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Engineering development of flexible selectivity grids for *Nephrops*

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Abstract:

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Keywords: Selectivity; By-catch; Size selection; Grid; *Nephrops*; Polyurethane; Damage resistance

Engineering Development of Flexible selectivity grids for Nephrops.

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Abstract

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Introduction

Pressure on fishing stocks has led to extensive research into selectivity devices in recent years. An ICES (International Council for the Exploration of the Sea) document provides an overview of selection gear and methods for evaluating their effectiveness (Wileman et al. 1996). Selection may be used to reduce by-catch and/or to improve size selection. Various ways of allowing juveniles to escape from nets have been investigated such as imposing larger mesh size (Briggs 1999), sieve nets (Polet et al. 2004), or escape windows (Madsen 1999). An alternative approach which appears promising is the inclusion of a grid in the net, as shown in Figure 1 for *nephrops*. Grids have been used for some years and are currently the subject of considerable research . The Fishing Technology group of IFREMER in Lorient has been developing a metallic grid for monkfish since 1993, derived from the Nordmore grid (Meillat 1994). Sea trials were performed on a commercial vessel in Spring 1996. They showed that the use of a rectangular grid in the codend could allow up to 60% of juvenile benthic fish to escape (ray, monkfish, hake, megrim). In spite of promising results with grids there remains considerable debate over the merits of different types of selection gear. In the early 1990's it was shown that for cod the selection characteristics of grids were sharper than in codend meshes (Larsen & Isaksen 1993). Graham et al reported recently (2004) that the addition of a grid in the extension reduced the selection range for haddock. However, Kvamme & Isaksen (2004) have presented results which indicated similar selection ranges for grid and codend selectivity for cod, while the NETRASEL project for *Nephrops* also concluded that, in comparison with the 70 and 80mm codend, selection grids offered no real advantage (Frid 2001). Simply increasing mesh size may therefore be adequate to achieve the required selectivity, but this may not be the case for multi-species fisheries. The clogging characteristics of inclined grids may also differ from those of codends when large catches are involved. The debate on the relative merits of different methods is still open, and will be addressed in the discussion section below, but that is not the main aim of the present paper. Here we are interested in the use of a novel approach to grid manufacture, namely the development of lightweight flexible grids, and their use for size selection of *Nephrops*. The aim of this paper is simply to show the development of a flexible grid and to present results from preliminary sea trials.

The *Nephrops* fishery suffers from a large by-catch as net mesh sizes are small for *Nephrop*s compared to white fish trawls. The combination of undersize commercial fish species and undersize *Nephrops* can be as much as 60% by number resulting in high discards. A means of separating these in the net is essential if stocks are to be maintained, and most of the work reported in this area has been concerned with by-catch reduction rather than size selection. Several recent papers discuss the use of grids for bottom trawl fishing. Isaksen (1992) showed that rigid metallic grids were effective for separating shrimp from fish. Graham (2003) used the so-called Nordmore rigid grid for by-catch reduction with brown shrimp. Polet (2002) used a similar grid design for by-catch reduction off the Belgian and Dutch coasts. He found a significant reduction in fish capture but also a 15% reduction in commercial brown shrimp. Clogging was significant in some cases and could make acceptance by the fishing industry difficult. Fonseca et al (2005) reported on the use of grids, for the Portuguese crustacean trawl industry, and also showed high rates of by-catch exclusion, but again expressed concern over loss of target species.

Various materials have been employed for this application. Initially metallic grids were used and stainless steel has proved quite efficient. However, as pointed out by Grimaldo & Larsen recently (2005) ‘steel grids have been associated with handling problems due to their excessive weight, especially in bad weather’. Eigaard & Holst (2004) also reported ‘marked signs of tear and wear’ on their grid section and recommended further research to establish the optimal design. Various plastics including polyamide, HMPE, PVC, ABS and even carbon fibre composites have been tried. Grimaldo & Larsen suggested a new grid design, the ‘Cosmos grid’, in 2005, based on fibre glass and polyamide materials but their main concern was to improve water flow to reduce shrimp losses. Within the European project EUROGRID polyamide grids were evaluated, but these were costly to produce as they were machined from thick plates. Also, in order to pass over drum rollers these grids may need to be produced in sections and hinged, and the hinge may be a source of weakness.

An internal study at IFREMER was therefore started in 2001 to examine alternative designs and materials in order to develop a damage tolerant grid without hinges. The design requirements for this application include;

- sufficient stiffness to maintain opening during fishing,
- ability to pass over the drum roller without damage,
- light weight,
- impact resistance,
- low cost.

It was initially thought that grids would need to be very stiff to maintain the spacing between bars, but trials at sea and in test tanks indicated that static loads are quite low during fishing, the most severe loading is seen during the passage over the drum at the end of the haul. This suggested that a very flexible material combined with a short bar design might be appropriate. The present paper presents a detailed discussion of the material development together with results from a preliminary campaign to evaluate this type of flexible grid for *Nephrops* in 2002.

Materials

Polyurethane (PU) was selected for this application for several reasons: First, the *Ureol* PU range developed by *Ciba* which was adopted here is well-suited to prototype development as it can be easily modified to enable a wide range of tensile properties (stiffness, strength and elongation to failure) to be obtained. This is because the system is based on several different liquid isocyanates and curing agents; by varying their proportions the polyurethane molecular structure is modified and hardness values from 30 Shore A to 65 Shore D can be obtained with the same ingredients. It is therefore not necessary to change the basic polymer chemistry. Shore hardness is widely used to characterise rubbery plastics and is measured by determining the resistance of the material to an indenter pushed into it with a special graduated tool. These values correspond to materials from very supple rubbers (the Shore A scale) to hard plastics (Shore D). Within each scale higher values indicate harder materials. The possibility to vary hardness was very important here as at the outset it was not clear what combination of stiffness and strength would be best-suited to this application. The low hardness materials are extremely flexible while increasing hardness allows improved stiffness and strength to be obtained, Figure 2. The results in this figure show nominal stress and strain values recorded in tensile tests; these are calculated as applied force divided by initial cross section and extension divided by the specimen length between grips. This follows a standard test procedure (ISO 37).

Second, there was considerable experience with this polymer in other marine applications and it was known, from a detailed internal study, that aging of the material selected would allow several years of use at sea. Laboratory aged specimens retained their strength very well after long immersion periods in artificial sea water at elevated temperatures, Figure 3. A small loss in strength was noted when tests were performed on wet specimens but specimens dried to constant weight showed no significant strength loss even after 2 years of accelerated aging. Immersion of samples at sea for up to 5 years confirmed these results.

Fabrication

A major benefit of these PU systems is that large components can be cast into moulds at room temperature and post-curing at elevated temperature is not necessary. Figure 4 shows an example. Resin components are mixed and out-gassed and then poured directly into a wooden mould. This allows design modifications to be rapidly implemented. Quite thick sections (>20mm) have been produced with very few voids.

While this fabrication method is quite adequate for prototypes and small quantities, the resin can also be injected into a closed mould once the design has been finalised. This allows larger numbers of grids to be produced more quickly and cheaply for industrial use. Following the prototype developments reported here injected grids with circular bars have been produced.

Cost is an important aspect of the overall performance of a grid. The exact price of a grid will depend on where it is produced (labour costs) and the number required (whether investment in a closed mould is economical or whether hand casting into an open mould is cheaper).

Nevertheless, based on hand casting of several grids during this development programme it is estimated that the cost of a flexible polyurethane grid will be less than half that of an equivalent machined polyamide version of the type used in the EUROGRID project. This could be reduced further if standard grid dimensions justify changing to a closed mould technique.

Laboratory Evaluation results

A series of tests has been performed in the laboratory, first to characterise the grid elements (bars), then to study the connections between these elements and finally to evaluate the complete grids.

i) Bar elements

The basic element in the prototype grid is the bar, typically a beam of rectangular section 13 by 20 mm^2. Tests were performed on these beams in flexure to examine their stiffness and failure behaviour. A three-point flexure fixture was used with a loading rate of 5 mm/minute. Figure 5 shows an example of the flexural response of a rectangular 13 mm thick 20 mm wide grid element, tested in the (thinner) direction which is the direction which must resist opening to maintain the selectivity. In addition to the material hardness the flexural rigidity is strongly dependent on the thickness and the span length, so during the design development these two parameters were adjusted, by increasing thickness and reducing span, in order to obtain a very stiff bar design. However, it is important to note that even this high hardness (Shore 50D) element did not break in flexure but deformed with the loading point until the test was stopped.

ii) Connections

The connections between the bars are potentially the weakest part of the grid. A series of connecting elements, Figure 6a, was cut from grids and subjected to various loadings including tension and torsion. The use of finite element analysis, Figure 6b, was valuable in both developing these tests (determining loading points) and in examining the influence of the radius of curvature on performance. This technique involves creating a model by discretization of the component into small elements, using commercial software (FEMLAB™ here). The material properties (such as the stress-strain plots in Figure 2) are then entered. The model can then be subjected to different loads and the response in critical areas can be examined before choosing the most suitable test configuration to highlight these.

iii) Complete grid tests

The laboratory evaluation was completed by folding tests on complete grids, Figure 7. A 100-ton capacity hydraulic test frame with a 1.5 metre course piston at the IFREMER Brest Centre was employed for these tests.

The final design of grid (Shore hardness 50D) was folded in half several hundred times but no damage was detected. Based on this experience trials at sea were initiated, using the grid described in Figure 8. This is the same as that shown in Figure 7 except for an additional escape window at the top.

Preliminary Sea Trial results

Several test campaigns with the IFREMER research vessel N/O *Gwen Drez* enabled this first version of the grid to be evaluated before proposing it to the fishing industry. The *Gwen Drez* is a 25.5 meter long research vessel, (GRT 106t, engine power 440 kW). The first tests, which will be presented here, were performed in April 2002 (during the SELMERL1 campaign) and a 20 mm spacing grid was used. These tests were intended to verify that mounting and handling were satisfactory as well as to obtain some initial selectivity data from a limited number of hauls. (Further data was obtained in the LANGRID 1 and 2 campaigns in 2003, before trials on commercial vessels began). The details of the grid mounting are given in Figure 9. The grid is inclined at 45° to the horizontal. In all cases the twin trawl technique was employed to allow a direct comparison between hauls with two nets of 70 mm as-gauged (40 mm edge) polyethylene braid mesh, Figure 10. Apart from their codends the two trawls were identical. The grid was placed in one net, as shown in Figure 11. In the other (the reference net) a fine 20 mm as-gauged mesh polyamide inner bag was placed in the codend to retain all the species entering. The grid test trawl codend was in standard 70 mm as-gauged *breizline.* The difference between the catch in the two nets thus indicates the influence of the grid together with the standard codend on selectivity.

The nets were used in the same position throughout, they were not inverted to eliminate bias as these were preliminary tests and only a short testing period was available. For each haul and both nets the *nephrops* catch was weighed and measured and certain other individual species were also weighed. A total of 6 hauls were performed, in the CIEM VIIIa Sud Bretagne sector in 90 to 120 meters water depth, each lasting on average 2.5 hours. Average vessel speed during fishing was 3.5 knots. Table 1 shows the weights caught for each haul. The rejects included large quantities of horse mackerel plus various debris. Table 2 shows the numbers of *nephrops* by length category. Figure 12 is a plot of these results for all the *nephrops* individuals versus length.

These data indicate that the grid with the 70 mm mesh codend reduces the number of juveniles caught by 88% and their weight by 87% However, it also shows that with this grid spacing the commercial catch was reduced by 61% by number and 53% by weight.

The length data for all hauls were analysed using the SELECPARA software. This is a programme using the method developed by Millar and Walsh (1990), often referred to as the SELECT (Share Each Length Catch Total) method, to fit a logistic selectivity curve to trouser trawl data. Individual hauls were not analysed due to the small quantities of catch.

Figure 13 shows the results from the statistical analysis From these data it is possible to determine the values of L50 and the selection range, Table 3. There is some scatter, particularly for the larger *nephrops,* which is not unexpected given the small number of hauls. Variance values for each parameter are also given, an approximate 95% confidence is given by an interval of plus or minus two standard deviations around the estimate (Wileman et al. 1996).

Discussion and Conclusions

The results from these first trials were very promising. The crew found the light weight of the grid (10 kg) made handling very easy. There were no concerns with damage during hauling and the grid was easily stored on the drum without requiring any particular precautions. It should be noted that drum diameters do vary between vessels, and the influence of very tight bending radii on small drums may need to be addressed. During hauling the grid does not necessarily arrive perpendicular to the drum, as shown in Figure 14, and a combination of flexure (in both width and height directions) and torsion may be imposed. However, as shown in Figure 2, there is considerable scope for improving damage resistance by reducing the Shore hardness if necessary. Subsequent experience with both this grid and alternative designs for selectivity of other species suggested that a further increase in flexibility might be advantageous for long term durability (repeated bending). This is being investigated in a current study.

The preliminary selectivity data, albeit from a small catch sample, suggest that flexible grids can provide interesting selection characteristics. The lower stiffness of the bars compared to metal can be compensated by design. Further sea trial data are clearly necessary to confirm this and quantify the selectivity characteristics. Nevertheless there appears to be a significant reduction in juvenile catch, which justifies pursuing the evaluation of flexible grids, but also an unacceptably high loss of commercial catch. These trials used a 20 mm bar spacing. A reduction would certainly be beneficial and in subsequent tests and commercial trials 18 and 15mm spacings were employed.

Polyurethane polymers offer a wide range of possibilities for fishing grids. Their light weight and ease of handling are beneficial for safety and their flexibility allows them to pass over drum rollers repeatedly without damage. Simple fabrication results in low cost and complex cross-sections (circular for example, or with improved hydrodynamic profiles) can be produced industrially.

Other studies of flexible selectivity grids being performed in parallel have indicated promising performance for other species and this work is continuing to optimise the concept.

References

Briggs RP, Armstrong MJ, Rihan D, (1999), The consequences of an increase in mesh size in the Irish Sea Nephrops fishery: an experimental approach, Fish. Res., 40, 45-53.

Eigaard OR, Holst R, The effective selectivity of a composite gear for industrial fishing : a sorting grid in combination with a square mesh window, Fish. Res., 68, 99-112.

Fonseca P, Campos A, Larsen RB, Borges TC, Erzini K, Using a modified Nordmore grid for by-catch reduction in the Portuguese crustacean-trawl fishery, Fish. Res., 71, 223-239.

Frid CLJ, (2001), NETRASEL (Nephrops trawl discard reduction using activating selection grids), European project FAIR984164, Executive summary, March.

Graham N, (2003), By-catch reduction in the brown shrimp (Crangon crangon) fisheries using a rigid sorting Nordmore grid (grate), Fish. Res., 59, 393-407.

Graham N, O'Neill FG, Fryer RJ, Galbraith RD, Myklebust A, Selectivity of a 120mm diamond cod-end and the effect of inserting a rigid grid or a square mesh panel, Fish Res., 67, 151-161.

Isaksen B, Valdermersen JW, Larsen RB, Karlsen L, (1992), Reduction of fish by-catch in shrimp trawl using a rigid sorting grid in the aft belly, Fish. Res., 13, 335-352.

Kvamme C, Isaksen B, (2004), Total selectivity of commercial cod trawl with and without a grid mounted,: grid and codend selectivity of north-east Artic cod, Fish. Res., 68, 305-318.

Larsen RB, Isaksen B (1993) Size selectivity of rigid sorting grids in bottom trawls for Atlantic cod and haddock, ICES Mar Sci Symp, 196, 178-182.

Madsen N, Moth-Poulsen T, Holst R, Wileman D, (1999), Selectivity experiments with escape windows in the North Sea Nephrops (Nephrops norvegicus) trawl fishery, Fish. Res., 42, 167-181.

Meillat, M., Dupouy, H., et al. (1994), Preliminary results of a trawl fitted with a selective grid for the fishery of benthic species from Celtic sea and Bay of Biscay. International Council for Exploitation of the sea. Fish capture committee CM1994 B:23 Ref.G. (Available from M. Meillat, IFREMER Centre de Lorient, 56100 Lorient, France).

Millar RB, Walsh (1990) Analysis of trawl selectivity studies with an application to trouser trawls, ICES CM 1990, B14, 1-14.

Polet H, (2002) Selectivity experiments with sorting grids in the North Sea brown shrimp (Crangon crangon) fishery, Fish Res., 54, 217-233.

Polet H, Coenjaerts J, Verschoore R, (2004) Evaluation of the sieve net as a selectivity improving device in the Belgian brown shrimp (Crangon crangon) fishery, Fish. Res. 69, 35-48.

Wileman DA, Ferro RST, Fonteyne R, Millar RB (eds), (1996), Manual of methods of measuring the sensitivity of towed fishing gears, ICES cooperative research report no. 215.

Haul no.		nephrops	hake	monkfish	megrim	dogfish	cephalopod	mullet	sole	diverse	reject
1	Ref.	1.5	3.6				1.2	0.4	0.1		14.2
	Grid	1	4.2	0.85			0.4	0.9	0.4	2.9	11.8
2	Ref.	5.7	2.3	2.5			0.8	0.8	0.9	3.4	27.9
	Grid	4.3	5.9	0.7			0.8	1.3	0.4	0.2	31.6
3	Ref.	18	4	7.6	1.0		2.1		1.2		38
	Grid	5.8	3.9	5.6	0.6		2.8	1.72	0.6	0.2	16
4	Ref.	19.4	12.4	6.9	2.7		7.6	1.1		2	51
	Grid	4.5	8.5	0.5	1.8	1.6	3.6	0.6	1.3	6.8	26.2
5	Ref.	7.9	6	1.4	2		5.3	0.6	1.2	1.1	21
	Grid	3.1	4.5		0.7		2.9	1.2	0.6	4.8	16.7
6	Ref.	6.7	4.5			3.3	3.7		0.2	1	32
	Grid	4.6	8.6	2.9		2.2	4.1	1.5	1.5	0.6	59
Total	Ref.	59.2	32.8	18.4	5.7	3.3	20.8	3	3.6	7.5	183.8
Total	Grid	23.2	35.5	10.5	3.1	3.8	14.6	7.2	4.8	15.4	161.1

Table 1. Campaign SELMERL1, 20mm grid spacing, all species by weight (kg).

length carapace, mm	Number TOTAL REF.	Number TOTAL GRID
10	0	0
11	0	0
12	12	0
13	0	0
14	0	0
15	12	2
16	14	0
17	48	0
18	45	3
19	44	6
20	106	7
21	74	11
22	146	22
23	224	21
24	226	43
total undersize	950	114
25	418	68
26	375	84
27	359	103
28	278	77
29	188	86
30	297	117
31	130	77
32	143	105
33	71	51
34	76	65
35	72	48
36	46	28
37	41	39
38	44	24
39	17	17
40	24	18
41	3	7
42	10	6
43	0	3
44	19	3
45	10	3
46	6	0
47	2	1
48	0	3
49	2	0
50	2	0
51	0	1
52	0	0
53	0	1
54	0	0
55	0	0
total commercial	2632	1033

Table 2. Numbers of *nephrops* versus length category, all hauls.

Parameter	Value, mm	Variance	Standard deviation
L1%	14.3	0.25	0.50
L5%	19.1	0.12	0.34
L25%	26.0	0.03	0.16
L50%	**30.8**	**0.03**	**0.17**
L75%	35.5	0.08	0.29
L95%	42.4	0.26	0.51
L99%	47.2	0.45	0.67

Table 3. Selectivity statistics, 20mm spacing grid with 70 mm codend.

Figure headings

Figure 1. Position of grid in trawl net

Figure 2. Stress-strain behaviour of different PU formulations measured on cast H-2 dog-bone specimens (insert photo).

Figure 3. Residual tensile strength of PU Shore 90A after aging in artificial sea water at 50°C for periods up to 2 years. 5 specimens tested wet, 5 tested after drying to constant weight. Error bars show standard deviations.

Figure 4. Casting into a wooden mould.

Figure 5. Flexural response of Shore 50D hardness bar element.

Figure 6. Connecting elements. a) geometry, b) FE simulation showing initial and deformed shape for load of 100N.

Figure 7. Grid on test frame during folding tests.

Figure 8. Description of grid used for sea trials.

Figure 9. Grid equipment for sea trials.

Figure 10. Details of net configuration, top and bottom dimensions.

Figure 11. View inside net showing grid mounting.

Figure 12 Total *nephrops* catch, all hauls by carapace length compared to mls (minimum landing size of 25mm).

Figure 13. Selectivity distribution, 20 mm spacing grid with 70 mm as gauged codend, versus carapace length.

Figure 14. Grid in net just before passing onto drum roller.

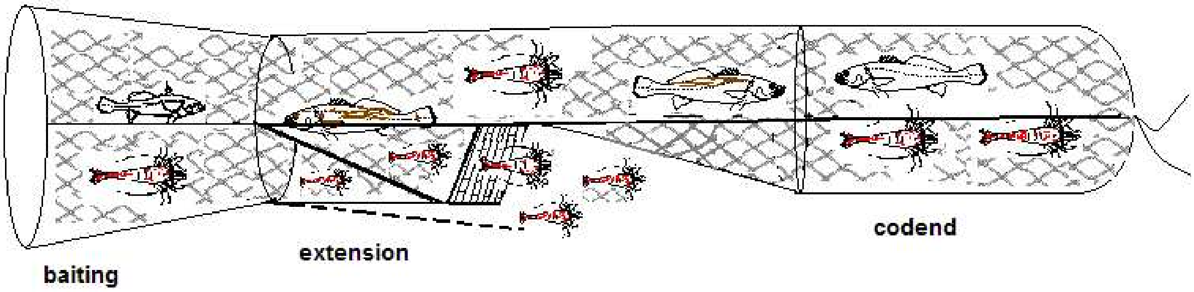
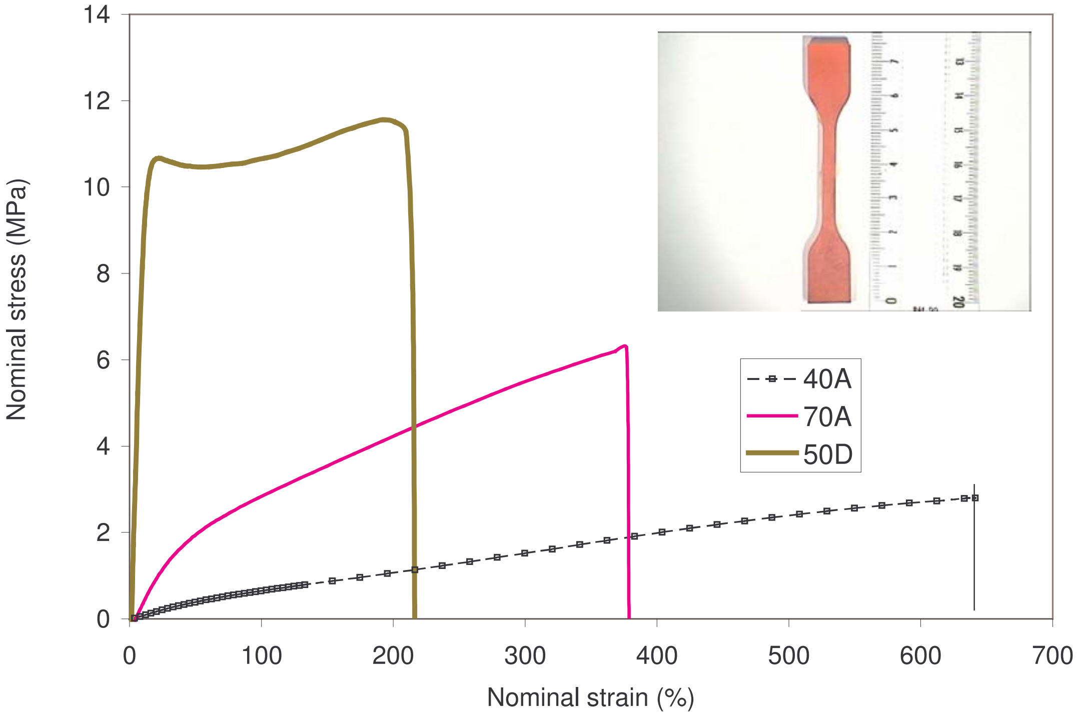


Figure 1. Schematic diagram showing the position of the grid in trawl net.



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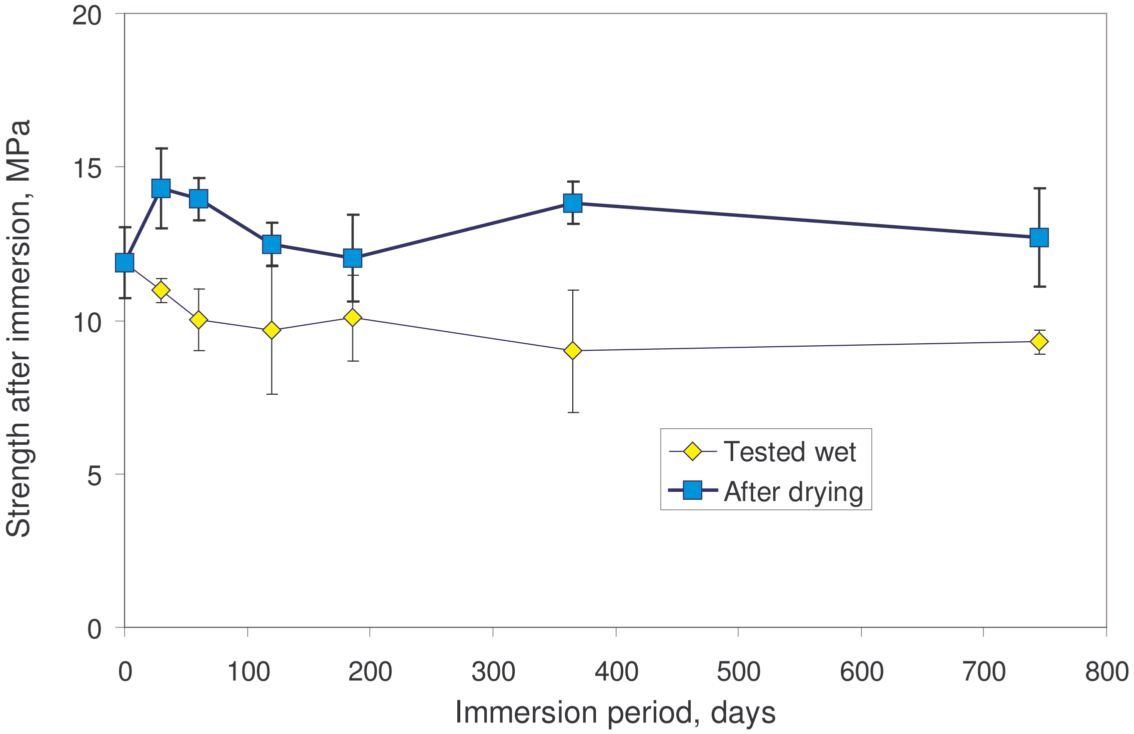

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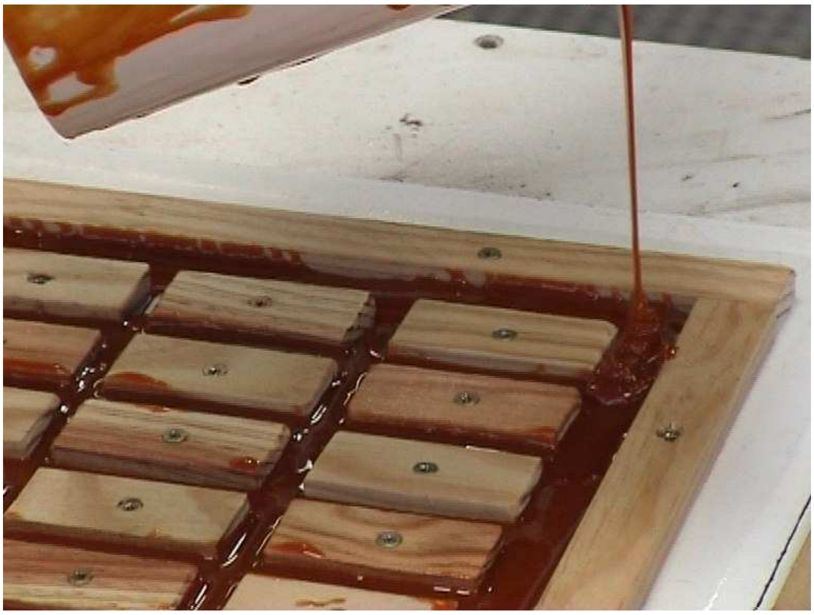


Figure 4. Casting into a wooden mould.

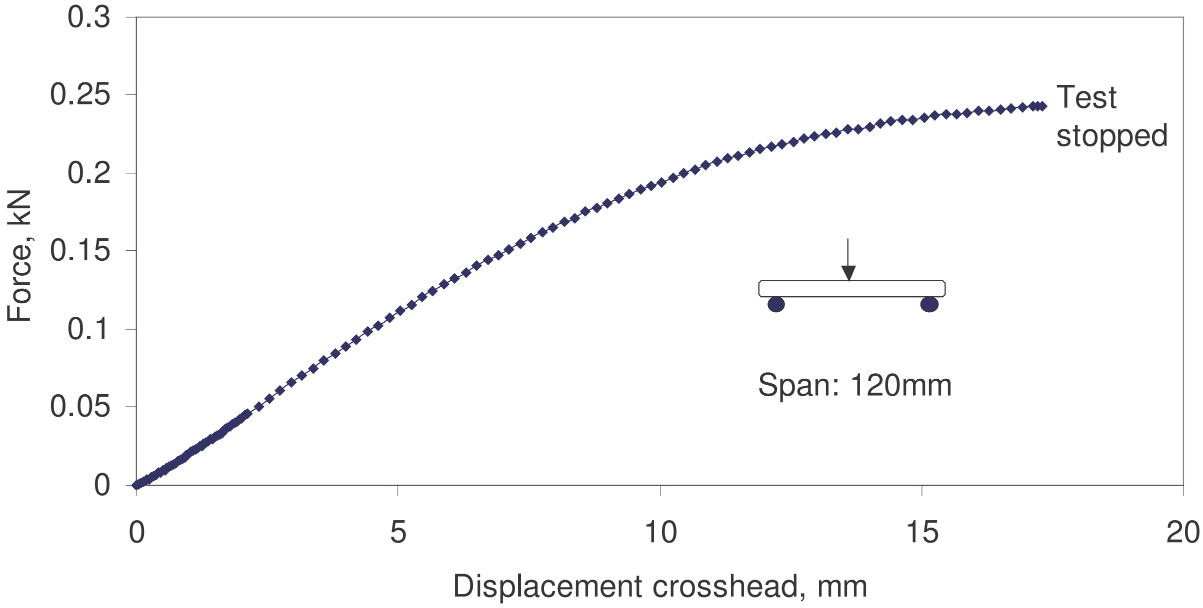


Figure 5. Flexural response of Shore 50D hardness bar element (13 mm thick).

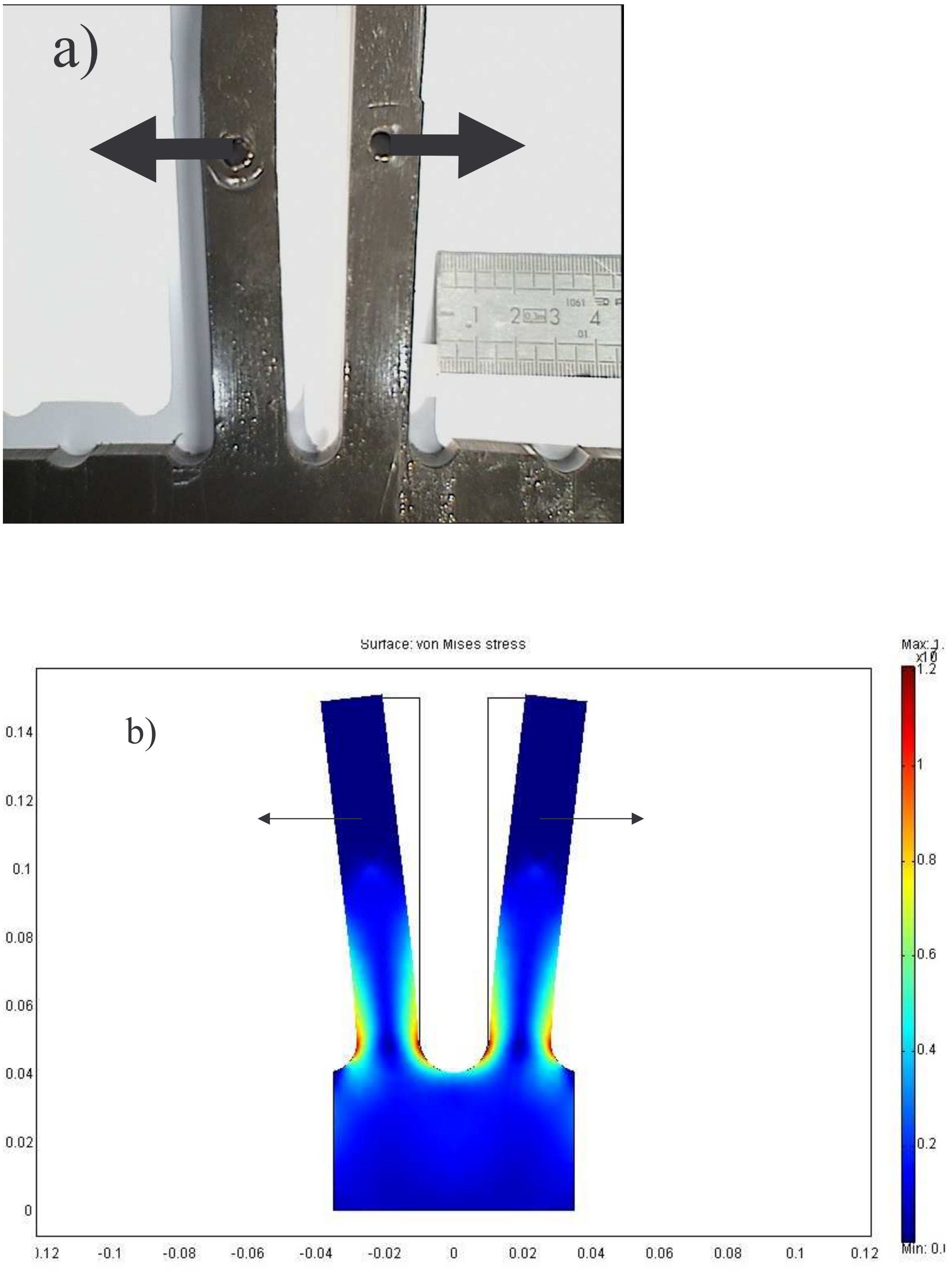


Figure 6. Connecting elements. a) geometry, b) FE simulation showing initial and deformed shape for load of 100N.

Figure 7. Grid on test frame during folding tests

Grid shape : Square

Dimensions : Width 1 m , Height 1 m

Bar spacing : 20 mm

Material : Polyurethane Shore 50D

Registered reference name: *Evaflex*

Figure 8. Description of grid used for preliminary sea trials

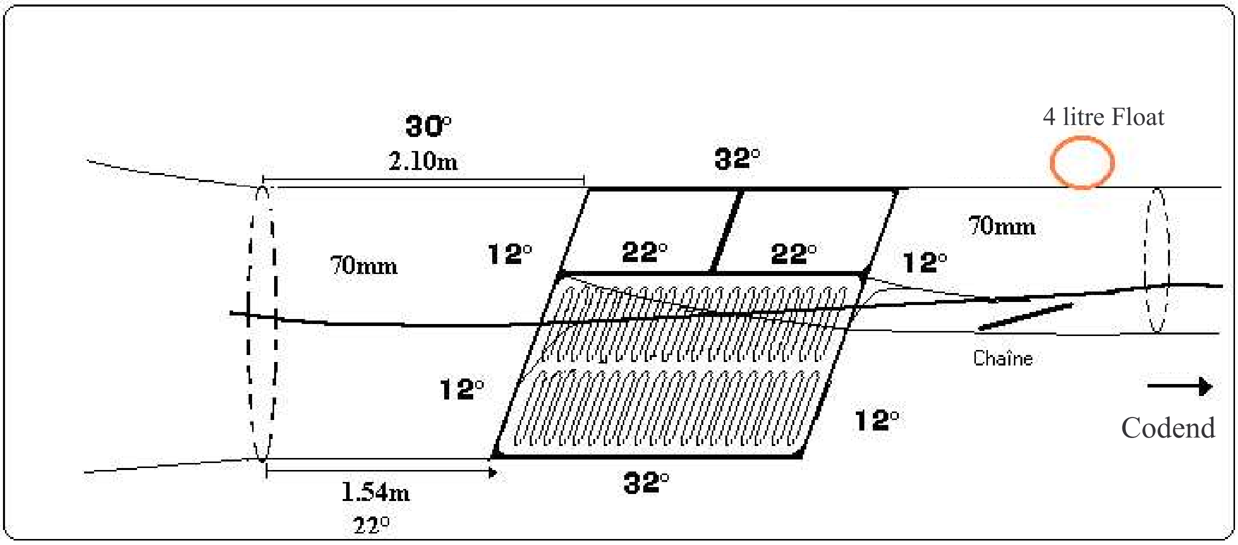
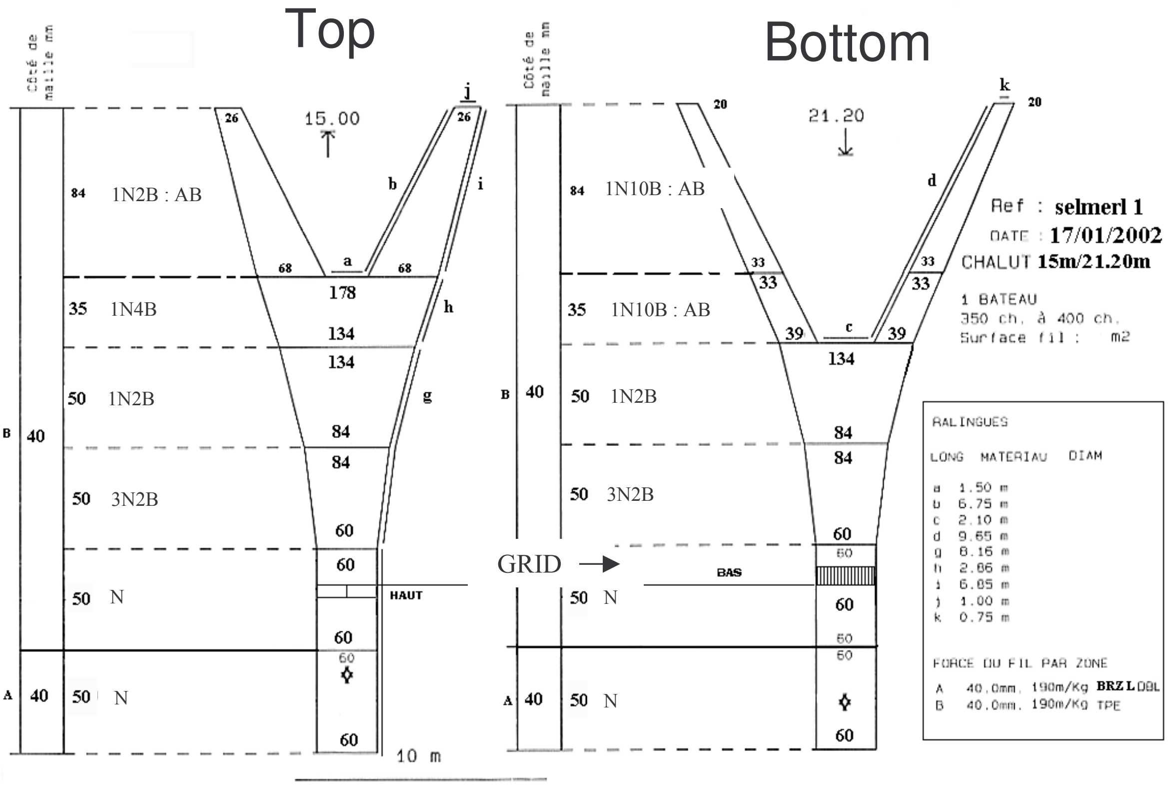


Figure 9. Grid mounting details (30° = 30 mesh units).



Ref : selmerl 1
DATE : 17/01/2002
CHALUT 15m/21.20m

1 BATEAU
350 ch. à 400 ch.
Surface fil : m2

RALINGUES

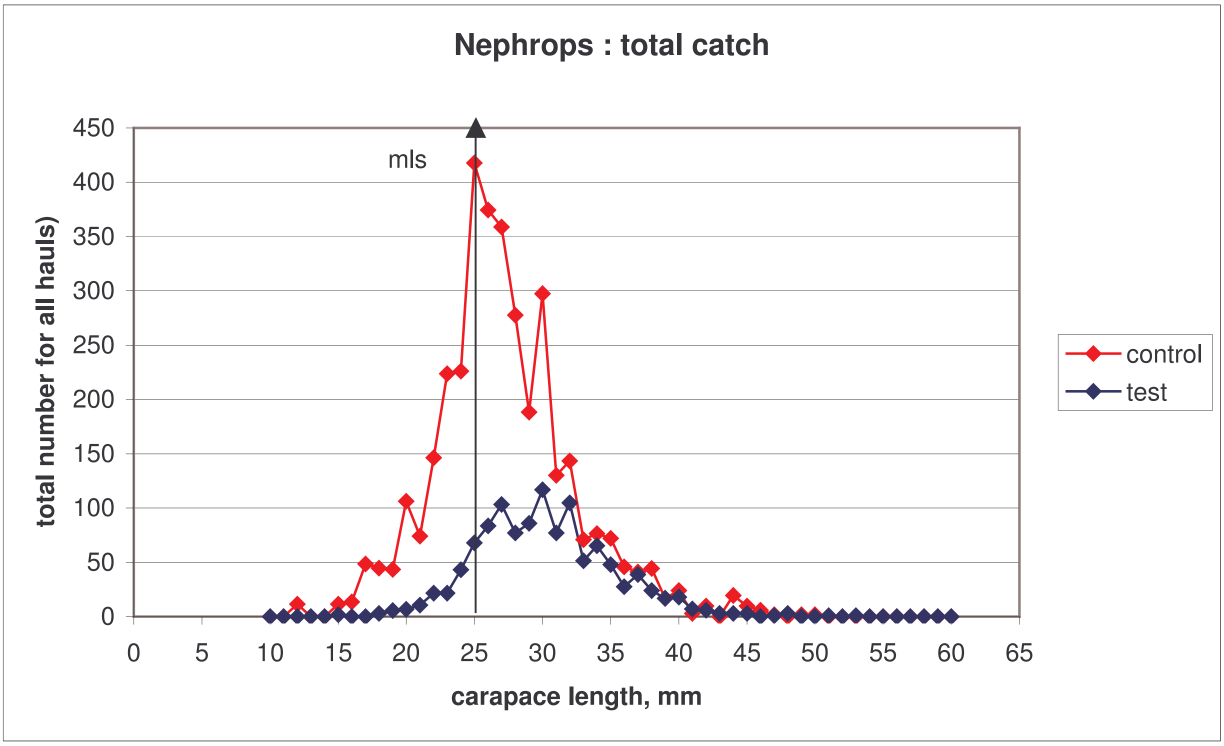
LONG MATERIAU DIAM

a 1.50 m
b 6.75 m
c 2.10 m
d 9.65 m
g 8.16 m
h 2.86 m
i 6.85 m
j 1.00 m
k 0.75 m

FORCE DU FIL PAR ZONE
A 40.0mm. 190m/Kg BRZ L DBL
B 40.0mm. 190m/Kg TPE

Figure 10. Details of net configuration, top and bottom dimensions.

Figure 11. View inside net showing grid mounting.



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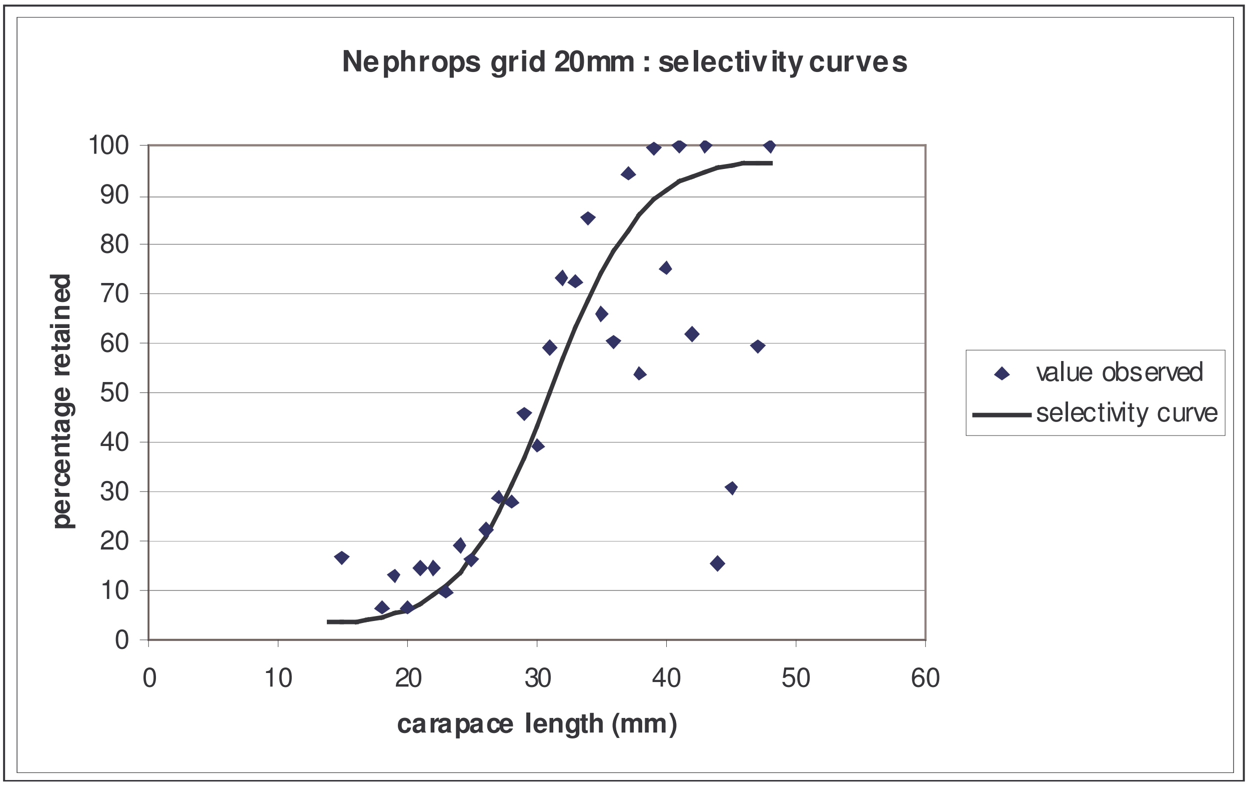

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