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ICES. C.M. 1991 Paper C.M. 1991 / G:51
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MESH SIZE AND EFFORT CHANGES IN MULTISPECIES FISHERIES IN ICES DIVISIONS VIIIc AND IXa.

by

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ABSTRACT

Different simulations varying trawl mesh size and effort changes for several fishing units in ICES Divisions VIIIc and IXa were carried out. Landings included in the analysis represent most of the catches in the southern area defined as the management unit for hake, megrim, monkfish, horse mackerel, blue whiting and mackerel. Three Nephrops stocks in Divisions VIIIc and IXa are also included. These species are mainly exploited by Spanish and Portuguese fleets, using various fishing gears to exploit different fractions of the populations, and for this reason nine fishing units were used in the analysis.

INTRODUCTION

The Atlantic continental platform of the Iberian peninsula supports several multispecies fisheries exploited by various fleets. ICES Divisions VIIIc and IXa and the different species which live there are taken to be stock units or management units for assessment purposes, but without any strong biological basis.

The species dealt with in this work are the most important from the commercial viewpoint, either on account of their economic value or the quantities landed, and are exploited by different strategies, at different intensities. The main species are hake (Merluccius merluccius), megrim (Lepidorhombus boscii and L. whiffiagonis), monkfish (Lophius piscatorius and L. budegassa) Norway lobster (Nephrops norvegicus), horse mackerel (Trachurus trachurus), blue whiting (Micromesistius poutassou) and mackerel (Scomber scombrus).

The percentage composition by species of the landings has been analysed for each kind of gear and for the two countries (Spain and Portugal) involved. By weight, the most important species are horse mackerel (43%), blue whiting (23%), mackerel (15%) and hake (10%). The other species form smaller proportions, monkfish (6%), megrim (1%) and Norway lobster (1%), as seen in Fig. 1. Nevertheless from the economic viewpoint, the relative value of these species changes, and using the mean value at first sale in Spain estimated by the authors, the most important is hake (31%) followed by horse mackerel (27%), blue whiting (10%), Norway lobster (8%), monkfish (6%), megrim (4%) and mackerel (4%) Fig.2.

The fleets use different types of gear to extract these resources. The most important are the trawl (51%) and the purse seine (29%). With the latter, the sardine is the most important species landed, species not take into account in this analysis because it is only captured by this gear. Of less importance are long lines (9%), the artisanal fleet (7%) and gillnets (4%)(Fig. 3).

The mesh size of the trawls is usually 40 mm, authorized by current community regulations for blue whiting, horse mackerel, mackerel and cephalopods in Division VIIIc; for the same species except horse mackerel and cephalopods in Division IXa, and for all unprotected species in the Gulf of Cadiz.

Up until now, assessments have been done independently for each species mainly by the respective ICES working groups, without taking into account the interactions between different kinds of gear and different species. It is also important to take into account that there is no biological justification for the arbitrary division between areas VIIIc and VIIIb. It could substantially alter the results if the distribution areas of the resources considered here were more extensive than considered here, as is the case for example with blue whiting, mackerel and horse mackerel.

Several authors have published studies on the effects of changes in mesh size and effort in addition to those of the ICES working groups. For some species, these assessments are based on individual stocks in this region, e.g. the hake (Fernández et al. 1977; Iglesias et al. 1978) and Norway lobster (Fernández et al. 1986). Only Cardador and Caramelo (1989) have dealt with fisheries using multispecies criteria and considering different kinds of gear.

This study, on the basis of the most recent data base, shows the possible effects of new technical measures, bearing on the multispecies nature of this fishery and the variety of gear used.

MATERIALS AND METHODS

The hake, horse mackerel and mackerel of the Atlantic waters of the Iberian Peninsula are considered independent stocks (southern stocks) for species assessment, as agreed by the ICES working groups. In the case of monkfish and megrim, this area is considered to be an assessment unit, as is the case with the hake working group. For blue whiting southern stock (VIIg-k, VIId-e, VIII and IX) data are only provided from Division VIIIc and IXa, as are available in the blue whiting working group. Three different Norway lobster stocks have been taken into account: North Galicia - including Cantabrian waters -, West Galicia and Portuguese stocks combined.

The fleets were defined on the basis of the different kinds of gear used to exploit the stocks, for both the Spanish and Portuguese fleets. The nine fleet units selected are shown in Table 1, which also indicates the mean landings by species by each of them in the period considered. For the blue whiting trawl fishery, landings were split into trawlers and pair trawlers because this species represents about 90% of the landings in the pair trawl fleet.

The size distributions of the catches by fleet and by species are the same as those of the ICES working groups (Table 2). Mortality rates were obtained using LCA (Length Cohort Analysis, Jones 1974). The mean values of the size distributions of the landings by species and by fleet for the years 1986 to 1989 are considered to be pseudo-cohorts. In the case of the Norway lobster, the mean distribution was obtained for years 1984 to 1989 and for the Spanish long line fishery of blue whiting the mean distribution was obtained from 1987 to 1989, since these data were considered to be the best available.

In these fisheries, the discards are considered to be negligible so that the landings are representative of the captures. Nevertheless in the case of the hake the landings probably do not include captured juveniles. Since the ogive for correcting the size distribution is not available this can lead to underestimates of the smaller size classes of this species.

The biological parameters used are listed in Table 3. These parameters were in some cases those accepted by the working groups and in other cases have been taken from other scientific studies (Table 4).

The selectivity values are those which appear in Robles et al (1985) for hake, horse mackerel, blue whiting and Norway lobster. Those for megrim were obtained in area VIIIc by Astudillo and Sánchez (1989). Values for mackerel are from Eltink (1983), and those for monkfish from the working group on Unit stocks in subareas VII and VIIIab.

The selection ratio (L75% - L25% / L50%) was calculated on the basis of the mesh sizes close to those values which give the best fit to the selectivity curve.

In order to choose the terminal fishing mortalities the starting values for horse mackerel and blue whiting were those used by Cardador and Caramelo (1989), and for the other species the values were chosen from the respective ICES working groups. After several trials, the terminal fishing mortalities were chosen on the basis of the degree of convergence of the different cohort analyses tested.

For selection of the plus group, two different tests were done, following the recommendations of the ICES Methods working group and the ACFM (Advisory Committee for Fisheries Management). In the first test, the plus group was set at 70% of L_∞. The second test repeated the whole assessment with the plus group at 80% of L_∞. The results of both tests coincided except in the case of blue whiting, and it was considered better to set the plus group at 80% of L_∞, since otherwise the length composition of the long line captures for this species would have been mainly included in the plus group. For this reason the plus group set at 80% of L_∞ was taken as the selection criterion for all species.

The fishing mortality rates by size class for each stock (Table 5) and fleet unit were estimated by length cohort analysis. These values allow estimate of immediate losses and long-term changes. Two kinds of mesh simulation in the trawling fleets (65 mm and 80 mm) were done, and also combined with linear reductions of 10%, 20% and 30% in effort. The program used for these simulations was that of Mesnil and Shepherd (1990). In these simulations results are considered significant when values greater than 10% are obtained.

RESULTS

The general results for all species and fleet units combined show immediate losses of 35% and 41% in weight for the two meshes (65 mm and 80 mm) tested, and long-term gains of 0% and 1% respectively.

The long term results obtained (Table 6) indicate that significant gains in weight for all species together and Fig. 4. by species are slight, only 12% for a mesh size of 80 mm and a reduction in effort of 30%. On the other hand, the immediate losses are between 35% (changing mesh size to 65 mm) and 59% (changing to 80 mm and reducing effort 30%) (Table 7).

Tables 8 and 9 show the long-term changes in percentage by species and gear with mesh size change to 65 mm and 80 mm respectively. Tables 10 and 11 indicate the corresponding immediate losses in those simulations. Figures 5.a,b show the immediate and long-term changes in tonnes by fishery unit for all species combined.

Megrim and monkfish in the long-term do not appear to be affected significantly by a mesh change to 65 mm or 80 mm due to their morphological characteristics. These species show only small long-term gains when changes in mesh are accompanied by a reduction in effort.

Long-term gains are obtained in other species such as hake (15% to 21%), Norway lobster(13% to 33%), mackerel (8% to 11%) and horse mackerel (19% to 20%), with the two changes in mesh size tried. In the case of hake, these gains may be underestimated due to uncertainties in the numbers of fish below the minimum legal size either discarded or landed. In the other species dealt with here, discards are thought to be negligible.

In these species, the long-term gains are slightly higher with an 80 mm mesh, but show much more important short term losses. When the change in mesh is accompanied by a progressive reduction in effort, there are important increases in the immediate losses and slight long-term gains (Tables 12 and 13).

For all these species except Norway lobster, long-term losses are produced for the trawl which are compensated by important gains in the long line, gillnet, purse seine, and small gillnet fisheries.

The most significant immediate and long-term losses are produced in blue whiting with different combinations of mesh size and effort. It should be pointed out that it is both the short (-96% to -98%) and long-term (-47% to -61%) losses of this species which most influence the results of the global analysis given their present importance in the fishery.

From the results of the analysis by fishing fleets, we see that it is in the trawl fishery that the most important short (Tables 10 and 11) and long-term (Tables 8 and 9) losses are produced, mainly in blue whiting and horse mackerel, and in the pair trawlers since the main part of their captures is blue whiting. The results obtained for both mesh sizes are similar, with a slight increase in the losses with an 80 mm mesh, and a slight decrease with reduced effort.

Attention is directed to the results obtained for hake, where mesh changes to 65 mm and 80 mm in the trawl lead to losses in the long-term.

All the other kinds of gear -longlines, gillnets, small gillnet, purse seine, and artisanal - are favoured in the tests undertaken, and it is the longline which gains most.

DISCUSSION

The long term changes in total biomass for this group of species are insignificant for the mesh changes tested if the present level of effort is maintained due to the fact that the large losses of blue whiting are offset by gains in other species. A gain of the order of 10% can only be reached with a 30% reduction in effort. Nevertheless, by analysing the percentage changes by species, one can see that the hake, the mackerel and Norway lobster (of high economic value) are those which produce the largest long-term gains. The species which causes long-term losses is the blue whiting (of lower economic value), which would need to be managed independently - a similar conclusion was reached by Cardador and Caramelo (1989) - especially by pair trawlers whose target species is the blue whiting.

It should be remembered when the long-term changes are considered that the migrations of the more pelagic species may remove them from the area of distribution considered in this analysis, so that the results may not be very realistic (Anon. 1991,a,b).

A comparison with earlier studies (Fernández et al. 1986, Iglesias et al. 1978, Cardador and Caramelo 1989), which deal mainly with hake, shows that in the present study, the benefits obtained by changes in mesh, and particularly with an 80 mm mesh, are smaller. This may be due to the fact that the earlier studies did not separate the plus group from L_∞, so that the mortality rates obtained may not have been realistic, or that juveniles form a lower proportion of recent length distributions in landings.

In this context, the establishment of close areas in the Spanish zone since 1982, the increased inspection of landings, and a possible decrease in the extent of juvenile hake (Pereiro et al. 1991) might all help to explain the decline in captured juveniles.

The results of this study indicate that management of this fishery must take into account its multispecific nature, the different kinds of gear which are employed, as well as the socioeconomic repercussions.

ACKNOWLEDGMENTS

We thank to A. Fernández and his family for the unforgettable working hours in the countryside.

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LANDINGS BY SPECIES

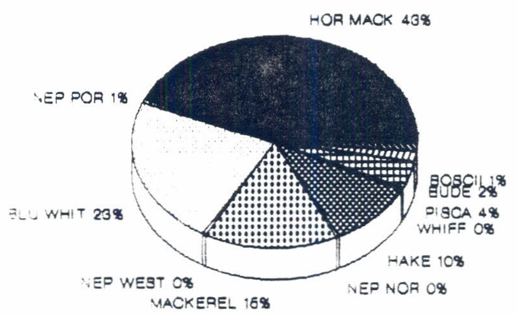


Fig.1 Landings by species in Div. VIIIc and IXa (%).

VALUE OF LANDINGS BY SPECIES

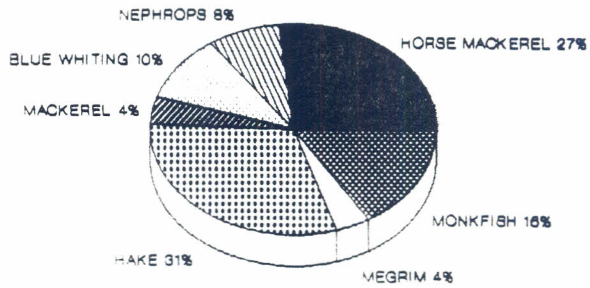


Figure 2. Economic value of landings (%)

LANDINGS BY GEAR

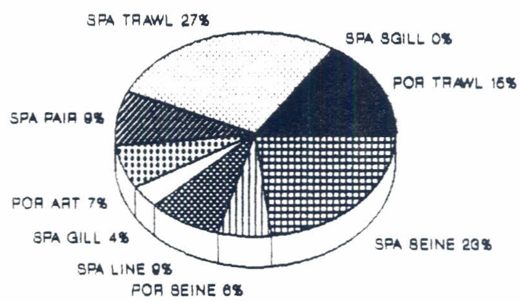
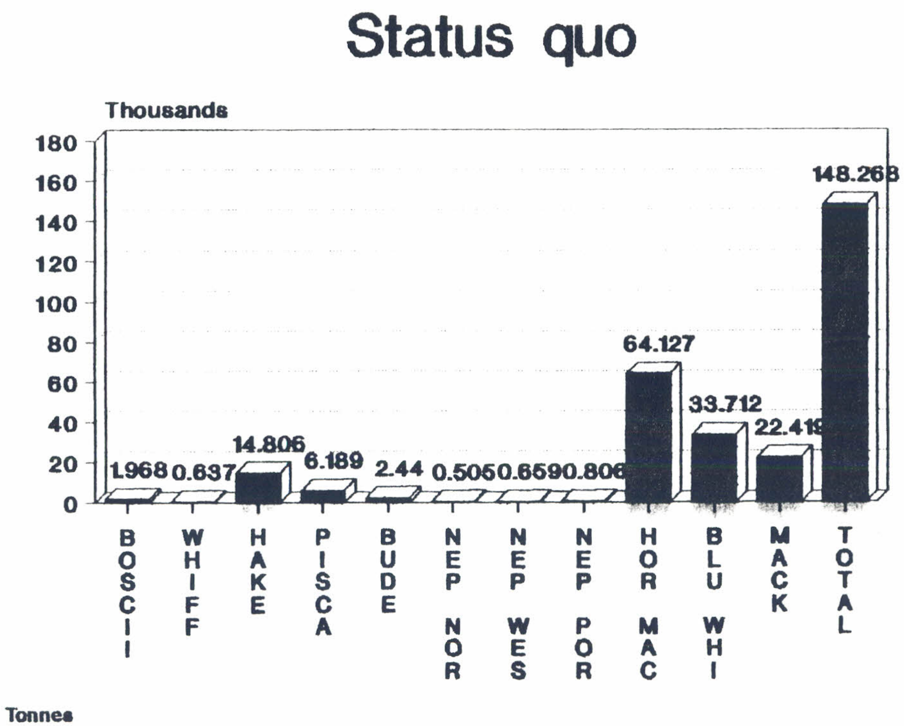
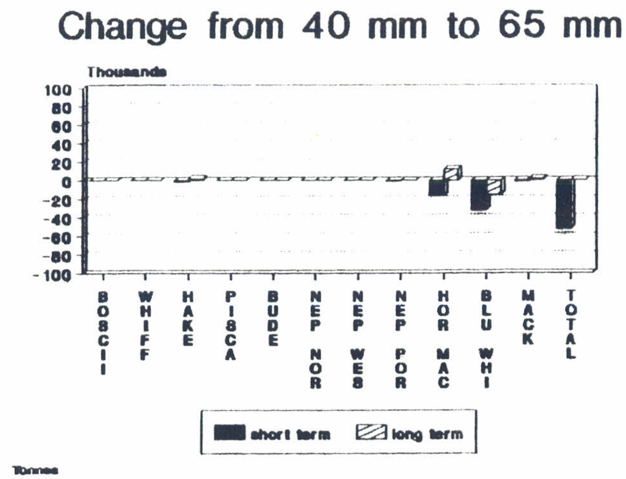


Fig.3. Landings by fishery unit in Div. VIIIc and IXa (%).





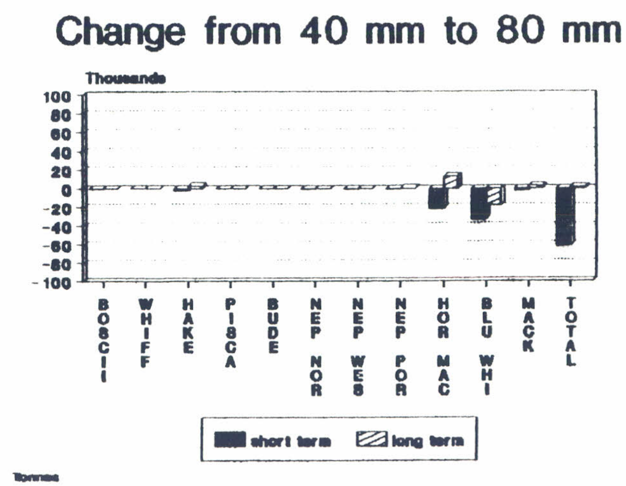


Fig. 4. Immediate and long-term changes in tonnes by species from mesh size change.

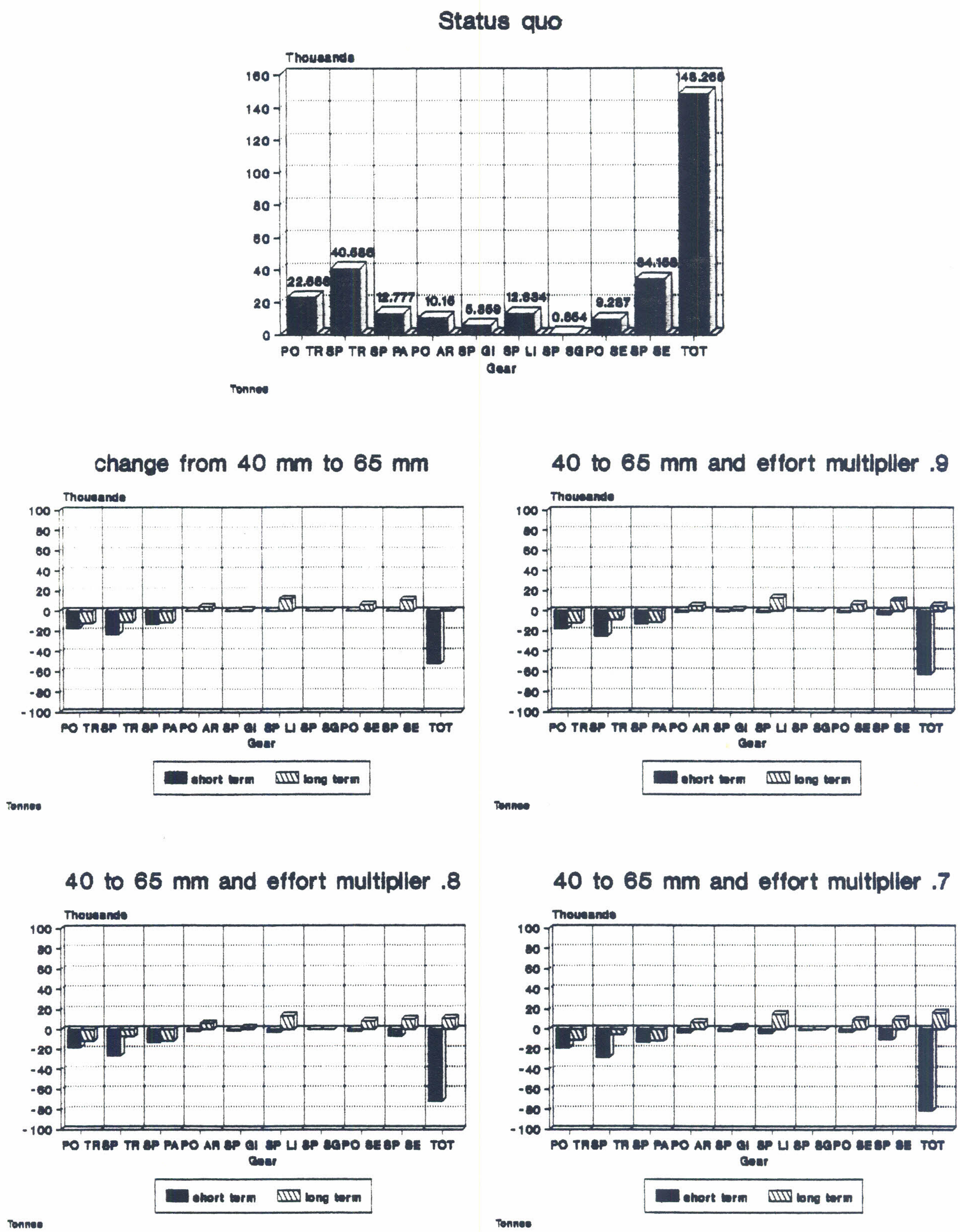
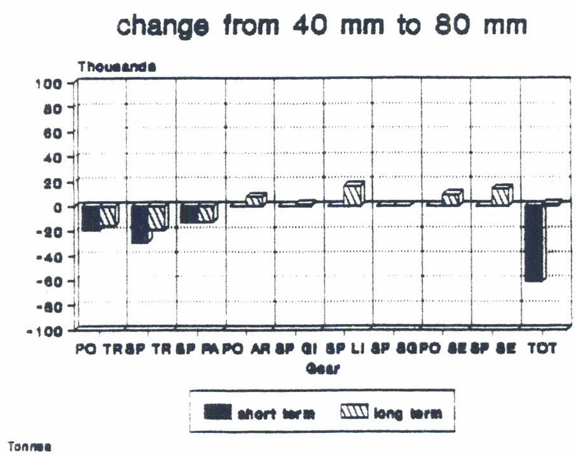
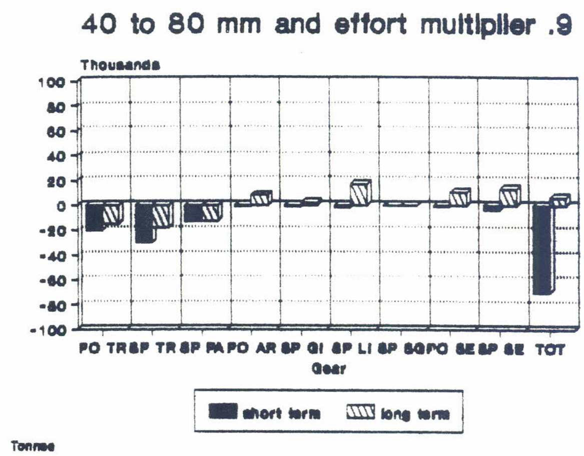
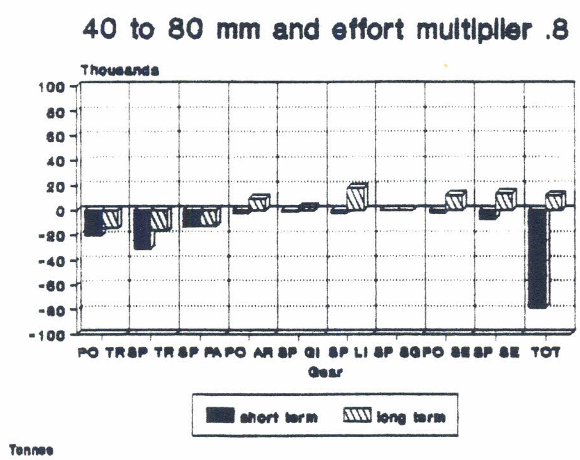


Fig. 5.a. Immediate and long-term changes in tonnes by fishing unit from mesh size of 65 mm. and effort change.







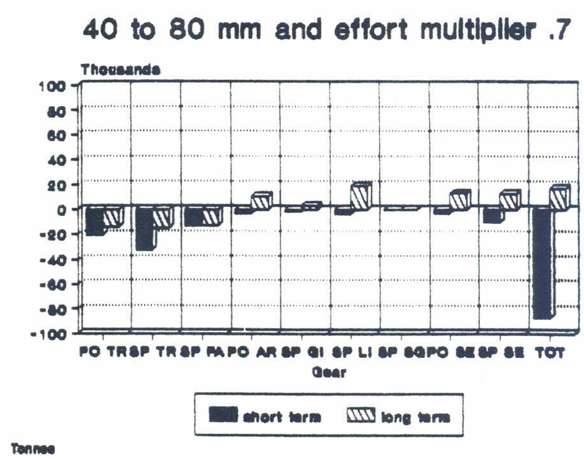


Fig. 5.b. Immediate and long-term changes in tonnes by fishing unit from mesh size of 80 mm. and effort change.

Sp \ unit	POR TRA	SPA TRA	SPA PAI	POR ART	SPA GIL	SPA LIN	SPA SGI	POR SEI	SPA SEI	TOTAL
L.boscii	315	1653	-	-	-	-	-	-	-	1968
L.whiff	51	586	-	-	-	-	-	-	-	637
Hake	1569	3997	-	3416	1973	3197	654	-	-	14806
L.pisca	218	2370	-	789	2812	-	-	-	-	6189
L.bude.	133	1254	-	819	234	-	-	-	-	2440
Neph.N.Gal	-	505	-	-	-	-	-	-	-	505
Neph.W.Gal	-	659	-	-	-	-	-	-	-	659
Neph.Port.	806	-	-	-	-	-	-	-	-	806
Horse Mack	10505	13071	-	4179	105	545	-	7800	27922	64127
Blue whit.	6687	13619	12777	-	-	629	-	-	-	33712
Mackerel	2383	2872	-	948	235	8263	-	1487	6231	22419
Total	22667	40586	12777	10151	5359	12634	654	9287	34153	148268

Portuguese Trawl: (POR TRA)
Spanish Trawl: (SPA TRA)
Spanish Pair Trawl: (SPA PAI)
Portuguese Artisanal: (POR ART)
Spanish Gillnet: (SPA GIL)
Spanish Long line: (SPA LIN)
Spanish Small gillnet: (SPA SGI)
Portuguese Purse seine: (POR SEI)
Spanish Purse seine: (SPA SEI)

Table 1.- Mean landings (tonnes) in Div. VIIIc and IXa with current mesh size.

L.BOSCII

CLASS	POR TRAWL	SPA TRAWL	TOTAL
10.0	1.81	6.27	8.08
11.0	3.02	8.23	11.25
12.0	1.63	5.31	6.94
13.0	4.78	60.60	65.38
14.0	27.70	273.55	301.25
15.0	99.34	948.42	1047.76
16.0	257.63	1381.30	1638.93
17.0	419.31	2054.02	2473.33
18.0	568.76	2502.51	3071.27
19.0	660.34	2909.49	3569.83
20.0	646.50	2842.03	3488.53
21.0	574.89	2648.29	3223.18
22.0	459.16	2182.33	2641.49
23.0	357.71	1866.11	2223.82
24.0	274.12	1495.72	1769.84
25.0	185.53	1172.97	1358.50
26.0	137.79	905.59	1043.38
27.0	97.27	623.44	720.71
28.0	53.08	392.91	445.99
29.0	48.99	287.18	336.17
30.0	20.55	164.69	185.24
31.0	16.23	98.43	114.66
32.0	13.84	81.02	94.86
33.0	4.01	38.09	42.10
34.0	5.25	32.95	38.20
35.0	1.44	19.45	20.89
36.0	.59	5.48	6.07
37.0	1.55	8.45	10.00
38.0	1.18	4.07	5.25
39.0	.85	3.66	4.51
40.0	2.48	12.72	15.20

L.WHIFF.

CLASS	POR TRAWL	SPA TRAWL	TOTA
10.0	.00	.00	.00
11.0	3.56	2.35	5.91
12.0	5.65	4.80	10.45
13.0	3.56	5.78	9.34
14.0	2.56	22.70	25.26
15.0	5.65	131.01	136.66
16.0	14.21	180.21	194.42
17.0	16.82	327.47	344.29
18.0	21.98	426.37	448.35
19.0	30.74	506.88	537.62
20.0	19.27	499.56	518.83
21.0	20.25	458.41	478.66
22.0	22.08	455.22	477.30
23.0	16.43	418.63	435.06
24.0	14.48	401.11	415.59
25.0	14.77	318.46	333.2
26.0	7.93	229.65	237.58
27.0	21.53	208.88	230.4
28.0	11.33	156.09	167.42
29.0	10.09	126.38	136.4
30.0	15.89	127.14	143.0
31.0	11.44	79.57	91.0
32.0	4.34	80.56	84.9
33.0	6.24	51.72	57.9
34.0	4.66	41.48	46.1
35.0	4.27	28.77	33.0
36.0	4.53	22.32	26.8
37.0	3.90	18.85	22.7
38.0	4.92	19.21	24.1
39.0	4.36	14.87	19.2
40.0	.00	11.41	11.4
41.0	2.22	8.34	10.5
42.0	4.46	11.35	15.8
43.0	1.05	4.29	5.3
44.0	3.14	10.86	14.0
45.0	1.27	5.82	7.0
46.0	1.17	3.84	5.0
47.0	.42	2.73	3.1
48.0	.17	3.86	4.0
49.0	.73	1.52	2.2
50.0	.00	1.22	1.2

HAKE

CLASS	POR TRAWL	SPA TRAWL	POR ART	SPA GILL	SPA LINE	SPA S.GILL	TOTAL
10.0	643.51	1127.43	556.39	.00	.00	.00	2327.33
15.0	3749.86	2096.74	2915.36	.00	.00	.52	8762.48
20.0	4295.81	4713.38	3758.07	.00	.00	515.37	13282.63
25.0	2634.71	4760.27	3032.26	56.39	3.55	2872.79	13359.97
30.0	1454.60	2868.55	3062.34	49.18	113.13	867.39	8415.19
35.0	729.20	1683.50	1958.20	131.58	361.95	35.75	4900.18
40.0	177.94	1095.27	765.77	232.52	925.56	21.92	3218.98
45.0	44.74	604.58	346.51	430.79	748.51	3.91	2179.04
50.0	20.22	312.74	219.99	512.15	824.35	.00	1889.45
55.0	10.36	135.87	126.03	328.05	472.80	.00	1073.11
60.0	2.78	42.07	52.04	147.29	115.16	.00	359.34
65.0	1.77	9.92	14.30	36.82	56.56	.00	119.37
70.0	.25	1.88	3.21	16.99	24.86	.00	47.19
75.0	.00	.54	.99	7.72	9.38	.00	18.63
80.0	.00	.00	1.48	9.53	5.33	.00	16.34

Table 2. Mean length composition by species in Div. VIIIc and IXa.

L.PISCA.

CLASS	POR TRAWL	SPA TRAWL	POR ART	SPA GILL	TOTAL
5.0	.00	.00	.00	.00	.00
10.0	.00	.00	.00	.00	.00
15.0	.00	.47	.00	.00	.47
20.0	2.37	43.92	6.31	.00	52.60
25.0	32.34	93.99	21.11	.25	147.69
30.0	67.95	170.97	28.88	.49	268.29
35.0	82.19	121.14	40.29	21.62	265.24
40.0	38.57	105.32	50.00	46.67	240.56
45.0	21.07	81.23	24.76	87.45	214.51
50.0	8.90	68.72	23.06	81.06	181.74
55.0	8.90	45.10	22.57	48.15	124.72
60.0	4.15	54.55	24.76	41.51	124.97
65.0	1.48	46.28	28.40	58.22	134.38
70.0	.00	50.30	15.05	64.36	129.71
75.0	.00	38.02	7.28	47.66	92.96
80.0	.00	31.17	9.47	46.92	87.56
85.0	.00	20.31	6.80	27.27	54.38
90.0	.00	17.00	3.88	24.07	44.95
95.0	.00	11.10	4.37	16.21	31.68
100.0	.00	13.70	2.67	26.53	42.90

L.BUDE.

CLASS	POR TRAWL	SPA TRAWL	POR ART	SPA GILL	TOTAL
5.0	.00	.00	.00	.00	.00
10.0	.00	.00	.00	.00	.00
15.0	.00	24.34	.00	.00	24.34
20.0	1.09	215.76	3.29	.00	220.14
25.0	35.28	330.55	22.81	.00	388.64
30.0	43.76	332.49	8.36	.00	384.61
35.0	6.56	286.02	1.27	.00	293.85
40.0	3.83	185.05	6.33	6.32	201.53
45.0	12.85	131.39	14.95	19.78	178.97
50.0	2.46	76.90	38.26	18.41	136.03
55.0	10.39	33.75	34.71	10.44	89.29
60.0	.00	22.13	33.70	12.91	68.74
65.0	2.46	13.00	50.43	10.72	76.61
70.0	7.11	19.64	48.40	8.24	83.39

NEP.NORTH

CLASS	SPA TRAWL	TOTAL
1.8	1.52	1.52
2.0	6.09	6.09
2.2	89.77	89.77
2.4	407.77	407.77
2.6	967.71	967.71
2.8	2061.70	2061.70
3.0	2582.07	2582.07
3.2	3008.10	3008.10
3.4	2728.14	2728.14
3.6	2617.06	2617.06
3.8	1611.32	1611.32
4.0	1346.57	1346.57
4.2	1033.13	1033.13
4.4	564.50	564.50
4.6	464.07	464.07
4.8	311.92	311.92
5.0	108.03	108.03
5.2	62.38	62.38
5.4	27.39	27.39
5.6	13.69	13.69
5.8	10.65	10.65
6.0	6.09	6.09
6.2	1.52	1.52
6.4	4.56	4.56
6.6	1.52	1.52
6.8	1.52	1.52
7.0	6.09	6.09

NEP.WEST

CLASS	SPA TRAWL	TOTAL
1.0	22.49	22.49
1.5	321.56	321.56
2.0	1850.68	1850.68
2.5	5713.95	5713.95
3.0	8242.61	8242.61
3.5	5798.27	5798.27
4.0	2642.22	2642.22
4.5	1092.87	1092.87
5.0	405.89	405.89
5.5	209.13	209.13
6.0	94.45	94.45
6.5	88.82	88.82
7.0	57.34	57.34
7.5	30.36	30.36
8.0	5.62	5.62

NEP.POR.

CLASS	POR TRAWL	TOTAL
1.0	7.95	7.95
1.2	.00	.00
1.4	.00	.00
1.6	.00	.00
1.8	19.87	19.87
2.0	127.19	127.19
2.2	416.00	416.00
2.4	2254.87	2254.87
2.6	4199.73	4199.73
2.8	5788.21	5788.21
3.0	4362.68	4362.68
3.2	4423.62	4423.62
3.4	4239.47	4239.47
3.6	3033.87	3033.87
3.8	2539.71	2539.71
4.0	1540.78	1540.78
4.2	1185.73	1185.73
4.4	1062.52	1062.52
4.6	590.88	590.88
4.8	467.67	467.67
5.0	267.62	267.62
5.2	235.82	235.82
5.4	263.64	263.64
5.6	139.11	139.11
5.8	84.79	84.79
6.0	34.44	34.44
6.2	13.25	13.25
6.4	7.95	7.95
6.6	2.65	2.65

Table 2. Cont.

HORSE MACK

CLASS	POR TRAWL	SPA TRAWL	POR ART	SPA GILL	SPA LINE	POR SEINE	SPA SEINE	TOTAL
5.0	.00	.00	1080.52	.00	.00	.00	4.19	1084.71
6.0	.00	.00	994.53	.00	.00	.00	127.76	1122.29
7.0	.00	.00	880.64	.00	.00	.00	1379.70	2260.34
8.0	40.53	.00	54.34	.00	.00	.00	5613.04	5707.91
9.0	695.98	145.09	87.66	.00	.00	.00	12815.17	13743.90
10.0	5043.09	471.07	396.69	.00	.00	130.57	60499.09	66540.51
11.0	11827.98	673.48	858.32	.00	.00	62.75	61791.73	75214.27
12.0	15770.97	449.46	1879.65	.00	.00	230.29	45073.48	63403.85
13.0	16152.45	953.83	1767.40	.00	9.79	528.51	37897.48	57309.46
14.0	20252.98	1840.07	3286.00	.00	6.61	3225.23	51810.21	80421.10
15.0	17951.01	2428.15	6063.56	.00	13.95	4070.43	80168.64	110695.70
16.0	19012.20	3716.71	2964.48	.00	50.43	3338.00	64041.34	93123.16
17.0	16322.12	5972.69	3378.27	.00	44.80	3797.58	51160.31	80675.77
18.0	12390.52	5670.81	3314.55	.00	73.20	3930.83	26599.40	51979.31
19.0	9370.35	4791.00	1878.06	11.95	101.60	2853.64	18986.11	37992.71
20.0	7190.21	4882.25	1359.54	19.84	45.05	3830.15	14683.72	32010.76
21.0	4780.87	4441.11	946.67	14.58	41.81	3917.43	15245.32	29387.79
22.0	3589.45	4073.08	1203.91	.72	30.85	3451.75	16505.40	28855.16
23.0	3305.51	4523.33	1524.61	6.69	30.11	4121.29	14402.80	27914.34
24.0	3515.34	6020.91	1010.66	5.50	20.32	3782.87	12107.56	26463.16
25.0	3375.00	6279.95	831.15	4.06	35.85	3458.26	8960.19	22944.46
26.0	3227.71	7413.06	1124.96	16.26	52.14	3485.88	7475.42	22795.43
27.0	2725.83	6943.40	1124.02	16.73	58.27	4856.16	5737.59	21462.00
28.0	2302.36	5607.71	1122.22	.96	53.08	3699.81	3344.44	16130.58
29.0	1631.30	4465.95	1120.27	5.02	49.06	2088.30	2419.79	11779.69
30.0	1116.73	3325.07	933.39	17.93	81.98	786.93	1604.15	7866.18
31.0	770.92	2722.63	702.13	26.10	112.25	803.72	1396.23	6533.98
32.0	640.85	2425.09	560.81	30.20	167.00	180.20	1517.33	5521.48
33.0	757.62	2093.47	789.37	33.78	169.35	744.42	1106.67	5694.68
34.0	701.55	1914.70	916.95	39.32	187.31	1763.18	1010.98	6533.99
35.0	643.36	1292.25	774.21	32.07	216.35	1251.13	422.25	4631.62
36.0	345.06	808.82	423.56	29.24	131.48	604.39	191.89	2534.44
37.0	311.04	576.76	311.87	20.36	120.09	604.24	121.10	2065.46
38.0	181.44	374.33	194.71	20.64	71.02	135.22	118.88	1096.24
39.0	71.54	179.87	99.20	11.00	52.90	19.79	29.60	463.90
40.0	21.30	71.90	44.08	12.95	77.43	16.93	16.03	260.62
41.0	8.16	36.61	15.84	1.67	4.26	.00	4.69	71.23
42.0	2.50	.00	4.35	.24	1.47	.00	13.57	22.13
43.0	4.55	2.06	.22	.00	1.61	6.43	2.71	17.58
44.0	.00	.00	.22	.00	.00	.00	.00	.22
45.0	.00	.00	.22	.48	3.21	.00	.00	3.91
46.0	.00	.00	.00	.00	.00	.00	.00	.00
47.0	.00	.00	.22	.48	.00	.00	.00	.70

BLUE WHIT

CLASS	POR TRAWL	SPA TRAWL	SPA PAIR	SPA LINE	TOTAL
10.0	.89	.00	.00	.00	.89
11.0	17.83	.00	.00	.00	17.83
12.0	35.65	3.27	.00	.00	38.92
13.0	425.18	69.74	.99	.00	495.91
14.0	5102.16	296.41	14.92	.00	5413.49
15.0	12151.94	584.11	52.72	5.33	12794.10
16.0	12473.72	2349.50	436.71	5.33	15265.26
17.0	21961.38	13485.68	3744.33	10.66	39202.05
18.0	34237.21	29559.51	10593.35	26.64	74416.71
19.0	33167.58	34044.93	28976.77	74.60	96263.88
20.0	22965.94	38881.25	49057.27	135.88	111040.30
21.0	13275.05	40843.89	50786.19	298.41	105203.50
22.0	6220.81	33505.50	38402.25	404.99	78533.55
23.0	2450.35	19094.63	20595.80	402.32	42543.10
24.0	1165.90	10416.94	8758.98	564.85	20906.67
25.0	532.14	6211.58	4236.74	562.19	11542.65
26.0	182.73	3722.59	1872.16	463.61	6241.09
27.0	79.33	2067.26	603.83	532.88	3283.30
28.0	42.79	1366.55	186.02	514.23	2109.59
29.0	13.37	581.93	65.66	458.28	1119.24
30.0	16.04	363.98	39.79	298.41	718.22
31.0	9.80	158.01	4.97	215.82	388.60
32.0	26.74	46.86	8.95	173.19	255.74
33.0	41.00	63.21	.99	63.95	169.15
34.0	55.26	31.60	1.99	50.62	139.47
35.0	29.41	21.80	.00	31.97	83.18
36.0	9.80	16.35	.99	7.99	35.13
37.0	15.15	11.99	.00	5.33	32.47
38.0	9.80	3.27	.99	2.66	16.72
39.0	.00	.00	.00	2.66	2.66
40.0	.89	2.18	.00	2.66	5.73

Table 2. Cont.

MACKEREL

CLASS	POR TRAWL	SPA TRAWL	POR ART	SPA GILL	SPA LINE	POR SEINE	SPA SEINE	TOTAL
11.0	5.50	.00	.00	.00	.00	.00	12.15	17.65
12.0	40.60	.00	.00	.00	.00	.00	108.68	149.28
13.0	52.53	.00	.00	.00	.00	.00	381.56	434.09
14.0	24.31	53.46	.00	.00	.00	.00	275.92	353.69
15.0	29.82	260.00	.00	.00	.00	.00	848.16	1137.98
16.0	16.74	184.95	.00	.00	.00	.00	2814.75	3016.44
17.0	116.75	326.42	.00	.00	.00	.00	2892.19	3335.36
18.0	549.11	176.31	.00	.00	.00	26.70	2939.70	3691.82
19.0	509.43	164.16	.54	.00	.00	159.58	3771.80	4605.51
20.0	540.85	799.72	2.98	.00	3.65	668.25	4311.50	6326.95
21.0	1329.18	2887.32	7.85	.00	1.60	988.38	3053.36	8267.69
22.0	2149.63	1791.14	31.68	.00	2.05	412.79	2917.79	7305.08
23.0	2092.75	729.52	48.20	.00	2.74	337.82	1982.65	5193.68
24.0	1695.26	333.44	42.78	.00	5.24	110.36	888.07	3075.15
25.0	1334.69	229.23	48.20	.00	10.03	240.02	403.90	2266.07
26.0	991.79	784.87	85.84	1.32	7.98	300.50	349.46	2521.76
27.0	765.17	795.94	145.41	1.32	40.12	256.10	141.21	2145.27
28.0	786.04	515.42	244.78	1.32	102.57	346.19	246.42	2242.74
29.0	822.97	246.77	486.58	.22	166.39	267.04	285.03	2275.00
30.0	669.52	221.40	509.87	.00	258.70	233.26	296.10	2188.85
31.0	542.91	356.66	378.54	.00	408.67	449.79	237.74	2374.31
32.0	359.42	341.27	324.93	1.32	631.81	634.14	585.47	2878.36
33.0	277.08	238.95	233.14	1.54	684.46	394.77	781.56	2611.50
34.0	205.97	283.76	185.21	10.36	874.10	545.99	605.86	2711.25
35.0	173.17	392.57	149.47	12.13	1075.81	290.85	751.63	2845.63
36.0	181.66	303.20	87.46	11.91	1406.76	247.09	961.61	3199.69
37.0	103.67	372.59	108.58	28.22	1822.73	156.69	857.05	3449.53
38.0	106.89	344.78	86.92	17.42	2058.40	180.17	960.09	3754.67
39.0	80.97	424.16	82.31	21.83	1908.66	64.67	1127.77	3710.37
40.0	48.17	257.03	68.51	38.81	1964.95	20.59	1068.55	3466.61
41.0	29.36	264.86	36.28	30.65	1421.12	3.86	546.64	2332.77
42.0	15.83	205.20	33.85	44.32	1128.92	1.61	528.63	1958.36
43.0	4.82	145.80	12.46	40.57	544.97	3.86	223.86	976.34
44.0	4.36	40.23	5.69	58.65	513.97	1.61	229.50	854.01
45.0	.69	67.23	2.44	34.62	151.34	.00	13.23	269.55
46.0	.69	55.08	1.35	13.45	37.15	.00	.43	108.15
47.0	.00	15.39	.54	.44	56.07	.00	.00	72.44
48.0	.00	.27	.27	6.61	2.74	.00	.43	10.32
49.0	.00	.27	.00	.00	5.01	.00	.00	5.28
50.0	.00	.00	.00	.66	.00	.00	.00	.66

Table 2. Cont.

SPECIES	Growth Parameters K	Growth Parameters L∞	Length-weigth relation. (Kgs.) a	Length-weigth relation. (Kgs.) b	Maturity L50	Maturity L75 -L25	Selectivity SF	Selectivity L75-L25 / L50
L. boscii	0.135	45.4	0.00490	3.080	20.2	3.0	2.18	0.519
L. whiffiagonis	0.120	53.0	0.00626	3.052	20.2	3.0	2.10	0.375
Hake	0.080	100.0	0.004	3.148	40.0	13.6	4.08	0.390
Monk (L.piscatorius)	0.102	140.0	0.01362	2.984	50.0	8.0	2.50	0.400
Monk (L.budegassa)	0.090	94.0	0.00762	3.131	30.0	8.0	2.50	0.400
Nephrops (N. Galicia)	0.135	8.0	0.428	3.158	2.5	0.5	0.49	0.493
Nephrops (W. Galicia)	0.135	8.5	0.428	3.158	2.5	0.5	0.49	0.493
Nephrops (Portugal)	0.200	7.0	0.420	3.126	2.5	0.5	0.49	0.493
Horse mackerel	0.140	50.0	0.01291	2.855	20.5	2.5	4.60	0.168
Blue whiting	0.085	38.6	0.00322	3.193	19.4	1.4	4.95	0.160
Mackerel	0.110	61.6	0.00400	3.200	28.6	2.9	3.90	0.304

SPECIES	Size Range	Size Interv.	Size Plus	Mortalities Ft	Mortalities M
L. boscii	10.0 - 40.0	1.0	36.0	0.50	0.20
L. whiffiagonis	10.0 - 50.0	1.0	42.0	0.20	0.20
Hake	10.0 - 80.0	5.0	80.0	0.20	0.20
Monk (L. piscatorius)	5.0 - 100.0	5.0	100.0	0.33	0.15
Monk (L. budegassa)	5.0 - 70.0	5.0	65.0	0.10	0.15
Nephrops (N. Galicia)	1.8 - 7.0	0.2	6.4	0.40	0.20
Nephrops (W. Galicia)	1.0 - 8.0	0.5	6.8	0.30	0.20
Nephrops (Portugal)	1.0 - 6.6	0.2	5.6	0.80	0.20
Horse mackerel	5.0 - 47.0	1.0	40.0	1.10	0.15
Blue whiting	10.0 - 40.0	1.0	31.0	0.25	0.20
Mackerel	11.0 - 50.0	1.0	49.0	1.30	0.15

Table 3. Parameters by species in Div. VIIIc and IXa applied in this analysis.

SPECIES	Growth Parameters	Length-weigth relation. (Kgs.)	Maturity	Selectivity	Natural Mortality
L. boscii	Hake W.G.	Hake W.G.	Cardador (1990)	Robles (1985)	Hake W.G.
L. whiffiagonis	Hake W.G.	Hake W.G.	VII-VIII W.G.	Astudillo (1989)	Hake W.G.
Hake	Hake W.G.	Hake W.G.	VII-VIII W.G.	Robles (1985)	Hake W.G.
Monk (L.piscatorius)	Hake W.G.	Hake W.G.	VII-VIII W.G.	VII-VIII W.G.	Hake W.G.
Monk (L.budegassa)	Hake W.G.	Hake W.G.	VII-VIII W.G.	VII-VIII W.G.	Hake W.G.
Nephrops (N.Galicia)	Nephrops W.G.	Nephrops W.G.	Nephrops W.G.	Robles (1985)	Nephrops W.G.
Nephrops (W.Galicia)	Nephrops W.G.	Nephrops W.G.	Nephrops W.G.	Robles (1985)	Nephrops W.G.
Nephrops (Portugal)	Nephrops W.G.	Nephrops W.G.	Nephrops W.G.	Robles (1985)	Nephrops W.G.
Horse Mackerel	Borges (1988)	Horse Mackerel W.G.	Lucio (1989)	Robles (1985)	Horse Mackerel W.G.
Blue Whiting	Meixide (per.com.)	Spanish data	Ehrich (1982)	Robles (1985)	Blue Whiting W.G.
Mackerel	Mackerel W. S.	Spanish data	Mackerel W.S.	Eltink (1983)	Mackerel W.G.

Table.4. Parameters derivation by species in Div. VIIIc and IXa.

L.BOSCII	
CLASS	TOTAL
10.0	.0007
11.0	.0010
12.0	.0006
13.0	.0059
14.0	.0278
15.0	.0997
16.0	.1639
17.0	.2660
18.0	.3662
19.0	.4886
20.0	.5672
21.0	.6421
22.0	.6600
23.0	.7120
24.0	.7457
25.0	.7717
26.0	.8234
27.0	.8111
28.0	.7142
29.0	.7754
30.0	.6167
31.0	.5303
32.0	.6251
33.0	.3913
34.0	.4932
35.0	.3866
36.0	.5000

L.WHIFF.	
CLASS	TOTAL
10.0	.0000
11.0	.0025
12.0	.0045
13.0	.0041
14.0	.0112
15.0	.0624
16.0	.0920
17.0	.1711
18.0	.2384
19.0	.3119
20.0	.3332
21.0	.3427
22.0	.3851
23.0	.4002
24.0	.4414
25.0	.4116
26.0	.3376
27.0	.3767
28.0	.3155
29.0	.2939
30.0	.3566
31.0	.2631
32.0	.2824
33.0	.2213
34.0	.2001
35.0	.1617
36.0	.1474
37.0	.1403
38.0	.1696
39.0	.1562
40.0	.1061
41.0	.1120
42.0	.2000

HAKE	
CLASS	TOTAL
10.0	.0279
15.0	.1209
20.0	.2309
25.0	.3226
30.0	.2985
35.0	.2546
40.0	.2458
45.0	.2529
50.0	.3752
55.0	.4404
60.0	.3245
65.0	.2172
70.0	.1640
75.0	.1254
80.0	.2000

L.PISCA.	
CLASS	TOTAL
5.0	.0000
10.0	.0000
15.0	.0003
20.0	.0315
25.0	.0928
30.0	.1831
35.0	.2026
40.0	.2080
45.0	.2119
50.0	.2066
55.0	.1621
60.0	.1861
65.0	.2371
70.0	.2839
75.0	.2589
80.0	.3213
85.0	.2713
90.0	.3127
95.0	.3290
100.0	.3300

L.BUDE.	
CLASS	TOTAL
5.0	.0000
10.0	.0000
15.0	.0060
20.0	.0581
25.0	.1155
30.0	.1342
35.0	.1225
40.0	.1002
45.0	.1071
50.0	.1001
55.0	.0815
60.0	.0788
65.0	.1000

NEP.NORTH	
CLASS	TOTAL
1.8	.0002
2.0	.0008
2.2	.0116
2.4	.0540
2.6	.1340
2.8	.3098
3.0	.4420
3.2	.6183
3.4	.7087
3.6	.9118
3.8	.7737
4.0	.9024
4.2	1.0334
4.4	.8565
4.6	1.1075
4.8	1.3455
5.0	.8297
5.2	.7540
5.4	.4911
5.6	.3294
5.8	.3347
6.0	.2494
6.2	.0750
6.4	.4000

NEP.WEST	
CLASS	TOTAL
1.0	.0009
1.5	.0136
2.0	.0833
2.5	.3017
3.0	.6174
3.5	.7537
4.0	.6446
4.5	.4772
5.0	.2845
5.5	.2164
6.0	.1401
6.5	.3000

NEP.POR.	
CLASS	TOTAL
1.0	.0007
1.2	.0000
1.4	.0000
1.6	.0000
1.8	.0018
2.0	.0117
2.2	.0386
2.4	.2152
2.6	.4315
2.8	.6786
3.0	.6002
3.2	.7239
3.4	.8648
3.6	.7893
3.8	.8540
4.0	.6679
4.2	.6504
4.4	.7647
4.6	.5607
4.8	.5744
5.0	.4217
5.2	.4769
5.4	.7897
5.6	.8000

HORSE MACK	
CLASS	TOTAL
5.0	.0044
6.0	.0046
7.0	.0093
8.0	.0236
9.0	.0573
10.0	.2868
11.0	.3441
12.0	.3090
13.0	.2967
14.0	.4492
15.0	.6962
16.0	.6781
17.0	.6820
18.0	.5027
19.0	.4091
20.0	.3796
21.0	.3838
22.0	.4184
23.0	.4556
24.0	.4932
25.0	.4938
26.0	.5770
27.0	.6603
28.0	.6121
29.0	.5462
30.0	.4363
31.0	.4280
32.0	.4305
33.0	.5473
34.0	.8615
35.0	.9411
36.0	.8097
37.0	1.1202
38.0	1.1820
39.0	1.0356
40.0	1.1000

BLUE WHIT	
CLASS	TOTAL
10.0	.0000
11.0	.0000
12.0	.0001
13.0	.0007
14.0	.0080
15.0	.0201
16.0	.0258
17.0	.0723
18.0	.1565
19.0	.2445
20.0	.3677
21.0	.5018
22.0	.5986
23.0	.5443
24.0	.4362
25.0	.3786
26.0	.3154
27.0	.2483
28.0	.2372
29.0	.1880
30.0	.1817
31.0	.2500

MACKEREL	
CLASS	TO
11.0	.00
12.0	.00
13.0	.01
14.0	.01
15.0	.03
16.0	.09
17.0	.10
18.0	.11
19.0	.15
20.0	.22
21.0	.31
22.0	.29
23.0	.22
24.0	.14
25.0	.10
26.0	.12
27.0	.11
28.0	.12
29.0	.13
30.0	.13
31.0	.15
32.0	.19
33.0	.19
34.0	.21
35.0	.24
36.0	.31
37.0	.39
38.0	.51
39.0	.65
40.0	.85
41.0	.85
42.0	1.15
43.0	.99
44.0	1.77
45.0	1.38
46.0	1.21
47.0	2.41
48.0	1.29
49.0	1.30

Table 5. Total fishing mortality rates by size class by species in Div. VIIIc and IXa.

Effort multiplier	Mesh Size 40 mm	Mesh Size 65 mm	Mesh Size 80 mm
1	-	0	1
0.9	4	4	4
0.8	8	7	8
0.7	12	11	12

Table 6. Long-term gains (percentages) obtained by mesh size and effort changes for all species and all fishery units.

Effort miltiplier	Mesh Size 40 mm	Mesh Size 65 mm	Mesh Size 80 mm
1	-	-35	-41
0.9	-10	-42	-47
0.8	-20	-48	-53
0.7	-30	-55	-59

Table 7. Inmediate losses (percentages) obtained by mesh size and effort changes for all species and all fishery units.

unit \ Sp	POR TRA	SPA TRA	SPA PAI	POR ART	SPA GIL	SPA LIN	SPA SGI	POR SEI	SPA SEI	TOTAL
L.boscii	3	4	-	-	-	-	-	-	-	4
L.whiff	3	2	-	-	-	-	-	-	-	2
Hake	-21	1	-	25	29	29	21	-	-	15
L.pisca	0	0	-	0	0	-	-	-	-	0
L.bude	1	0	-	1	1	-	-	-	-	1
Neph.N.Gal	-	13	-	-	-	-	-	-	-	13
Neph.W.Gal	-	19	-	-	-	-	-	-	-	19
Neph.Port.	20	-	-	-	-	-	-	-	-	20
Horse mack	-58	-16	-	81	126	125	-	77	36	19
Blue whit.	-80	-61	-88	-	-	1451	-	-	-	-47
Mackerel	-27	-9	-	16	17	17	-	14	13	8
Total	-54	-25	-88	43	14	96	21	67	32	0

Tabla. 8 - Long-term gains (percentages) by species and fishery unit with mesh size change to 65 mm.

unit \ Sp	POR TRA	SPA TRA	SPA PAI	POR ART	SPA GIL	SPA LIN	SPA SGI	POR SEI	SPA SEI	TOTAL
L.boscii	6	10	-	-	-	-	-	-	-	9
L.whiff	10	4	-	-	-	-	-	-	-	5
Hake	-41	8	-	39	51	51	29	-	-	21
L.pisca	0	1	-	1	1	-	-	-	-	1
L.bude	2	1	-	3	3	-	-	-	-	2
Neph.N.Gal	-	22	-	-	-	-	-	-	-	22
Neph.W.Gal	-	31	-	-	-	-	-	-	-	31
Neph.Port.	33	-	-	-	-	-	-	-	-	33
Horse mack	-78	-59	-	137	282	276	-	116	44	20
Blue whit.	-80	-80	-97	-	-	1681	-	-	-	-54
Mackerel	-54	-24	-	25	31	29	-	23	22	11
Total	-67	-47	-97	72	26	127	29	101	40	1

Tabla. 9 - Long-term gains (percentages) by species and fishery unit with mesh size change to 80 mm.

Sp \ Unit	POR TRA	SPA TRA	SPA PAI	TOTAL
L.boscii	-10	-9	-	-9
L.whiff	-2	-2	-	-2
Hake	-36	-20	-	-9
L.pisca	0	0	-	0
L.bude	0	0	-	0
Neph.N.Gal	-	-30	-	-30
Neph.W.Gal	-	-28	-	-28
Neph.Port.	-31	-	-	-31
Horse mack	-80	-61	-	-25
Blue whit.	-98	-97	-98	-96
Mackerel	-36	-22	-	-7
Total	-73	-57	-98	-35

Tabla.10 - Immediate losses (percentages) by species and fishery units with mesh size change to 65 mm.

Sp \ Unit	POR TRA	SPA TRA	SPA PAI	TOTAL
L.boscii	-25	-23	-	-23
L.whiff	-6	-9	-	-9
Hake	-57	-37	-	-16
L.pisca	-1	0	-	0
L.bude	-1	-2	-	-1
Neph.N.Gal	-	-51	-	-51
Neph.W.Gal	-	-47	-	-47
Neph.Port.	-51	-	-	-51
Horse mack	-94	-89	-	-33
Blue whit.	-99	-99	-100	-97
Mackerel	-62	-40	-	-12
Total	-85	-71	-100	-41

Tabla.11 - Immediate losses (percentages) by species and fishery units with mesh size change to 80 mm.

SPECIES	Mesh Size 65 mm				Mesh Size 80 mm			
	Effort multiplier				Effort multiplier			
	1	0.9	0.8	0.7	1	0.9	0.8	0.7
Megrim (L.boscii)	-9	-19	-28	-37	-23	-31	-39	-46
Megrim (L.whiffiagonis)	-2	-12	-22	-32	-9	-18	-27	-32
Hake	-9	-18	-27	-36	-16	-24	-33	-41
Monk (L.piscatorius)	0	-10	-20	-30	0	-10	-20	-30
Monk (L.budegassa)	0	-10	-20	-30	-1	-11	-21	-31
Nephrops (N. Galicia)	-30	-37	-44	-51	-51	-56	-61	-66
Nephrops (W. Galicia)	-28	-35	-42	-50	-47	-52	-58	-63
Nephrops (Portugal)	-31	-38	-45	-52	-51	-56	-61	-65
Horse Mackerel	-25	-33	-40	-48	-33	-40	-47	-53
Blue Whiting	-96	-96	-96	-97	-97	-98	-98	-98
Mackerel	-7	-16	-25	-35	-12	-21	-29	-38
TOTAL	-35	-42	-48	-55	-41	-47	-53	-59

Table 12. Immediate losses (percentages) by species with effort and mesh size change to 65 mm and 80 mm.

SPECIES	Mesh Size 40 mm			Mesh Size 65 mm				Mesh Size 80 mm			
	Effort multiplier			Effort multiplier				Effort multiplier			
	0.9	0.8	0.7	1	0.9	0.8	0.7	1	0.9	0.8	0.7
Megrim (L.boscii)	2	4	6	4	6	8	10	9	11	12	14
Megrim (L.whiffiagonis)	0	0	-1	2	2	1	0	5	5	4	2
Hake	4	7	10	15	18	2	22	21	24	25	26
Monk (L.piscatorius)	4	7	11	0	4	7	11	1	5	8	11
Monk (L.budegassa)	-2	-4	-7	1	-1	-3	-7	2	0	-2	-6
Nephrops (N. Galicia)	3	5	8	13	15	17	19	22	24	25	-26
Nephrops (W. Galicia)	3	6	9	19	21	23	24	31	32	32	32
Nephrops (Portugal)	4	7	11	20	23	26	29	33	35	37	39
Horse Mackerel	7	14	23	19	26	33	42	20	27	35	43
Blue Whiting	-1	-2	-5	-47	-49	-52	-55	-54	-56	-58	-61
Mackerel	3	7	11	8	11	14	17	11	14	17	20
TOTAL	4	8	12	0	4	7	11	1	4	8	12

Table 13. Long-term changes (percentages) by species with effort and mesh size change.