Assessing immediate and long-term effects on landings and spawning stock biomass in Norway lobster (*Nephrops norvegicus*) from the Southwest and South of Portugal by changing trawl codend mesh size, mesh configuration and introducing sorting grids.

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INTRODUCTION

The Norway lobster (*Nephrops norvegicus*) is distributed along the Portuguese coast, at depths ranging from 200 to 800 m. The main fishing grounds are located off the southwest and south coasts, respectively, Alentejo and Algarve. This species is exploited in a mixed crustacean trawl fishery, together with the rose shrimp (*Parapenaeus longirostris*) and other deepwater shrimp species. The Norway lobster and the rose shrimp constitute the bulk of the catches and according to their relative abundance and market value, among other factors, the fleet may re-direct the effort preferentially to one of them, as it becomes apparent with the existence of two distinct landing profiles in the fishery (Campos *et al*., 2007).

Although the total landings are low when compared to fish stocks landings, the crustacean trawl fishery is important by its value. In 2005, the total crustacean landings in Portugal were 807 tonnes, 40% of these (324 tonnes) were constituted by Norway lobster. In value, *Nephrops* landings made up 6 millions euros, which represents 60% of total crustacean value in that year (INE, 2006).

The main by-catch fish species landed are hake (*Merluccius merluccius*) and anglerfish (*Lophius* spp.). Blue whiting (*Micromesistius poutassou*) landings increased in the second half of 2003 and became the first by-catch species landed in 2004 and 2005. Hake and blue whiting are also among the most important species discarded (Portuguese discards programme). In 2005, there were 32 trawlers involved in the crustacean fishery with an overall length range of 23-32 meters, gross tonnage of 96-241 tonnes and engine power of 316-577 kW. They were licensed for two classes of mesh-sizes, 55 mm for shrimp species and 70 mm for *Nephrops*. There are also a few demersal fish trawlers (about 4 in 70 vessels) that direct 25% to 50% of their trips towards the catch of *Nephrops*[1]. The demersal fish trawlers are licensed for a mesh-size of 65 mm or greater. The Minimum Landing Size (MLS) established by the Council Regulation (EC) No. 850/98 for *Nephrops* in this region is 20 mm of carapace length (CL).

Nephrops was assessed in the ICES Working Group on *Nephrops* stocks (WGNEPH) up to 2003, moving to the Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim (WGHMM) in 2004. Due to its benthic characteristics, *Nephrops* is assessed in smaller subdivisions of the ICES Management Areas, the so-called Functional Units (FU). The Management Area Q or ICES Division IXa is constituted by five FUs: West Galicia (FU 26), North Portugal (FU 26), Alentejo or Southwest Portugal (FU 28), Algarve or South Portugal (FU 29) and Gulf of Cadiz (FU30). Due to difficulties in having landings by FU, FUs 26 and 27 are assessed together as well as FUs 28 and 29. The five FUs are managed with one TAC value for the whole area (ICES, 2006)

Up to 1992, landings from FUs 28 and 29 have fluctuated between 450 and 530 t and declined sharply afterwards to an all time low of 132 t in 1996. From 1997 to 2005, landings have increased to levels observed during the early 1990s but never attaining the levels of the 1980s. Males dominate the landings being the most exploited component of the stock, thus constituting the reference of its state of exploitation. Females reach the first maturity at 30 mm and males around 28 mm of carapace length (ICES, 2006, a). It is assumed that 25% of the individuals at age 2 are mature (ICES, 2006, b)

Results from the last assessment (ICES, 2006, b) indicate that fishing mortality for both males and females has increased steadily since 1998. Males spawning stock biomass (SSB) had a declining trend in the period 1989-95, increased in 1996-2001 and are fluctuating around the long term average since then. Female SSB shows the same but less pronounced pattern as males but increased in the last two years. The recruitment shows a clear

[1] C. Silva, 2007, unpublished, data source: General Directorate of Fisheries and Aquaculture.

increase in recent years, after a period of stability at low levels. Although the absolute recruitment values are not considered due to the retrospective pattern, this increase is in good agreement with the trends observed in surveys.

A reduction in TAC has been recommended since 1997 (ICES, 1997) and a 0-TAC or the implementation of a recovery plan since 2002 (ICES, 2002). A Sub-Group on Management Objectives (SGMOS) of the Scientific, Technical and Economical Committee for Fisheries (STECF) was formed in 2003 to address the topic of the recovery plans for southern hake and Iberian *Nephrops* stocks. This group performed simulations to evaluate different scenarios, combining two variables, recruitment and fishing mortality strategy. Several technical measures as closed areas/seasons and changes in the fishing gear design, were discussed. Due to the mixed-species nature of the fishery, changes in the fishing gear design were not considered and different patterns of selectivity were not simulated. The final proposal set the level of $F_{0.1}$ as the recovery plan target for hake and recommended a yearly 10% reduction in fishing mortality relative to the preceding year. Under this strategy, it is expected to rebuild the hake stock within 10 years. Considering that the *Nephrops* stocks were in worse condition, it was proposed to complement the reduction in fishing mortality with the permanent closure of five boxes to trawl and creel fishing (STECF/SGMOS, 2004).

In December 2005, the recovery plan for the southern stock of hake and Iberian *Nephrops* stocks was approved and started in January 2006. The aim of the plan finally adopted is to rebuild the stocks to safe biological limits within a period of 10 years, through a reduction in fishing mortality of 10% relative to the preceding year. In addition, in order to reduce the fishing mortality of *Nephrops* even further, a 3 and 4-month closed areas in the peak of the fishing season were introduced in FU 26 (West Galicia) and FU 28 (Alentejo), respectively (Council Regulation (EC) No. 2166/2005) (Figure 1).

Alterations to existing commercial trawls, designed to improve both size and species-selectivity, have been tested worldwide in crustacean-trawl fisheries. Similarly, the Portuguese Institute for Fisheries Research has carried out an extensive work on board research and commercial trawlers, on cod-end selectivity for crustaceans (Fonseca *et al*.,2007); selectivity of trawls equipped with separator mesh panels and square mesh windows (Campos and Fonseca, 2004); and grid selectivity (Fonseca *et al* 2005, Fonseca *et al*, in press).

The aim of this work is to assess the effects on landings and on the spawning biomass, of changes in technical measures, including alterations to the cod-end mesh size or mesh configuration, as well as the use of sorting grids to exclude immature *Nephrops*, in the crustacean trawl design. These analyses are made for the *Nephrops* Case Study within the project EFIMAS (Operational Evaluation Tools for Fisheries Management Options) in cooperation with the project NECESSITY (NEphrops and Cetacean Species Selection Information and TechnologY), both EU projects financed by the 6th Framework Programme

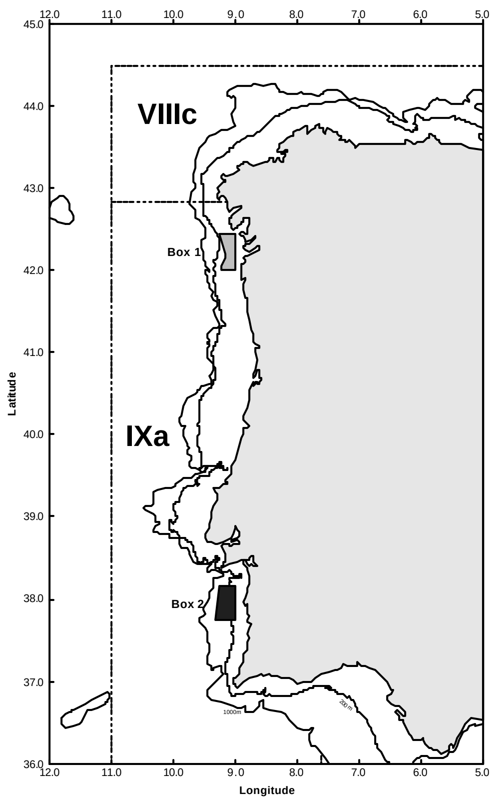

Figure 1. Temporarily closed areas for *Nephrops* (Council Regulation (EC) No. 2166/2005).

MATERIAL AND METHODS

The management advice for *Nephrops* stocks from the southwest and south of Portugal is dependent of the level of exploitation of males which according to their behaviour are subject to higher fishing pressure than females. Under this consideration, in the present study, the evaluation of the effects of changing the mesh size and/or mesh configuration was performed on the population of males.

Stock Input Data

The data source were the output derived from the assessment performed in 2006 and presented in the report of the ICES Working Group of Hake, Monkfish and Megrim (WGHMM) in 2006 (ICES, 2006).

Stock numbers-at-age 2-8+, in 2006, were those estimated by XSA assessment: the population at age 2 (recruitment) adopted was the geometric mean for 1984-2003 population estimates (10272). Population at age 3 was estimated from the survivors at age 2 in 2005 which were replaced by the same geometric mean.

Fishing mortality at age at the starting year was considered as the average fishing mortality for the period 2003-2005 estimated from the 2006 assessment.

The values of the biological parameters adopted are those used in the assessment (ICES, 2006), namely: (i) natural mortality constant for all ages and equal to 0.3, (ii) weight-at-age data from both catches and stock constant and estimated as the average weight-at-age for the period 2003-2005 and (iii) maturity-at-age constant for all the projected years.

According to the information provided by the Portuguese discards programme on board of the crustacean trawlers, the trawl codend mesh size of 55 mm is the most used by the Portuguese crustacean fleet. This is the legal mesh size to catch rose shrimp (*Parapenaeus longirostris*).

Selectivity data

The selection curves parameters used herein were obtained during different surveys aiming at the characterization of crustacean trawls size- and species-selectivity, onboard commercial vessels fishing off the Portuguese continental south coast.

Selectivity data for PET double-twine 55, 70 and 80 mm mesh size codends have been modelled by Fonseca *et al*. (2007). The L_{50} was found to vary with mesh size and twine material while the selection range was constant. Selectivity parameters for those mesh sizes, and additionally for 60 and 65 mm codends were found by using the model in Fonseca *et al*. 2007 (table 1).

Data for the square mesh codend come from a trial carried out on board the F/V 'Saturno', between 11 and 17 August 2006[2]. Twenty two hauls were carried out using an 'Euroline Premium Plus' 3.5 mm single twine codend with a mesh size of 60 mm (30 mm bar length). A logistic model was adjusted by Maximum Likelihood (ML) to the pooled data. Extrapolation to mesh sizes of 55 and 60 mm was done assuming that both selection range (SR) and selection factor (SF) were constant. These are mild assumptions since square meshes maintain their shape during the entire haul and no improvement in escape of Norway lobster is expected as mesh size increases.

The information on grid selectivity was collected during experiments on board the R/V 'Gemini', between 26 October and 11 November 2005, where 27 hauls were carried out with a grid with a selective section made of 60 mm square mesh (30 mm bar length). The square mesh section selected small Norway lobsters which subsequently escaped through an opening in the bottom panel, while the remaining catch was conduced to upper section of the grid crossing it into the codend (Fonseca *et al*., in press). The methodological procedure in estimating the selection curve followed that used for the square mesh codend, and so did the extrapolations for mesh sizes of 65 and 70 mm. For this device, overall gear selectivity resulted from grid times codend selectivity with the latter.

Methods

The evaluation of the impact on the spawning stock biomass (SSB) and on the landings produced by increasing the mesh size or changing the mesh size configuration were performed using a simulation package (CP2) developed in R (Jardim & Azevedo, 2006, pers. com). When running CP2, 500 resamples were performed, with a seed of 1254 in the random number generator. The projection period is 10 years with 2006 as the starting year.

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[2] Experiments carried out under projects NECESSITY (EU-FP6, SSP8-CT-2003-501605) and MARE – Fishing Technologies'(QCAIII 22-05-01-FDR00014)

The starting numbers for projections were sampled from a normal distribution with mean equal to the estimated stock numbers-at-age and CV of 0.4 for ages 2 and 3 and 0.2 for the older ages. Recruitment at age 2 was considered constant but subject to a CV of 0.4.

Fishing mortality at age at the starting year was sampled from a normal distribution with the mean equal to the average fishing mortality for the period 2003-2005 and a CV of 0.2 for all ages.

Uncertainties in natural mortality, maturity-at-age, mean weight-at-age in the stock and in the landings are not taken into account in this process.

The current trawl codend mesh size in use by the Portuguese trawl fleet was considered to be 55 mm, with a selectivity-at-age denoted as $s_{55,a}$.

Selectivity-at-age was estimated from the selectivity-at-length by applying the slicing technique to convert length to age groups, and then averaging the percentage retention of the lengths belonging to each age group. The von Bertalanffy growth parameters used in the slicing were L_{8} = 70 mm of carapace length and K =0.2 year $^{-1}$ (ICES, 2006). Selectivity-at-age was considered not subject to variation.

It was assumed that changes in mesh size took place in the beginning of year 2006, consequently, the F-at-age in 2006 was estimated as being proportional to the new selectivity-at-age (proportion retained), which we denote by $s_{new,a}$.: $F2006_{new,a} = F2006_{55,a} * s_{new,a} / s_{55,a}$.

The following scenarios were considered:

- Diamond mesh sizes of 70 and 80 mm
- Square mesh sizes of 45, 50, 55 and 60 mm
- Sorting Grids with 30.0, 32.5 and 35.0 mm (distance between bars) square mesh panels mounted, each one equipped with diamond codends of 55, 60 and 65 mm mesh sizes, in a total of 9 cases.

For each scenario the percentiles of 10%, 25%, 50%, 75% and 90% of the spawning stock biomass, landings in weight and in numbers were estimated for 2006-2017 period.

Mean weight of the landings was calculated dividing the landings in weight by the total number in landings, using the 50% percentile values of both. This value can be considered as an economic indicator because the price per kg increases with the individual weight.

The effects in spawning stock biomass (SSB) and landings (in weight) were estimated for each scenario and by year and expressed in percentage of change relative to the current values. These percentages were estimated with the values corresponding to the 50% percentiles.

RESULTS

Selectivity-at-age

Selectivity-at-age of *Nephrops* males estimated for the current trawl mesh size (55 mm), 70 and 80 mm diamond are presented in Table 1.

The increase in mesh size from 55 mm to 70 and 80 mm has a high impact in the proportions retained at age-groups 1 and 2. However age-group 1 is not landed so its effect is not evident. For age-group 2 the proportion retained is reduced by 34% and 64% when mesh sizes increase from 55 to 70 and 80 mm, respectively. The increase in mesh size from 55 to 80 mm reduces in 20% the retention of age-group 3.

Table 1 - Trawl diamond mesh sizes: proportion retained at age

Age group	55 mm	70 mm	80 mm
1	0.54	0.17	0.06
2	0.89	0.59	0.32
3	0.99	0.92	0.79
4	1.00	0.99	0.96
5	1.00	1.00	0.99
6	1.00	1.00	1.00
7	1.00	1.00	1.00
8+	1.00	1.00	1.00

The adoption of a squared mesh configuration reduces substantially the proportion of retained individuals at age groups 1 to 4. The 55 mm square mesh reduces in more than 50% the selectivity-at-ages 1 and 2, 64% and 55%, respectively when compared with the retention of the 55 mm diamond mesh (Figure 2). For ages groups 3 and 4 the retentions decrease by 32% and 16 %, respectively.

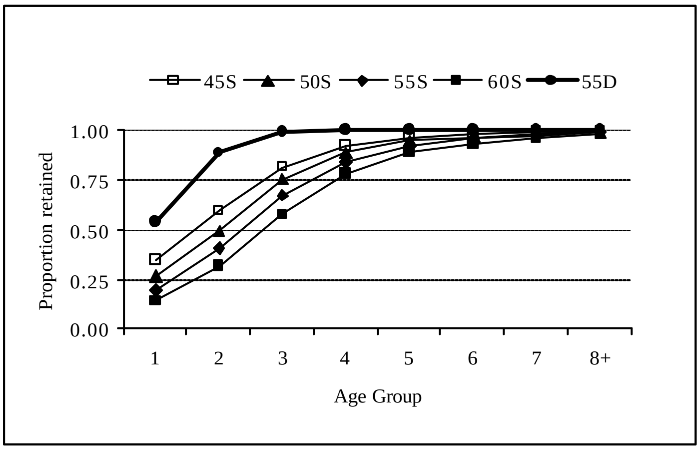

Figure 2 - Trawl selectivity-at-age for Nephrops - Square mesh size (S) and Current Diamond (55D)

The proportions retained at age, when applying the sorting grids with the diamond mesh sizes of 55, 60 and 65 mm, are presented in Figures 3, 4 and 5. The use of the grid decreases the retention of the individuals at ages 1-3. For example, if 55 mm codend mesh size is used with the three different grids, the retention is reduced, in average by 69% at age 1, 34% at age 2 and 10% at age 3 when compared with 55 mesh size without sorting grid.

The effect of the use of the three different dimensions of grids with the same diamond mesh is small but visible at age-groups 1 and 2. At age-group 3 the effect is negligible.

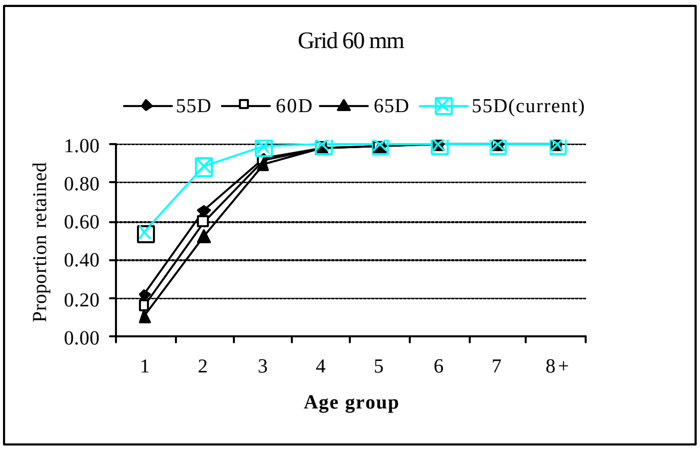

Figure 3 - Trawl selectivity-at-age for Nephrops with sorting grid (60 mm) plus diamond mesh sizes and current mesh size (55D)

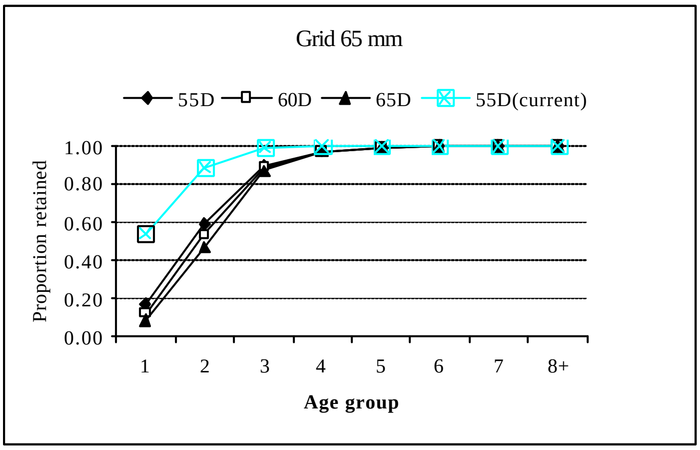

Figure 4 – Trawl selectivity-at-age for Nephrops with sorting grid (65 mm) plus diamond mesh sizes and current mesh size (55D)

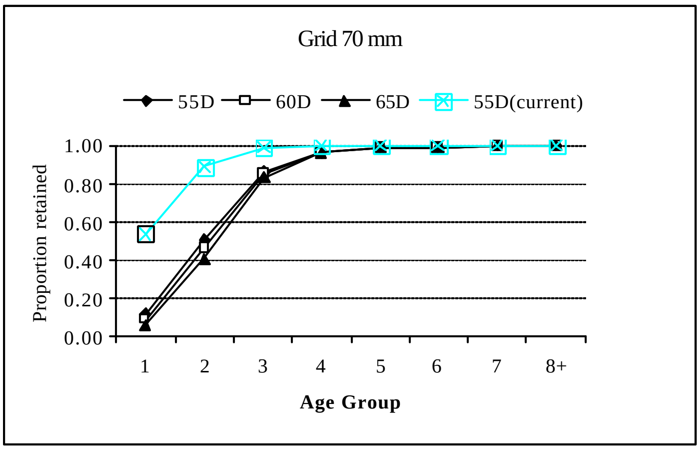

Figure 5 – Trawl selectivity-at-age for Nephrops with sorting grid (70 mm) plus diamond mesh sizes and current mesh size (55D)

Fishing mortality at age

Fishing mortality at age in 2006 for the current mesh size was calculated as described in methodology. Figure 6 shows the values of fishing mortality-at-age group expected when mesh size increases from 55 mm to 70 mm and 80 mm diamond. Fishing mortality at age group 2 is reduced by 34% and 64% if 70 and 80 mm mesh are used, respectively; for age group 3 decreases by 6 % and 20% and for age group 4 the reduction is negligible for 70 mm and 4% for 80 mm.

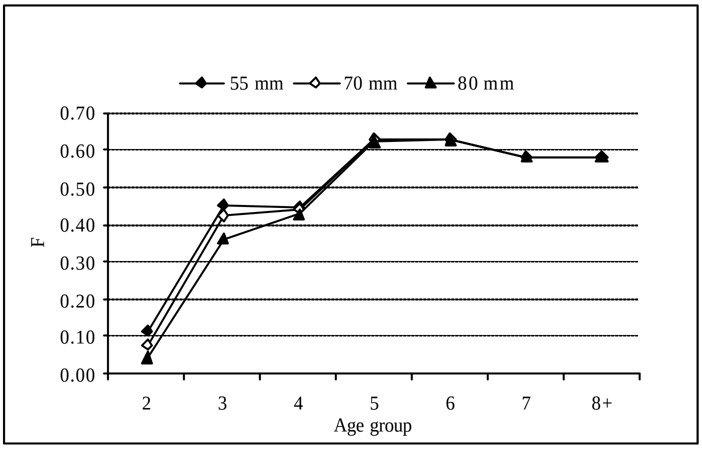

Figure 6 - Fishing mortality at-age for Nephrops – Diamond mesh size

The use of a squared mesh size configuration reduces considerably the fishing mortality at ages 2 to 4 (Figure 7). For example, the use of 55 mm square mesh size reduces in more than 50% and more than 30% the Fs-at-age 2 and 3, respectively; F-at-ages 3 and 4 are reduced by 16% and 8%, respectively. In the case of 60 mm square mesh size, the reductions on F are around 65% for age 2, 40% for age 3, 20 % for age 4 and 12% for age 5.

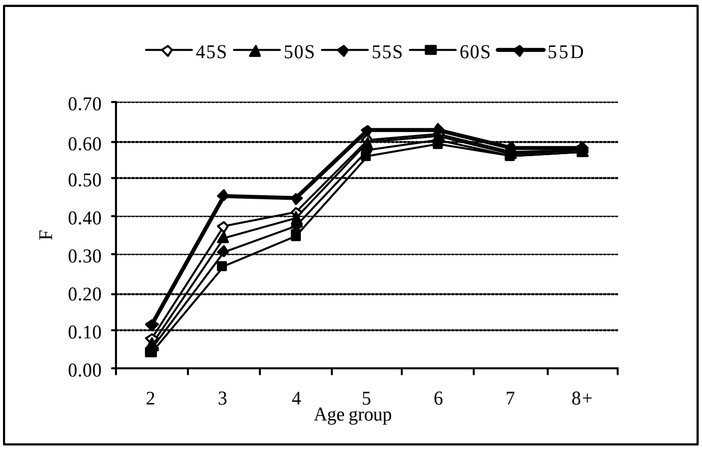

Figure 7 - Fishing mortality at-age for Nephrops – Square mesh size (S) and current Diamond (55D)

Fishing mortality at age resulting from the use of sorting grids with the diamond mesh sizes of 55, 60 and 65 mm are shown in Figures 8, 9 an 10. The use of this device decreases the F at ages 2-3. The reduction is in average 34% at age 2 and 10% at age 3 if the 55 mm codend mesh size is used with the three different grids. The effect of the use of the three different sorting grids with the same diamond mesh size is very small.

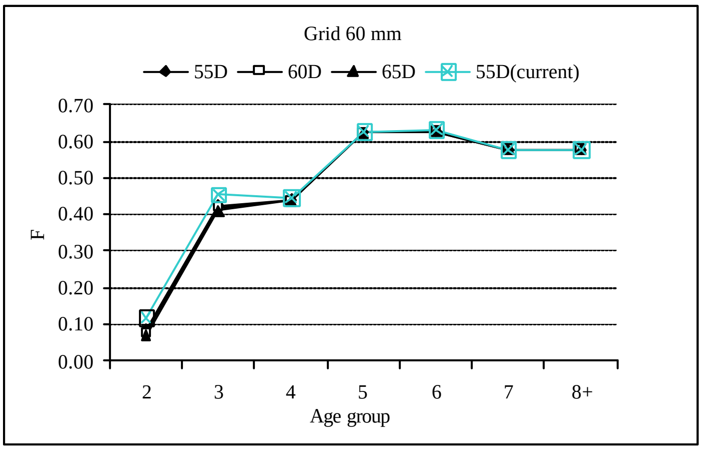

Figure 8 - Fishing mortality at-age for Nephrops with sorting grid (60 mm) plus diamond mesh sizes and current mesh size (55D)

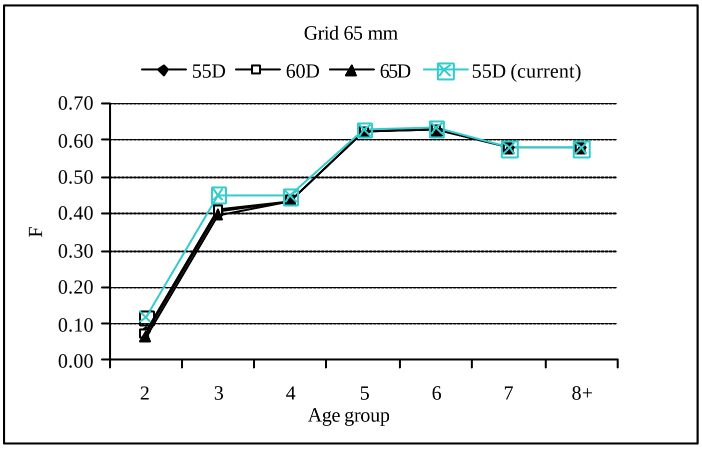

Figure 9 - Fishing mortality at-age for Nephrops with sorting grid (65 mm) plus diamond mesh sizes and current mesh size (55D)

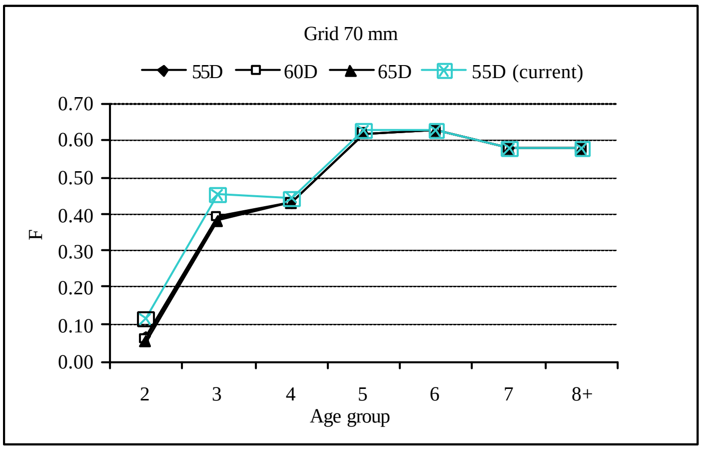

Figure 10 - Fishing mortality at-age for Nephrops with sorting grid (70 mm) plus diamond mesh sizes and current mesh size (55D)

Short and long-term effects in landings and in SSB with the current trawl mesh size of 55mm

In *status quo* conditions, e.g., keeping the current fishing mortality and mesh size, the predictions (percentiles) on landings and SSB are illustrated in Figures 8 and 9 for 2006-2016. The predictions in landings and SSB are relatively stable after the fourth year. The 2006 predictions estimates are 226 t (50% percentile) for landings and 645 t for SSB. These estimates are very similar to those indicated in the assessment for the year 2005, e.g., 230 t and 675 t, for landings and SSB, respectively (ICES, 2006, b).

Tables 2 and 3 summarize landings and spawning stock biomass changes, from the first until the fifth year, and in the long-term, relative to the first year (2006).

The results indicate a 50% probability that a decrease of 14% in landings and 15% in spawning stock biomass will occur in the long-term.

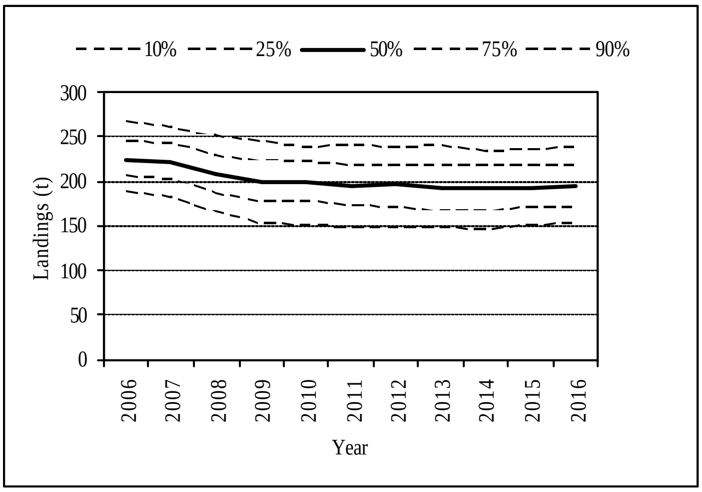

Figure 11 – Landings percentiles with the current trawl mesh size (55 mm) for male *Nephrops norvegicus*

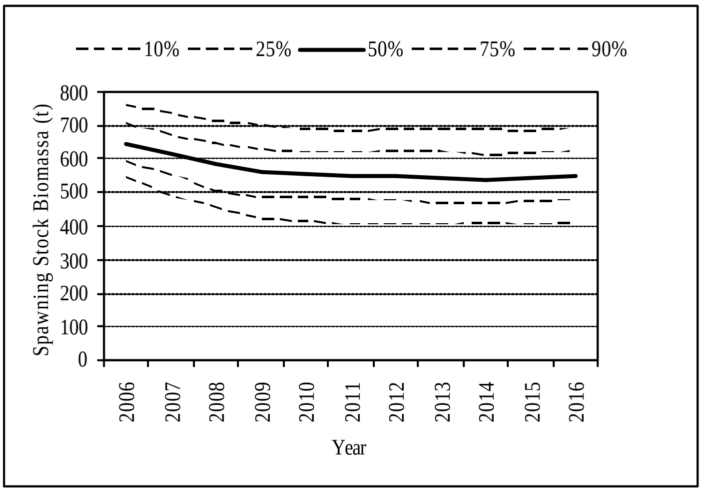

Figure 12 – Spawning Stock biomassa percentiles with the current trawl mesh size (55 mm) for male *Nephrops norvegicus*

Table 2 - Status quo: Short, intermediate and long-term effects in the landings relative to the first year in male Norway lobster (SW and S of Portugal)

Percentiles	Second year	Third year	Forth year	Fifth year	Long-term 2016
10%	-3.1	-12.2	-18.6	-20.4	-19.3
25%	-2.4	-10.7	-14.6	-15.0	-17.1
50%	-2.4	-8.0	-11.3	-11.3	-14.0
75%	-1.0	-5.7	-7.9	-9.4	-10.5
90%	-2.9	-6.8	-9.0	-11.2	-10.9

Table 3 - Status quo: Short, intermediate and long-term effects in the spawning stock biomassa relative to the first year in male Norway lobster (SW and S of Portugal)

Percentiles	Second year	Third year	Forth year	Fifth year	Long-term 2016
10%	-9.4	-16.6	-22.8	-24.2	-24.7
25%	-7.0	-15.3	-17.4	-17.8	-19.7
50%	-5.1	-9.8	-13.1	-13.9	-15.2
75%	-4.8	-8.1	-10.8	-12.0	-11.3
90%	-2.7	-5.9	-7.3	-9.3	-8.6

Effects of increase in mesh size and in mesh configuration

Table 4 shows the effects of increasing mesh size from 55 mm (diamond) to 70 and 80 mm (diamonds) and of making use of square mesh sizes of 45, 50, 55 and 60 mm.

The immediate losses in landings vary from 4% to 9%, if mesh size increases to 70 and 80 mm diamond, respectively. The use of square meshes produces higher immediate losses then the increase to diamond mesh sizes. The losses in landings in the first year vary from 8% to 21%, depending on the increase in mesh size. However after the third year, increases in landings will occur with all mesh sizes. Higher long-term gains in landings and in SSB are estimated to be obtained with the 60 mm square mesh with increases of 4% and 29%, respectively.

When using the minimum legal mesh size directed to catch *Nephrops* (70 mm) the expected increase in the long-term landings is 1% and in SSB is 6%. If the 55 mm mesh size change from diamond to square the long-term gain in SSB is 22%.

Table 4 - Short, intermediate and long-term effects in the landings and long-term effects in the spawning stock biomass (%) relative to status quo (55mm diamond) in male Norway lobster (SW and S of Portugal)

Mesh size (mm) - shape	Landings (% change)					Long-term SSB (2016) (% change)
	First year	Second year	Third year	Fourth year	Long-term (2016)	
70 - Diamond	-3.5	-1.8	-0.4	+0.6	1.4	6.2
80 - Diamond	-9.1	-5.1	-1.9	+1.3	3.5	15.3
45 – Square	-8.3	-4.1	-1.6	+ 0.4	2.1	11.5
50 – Square	-11.8	-6.1	-2.3	+ 0.5	2.5	16.1
55 - Square	-16.0	-8.8	-3.4	+0.5	3.3	22.0
60 - Square	-21.2	-12	-4.7	+0.4	4.3	28.9

Effects of using sorting grids with diamond mesh sizes

The effects in landings and in SSB resulting from changing the 55 mm diamond current trawl to the combined use of sorting grids and diamond codend mesh sizes are shown in Table 5.

The immediate losses in landings are higher when using the 70 mm sorting grid. The effects of using different mesh sizes are of the same level of magnitude (7-8%). As expected, the long-term SSB is higher when using the 70 mm sorting grid with 65 mm mesh size. There is 50% probability that SSB in the long-term increases by 13% when compared to the *status quo*.

Table 5 - Short, intermediate and long-term effects in the landings and long-term effects in the spawning stock biomass (%) relative to status quo (55mm diamond) in male Norway lobster (SW and S of Portugal)

Grid - mesh size (mm) - shape	Landings (% change)					Long-term SSB (2016) (% change)
	First year	Second year	Third year	Fourth year	Long-term (2016)	
G60_55_Diamond	-3.4	-1.7	-0.4	0.4	1.1	5.4
G60_60_Diamond	-3.9	-2.1	-0.4	0.6	1.4	6.6
G60_65_Diamond	-4.9	-2.6	-0.6	0.7	2.0	8.4
G65_55_Diamond	-4.7	-2.4	-0.4	0.6	1.7	7.6
G65_60_Diamond	-5.2	-2.7	-0.5	0.7	2.0	8.8
G65_65_Diamond	-6.0	-3.2	-0.8	0.9	2.1	10.2
G70_55_Diamond	-6.5	-3.3	-1.0	0.8	2.2	10.4
G70_60_Diamond	-6.8	-3.7	-1.1	0.8	2.5	11.1
G70_65_Diamond	-7.8	-4.2	-1.4	1.0	3.0	12.7

The use of the sorting grids with the current trawl mesh size of 55 mm produces immediate losses of 3%, 5% and 7 %, according to the increase applied in the mesh grid. The long-term increase in SSB is higher with 70 mm sorting grid (10%).

Effects in the individual weight landed

As it was mentioned in section methodology, mean weight of the landings may provide an economic indicator because the price per kg increases with the individual weight.

The analysis of this parameter was investigated for each simulation and the results, expressed in percentage relative to the mean weight of the landings with the current mesh size, are shown in tables 6 and 7.

It is expected an increase in mean weight of the individuals landed in the first year, being higher with the use of 80 mm diamond (10% increases) and with 60 mm square with 13% increase. In the long-term, the mean weight will be higher if 55 mm square mesh size is adopted (18%) or 60 mm square (25%).

Table 6 – Change in the mean weight relative to status quo (55 mm diamond)

Mesh size (mm) - shape	Mean weight (% change)				
	First year	Second year	Third year	Fourth year	Long-term (2016)
70 - Diamond	3.9	4.4	5.7	5.4	5.2
80 - Diamond	9.7	11.1	11.9	13.5	14.8
45 – Square	4.7	6.1	8.0	8.5	8.9
50 – Square	7.1	8.5	11.6	11.9	12.7
55 - Square	9.5	11.4	14.7	16.1	17.9
60 - Square	12.7	15.2	19.4	21.8	24.9

When using sorting grids with diamond mesh sizes, mean weight is expected to be higher with 70 mm grid with 65 mm diamond mesh size. In the first year the increase is around 8% and 12% in the long-term.

Table 7 – Change in the mean weight relative to status quo (55 mm diamond)

Grid - mesh size (mm) - shape	Mean weight (% change)				
	First year	Second year	Third year	Fourth year	Long-term (2016)
G60_55_Diamond	3.1	3.4	4.7	4.6	4.5
G60_60_Diamond	3.9	4.3	5.6	5.6	5.4
G60_65_Diamond	5.3	5.6	7.4	7.1	7.4
G65_55_Diamond	4.1	4.8	6.5	6.2	6.2
G65_60_Diamond	5.2	5.6	7.7	7.2	7.5
G65_65_Diamond	6.2	7.2	8.3	8.8	9.0
G70_55_Diamond	5.7	6.8	8.4	8.6	8.7
G70_60_Diamond	6.4	7.4	8.9	9.4	9.8
G70_65_Diamond	7.7	8.4	9.9	10.9	11.7

DISCUSSION AND CONCLUSIONS

The simulations performed show that if recruitment and fishing effort remain at average levels, the landings and spawning stock biomass of males of the *Nephrops* stocks from southwest and south of Portugal will decrease if the current trawl mesh size of 55 mm remains unchanged. The predictions indicate a 50% probability that a 14% decrease in long-term landings and 15% decrease in spawning stock biomass will occur.

Landings and spawning stock biomass will improve if increases in trawl mesh size take place.

In the case of increase the mesh size to 70 mm and 80 mm diamond, the estimated increases range from 1% to 4 % and from 6% to 15% for long term yield and stock spawning biomass, respectively. The short-term losses can be compensated 4 years after the increase in trawl mesh size.

If square mesh size is used then the long term yield is slightly higher with 60 mm mesh size (4% increases) then with 80 mm diamond, but the increase in spawning stock biomass is higher (29%). The short-term losses are high (21%) but it will be compensated 4 years after the increase in mesh size.

The adoption of sorting grids with the current trawl mesh size of 55 mm (diamond) can provide increase in long-term yield of 1%-2%. Long-term spawning stock biomass is expected to increase by 5%, 8% and 10%, respectively, with grids of 60, 65 and 70 mm.

The highest long-term increase in SSB (13%) is predicted to be achieved with 65 mm mesh size and 70 mm grid.

According to these results it is clear that the adoption of a square mesh would be more beneficial for the stock, although the immediate losses in landings are high.

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