= .400

F= .050

	AGE	POPULATION	CATCH NO.	CATCH WT.	WT AT AGE	F
	1	1000.00	28.381	8.514	.30	.04
	2	647.26	23.765	28.518	1.20	.05
	3	414.58	16.203	35.646	2.20	.05
	4	264.74	10.659	34.110	3.20	.05
	5	168.81	6.797	29.906	4.40	.05
	6	107.64	4.354	23.836	5.50	.05
	7	68.63	2.763	19.067	6.90	.05
	8	43.76	1.762	14.272	8.10	.05
	9	27.90	1.123	10.111	9.00	.05
	10	17.79	1.977	18.978	9.60	.05
	CATCH NUMBER PER RECRUIT =			.0978		
	YIELD WEIGHT PER RECRUIT =			.2230		

M= .400

F= .150

	AGE	POPULATION	CATCH NO.	CATCH WT.	WT AT AGE	F
	1	1000.00	82.439	24.732	.30	.11
	2	603.51	63.754	76.505	1.20	.14
	3	352.92	39.579	87.073	2.20	.15
	4	204.54	23.599	75.517	3.20	.15
	5	118.01	13.615	59.908	4.40	.15
	6	68.08	7.855	43.205	5.50	.15
	7	39.28	4.532	31.277	6.90	.15
	8	22.66	2.615	21.180	8.10	.15
	9	13.08	1.509	13.578	9.00	.15
	10	7.54	2.057	19.752	9.60	.15
	CATCH NUMBER PER RECRUIT =			.2416		
	YIELD WEIGHT PER RECRUIT =			.4527		

M= .400

F= .250

	AGE	POPULATION	CATCH NO.	CATCH WT.	WT AT AGE	F
	1	1000.00	133.090	39.927	.30	.18
	2	562.70	95.083	114.100	1.20	.23
	3	300.44	53.753	118.256	2.20	.24
	4	158.03	29.050	92.959	3.20	.25
	5	82.50	15.165	66.727	4.40	.25
	6	43.07	7.917	43.543	5.50	.25
	7	22.48	4.133	28.518	6.90	.25
	8	11.74	2.158	17.477	8.10	.25
	9	6.13	1.126	10.137	9.00	.25
	10	3.20	1.230	11.811	9.60	.25
	CATCH NUMBER PER RECRUIT =			.3427		
	YIELD WEIGHT PER RECRUIT =			.5435		

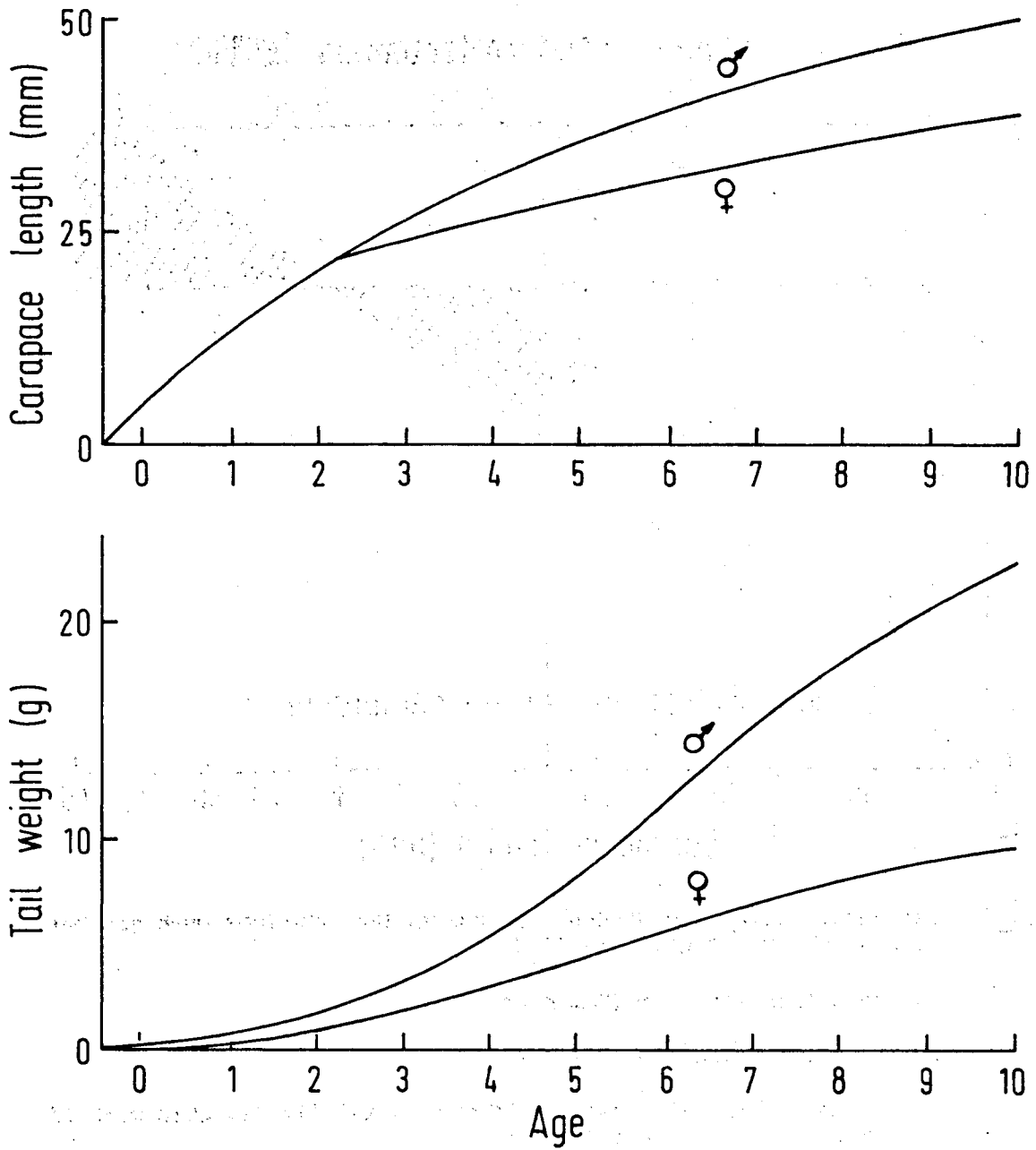


Fig 1 Growth of Irish Sea Nephrops (after Farmer)

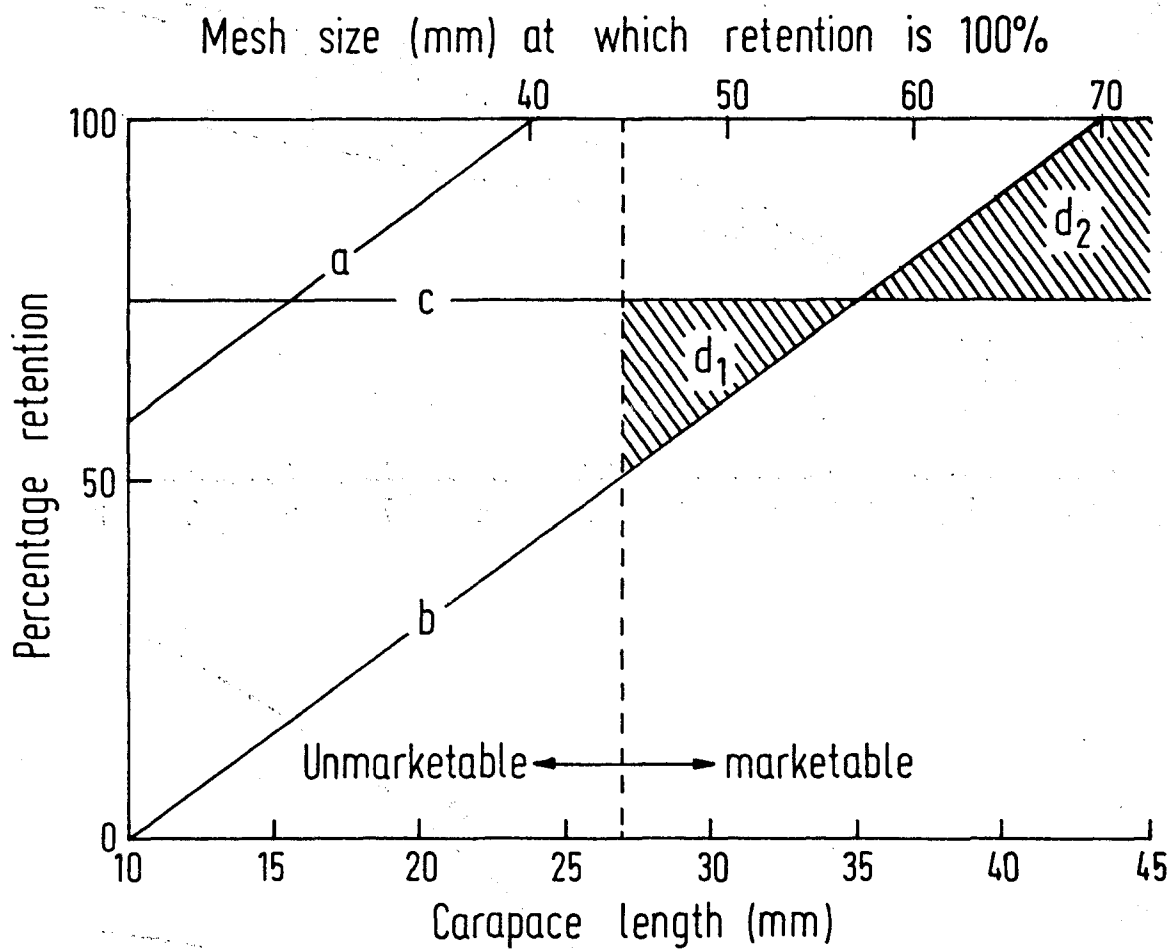


Fig 2 Percentage retention of Nephrops using 40mm and 70mm mesh and mesh size at which retention is 100%

a. selection line for 40mm mesh

b. selection line for 70mm mesh

c. reduction in catch rate by 70mm mesh relative to 40mm mesh if there is no length selection

d₁ and d₂ - see text

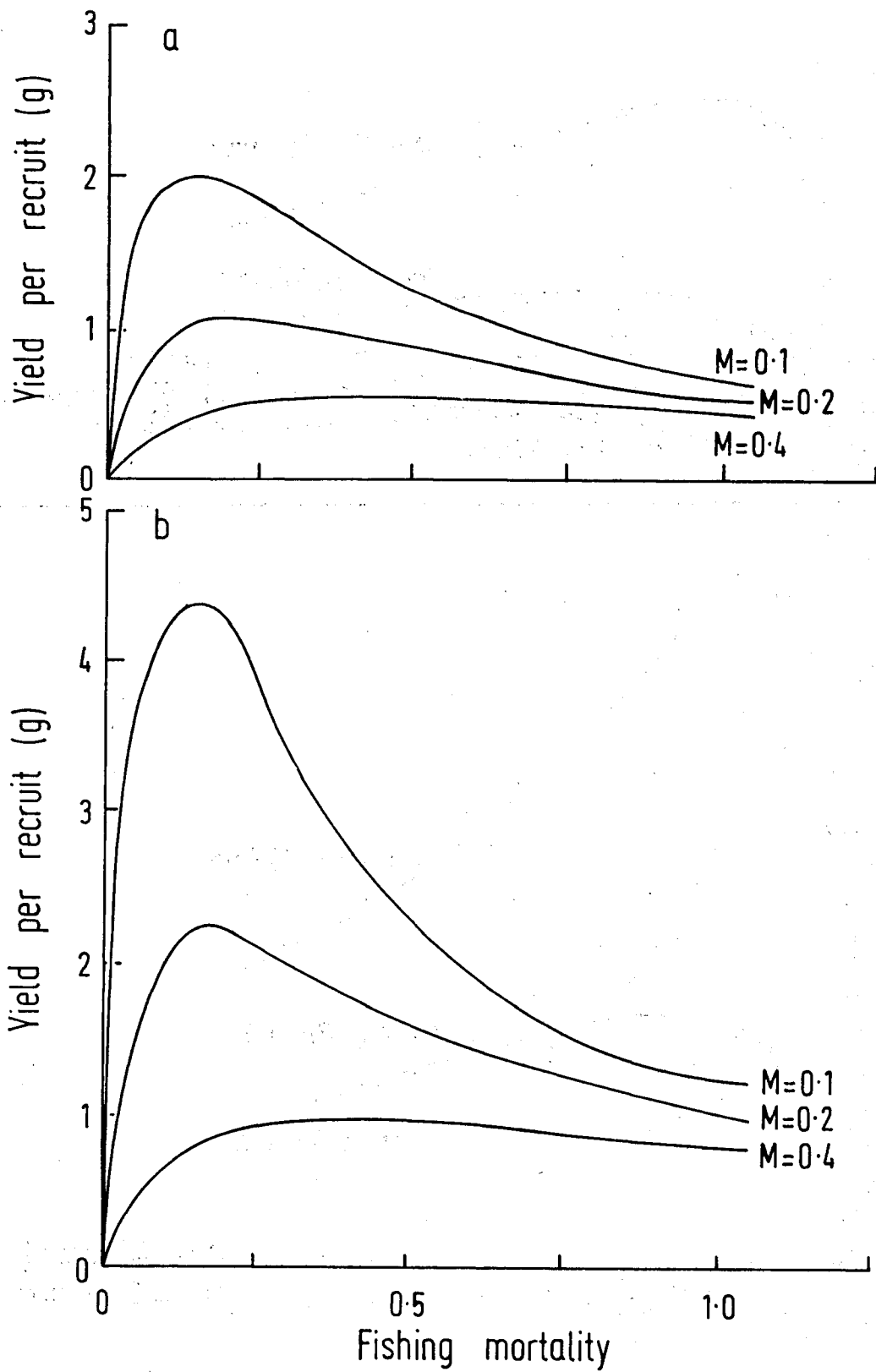


Fig 3 Yield curves for Nephrops. No selection operating

a. Females

b. Males

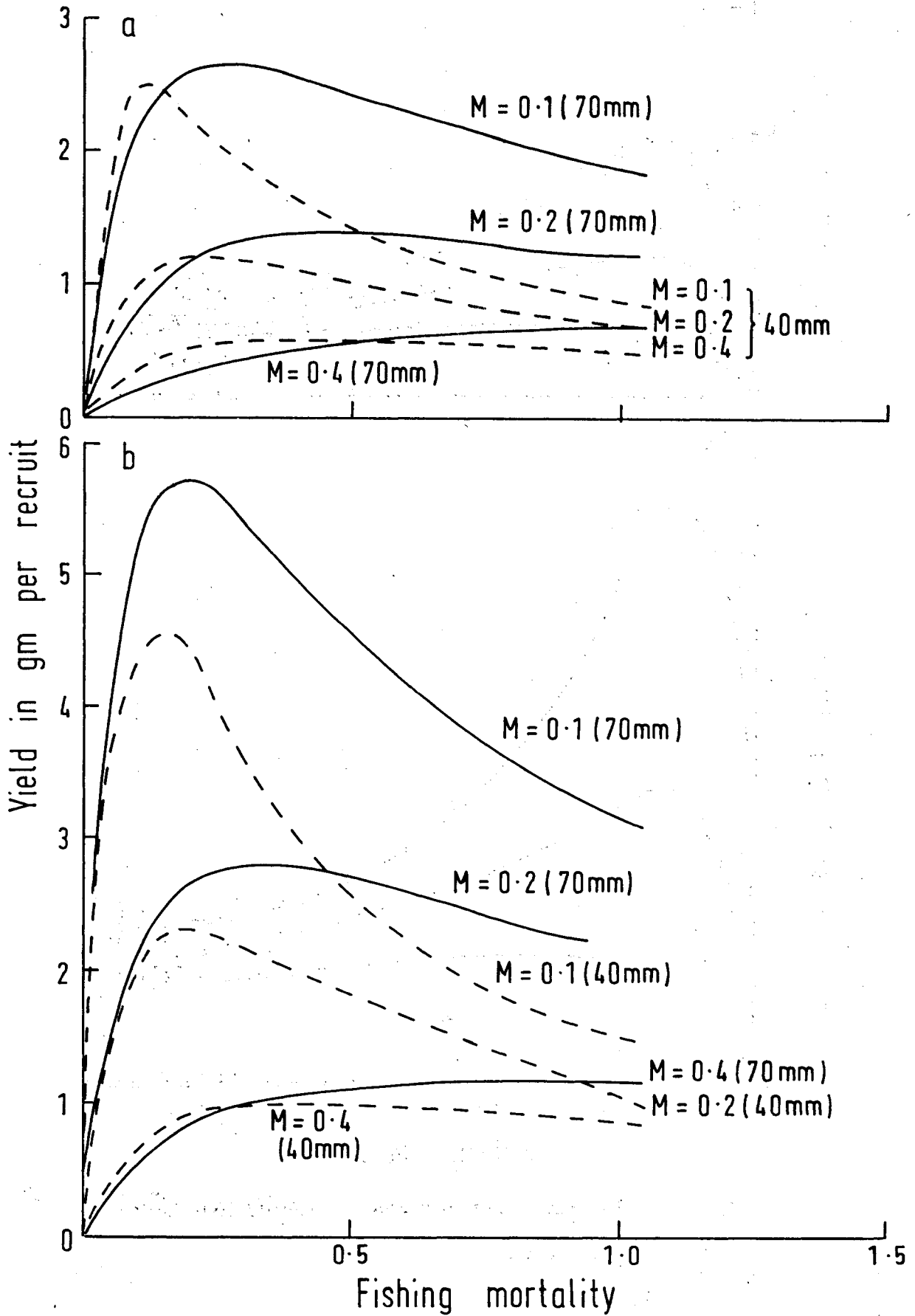


Fig 4 Yield curves for Nephrops with 40mm and 70mm uniform mesh size

a. Females

b. Males