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6–8 February 2007

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International Council for the Exploration of the Sea

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Contents

Executive summary

- The workshop was set up to start to summarize progress in measuring and explaining *Nephrops* selectivity and to develop new analytical methods to parameterise *Nephrops* selection profiles that can be used for management purposes.
- Data from approximately 56 different data sets from 9 countries and 7 areas were collated on a haul-by-haul basis. The proportions of *Nephrops* retained in the test cod-end, relative to those retained in the test and control cod-ends combined, were plotted against carapace length.
- Parametric analysis of the data provided was difficult given the mixture of experiment types. A non-parametric analysis based on smoothers was therefore used and the relationship between the standard errors and the gear explanatory variables was modelled using a linear mixed model.
- The effects of various parameters on L50 and SR derived from a logistic model were further investigated by linear regression for the covered codend data. Parametric analysis is more powerful than the smoother-based analysis used in the meta analysis but realistically we can only apply it to covered cod-end data.
- The meta analysis carried out shows at length classes 20, 25, 30, 35, and 40 mm, three variables – mesh size, mesh shape and the presence / absence of a lifting bag – had highly significant effects on *Nephrops* selection.
- The analysis perhaps surprisingly showed twine thickness not to be a significant factor except in one specific data set. It is felt though that twine thickness remains a gear parameter that should be considered further given its implicit effect on selectivity.
- The analysis showed a significant effect of the strengthening or lifting bag on *Nephrops* selection but this result should be considered with caution. Further studies should be carried out to confirm these models predictions but also to assess whether their use is necessary from a strength and safety perspective.
- The data set on *Nephrops* selection should be explored further, particularly to investigate the robustness of the results to different modelling assumptions e.g. Bayesian techniques and to identify if there are fundamental differences between models for the square and diamond mesh codend data when analysed independently.
- There is considerable amount of catch comparison data for both *Nephrops* and whitefish selectivity in *Nephrops* trawls and this data should be further analysed by SGCOMP.
- The potential for improving *Nephrops* size selection by the use of other selective devices such as the French flexi-grid should be considered.
- Under WGFTFB a similar workshop be held to consider whitefish selectivity data from *Nephrops* fisheries.
- The modelling approach used to examine what population effects might result when implementing gear changes should be repeated with other fisheries to fully assess its value and accuracy

1 Terms of Reference

The **Workshop on *Nephrops* Selection** [WKNEPHSEL], chaired by Dominic Rihan, BIM, Ireland met in Aberdeen, UK, from 6–8 February 2007 to:

a) Update information on the selectivity of *Nephrops* gears suitable for use in assessments and stock predictions;

b) Collate selectivity data relevant to current *Nephrops* fisheries using regional or geographic grouping, if appropriate;

c) Develop models of retention as a function of length taking account of other significant variables related to gear design, catch and environmental factors, for *Nephrops* and, where possible, by-catch species.

1.1 Scientific Justification

Members of the ICES-FAO WGFTFB recently provided information and data to an ICES Workshop on *Nephrops* fisheries (WKNEPH). It was noted that in many instances there are analytical problems associated with modelling *Nephrops* size selection and much of the information was based on an ICES study group that met in 1995. Since then, considerably more data has been collected from a number of national and international programmes and the technical specifications of legislation pertaining to *Nephrops* trawls and commercial codends has changed considerably. Additionally, recent experiments have shown that on many occasions, the selection profiles of *Nephrops* do not conform to standard selection models e.g. logistic functions. As a consequence of this, data from individual hauls are disregarded from analysis to determine mean selection profiles. It is necessary to develop new analytical methods to parameterise *Nephrops* selection profiles that can be used for management purposes.

2 Participants

A total of 15 participants attended the workshop. The full list is given in Annex I.

3 Background

3.1 Overview

Traditionally, standard *Nephrops* selectivity information in terms of Selection Factor (SF) and Selection Range (SR) (ICES, 1996) has been used to make stock predictions for each functional unit for which a separate stock is recognized. These were based on early selectivity experiments in the 1960s to 1980s. As technology changes and fishing gear designs evolve there is no certainty that the same selectivity parameters will continue to be appropriate and there is a need to update the estimates.

In 1995 an ad hoc group formed by WGFTFB reviewed available *Nephrops* selectivity data relevant to current commercial gears and modelled 50% retention length (L50) and selection range (SR) in terms of codend design variables (ICES, 1995). Separate significant models in terms of mesh size were found for the data collected in the so-called northern area (Scottish, Danish, Swedish and large-mesh Belgian data) and southern area (Portuguese, Spanish and small-mesh Belgian data) on diamond mesh codends. Subsequently in 2006 the ICES *Nephrops* Working Group reported (ICES, 2006) a reanalysis of these data producing a model of L50 in terms of twine thickness and open meshes round the codend as well as mesh size and a model of SR in terms of twine thickness. These models were produced using all the data from northern and southern areas, but for polyethylene twines only – see section 3.2.

Selection of *Nephrops* is not consistent with some hauls showing a typical s-shaped or logistic curve of proportion retained against carapace length while others show little or no indication that retention is a function of length i.e. a constant proportion captured over the whole range of lengths. Unlike finfish, *Nephrops* tend not to swim actively towards meshes and may be more dependent on passive escape. Escape can be impeded by their shape and appendages, which can hook onto meshes or other animals in the trawl.

Analyses of *Nephrops* selectivity data such as those described above often omitted hauls that did not exhibit length-related selection. Only the data, which fitted the sigmoid selection curve model, would be used to produce the estimates of selection parameters. The proportion of hauls, which do not show length-related selection varies, but can be as much as 50%. The resulting models may not therefore represent true selection by commercial vessels, especially in the smaller size range of *Nephrops*. Recent experimentation has shown that this type of analysis is not robust and that *Nephrops* selectivity by diamond mesh codends can be poor. Many hauls show no length dependency with low L50's and high selection ranges. Recently methods have been developed which do not require a fit to a logistic or similar curve but make use of all the data to give a more representative model of *Nephrops* retention.

Various individual studies in the past 15 years have assessed the effect on *Nephrops* selectivity of a range of additional variables. These include other descriptors of codend design (twine material, lifting bag, extension length), environmental conditions (sea state, tide state, time of day) or the experimental process (towing speed, catch size and vessel or gear size). Furthermore, new designs of selective device such as rigid or semi-rigid grids have been tested in an attempt to improve *Nephrops* selection.

At the April 2006 meeting, WGFTFB proposed a workshop to start to summarize progress in measuring and explaining *Nephrops* selectivity. It was considered that there was an adequate body of experiments, specifically on codend mesh selectivity, throughout the European region from the Baltic to Mediterranean Seas. Although there were also trials of other *Nephrops* size selectors such as grids, each design tended to be unique and it was recognized that overall models combining a wide range of grid data would be difficult to develop.

3.2 Existing selection model

The ICES 2006 meeting of WGNEP reported a model for polyethylene codends relating L50 and SR to mesh size, twine thickness and open meshes round the circumference of the codend.

$$L50 = 28.12 + 0.447 * MS – 4.87 * Ts – 0.095 * MR$$

and

$$SR = 2.32 + 3.21 * Ts$$

where MS is mesh size in mm, Ts is equivalent nominal single twine thickness mm and MR is number of open meshes round codend circumference. For double twine with thickness Td, it is assumed that a single twine with the same total twine cross-section is equivalent, i.e. Ts = SQRT(2) * Td. Note that a somewhat different formulation is used in the current report – see definition of twine index in section 6 The formulae for L50 and SR should be used with caution and only within the range of codend designs used to derive them (see table 1). They may be derived using only hauls exhibiting length-related selection.

Table 1 *Nephrops* selectivity data from ICES FTFB Report 1995/B:2 (All PE material)

Twine Size mm	Mesh SizE MS mm	Equiv. Sinle twine size mm*	oPEN mESHES ROUND	50% RETENTION LENGTH L50mm	Selection range SR mm	Selection factor =L50/ms	No of hauls
2.5s	55.2	2.50	218	23.9	9.7	0.43	13
2.5s	60.3	2.50	200	25.7	10	0.43	11
2.5s	70.6	2.50	170	26.9	12.4	0.38	10
4s	71.1	4.00	122	26.1	8.4	0.37	6
4s	72.7	4.00	100	28.4	13.6	0.39	5
4s	74.2	4.00	143	24.5	14.7	0.33	5
4d	81.4	5.66	82	30.3	23.9	0.37	2
4d	83.2	5.66	100	28	18.7	0.34	3
4d	83.5	5.66	118	26.4	25.1	0.32	2
4d	106.8	5.66	85	41.3	15.4	0.39	5
4d	108	5.66	70	43.2	20.5	0.40	4
4d	108	5.66	100	39.7	21.7	0.37	3
2.5s	72.8	3..54	94	37.1	16.2	0.51	10
2.5s	72.9	3..54	94	37.9	16.4	0.52	10

***Equivalent single twine size for double twine is equivalent to twine thickness x √2**

3.3 Review of research, legislation and technical options

A comprehensive review of the fishing gear designs in use in all European *Nephrops* fisheries from the Baltic and Iceland to the eastern Mediterranean has been undertaken recently (Graham and Ferro, 2004). Not only are the current commercial gears in each of the major areas identified and assessed for their effectiveness in achieving size and species selectivity but also the most recent research is described and assessments made of appropriate technology to improve the exploitation pattern of *Nephrops* and the other by-catch species for each fishery. Finally the review is also a useful source of information on the legislation (current in 2003 and largely current still in 2007). The review made use of information from most of the selectivity trials whose data has been utilized by this Workshop.

4 Selectivity Data Provided

A total of 56 individual data sets were provided as follows:

1) Denmark (4 trials)
2) UK-England (3 trials)
3) Ireland (3 trials)
4) Italy (3 trials)
5) Portugal (11 trials)
6) UK-Scotland (14 trials)
7) Sweden (9 trials)
8) France (2 trials + 6 trials with flexi-grids or Square mesh windows)
9) Norway (1 trial)

The selectivity is shown in Annex 3 for all hauls used in the subsequent analysis. Of the data provided 40 data sets were for diamond mesh codends in a mesh size range from 45–120 mm with twine thickness from 2.5 mm–6 mm single and 4 mm–6 mm double. The remaining 9 were for square mesh codends in a mesh size range from 43–68 mm with twine thickness ranging from 1.8 mm–4 mm single and 3.5 mm double twine. For the purposes of this analysis codends were split into those constructed in Polyamide (PA) and those made in Polyethylene (PE). No differentiation was made between the different types of PE e.g. low tenacity, high tenacity, Brezline or compact twine as this was considered irrelevant for the modelling analysis although it should be stressed, that there are undoubtedly differences in selectivity between such materials and standard PE given their increased flexural stiffness.

Some additional older data sets e.g. Scottish data which were available and had been included in the original 1995 FTFB analysis, were omitted from this data analysis as it was considered these codends were not representative of codends in common use by the commercial sector and therefore not comparable. Other data sets that had been included in the 1995 analysis e.g. Portuguese and Swedish data were included, however, as codend construction had not changed significantly in the intervening period. After this initial analysis a number of French cruises were omitted from the data as a flexible grid (See Section 9.10) designed to size select *Nephrops* was used but were not considered compatible with the other tests.

5 Description of Gears & Methodologies By Area

5.1 Overview

The following sections provide brief descriptions of the gear types and methodologies used for collection of data by area. This is designed to illustrate the differences between the different data sets and also helps to illustrate the rationale for the meta-analysis methodology used, as described in Section 6.

5.2 The Kattegat/Skagerak Area (FU 34)

All of the Swedish gear tests bar two were carried out on board commercial vessels and using conventional low headline (1–2 m) *Nephrops* trawls. Gear tests "sw 49.4PA" and "sw 70PE" were, however, carried out using a non-typical higher headline trouser trawl. Trawl groundgear used in all cases was generally 4 to 8′′ rubber discs that are normally used in commercial practise. Strengthening or Lifting bags are used by the majority of vessels in the Swedish *Nephrops* fisheries in the Skagerak/Kattegat area.

A 294 kW commercial twin-trawler was used for all of the Danish sea trials. The gear is hauled to the stern but the codends are emptied into a forward hatch. For the trials conducted in 2005, the trawls used were 'Kile trawls' with a nominal mesh size of 100 mm and 320 meshes in circumference. The ground gear consisted of wire with rubber discs. For the trials conducted in 2006, a low headline 'Combi trawl' measuring 480 meshes round (80 mm) and with nominal mesh sizes of 200 mm in the upper wing, 100 mm in the lower wing and 80 mm in the belly was fished. Ground gear consisted of chain and lead and no tickler chains. Strengthening bags are not used in Denmark. Covers were used in the experiments in 2006 and they were kept open by use of kites and weights as described by Madsen et al. (2001). The other experiments were conducted using the twin-trawl method.

5.3 North Sea (FU 67 9)

There are 2 common designs of 2-panel *Nephrops* trawl used by the Scottish fleet. A dual purpose fish/prawn trawl is used in the mixed fishery for *Nephrops*, gadoids and flatfish, particularly in the North Sea and has longer wings and higher headline height compared to traditional prawn trawls. The latter are used mainly on the West coast of Scotland where the fishery targets *Nephrops* alone with only seasonal by-catch of gadoids. In the North Sea most *Nephrops* vessels are capable of fishing twin-trawls, usually with a 3-warp system. Many vessels haul the gear to the stern but empty the codends into a forward hatch which requires a 10–20 m long parallel-sided netting section (extension) between the tapered part of the net and the codend. In the Scottish selectivity trials, dual-purpose twin-rigged nets were used on all trips. Typically the maximum diameter of rubber discs at the centre of the groundgear was 200 mm. Strengthening bags are universally used by Scottish fishermen targeting *Nephrops* in the North Sea. The twin-trawl method was used in all cases.

For the one Norwegian cruise for which data was available, the twin-trawl method was used with the control trawl fitted with a small mesh retainer codend. The twin-rig trawls used were from Skagerak trål og Notbøteri (similar to Cosmos Danish Trawl) with 100” Thyborøn Doors and 1500kg centre roller clump. These trawls are typical low opening two-panel trawls but it should be noted that they have short extensions in comparison to those used buy other fleets i.e. Scotland, but is typical of Norwegian and Danish vessels fishing in the Skagerak and North Sea. The Norwegian fleet considers it unnecessary to have long extensions, even though the codend handling is similar to that of other fleets e.g. the codends are emptied in a fish hopper situated well forward in the vessel. When taking the codends forward for emptying, they simply run the belly sections off the net drum, this is similar to the practice of the Danish fleet.

5.4 Bay of Biscay (FU 23, 24)

All data for FU 23, 24 was provided by IFREMER from selectivity trials carried out onboard IFREMER’s RV Gwen Drez using the twin-trawl method. Between 2002 and 2005, eight gear tests were carried out in total in the Bay of Biscay. Standard two panel French style *Nephrops* trawls with 15 m-headline and rubber disc footropes were tested. These nets are of a fairly simple construction with short extensions and are as used extensively by fishermen from the port of Concarneau and were of the same design as used for testing square mesh and large mesh panels during 2001 as part of the EU’s Hake Recovery Programme. Two trials aimed to measure the selectivity of standard 70 mm mesh size x 4 mm double twine polyethylene (Brezline) codends, without strengthening bags, which are prohibited under French National legislation. The rest of the experiments concentrated on testing flexible grids installed in the extension of standard *Nephrops* trawls with the same 70 mm codends. For the experiments the control trawl had a 20 mm small mesh liner was inserted inside the commercial codend.

5.5 Mediterranean (GFCM-17)

All of the Italian selectivity trials and the visual observation tests were carried out on the RV “G. Dallaporta” (810 kW at 1650 rpm, LOA of 35.30 m and 285 GT) using the covered codend method. The gear utilized during the most recent experiments was a typical Italian bottom trawl used in the Central Adriatic Sea. These bottom trawls are generally made of knotless polyamide netting and have a low vertical opening (around 1.5 m). All the other gear components coincided with the common commercial practice used in the Central Adriatic bottom trawl fishery. In light of the netting materials used at present by the Mediterranean fishing industry, two codends having the same mesh opening (around 44 mm) but different mesh structures, diamond and square mesh were made. The two codends had the same nominal circumference (around 3 m). These two codends were used for experimental trials at sea, in order to study the effects of inserting square mesh panels in the Adriatic *Nephrops*/Shrimp fisheries for the reduction of hake by-catch. A third diamond mesh codend with larger circumference (around 3.8 m) was produced and tested at sea. However, the codend mesh configuration (diamond or square-mesh) was considered the most important factor and particular emphasis was placed on it in terms of number of hauls. Strengthening bags were fitted on all occasions as these are used universally in Italian fisheries.

5.6 South Portuguese Waters (FU 28, 29)

Six sets of covered-codend selectivity experiments were carried out by IPIMAR, between 1993 and 2006, resulting in a total of 175 hauls (with *Nephrops* catches). The gear trials were conducted onboard the R/V Noruega and two commercial F/V (fishing vessels), using standard Portuguese long winged 4–panel crustacean trawls constructed in braided PE with rope wrapped footropes. These trawls have an effective headline height of between 1–2 m. Mesh sizes ranging from 55 to 80 mm (4 nominal stretched sizes, including the legal minimum mesh size for *Nephrops* target fisheries, 70 mm) were tested, with no stengthening bags. Additional variables considered to affect size selectivity were analysed including a change of mesh configuration (from diamond to square mesh shape) and type of twine (PA versus PE).

5.7 West of Ireland (FU 17)

In FU17 where the Irish trials were carried out, traditional low headline (<2 m) *Nephrops* trawls constructed in single polyethylene twine of 80 mm in the bottom wings, bellies and 160 mm top wings and square with 80 mm top bellies were used. Although fish are taken using this type of trawl, they are predominantly designed to target *Nephrops*. The ground substrate in the area in which the trials were carried out is predominantly soft mud, so groundgears used are constructed with light rubber discs. Codends are usually of 80 mm mesh size with 6 mm single PE twine and strengthening bags are universally used. All experiments were carried out on a commercial trawler using the twin-trawl method with the control trawl fitted with a 40 mm small mesh codend.

5.8 West of Scotland (FU 12)

The gear and methodology used for these trials were virtually identical to that used in the North Sea trials.

6 Meta Analysis of *Nephrops* Selectivity Data

Prior to the workshop an excel template document was circulated for provision of data on a haul-by-haul basis and also for defining all the variables that might influence selectivity e.g. mesh size, twine thickness, twine material, codend circumference. Such variables were considered potentially important from a modelling perspective. Each individual data set was then assigned a unique reference number by country, mesh size, material, twine thickness, single or double twine, presence or absence of a cover bag, number of meshes in the circumference, length of vessel and mesh shape e.g. DE 68.93 PA 3 1 N 100 21 SQ.

Annex 4 shows the data plotted by country, gear, and haul. The proportions of *Nephrops* retained in the test codend, relative to those retained in the test and control codends combined, are plotted against carapace length. The gear code is a combination of country, mesh size, material, twine thickness, number of twines, presence of a lifting bag, number of open meshes round, boat length and mesh shape. The data arise from a mixture of covered codend and twin-trawl experiments, which can be inferred by looking at whether the proportions retained approach 100% (covered codend) or 50% (twin-trawl) at large lengths. Many hauls, particularly those using the twin-trawl method, show little evidence of any change in retention with length.

Parametric analysis of the data would be challenging given the mixture of experiment types and the lack of a clear selection curve for many of the twin-trawl experiments. A non-parametric analysis based on smoothers was therefore used. A smoother was fitted to the data for each haul (Annex 4) and a mean curve was then estimated for each gear with at least three hauls. Annex 5 shows the mean curves with pointwise 95% confidence bands.

The conventional way of summarising the mean curves would be to use the L50 and selection range. In Annex 5, the dashed horizontal line at 50% can be used to estimate the L50 for covered codend experiments and shows where we would expect the mean curve to asymptote for twin-trawl experiments. The dashed line at 33% can be used to estimate the L50 for twin-trawl experiments (provided that the mean curve asymptotes at 50%) and there are some gears where this is convincing (e.g. IR 103 PE 6 1 Y 100 26 DIA). However, there are quite a few gears where the L50 cannot be estimated (because the mean curve does not cut the 50% or 33% lines) and many more where the selection range cannot be estimated. For example, some of the Scottish gears with thick twine have mean curves with confidence bands that straddle the 50% line at large lengths, but where the mean curve appears to be still increasing.

Instead, the mean curves were summarised by the logit of the fitted retention probabilities (and their standard errors) for each length class in turn. For simplicity, consider length class l and let pg be the fitted proportion for gear g at length l (as plotted in Annex 5). For covered codend data, the estimated retention probability is simply pg, the logit of which is given by

$$\alpha_g = \log\left(\frac{p_g}{1-p_g}\right)$$

The standard error of αg, denoted σg, arises automatically from the fitting procedure which is done on the logistic scale. For twin-trawl data, assuming the mean curve asymptotes at 50%, the retention probability can be estimated as

$$\frac{p_g}{1-p_g}$$

the logit of which is given by

$$\alpha_g = \log\left(\frac{p_g}{1-2p_g}\right)$$

The standard error of αg can now be approximated using a Taylor series expansion. Sometimes pg >0.5 which leads to retention probabilities >1; in such cases, the retention probability was set to 0.99 and αg calculated accordingly. For length classes outside the range of the data, αg and its standard error were estimated by extrapolation.

The relationship between the αg and the gear explanatory variables was then modelled using a linear mixed model of the form

$$\alpha_g = \text{explanatory variables} + \gamma_g + \varepsilon_g$$

where γg is a between-gear random effect, assumed to be normally distributed with standard deviation τ (common across gears) and where εg is a within-gear random effect, assumed to be normally distributed with known standard deviation σg. First a ‘full’ model was fitted to the data:

α ~ mesh * shape * bag + twine-index + material + cover + log-catch + log-meshes-round

where

- mesh is the mesh size (continuous)
- shape: square or diamond mesh (categorical)
- bag: lifting bag present or absent (categorical)
- twine-index = twine-thickness if single twine or twine-thickness × 60.25 if double twine (continuous)
- material: PA or PE (categorical)
- cover: covered codend or twin-trawl (categorical)

- log-catch: the log of the mean total catch for that gear (continuous)
- log-meshes-round: the log of the number of open meshes round (continuous)

and where * denotes interactions. The model was then simplified in a backwards stepwise fashion using Wald tests.

Preliminary analysis showed that the Italian data had high leverage, having the smallest mesh size; the largest number of open meshes round, and very high retention probabilities in relation to other gears. The Italian data were therefore treated as a special case and omitted from the Meta analysis.

Further analysis at length classes 20, 25, 30, 35, and 40 mm, showed that three variables – mesh size, mesh shape and the presence / absence of a lifting bag – had highly significant effects on selection. In general, retention at a particular length decreased with mesh size, was lower for square mesh than diamond mesh and higher when there was a lifting bag. There was no strong evidence of any interactions, or of any main effect of any other variable. Therefore, for stock predictions, the model

$$\alpha \sim \text{mesh} + \text{shape} + \text{bag}$$

was fitted to each length from 9 to 65 mm (in steps of 2 mm). The parameter estimates are given in Table 2. At small lengths, the mesh size effect became non-significant and then changed direction: positive coefficients were set to zero and the model refitted. Conversely, at large lengths, the bag effect became non-significant and then changed direction: negative coefficients were set to zero and the model refitted.

There are inevitably caveats to the analysis:

- Many explanatory variables were correlated: in particular, most gears with PA netting or with thin twine or tested in Southern waters also had relatively small mesh (≤ 70 mm). Mesh size is thus a proxy for all these variables.
- Most of the covered codend data are associated with mesh sizes ≤ 70 mm. Thus any differences in retention due to experimental methodology are also partially confounded with mesh size and would be hard to detect.
- Most square mesh experiments used mesh ≤ 70 mm, so care should be taken when using the parameter estimates in Table 2 not to extrapolate too far outside the range of the data.
- The lack of a significant relationship does not mean that an explanatory variable has no effect. For example, analysis of the Portuguese data revealed a strong twine-index (thickness) effect. These data were collected using covered codends and thus gave more precise estimates of retention than were typically obtained from twin-trawl experiments.
- There is a case for undertaking the analysis separately for square and diamond mesh codends. Some interaction terms were considered but few found to be significant. However, it is not clear whether interaction terms would take full account of the difference in effect that some variables would have on square and diamond mesh codend selectivity. For example, meshes round is defined in a rather different way for the two mesh shapes.

From a statistical perspective, the greatest failing in the analysis is the somewhat ad-hoc estimation of the retention probabilities from the twin-trawl experiments. A parametric analysis of the covered codend data is described in Section 7. However, a parametric analysis of the twin-trawl data would probably require many gears to be omitted before models would converge. Bayesian techniques might provide the best chance of developing a coherent model of both the covered codend and twin-trawl data.

Table 2. Parameter estimates from meta analysis. Retention probabilities are given by exp(y) / (1 + exp(y)) where y = constant + m * (mesh–80.6) + s * I(shape = square) + b * I(bag = present) where I is the indicator function that equals 1 when true and 0 when false.

LENGTH	CONSTANT	M	S	B
9	-3.12	0.0000	-0.22	1.91
11	-2.80	0.0000	-0.28	1.77
13	-2.47	0.0000	-0.35	1.62
15	-2.13	0.0000	-0.43	1.48
17	-1.76	-0.0028	-0.57	1.37
19	-1.39	-0.0070	-0.73	1.24
21	-0.99	-0.0116	-0.93	1.14
23	-0.59	-0.0163	-1.12	1.05
25	-0.12	-0.0242	-1.34	0.89
27	0.36	-0.0303	-1.58	0.79
29	0.79	-0.0359	-1.80	0.66
31	1.18	-0.0407	-1.99	0.52
33	1.55	-0.0450	-2.14	0.38
35	1.87	-0.0489	-2.24	0.24
37	2.15	-0.0516	-2.28	0.12
39	2.41	-0.0539	-2.29	0.00
41	2.72	-0.0565	-2.29	0.00
43	3.21	-0.0593	-2.17	0.00
45	3.55	-0.0599	-2.02	0.00
47	3.87	-0.0611	-1.90	0.00
49	4.21	-0.0620	-1.83	0.00
51	4.50	-0.0645	-1.80	0.00
53	4.75	-0.0695	-1.79	0.00
55	5.01	-0.0752	-1.80	0.00
57	5.27	-0.0812	-1.81	0.00
59	5.52	-0.0859	-1.82	0.00
61	5.69	-0.0930	-1.76	0.00
63	5.86	-0.0996	-1.68	0.00
65	6.03	-0.1050	-1.55	0.00

7 A parametric analysis of the covered codend data

50% retention length

The effects of various parameters on L50 and SR derived from a logistic model were further investigated by linear regression for the covered codend data. Parametric analysis are more powerful than the smoother-based analysis used in the meta analysis but realistically we can only apply it to covered cod-end data, because a parametric curve could often not be fitted to much of the twin-trawl data. The Italian data were removed as they deviate from the rest in terms of e.g. lower mesh sizes, smaller catches, higher codend circumference, thinner twine and twine material mostly of PA. Three hauls having the largest impact on the regression models were also removed, namely hauls no. 32, 34 (Danish data), and 300 (Swedish). This analysis is based on the remaining 247 hauls; 34 from DIFRES Denmark, 47 from IMR Sweden and 166 from IPIMAR Portugal. Of those hauls, 80 were taken with square mesh codends, 36 with lifting bags and 198 with PE twine. Twine thickness and codend circumference were excluded as they were correlated to mesh size (R2 >0.6).

The *Nephrops* catches were normalised by taking the third root of the weight. The following model in table 3 describes the effects on L50:

Table 3. Parameter estimates for L50 for *Nephrops*

COEFFICIENTS:	ESTIMATE	SE	T-VALUE	PR(>|T|)	
(Intercept)	25.378	2.119	11.975	< 2e-16	***
mesh.codend	0.029	0.034	0.843	0.39985	
ShapeSQ	-4.645	6.855	-0.678	0.49864	
root3.*Nephrops*	-2.474	0.365	-6.786	8.90E-11	***
Duration	0.015	0.005	2.853	0.00471	**
mesh.codend:shapeSQ	0.249	0.110	2.264	0.02447	*

Codend mesh size and shape affects L50 significantly. The non-significant main effects in the precence of interaction indicate some masking of effects. In the absence of tow duration and *Nephrops* catches from the model, i.e. only looking at physical measures of the codend, mesh size (and the interaction term) becomes insignificant. There are marginal effects of mesh size on selection, but it should be noted that mesh size is positively correlated to codend circumference and twine thickness, which again are likely to have negative impact on selection, and thereby L50. Figure 1 shows the predicted L50s for diamond and square mesh codends.

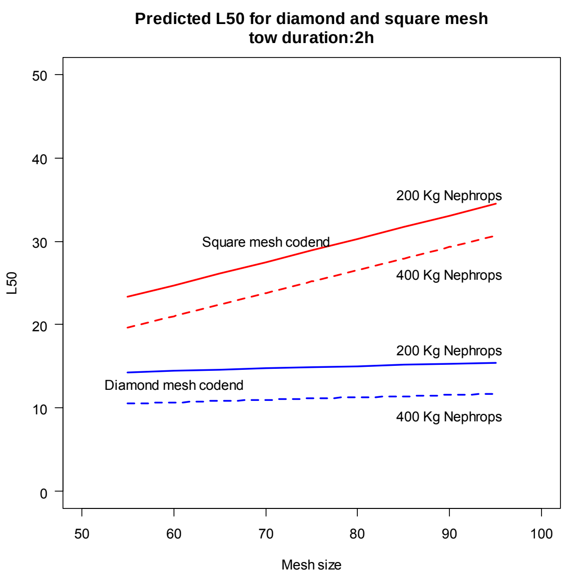

Figure 1: Predicted L50 for diamond and square mesh for a tow duration of 2 hours

Selection range

Codend mesh size, shape and *Nephrops* catches affect the selection range (SR) significantly. Increase in mesh size appears to result in wider SR for both square mesh and diamond codends. Also, there seem to be some interaction between effects of *Nephrops* catches and mesh sizes, with bigger catches resulting in wider SR's for larger mesh sizes, but narrower SR's for smaller mesh sizes. The paramerter estimates are shown in Table 4 and Figure 2.

Table 4. Parameter estimates for SR for *Nephrops*

Coefficients:	Estimate	SE	t-value	Pr(>|t|)	
(Intercept)	10.164	2.603	3.904	1.23E-04	***
mesh.codend	-0.020	0.040	-0.497	6.19E-01	
shapeSQ	19.136	3.784	5.057	8.44E-07	***
root3.*Nephrops*	-4.894	1.083	-4.521	9.68E-06	***
mesh.codend:shapeSQ	-0.215	0.0610	-3.521	0.000515	***
mesh.codend:root3.*Nephrops*	0.078	0.0156	4.999	1.11E-06	***

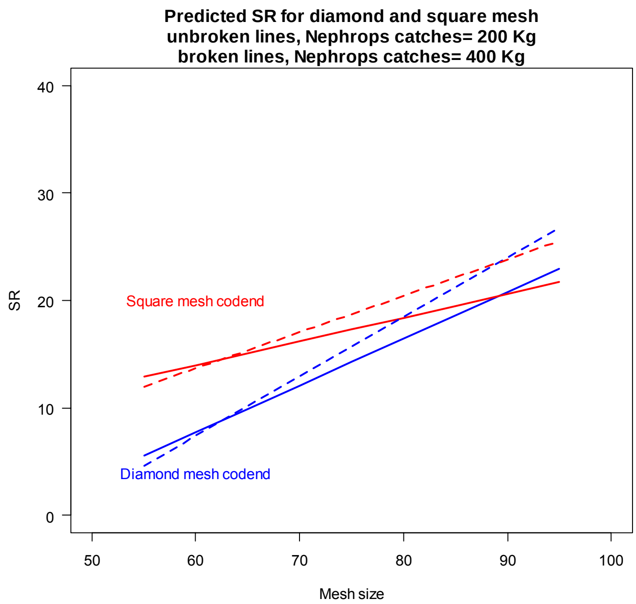

Figure 2. SR described as a function of mesh size, mesh shape and *Nephrops* catches.

8 Stock Predictions

The new estimates of selectivity (proportions retained) at length derived using a modelling approach but without assuming any particular underlying selectivity model (see section 6), provided an opportunity to examine what population effects might result when implementing gear changes. As a preliminary trial, the simple length based assessment method based on the principles of Length Cohort Analysis (LCA) was employed. Various implementations of this approach (the LBA programs) were used previously by the ICES *Nephrops* WG (eg WGNEPH, 2003). In its original implementation, the program allows the simultaneous evaluation of mesh and effort changes from ‘the current position’ (=baseline) using yield per recruit principles to calculate long (and short) term gains and losses in landings and stock biomass. In the approach, the absolute numbers contained in the length composition used for analysis is not important, rather the shape of the length distribution is the important feature. Selectivity in the original program is assumed to follow a typical selectivity ogive.

For this study, the LBA program was modified to read in vectors of proportions retained at length for as many mesh changes as required. Length composition data were available for a number of populations .For comparison, analysis was performed on three of these where the size compositions and existing mesh sizes are different. In each of these cases, four different gear options were compared against the baseline (no change) scenario. Owing to the different biological parameter values of males and females, separate assessments were performed although in future a combined approach would be more helpful for informing management. Parameter values for the males and females in the three stocks were taken from the ICES

Nephrops WG and average length compositions for a recent period were generated for each stock.

Table 5a summarizes the baseline, and gear options for the Firth of Forth, Bay of Biscay and Skagerak example populations. Predicted output (table 5b) following the changes is shown as a percentage change (+ve or –ve) from the baseline for the long-term effect (of the order of 10 years although most of the change occurs in the first 3) and the short (1 year effect). Predictions of the effects on landings and biomass are shown side by side. The results are also shown graphically in Annex 6.

These examples are given mainly to illustrate the use to which the selectivity model may be put and therefore should be treated with caution. Some characteristics are noticeable, however. In the short term improving selectivity has a greater negative effect on landings of females than of males and smaller positive effect on female biomass.

In all the gear options chosen, a positive effect on biomass is seen – as expected – but it is only for males in the long term that there may also be a positive effect on landings. In most cases, the increase in biomass does not counteract the loss of marketable *Nephrops* due to the selectivity increase.

Of the gear options applied to the Firth of Forth fishery it appears that a very modest change (option 2), removing the lifting bag may have the best outcome for the fleet in terms of overall landings, despite the fact that the biomass benefits considerably more from the more selective options 3 and 4. In the other two fisheries, the 70 mm square mesh codend option with no lifting bag appears to achieve the better overall landings in the long term. These particular options show some short-term losses (at least for females), however. Finally for the same technical change, stocks in the Firth of Forth and Bay of Biscay have more potential for improvement in the long term, reflecting the relatively poorer selectivity of current gears in these areas compared to the Skagerak.

Table 5a Options for changes from a current typical baseline gear chosen to illustrate the effects on biomass and landings in 3 areas. Mesh shape is diamond unless indicated as square (sq). Twines are either single (s) or double (d). Presence of a lifting bag is denoted by y (yes) or n (no).

Area	**Firth of Forth**				
	Baseline	Option 1	Option 2	Option 3	Option 4
Mesh size mm	80	90	80	70sq	120
Twine size mm	4s				
Lifting bag	y	y	n	y	n
Area	**Skagerak**				
	Baseline	Option 1	Option 2	Option 3	Option 4
Mesh size mm	90	100	110	70sq	120
Twine size mm	5d				
Lifting bag	n	n	n	n	n
Area	**Bay of Biscay**				
	Baseline	Option 1	Option 2	Option 3	Option 4
Mesh size mm	70	80	90	70sq	100
Twine size mm	4s				
Lifting bag	n	n	n	n	n

Table 5b Percentage change in landings and biomass from baseline gear with different gear options

FIRTH OF FORTH						FIRTH OF FORTH					
Percentage change in landings from baseline						Percentage change in Biomass from baseline					
Gear Option	Base	1	2	3	4	Gear Option	Base	1	2	3	4
	80/y	90/y	80/n	70sq/y	120/n		80/y	90/y	80/n	70sq/y	120/n
Short term (1 yr)	Male	-0.5	1.3	-7.2	-15	Short term (1 yr)	Male	3.4	7.7	20.3	33.3
	Female	-4.7	-7.1	-26.7	-42.1		Female	1.7	4.1	9.5	14.8
Long term	Male	2.6	11.6	15.2	25.5	Long term	Male	5.2	12.9	36.4	70.5
	Female	-1.3	5.5	-10.1	-17.6		Female	5.1	14.9	32.4	56.5

Bay of Biscay						**Bay of Biscay**					
Percentage change in landings from baseline						Percentage change in Biomass from baseline					
Gear Option	Base	1	2	3	4	Gear Option	Base	1	2	3	4
	70/y	80/n	90/n	70sq/y	100/n		70/y	80/n	90/n	70sq/y	100/n
Short term (1 yr)	Male	-0.1	-1.3	-13	-4.2	Short term (1 yr)	Male	4.3	9.5	32.6	16
	Female	-3.5	-8.8	-33	-16		Female	2.2	5	16.2	8.1
Long term	Male	5.4	11.4	39.4	17.8	Long term	Male	8.4	19.5	81	34.5
	Female	1.8	2.5	0.9	1.3		Female	11.2	25.5	102.2	43.6

Skagerak						**Skagerak**					
Percentage change in landings from baseline						Percentage change in Biomass from baseline					
Gear Option	Base	1	2	3	4	Gear Option	Base	1	2	3	4
	90/n	100/n	110/n	70sq/n	120/n		90/n	100/n	110/n	70sq/n	120/n
Short term (1 yr)	Male	-2.1	-5.8	-4.3	-12.3	Short term (1 yr)	Male	1.9	4.5	5.3	8
	Female	-4	-10.1	-8.7	-19.2		Female	1.1	2.4	3	4.1
Long term	Male	4.1	8.2	14.3	11.3	Long term	Male	6.7	16.7	18.5	32.2
	Female	1.7	2	7.9	-0.3		Female	4.9	11.5	14.7	20

9 Discussion

9.1 Mesh Size and Shape

The 1995 WGFTFB analysis concluded that it was probable that an increase in mesh size will result in a higher L50 for *Nephrops*. That report also indicated *Nephrops* selectivity is sensitive to technical changes in the gear such as increasing the number of meshes in the codend circumference, switching from single to double twines, increasing twine thickness and a change to stiffer, compact or high tenacity netting materials. The meta analysis carried out at WKNEPHSEL has shown that at length classes 20, 25, 30, 35, and 40 mm, that the three variables of mesh size, mesh shape and the presence / absence of a lifting bag have highly significant effects on selection. Thus the meta analysis confirms that mesh size and shape affect *Nephrops* selection but provides no strong evidence of any interactions, or of any main effect of any other unbalanced e.g. twine thickness/material although the data sets used are highly variable as described in Section 6.

9.2 Strengthening or Lifting Bags

Very little is known about the effect of lifting bags on the selective properties of the codend and therefore the significant effect of the lifting bag obtained in this analysis is an interesting outcome. Limited studies by Briggs (1981, 1983) in the Irish Sea, in fact, showed there to be no significant difference in *Nephrops* size distribution caught by nets with and without a lifting bag, although the results are based on only a small number of tows. Similar work in French waters by Charuau et al. (1982) suggested that a lifting bag steepens the *Nephrops* selection ogive but does not affect the selection factor. This steepening of the ogive means the selection range is reduced but no satisfactory explanation is put forward other than it may be a factor of how the lifting bag is rigged. It should be noted that the main purpose of lifting bags is to strengthen the codend and to prevent it from bursting when the trawl is hauled on board. In recent years, however, with the advent of much stronger twines and materials for codend construction, the likelihood for damage is perhaps reduced. Given that this analysis has shown that lifting bags significantly reduce codend selection for *Nephrops* their continued use should be tested not only for the differences in selection parameters but also to include an analysis of the safety implications on board vessels if they were removed.

9.3 Twine Thickness

The results from the main analysis showing twine thickness not to be a significant factor in *Nephrops* selection when taking all the data sets combined was considered surprising by the workshop participants. This result may therefore reflect the variability of the data, more twin-trawl than covered codend data used and also a lack of dedicated selectivity experiments specifically testing differences in selection with twine thickness. As part of the preliminary exploration of the data, the Portuguese data were analysed alone and a strong twine effect was identified. The data was collected using covered codends and thus gave more precise estimates of retention than were typically obtained from twin-trawl experiments.

Apart from the data used at WKNEPHSEL, few other studies can be found that either support or contradict the results from the meta analysis. Graham and Ferro (2004) in their review of the *Nephrops* fisheries of the Northeast Atlantic and the Mediterranean indicate that the twine used in the construction of codends can also influence selectivity on the basis of studies by O'Neill (2002) that showed restricting either the number of individual twines, the twine thickness or the twine stiffness reduces the mesh resistance to opening. The effect of twine thickness was assessed by Anon. (2000) during a series of catch comparison exercises carried out in the Irish Sea on board an Irish vessel. Codends of 80 mm x 3.5 mm single twine was tested against 80 mm x 6 mm single and 80 mm x 8 mm single twine. Comparing the catches with the 3.5 mm codend, the 6 mm and 8 mm twine thickness codends caught 34% and 38% more *Nephrops* respectively, although no measurement of selectivity was carried out during these trials. Sala et al. (2006) also demonstrated that the twine thickness of the codend netting played an important role in selectivity by substantial reducing the selectivity with increased twine size for all species considered.

It was generally agreed by the workshop participants that twine thickness remains a gear parameter that should be considered further given its implicit effect on selectivity and even though the analysis has shown it to be significant in only one specific case.

9.4 Other Gear Variables

Codend circumference (meshes round) was not found to be significant in the meta analysis and there are few studies specifically looking at the effect of codend circumference. Work by Larsvik and Ulmestrand (1992) did suggest that codend circumference might have a significant impact on *Nephrops* selection with both square mesh and diamond mesh codends but there is only limited data available to support this theory.

The effect of extension length was also considered but due to the resolution of the data it was not always possible to establish this from all of the data sets. Similar to codend circumference no specific studies looking at the effects on *Nephrops* selection of increasing extension length can be found. Anon (2002) does report on trials carried out to measure the effect of extension length on the selectivity of a 110 mm mesh codend in a whitefish trawl but no differences in catches were found and no differences in selection for haddock recorded. This would suggest extension length is unlikely to have an effect on *Nephrops* selection.

The effect of different materials i.e. PA and PE was not found to be significant in the meta analysis. Polet and Redant (1994) report that the L50 for a PA 70 mm codend was higher than a PE 90 mm codend and suggest that this may be due to the effect of the softer PA material. Briggs review, *Nephrops* selection (1984), quotes the following: “Charuau (1979) found no difference but says that catch effect may have masked any material effect”. Pope and Thomas (1965) present results showing much higher selection factors for PA than for manila and cotton.

9.5 Operational, Vessel Characteristics & Catch Size

Operational variables such as towing speed and vessel characteristics relating to vessel length and horsepower were considered but neither proved to be significant or the resolution of the data was such that nothing could be inferred. No specific work has been carried out to assess the effect of towing speed on *Nephrops* selection. Anon (2002) does report on one set of trials carried out to determine the effect of towing speed on the selectivity of whitefish in a 110 mm codend but no changes in selectivity were noted. Parameters such as towing speed, even if they were found to have a significant effect, are difficult to record accurately and in most cases are noted as average towing speeds over the course of a tow and in reality from a management perspective are impossible to effectively enforce.

Similarly the effects of vessel characteristics were felt to be difficult to analysis given the differences between vessels and the number of parameters that would need to be recorded. Again they have limited relevance for an analysis of this type.

Catch size was also considered but as the majority of the data was provided from tows with low catch rates due to the fact that tow duration was generally shorter than average tow duration for experimental purposes and catch rates not comparable with typical commercial catches. According to French studies (Charuau, 1978), mesh configuration has been found to change as the retained catch in the codend increases, allowing the escape of small animals from an area in front of the bolus of the catch. This study found selection factor was directly affected by the weight of catch in the codend. Studies by Briggs (1981. 1983) in the Irish Sea also demonstrated that a full codend reduced the number of escapes through codend meshes. The effect of catch size, however, as with the other parameters described above is impossible to regulate and therefore from a management perspective has limited relevance.

9.6 Catch Comparison Data

It was recognised by the workshop participants that a considerable amount of catch comparison data for both *Nephrops* and whitefish selectivity in *Nephrops* trawls which has considerable value but has not be considered by this group. The data should be further analysed by the SGCOMP set up under WGFTFB.

9.7 Sex Selectivity

An analysis of the Italian data for which sex had been recorded did not show any significant difference in selectivity between male and female *Nephrops*. This, however, should be treated with caution given that only limited data from one area were available.

9.8 Environmental Factors

Environmental factors such as tides, currents, light levels, temperature and weather may have an effect on selectivity and several studies by Abbas and Earluzel (1970) and Polet and Redant (1994) have shown some evidence that selection factor increases in bad weather. For this analysis, however, due to a lack of accurate data or data recorded at sufficient resolution in many trials these factors could not be considered.

9.9 Selectivity devices

The majority of trials carried out have investigated changes in *Nephrops* selectivity as a result of changes in mesh size, twine thickness, meshes in the circumference or other modifications to the codend. It is important, however, to note that IFREMER in France have also carried out extensive trials with a flexible grid in the extension piece of *Nephrops* trawls, purposely to improve *Nephrops* selectivity. Due to the fact that the selectivity estimates provided included both selection by the grid and the codend, these results were not considered compatible with the other tests and were therefore omitted from this meta analysis. It is interesting to note, though, that the tests with two types of grids with bar spacing ranging from 13 mm to 20 mm and with a square or cylindrical section, gave increased L50's e.g. with a 20 mm bar spacing, the L50 was increased from 26.5 mm with a 70 mm codend to 35.8 mm with a 70 mm codend and grid. Trials also indicated that the cylindrical bars provided better selectivity results than the square ones, for the same bar spacing. This work was prompted by the fact that discarding of *Nephrops* by the French fleet has been reported to be substantial (ICES, 1999) due to a MLS of 35 mm Carapace Length being set by the French fishermen's organisation and warrants further investigation in other *Nephrops* fisheries. A short review of these trials is included in Annex 7.

9.10 Whitefish selectivity in *Nephrops* trawls

At the workshop, information on the design of any selectivity devices e.g. square mesh panels or grids etc. fitted to gears used in the trials was collated by country. This information is summarised in Annex 8. The collation of this information indicated that there are in fact a myriad of different devices being used and given that these devices have different characteristics and improve selectivity for different species, it was felt that it would be very difficult to develop a similar retention model. There was also the added complication that in gears with selectivity devices fitted for demersal fish species there is often a dual selection process from the device and also the codend.

Eight institutes provided information about the non-*Nephrops* species that had been measured on the different cruises. Also information on additional selective devices that are often included in *Nephrops* gears in order to improve selectivity of fish was collected. For all gear types with additional selective devices, estimation of selectivity parameters is complex and to a large degree depends upon assumptions on the chance of contact between the individual and the selective device.

Five institutes have collected fish data from a total of seventeen gear types without additional selective devices. Seven of these gears had square mesh codends, while diamond mesh codends were used in the remaining gears. A total of nine species were measured, of which seven were collected by at least two institutes and from both square and diamond mesh codends.

The additional selective devices used in these experiments can be separated into two main groups; grids and square mesh panels (SMP's). The grids are either designed to deflect fish by-catch as is the case for the Swedish experiments carried out by IMR or to improve size selectivity of *Nephrops* as is the case for data from IFREMER in France. The square mesh panels were either positioned in the centre of the top panel (BIM, DIFRES and IMR-SE) or in the sides of the top panel (IFREMER).

Three institutes have conducted experiments with a 120 mm SMP positioned 6 to 9 meters from the codline in 90 mm diamond mesh codends. With this one exception, the additional selective devices are very different both in dimension, position and function and a comparison between the selectivity of the devices was therefore deemed to be not feasible at this workshop but should be considered at a later date.

10 Conclusions

10.1 General Conclusions

WKNEPHSEL concludes that the variability in results from *Nephrops* selection experiments, make analysis of the data difficult and the principal factors affecting size selection are still poorly understood. Unlike finfish, *Nephrops* tend not to swim actively towards meshes and may be more dependent on passive escape. Escape can be impeded by their shape and appendages, which can hook onto meshes or other animals in the trawl.

Although there may be no reason at present to improve *Nephrops* selection from a biological perspective, there is still a need for management to improve the selectivity for the whitefish by-catch in many fisheries where there are problems with whitefish discards. Therefore research into ways of improving selectivity in *Nephrops* trawls should concentrate on the selection of by-catch species, except in cases where a specific *Nephrops* discard problem is identified by Stock Assessment Working Groups. *Nephrops* selectivity experiments should be more targeted in the future to deal with specific problems in fisheries.

10.2 Meta Analysis

The meta analysis carried out seems an appropriate modelling technique for this type of variable data set but needs further refinement given the somewhat ad-hoc estimation of the retention probabilities from the twin-trawl experiments. Bayesian techniques might provide the best chance of developing a coherent model of both the covered codend and twin-trawl data. It was also concluded that it would be important to collate information from this workshop on how experiments should be structured in the future to ensure that there is consistency amongst data from individual countries and allow similar analysis to be more valuable, as differences in data make these type of analysis often misleading.

WKNEPHSEL, however, notes that the analysis has shows at length classes 20, 25, 30, 35, and 40 mm, three variables – mesh size, mesh shape and the presence / absence of a lifting bag – had highly significant effects on selection. In general, retention at a particular length decreased with mesh size, was lower for square mesh than diamond mesh and higher when there was a lifting bag. There was no strong evidence of any interactions, or of any main effect of any other variable. Thus the meta analysis confirms the findings of earlier analysis of *Nephrops* selection data in that mesh size and shape effect *Nephrops* selection.

The results from the analysis showing twine thickness not to be a significant factor when taking all the data sets combined was considered surprising by the workshop participants. It should be noted, however, that the analysis of the Portuguese data did reveal a twine thickness effect. This data was collected using covered codends and thus gave more precise estimates of retention than were typically obtained from twin-trawl experiments. This result may therefore reflect the variability of the data and the assumptions made in the analysis. It was generally agreed that twine thickness remains a gear parameter that should be considered further given its implicit effect on selectivity and even though the analysis has shown it to be significant in only one specific case.

WKNEPHSEL notes the finding of the analysis regarding the significant effect of the strengthening or lifting bag as an interesting outcome. Given that this analysis has shown that lifting bags significantly reduce codend selection for *Nephrops*, their use should be tested not only for the differences in selection parameters but also to include an analysis of the safety implications on board vessels if their use was prohibited in *Nephrops* fisheries.

WKNEPHSEL considered a number of other gear variables such as extension length, codend circumference and mesh material, as well as operational factors, vessel characteristics, catch size and environmental factors. None of these factors proved significant but in many cases the data was very limited and not at a high enough resolution to be properly analysed. Only limited information was found from the literature reviewed and it is therefore difficult to draw any firm conclusions. It should also be noted that while operational factors, vessel characteristics, catch size and environmental factors may have an effect on selection, in reality from a management perspective they have only limited value, as they cannot be easily controlled.

10.3 Stock Prediction Models

WKNEPHSEL conclude that the stock prediction models generated during the workshop provided an opportunity to examine what population effects might result when implementing gear changes. It should be stressed, though, that the examples given are for illustrative purposes and the use to which the prediction model may be put should be treated with caution. WKNEPHSEL does note, though that some characteristics are noticeable from this analysis and that the modelling technique used has potential benefit for predicting changes in selectivity.

10.4 Selectivity Devices

While not considered in this analysis, WKNEPHSEL concludes that the results from the French flexible grid are promising and the results show clear size selection of *Nephrops*. This device should be tested in other fisheries to confirm these findings and provide better definition of appropriate rigging and accurate selection parameters.

10.5 Whitefish Selectivity

The collation of information on whitefish selectivity completed at the workshop indicates the myriad of different devices being used in *Nephrops* fisheries to improve whitefish selectivity. Given that these devices have different characteristics and improve selectivity for different species, it was, however, impossible to develop a similar retention model given the time constraints. There was also the added complication that in gears with selectivity devices fitted for demersal fish species there is often a dual selection process from the device and also the codend. WKNEPHSEL concludes though that a similar workshop to consider this and similar data sets would be useful.

11 Recommendations

1) The group considered the main outcomes of the workshop and drew up a limited number of recommendations as listed below:

2) The data set on *Nephrops* selection be explored further, particularly to investigate the robustness of the results to different modelling assumptions e.g. Bayesian techniques and to identify if there are fundamental differences between models for the square and diamond mesh codend data when analysed independently.

3) The results of the analysis concerning the effect of strengthening bags should be considered with caution. Further studies should be carried out to examine whether the model predictions are accurate but also to assess whether their use is necessary from a strength and safety perspective.

4) There is a considerable amount of catch comparison data for both *Nephrops* and whitefish selectivity in *Nephrops* trawls and the data should be further analysed by SGCOMP set up under WGFTFB.

5) The potential for improving *Nephrops* size selection by the use of other selective devices such as the French flexi-grid should be considered.

6) Under WGFTFB a similar workshop be held to consider whitefish selectivity data from *Nephrops* fisheries.

7) The modelling approach used to examine what population effects might result when implementing gear changes should be repeated with other fisheries to fully assess its value and accuracy.

12 References

Anon., 2002. Report of Scottish trials assessing the selectivity of trawls and seines. Industry/Science Partnership 2001–2002. Vol 1. FRS Marine Laboratory.

Anon., 2000. Cruise Report of Irish Sea Mesh Trials mfv “Northern Dawn” 23rd May – 22nd July 2000. BIM Internal Report.

Briggs, R. P., 1983. Net selectivity studies in the Northern Ireland *Nephrops* fishery. Fish. Res., 2: 29–46.

Briggs, R. P. 1981. Preliminary observations on the effects of a codend cover or lifterbag on catch composition in the Northern Ireland *Nephrops* fishery. ICES Fish Capture Comm., CM 1981/b:11 (mimeogr.).

Campos, A., Fonseca, P., Erzini, K., 2002. Size selectivity of diamond and square mesh cod ends for rose shrimp (*Parapenaeus longirostris*) and Norway lobster (*Nephrops norvegicus*) off the Portuguese south coast. Fish. Res. 58, 281–301.

Charuau, A., Morizur, Y., and Rivoalen, J. J., 1982. Sélectivité des fonds de chalets équipés d’un sac de reinforcement dans la pêche de la langoustine, *Nephrops norvegicus*. ICES Fish Capture Comm., C. M. 1982/B: 15 (mimeogr.).

Charuau, A., 1978. Comparison des prises de langoustines par les chalets equips de poches de maille de 45 mm, 60 mm et 70 mm. ICES Shellfish Comm., C. M. 1979/K:2 (mimeogr.).

Fonseca, P., Campos, A., Millar, R., (in press). Codend selection in the deep-water crustacean trawl fishery in Portuguese southern waters. Fish. Res.

Fryer RJ, Zuur AF, Graham N, 2003. Using mixed models to combine smooth size-selection and catch-comparison curves over hauls. Canadian Journal of Fisheries and Aquatic Sciences 60: 448–459.

Graham, N., and Ferro, R. S.T. 2004. The *Nephrops* fisheries of the Northeast Atlantic and Mediterranean – A review and assessment of fishing gear design. ICES Cooperative Research Report, No. 270. 40 pp.

ICES. 2006. Report of the Workshop on *Nephrops* Stocks (WKNEPH), 24–27 January 2006, ICES Headquarters. ICES CM2006/ACFM:12. 85 pp.

ICES. 2003. Report of the Working Group on *Nephrops* Stocks, 2003. ICES CM 2003/ACFM:18.

ICES. 1999. Report of the Working Group on *Nephrops* stocks. ICES CM 1999/Assess:16.

ICES. 1996. Manual of Methods for Measuring the Selectivity of Towed Gears. ICES Cooperative Research Report, No. 215. 126 pp.

ICES. 1995. Report of Working Group on Fishing Technology and Fish Behaviour. ICES CM1995/B:02.

Kynoch R. J., O'Dea M. C., and O'Neill F. G. 2004. The effect of strengthening bags on codend selectivity of a Scottish demersal trawl. Fisheries Research. 68: 249–257.

Larsvik, L., and Ulmestrand, M., 1992. Square and diamond mesh trawl codend selection on *Nephrops norvegicus* (L.), with the curve-fit method isotonic regression. ICES CM 1992/B:36: 11 pp.

Madsen, N., Hansen, K. E., and T. Moth-Poulsen, 2001. The kite cover: a new concept for covered codend selectivity studies. Fisheries Research, 49: 219–226.

O'Neill, F. G. 2002. A theoretical study of the effect of twine bending stiffness on mesh measurement. Contributions of the theory of fishing gears and related marine systems. Volume 2. Ed. By. M. Paschen, Rostock, Germany.

Polet, H., and Redant. F. 1994. Selectivity experiments in the Belgium Norway lobster (*Nephrops norvegicus*) FISHERY. Ices cm 1994/B:39.

Sala A, Lucchetti A, Buglioni G (2007). The influence of twine thickness on the size selectivity of polyamide codends in a Mediterranean bottom trawl. Fisheries Research, 83: 192–203

Zuur G, Garthwaite PH, Fryer RJ, 2002. Practical use of MCMC methods: lessons from a case study. Biometrical Journal 44: 433–455.

13 Glossary

13.1 Gear and vessel terms

Braided Twine: Netting twine obtained by interlacing three or more strands in such a way that they cross each other in diagonal directions to the edge of the fabric.

Brezline: Brezline is a very compact mesh that has been very tightly braided and coated to reduce the penetration of impurities. To maintain such a hard mesh, Brezline netting goes through a double autoclave treatment.

Bycatch: That part of the catch, which is not the targeted species including discards.

Carapace length: For Crustaceans the distance between base of eye socket and mid dorsal distal edge of carapace

Codend: The rearmost part of the trawl, having either a cylindrical shape, i.e. the same circumference throughout, or a tapering shape. Made up of one of more panels (pieces of netting) of the same mesh size attached to one another along the axis of the trawl by a seam where a side rope maybe attached.

Covered Codend: A method of measuring selectivity, where a small mesh cover is placed over the test codend to retain the fish escaping. The catch in the codend and cover together provides a measurement of the population entering the codend and hence allows the codend selectivity to be estimated.

Diamond mesh: Normal rhomboid shape of meshes in sheet netting.

Discard rate: That fraction of the catch that consists of species and/or sizes that is not retained for sale but rejected at sea.

Extension: Sections of netting between belly and codend. May be tapered but the taper should be much lower than that of the belly.

Fishing circle: Stretched circumference of a trawl or seine expressed as the number of meshes round at the centre of the front edge of the belly multiplied by the mesh length.

Flexural stiffness: Resistance of a twine to lateral or bending deformation. It may be defined as the force required causing a unit of bending deflection.

Grid: Structure made of parallel bars used to separate fish or *Nephrops* of a different size.

Groundrope or Footrope: Connected sections of rope, wire or chain protected with rope rounding or rubber discs or various types of bobbins, attached to and in front of the fishing line, to shield the lower leading margin of a bottom trawl from ground damage, whilst maintaining ground contact.

ICES gauge: A gauge which exerts a longitudinal force between opposite knots of the mesh, i.e. a force across the inside of the mesh in the plane of the netting, often controlled by a spring and stopping device limiting the applied load to a preset value.

Knotless Netting: Netting made by machine from yarns that are interlaced at intervals to form meshes.

Linear Density: Mass per unit length of a twine. Expressed in tex (mass in grams per 1000 m)

50% Retention length (L50): Length of fish that has a 50% probability of being retained or escaping after entering the codend. It is basic measure of selectivity of the selectivity of the gear stating that the gear will retain most of the fish above this length that enter the codend.

Mesh Length: For knotted netting, the distance between the centres of two opposite knots in the same mesh fully extended in the N-direction. The N-direction is the direction at right angles (Normal) to the general course of the netting. For knotless netting, the distance between the centres of two opposite joints in the same mesh when fully extended along its longest possible axis.

Mesh opening: For knotted netting, the inside distance between two opposite knots in the same mesh fully extended in the N-direction. The N-direction is the direction at right angles (Normal) to the general course of the netting. For knotless netting, the inside distance between two opposite joints in the same mesh when fully extended along its longest possible axis.

Mesh size: Opening of a mesh determined by an authorised testing procedure, expressed as the distance between the centres of two opposite knots I the same mesh when fully extended in the N direction.

Omega gauge: The Omega gauge applies a pre/selected longitudinal force to stretch the mesh through extensible jaws. The mesh size measured is the calibrated extended distance of the jaws. The result is independent of manual force and of friction between gauge and twine.

Selection range (SR): The difference in length between the fish that has a 75% probability of retention and that with a 25% probability of retention. This is a measure of the sharpness of selection i.e. the shape of the selection curve.

Selvedge: The bulky seam formed by gathering together adjacent side margins, several meshes wide, of two panels of a net and lacing them together.

Square Mesh: Mesh shape originating from mounting netting with 45º deviation from the N-direction such that the bars run parallel and at 90º to the trawl axis.

Square Mesh Window: Rectangular piece of netting with square meshes, inserted into a codend or net of rhomboid meshes, usually into the upper panel in order to increase the release of fish.

Strengthening, lifting or cover bag: A cylindrical piece of netting completely surrounding the codend of a trawl. It shall have at least the same dimensions (length and width) as that part of the codend to which it is attached. Its purpose is to strengthen the codend and to prevent it from bursting when filled with fish and when the trawl is hauled on board.

Twin-trawl method: A method of measuring selectivity, where one vessel tows two similar trawls simultaneously side by side. The test codend is attached to one of the twin-trawls and a small mesh codend is attached to the other trawl to obtain an estimate of the total fish population entering the test codend.

Twisted twine: Twine resulting from a twisting process of two or more yams or strands.

Wedge Gauge: A flat tapering piece of metal of graduated width which is inserted into the meshes between opposite knots at right angles to the plane of the netting, possibly with a means of measuring and controlling the force applied in inserting the gauge such as a hanging weight.

Annex 1: List of participants

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Annex 2: Recommendations

The following Table summarises the main recommendations arising from WKNEPHSEL and identifies responsibilities for action.

RECOMMENDATION	ACTION
1. The data set on *Nephrops* selection be explored further, particularly to investigate the robustness of the results to different modelling assumptions e.g. Bayesian techniques and to identify if there are fundamental differences between models for the square and diamond mesh codend data when analysed independently..	WGFTFB in conjunction with modellers to explore the posibility of a follow-up workshop.
2. The results of the analysis regarding the effect of cover bags be considered with caution. Further studies should be carried out to examine whether the model predictions are accurate but also to assess whether their use is necessary from a strength and safety perspective.	FTFB, ACFM, managers and Regional WG chairs to note. FTFB to investigate the possibility of further research.
3. There is considerable amount of catch comparison data for both *Nephrops* and whitefish selectivity in *Nephrops* trawls. It is recommended that this data should be further analysed by SGCOMP set up under WGFTFB.	FTFB to investigate through SGCOMP.
4. The potential for improving *Nephrops* size selection by the use of other selective devices such as the French flexi-grid should be considered.	FTFB to investigate the possibility of further research.
5. A similar workshop be held to consider whitefish selectivity data from *Nephrops* fisheries.	WGFTFB in conjunction with modellers to explore the posibility of a follow-up workshop/analysis.
6. The modelling approach used to examine what population effects might result when implementing gear changes should be repeated with other fisheries to fully assess its value and accuracy.	FTFB, ACFM, managers and Regional WG chairs to note.

Annex 3: Selectivity Data

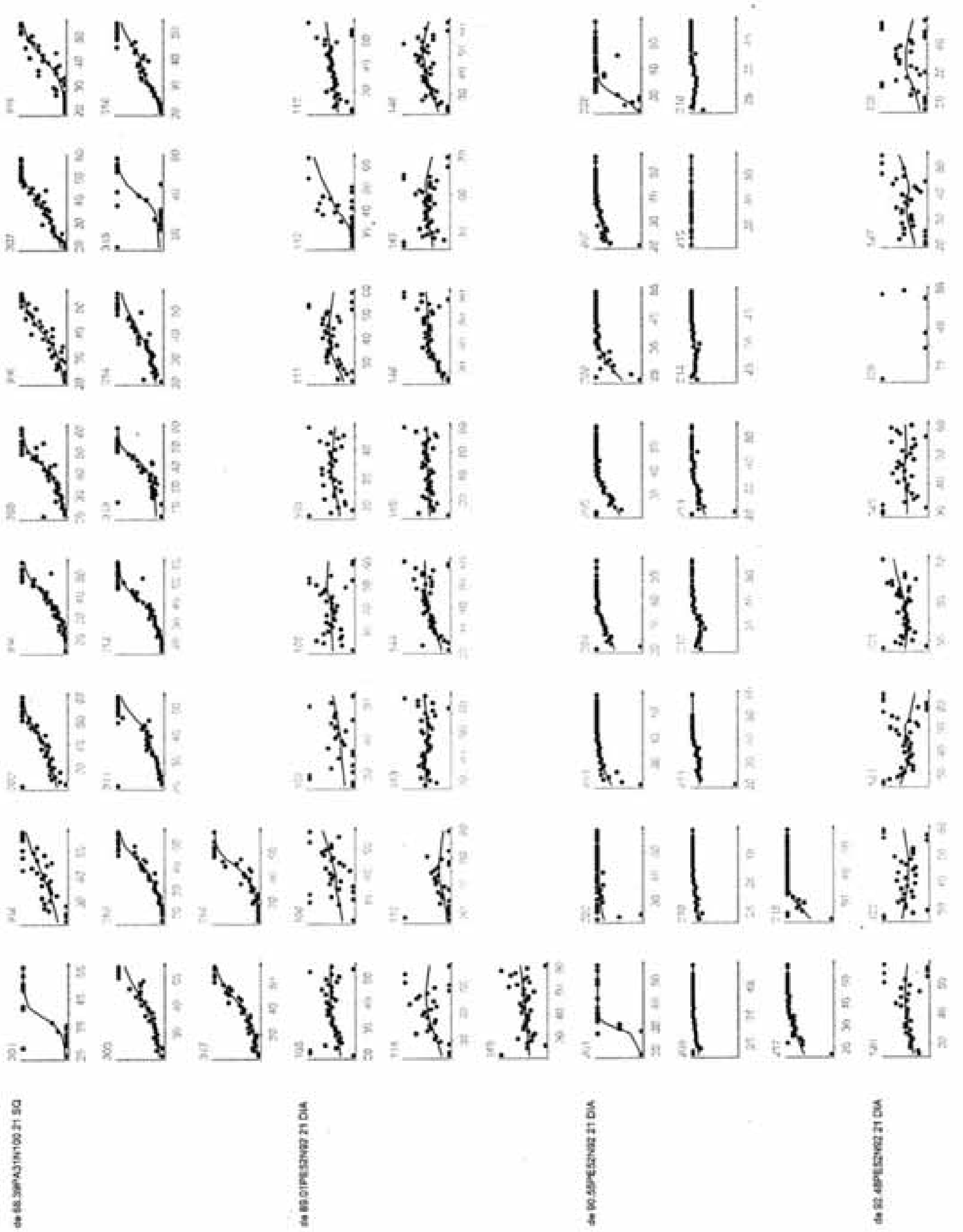
Country	Denmark	Denmark	Denmark	Denmark
Unique Gear Identifier	89.01.PE52N92DIA	92.48PE52N92SQ	68.39PA31N100DIA	90.55PE52N92DIA
Date Month/Year	Sep-05	Sep-05	Sep-06	Sep-06
Fishing Area	IIIa	IIIa	IIIa	IIIa
L50	24.7		41.8	
Lower L50			40.8	
Upper L50	28.2		42.8	
Country	England	England	England	France
Unique Gear Identifier	84PE41Y100DIA	80PE41Y100	82PE41Y100	70PEBREZ42N108
Date Month/Year	Nov-Dec/06	Dec 06	Nov 06	Jun-02
Fishing Area	IVa	IVa	IVa	VIIIa
L50	14.8	19.8	16	
Lower L50	14.2	19.2	15	
Upper L50	15.3	20.5	17.3	
Country	Ireland	Ireland	Ireland	
Unique Gear Identifier	103PE61Y100DIA	94PE61Y100DIA	74PE61Y100DIA	
Date Month/Year	Nov-06	Nov-06	Nov-06	
Fishing Area	VIIb	VIIb	VIIb	
L50	15.2			
Lower L50				
Upper L50	18.7			
Country	Italy	Italy	Italy	
Unique Gear Identifier	45.2PA1Y275DIA	43.3PA1Y70SQ	46.4PA1Y326DIA	
Date Month/Year	May-05/Sept-06	May-05/Sept-06	May-05/Sept-06	
Fishing Area	GFCM-17	GFCM-17	GFCM-17	
L50	14.8	19.8	16	
Lower L50	14.2	19.2	15	
Upper L50	15.3	20.5	17.3	
Country	Portugal	Portugal	Portugal	Portugal
Unique Gear Identifier	55PE2.51N109DIA	70PE2.51N85DIA	55PE21N65SQ	60PE2.51N100DIA
Date Month/Year	Mar-April-04	Mar-04	Mar-04	May-93
Fishing Area	IXa	IXa	IXa	IXa
L50	23.7	26.7	37.7	26.2
Lower L50	21.6	25.2	35.6	24.8
Upper L50	25.3	28.2	39.7	27.3
Country	Portugal	Portugal	Portugal	Portugal
Unique Gear Identifier	70PE4.51N123DIA	55PE4.51N156DIA	80PE4.51N107DIA	70PA31N123DIA
Date Month/Year	May-99	May-99	Oct-98	Oct-98
Fishing Area	IXa	IXa	IXa	IXa
L50	25.1	22.5	30.8	28.4
Lower L50	21.7	19.6	27.3	24.6

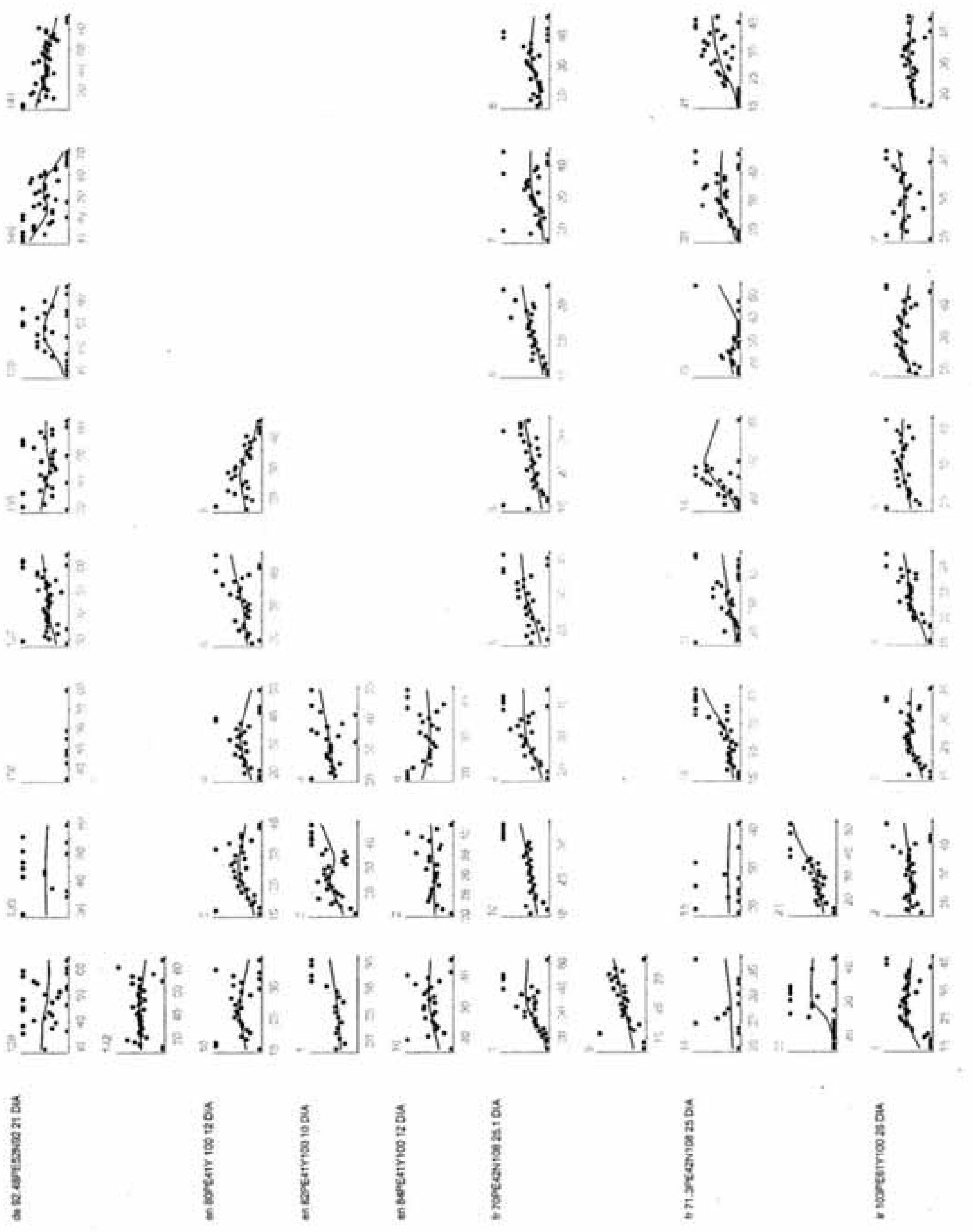
Upper L50	28	24.1	33.5	31
Country	Portugal	Portugal	Portugal	
Unique Gear Identifier	80PA31N107DIA	55PA31N156DIA	60PE3.52N120SQ	
Date Month/Year	Oct-98	Oct-98	Aug-06	
Fishing Area	IXa	IXa	IXa	
L50	28.4			
Lower L50	24.6			
Upper L50	31			
Country	Scotland	Scotland	Scotland	Scotland
Unique Gear Identifier	100PE5ZN100DIA	120PE52N100DIA	81PE41Y116DIA	80PE41Y100DIA
Date Month/Year	Nov-03	Nov-03	May-05	Sept-04
Fishing Area	IVa	IVa	VIa	IVa
L50	35.3	41.6	23.7	25.2
Lower L50	24.8	29.4		20.9
Upper L50	43.9	49.8	28.1	27.7
Country	Scotland	Scotland	Scotland	Scotland
Unique Gear Identifier	82.9PE41Y120DIA	104.1PE41Y102DIA	113PE41Y101DIA	93.2PE41Y100DIA
Date Month/Year	March-05	March-05	March-05	March-05
Fishing Area	VIa	VIa	VIa	VIa
L50				
Lower L50				
Upper L50				
Country	Scotland	Scotland	Scotland	Scotland
Unique Gear Identifier	95.1PE52Y100DIA	82.5PE52Y120DIA	83PE51Y100SQ	106PE52N100DIA
Date Month/Year	Sept-06	Sept-06	Oct-02	Oct-02
Fishing Area	IVa	IVa	IVa	IVa
L50			49.3	24.3
Lower L50			41.5	
Upper L50				29.4
Country	Scotland	Scotland		
Unique Gear Identifier	111PE52N100DIA	95PE41Y100SQ		
Date Month/Year	Jan-03	Jan-03		
Fishing Area	IVa	IVa		
L50	41.7			
Lower L50	40.9			
Upper L50	42.9			
Country	Sweden	Sweden	Sweden	Sweden
Unique Gear Identifier	63.PA31N95SQ	69.3PE31N100DIA	49.4PA1.81N80SQ	70PE31N100DIA
Date Month/Year				
Fishing Area	IVa	IVa	IIIa	IIIa
L50	24.8	20.7	28.9	21.5
Lower L50	22.3	18.7		
Upper L50	26.6	22	32.2	28.2

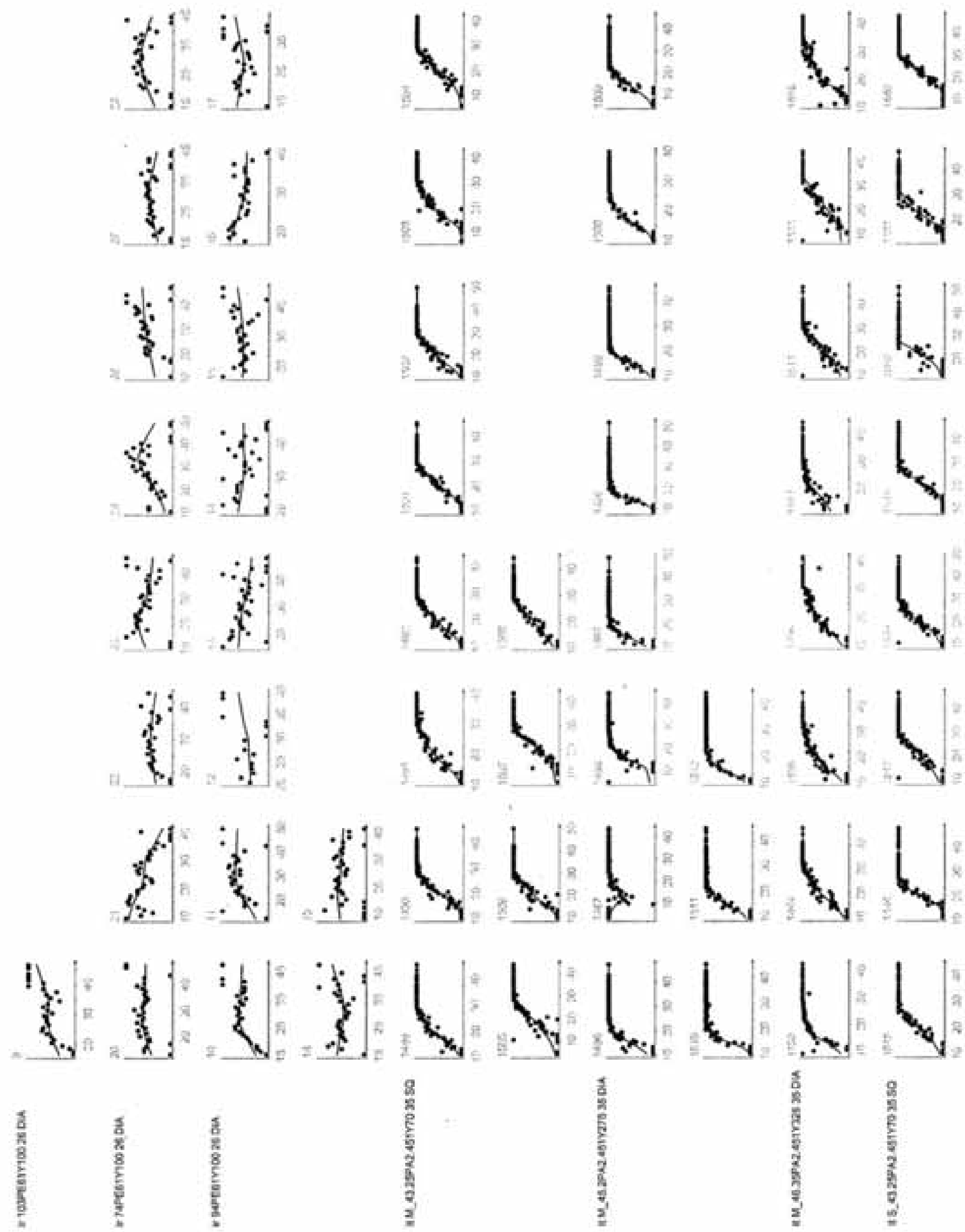
Country	Sweden	Sweden	Sweden	Sweden
Unique Gear Identifier	69.1PE42Y100DIA	64.5PA31Y92SQ	92.3PE42Y104DIA	66.7PE42Y100DIA
Date Month/Year				
Fishing Area	VIa	VIa	VIa	VIa
L50	21.3	27.3	26.6	24.7
Lower L50	17.8	25.2	22.7	
Upper L50	24.1	29.3	29.9	27.6
Country	Sweden	Norway		
Unique Gear Identifier	88.9PE42Y104DIA	92.4PE42Y100DIA		
Date Month/Year		Nov-Dec-05		
Fishing Area	VIa	IIIa		
L50				
Lower L50				
Upper L50				

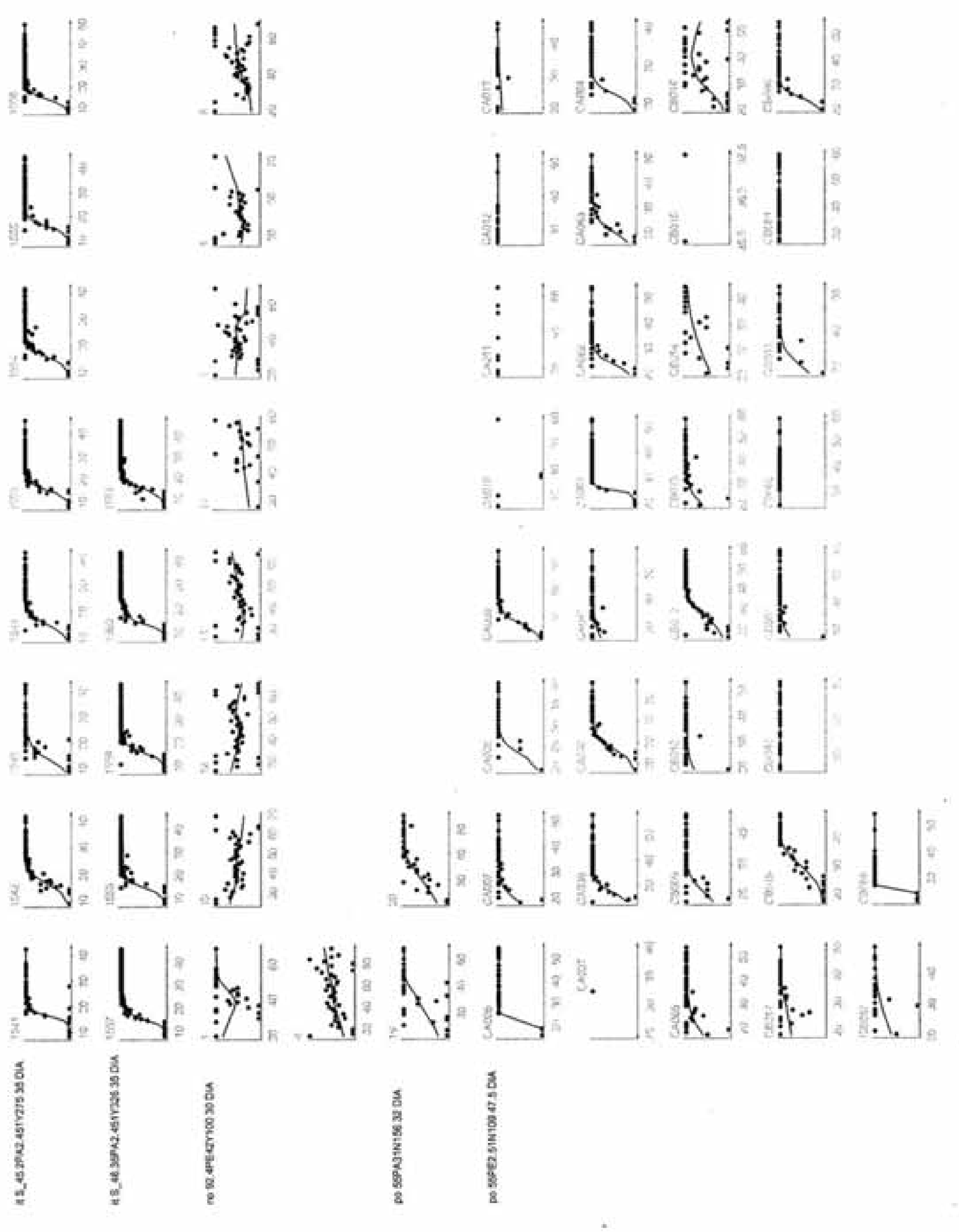
Unique Gear Identifiers: mesh size. material. diameter. single/double. lifting bag present/absent meshes round Square or diamond mesh e.g. 88.9PE42Y104DIA = 88.9 mm mesh size; PE material; 4 mm twine; double; cover bag present; 100 meshes round; Diamond mesh.

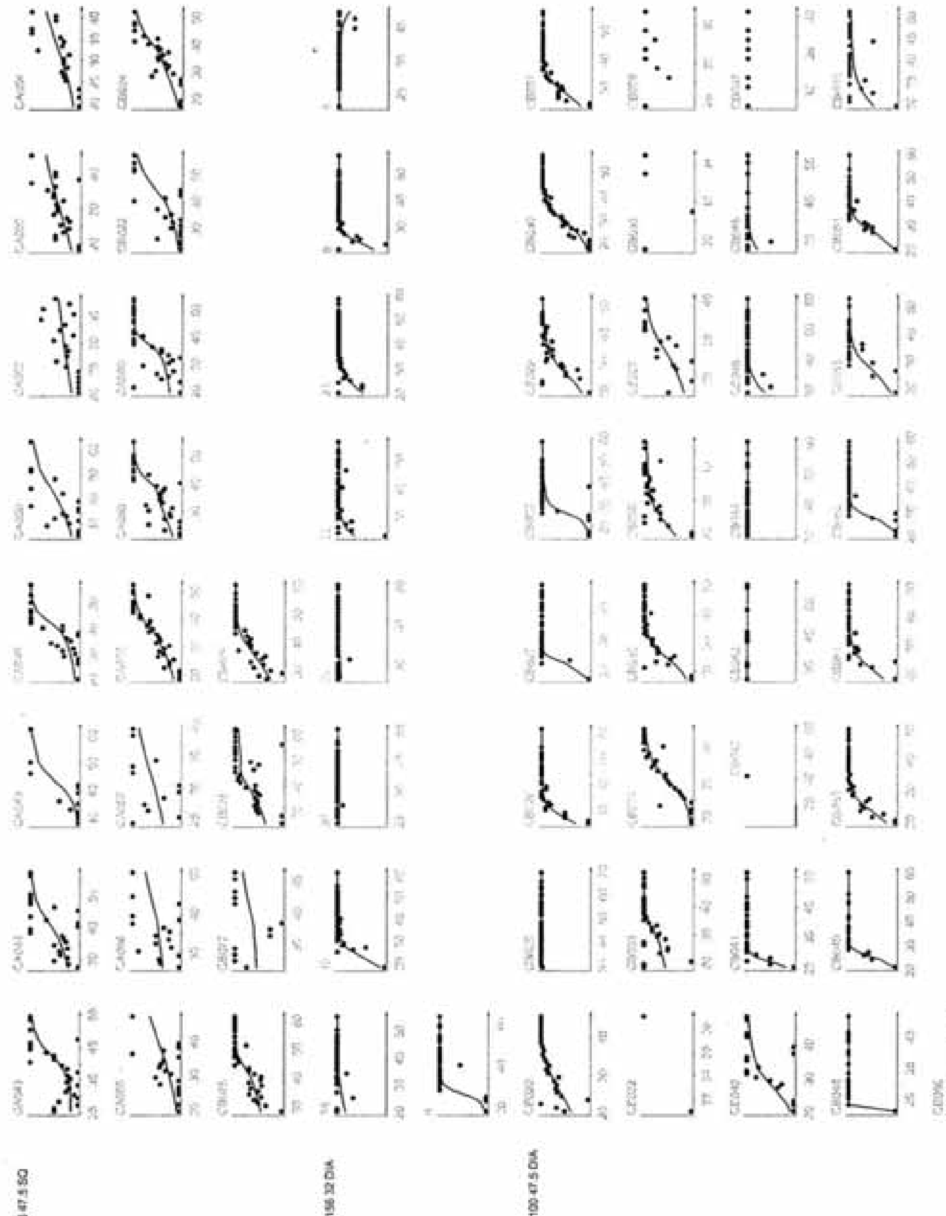
Annex 4: *Nephrops* retention plots

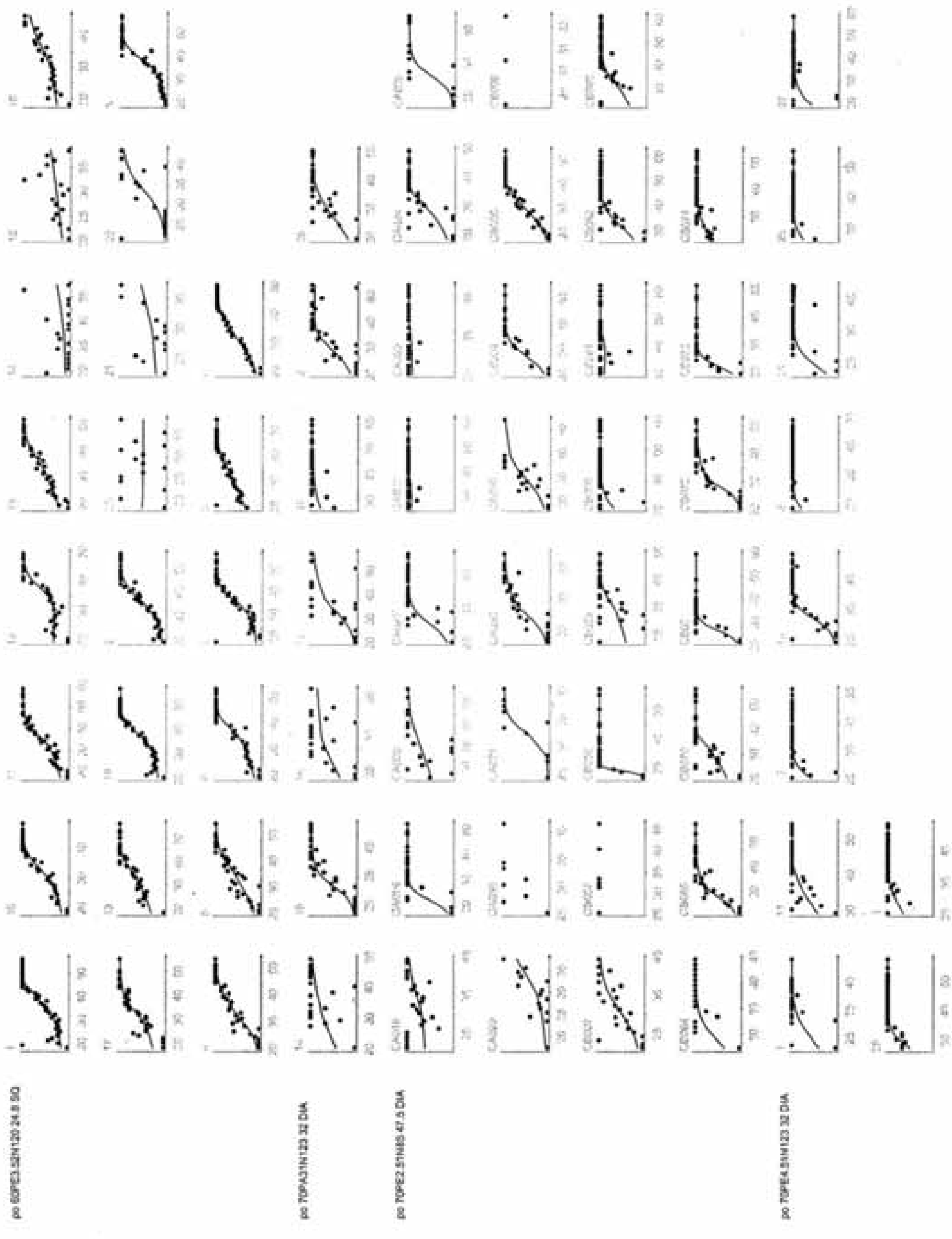


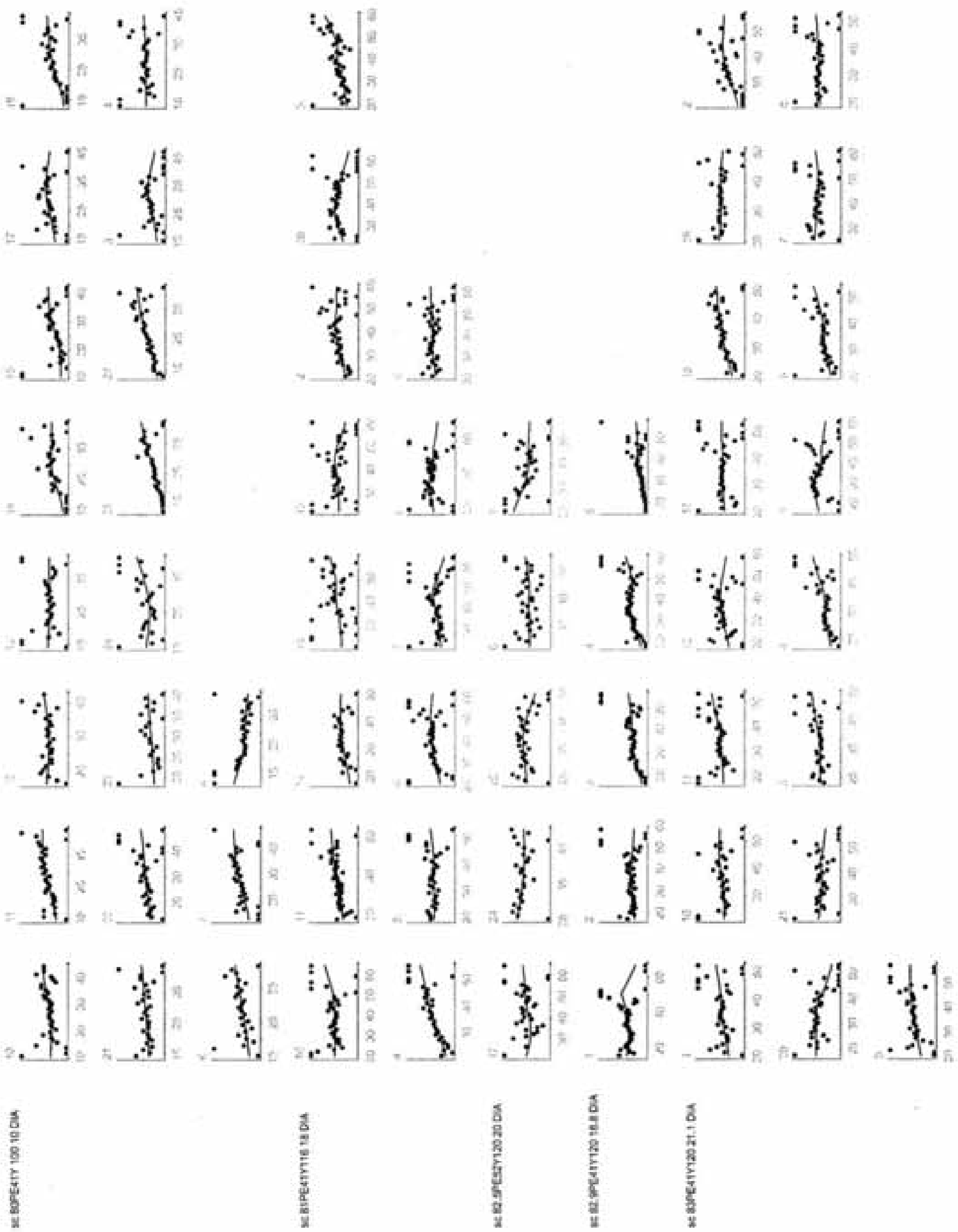


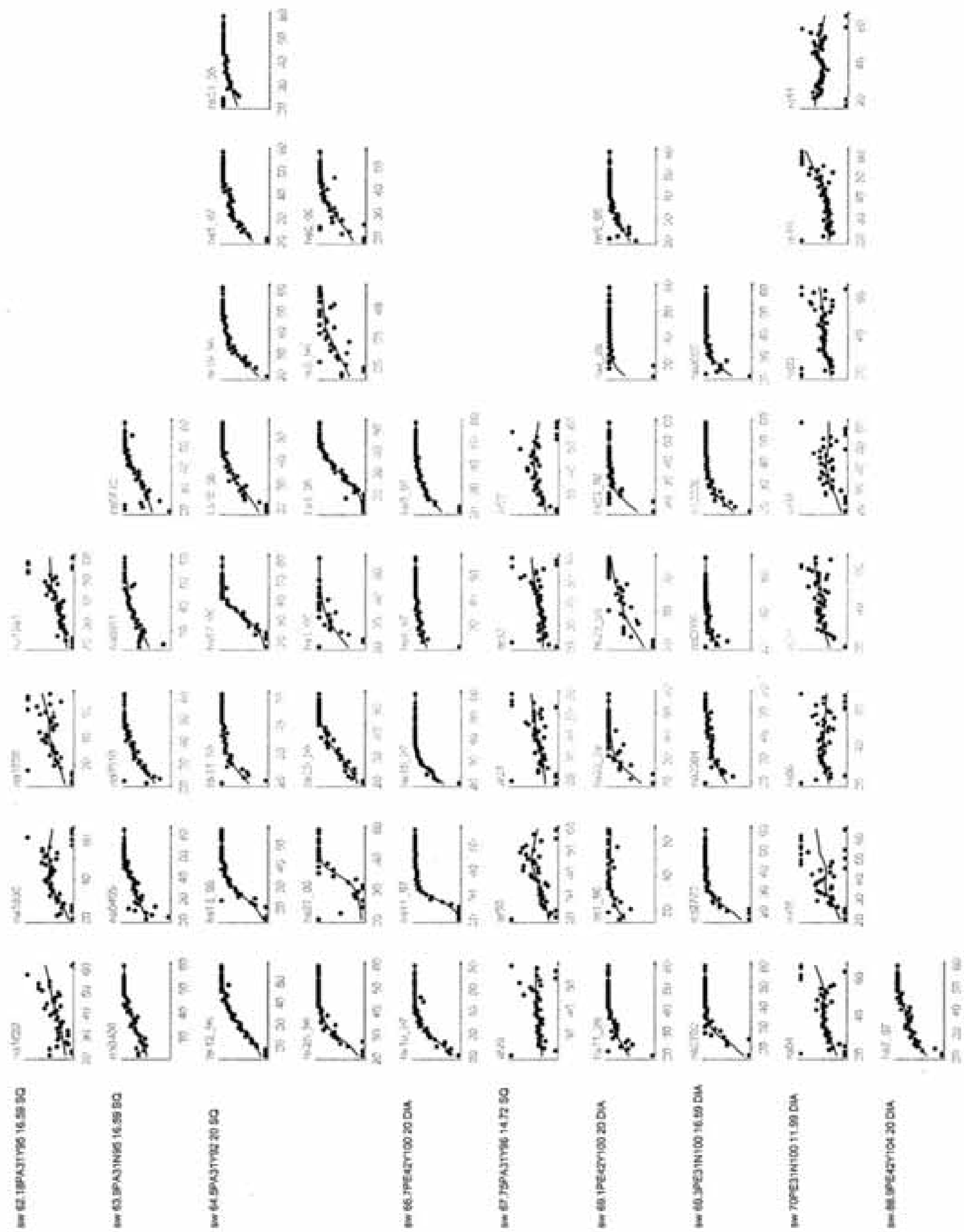


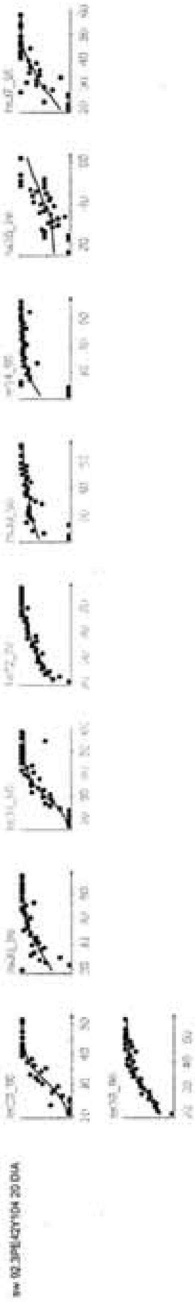




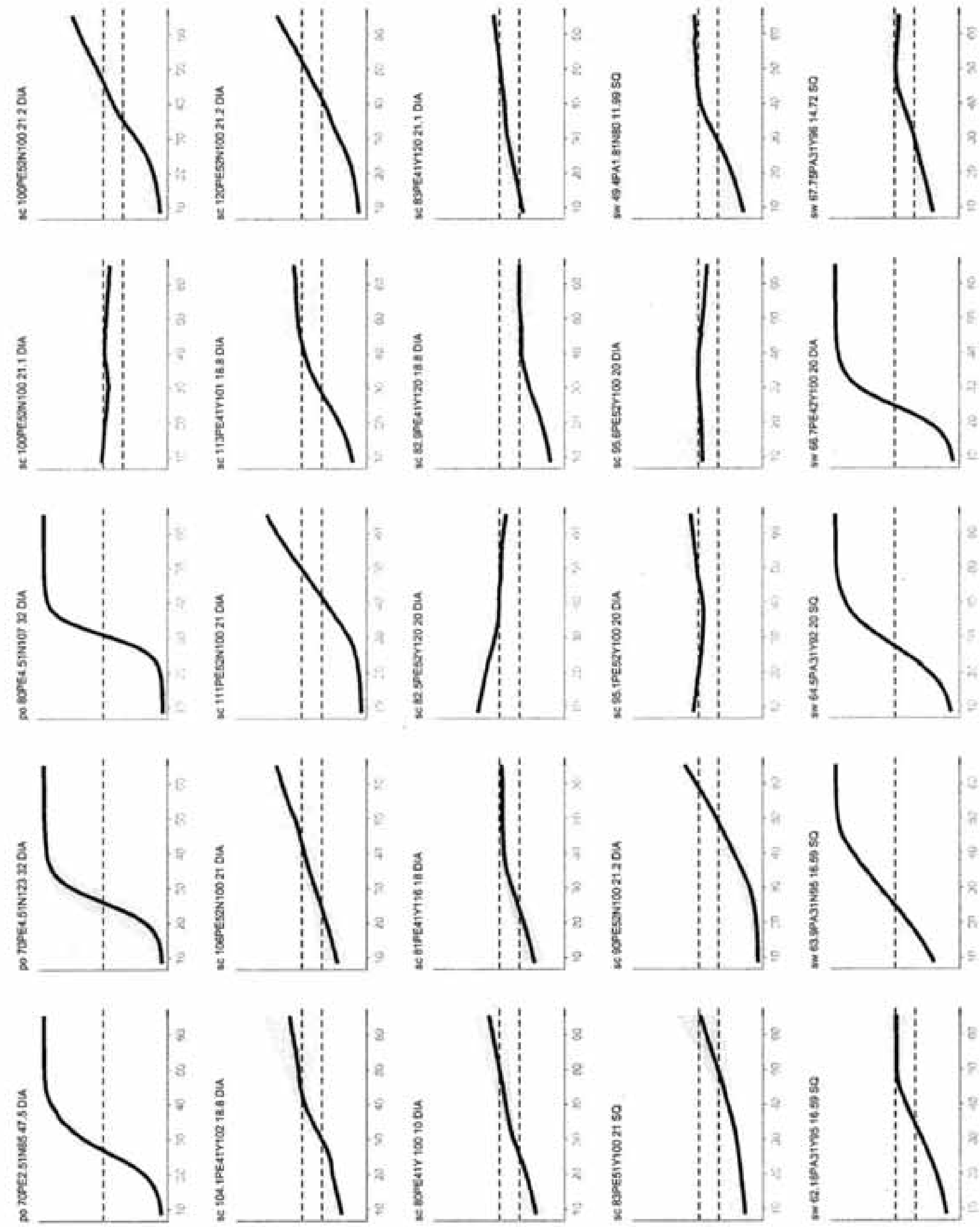


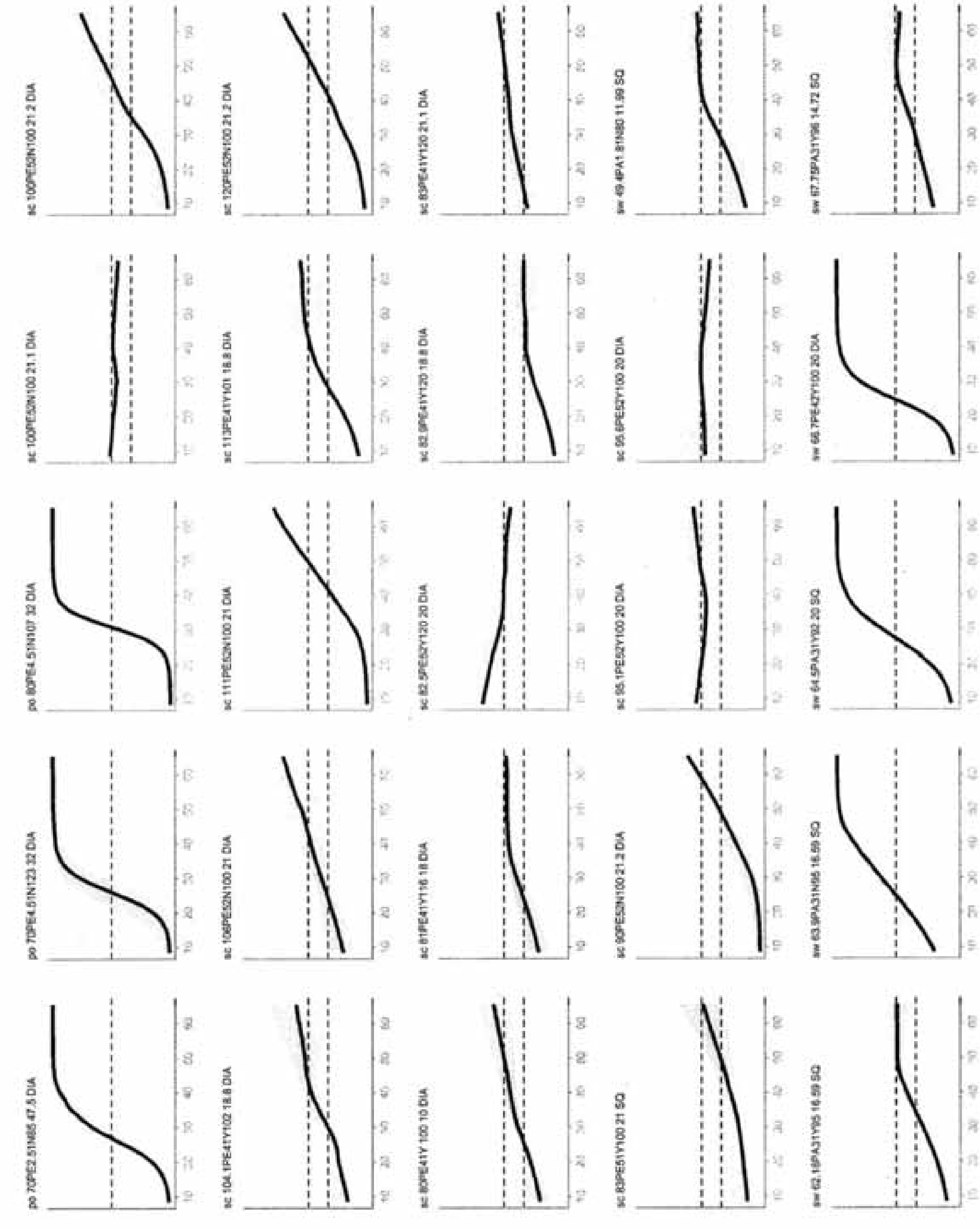


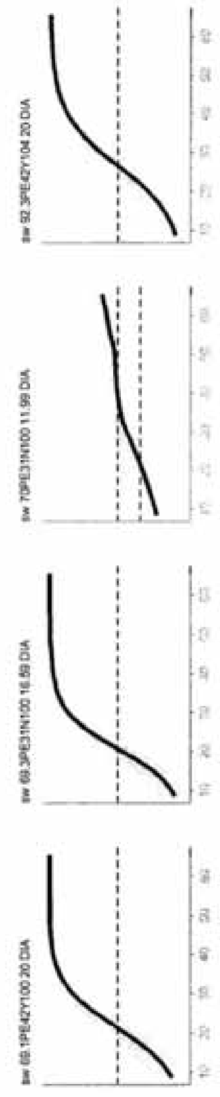




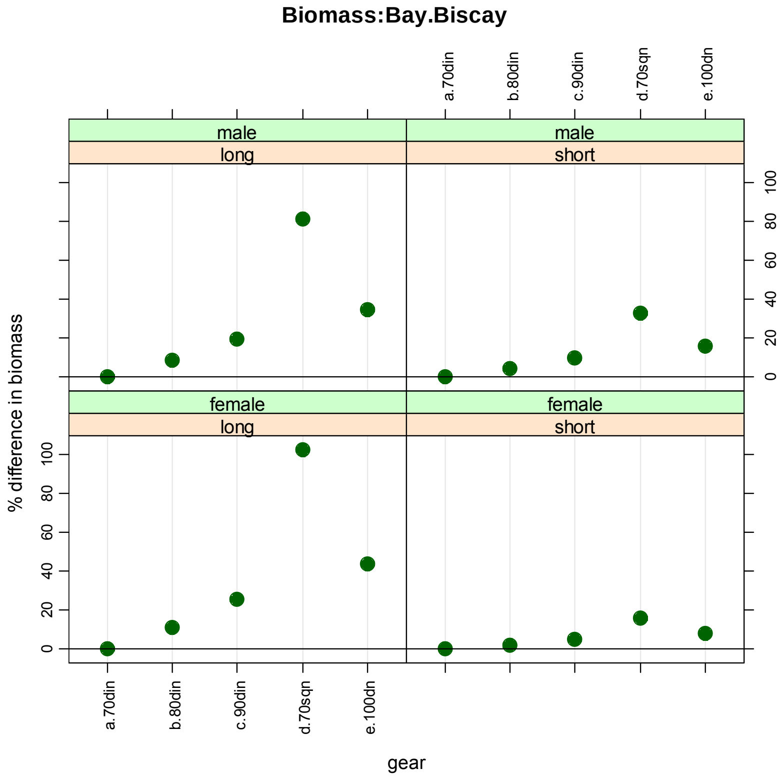
Annex 5: Smoother Plots



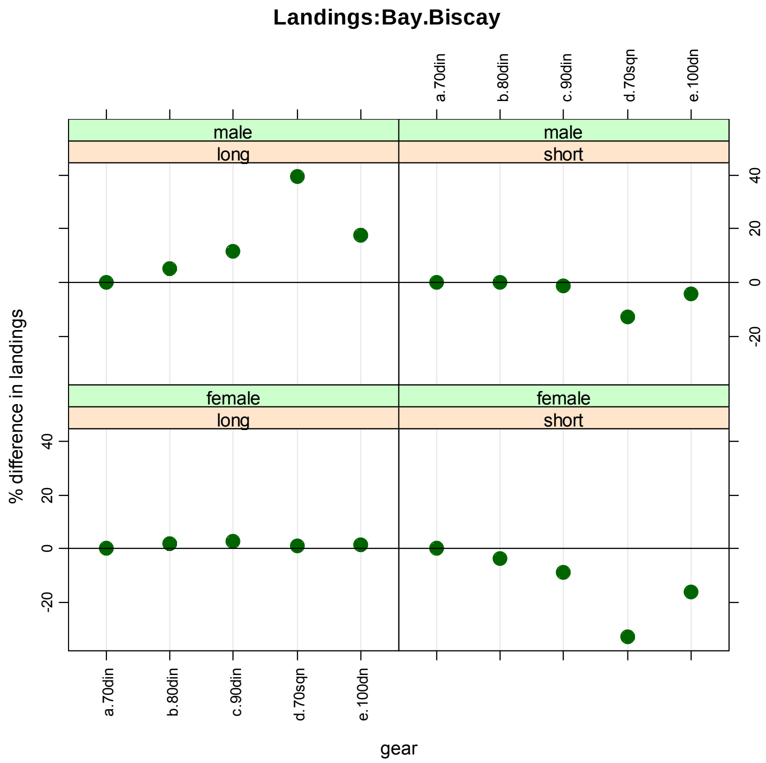




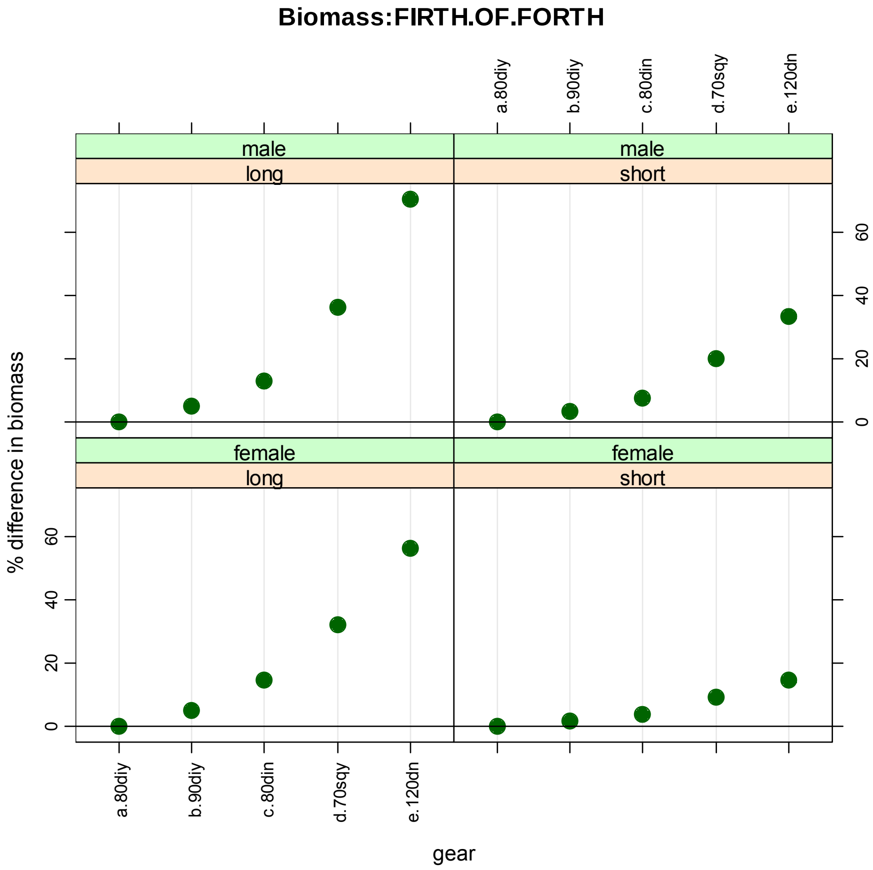
Annex 6: Stock Prediction Plots



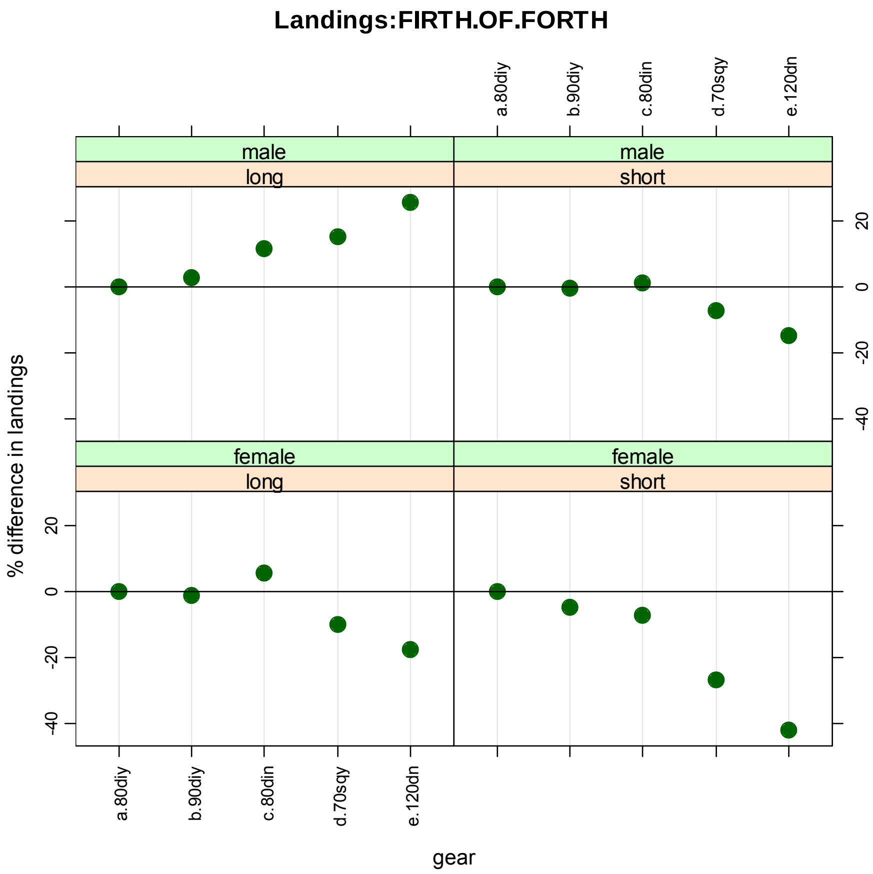
% difference in biomass at SQ effort by gear, sex and short/long term



% difference in landings at SQ effort by gear, sex and short/long term

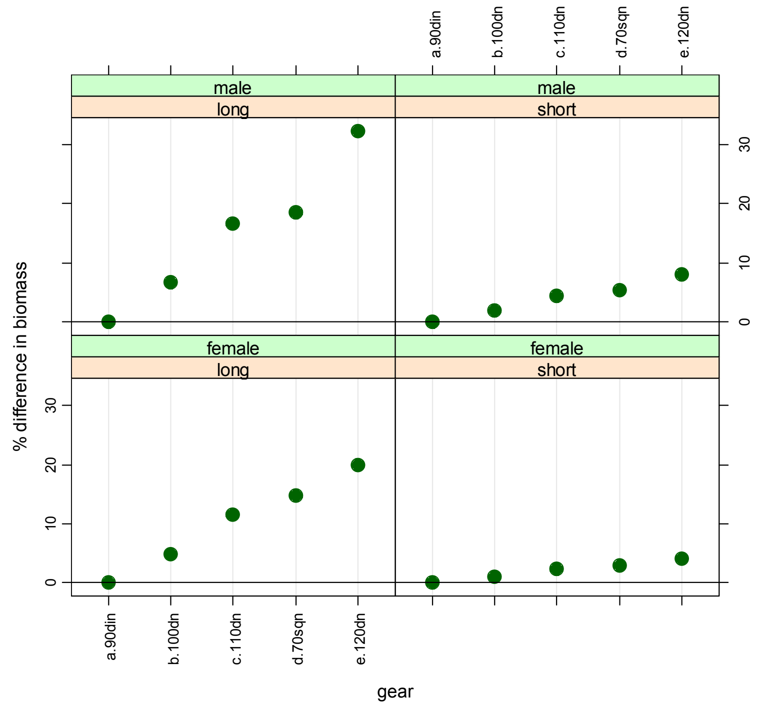


% difference in biomass at SQ effort by gear, sex and short/long term



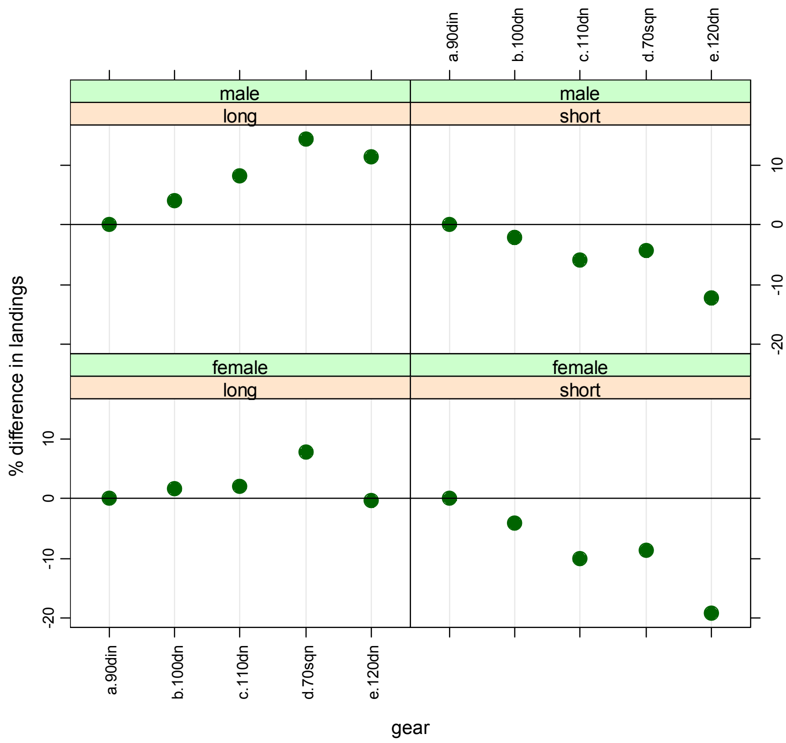
% difference in landings at SQ effort by gear, sex and short/long term

Biomass:Skag



% difference in biomass at SQ effort by gear, sex and short/long term

Landings:Skag



% difference in landings at SQ effort by gear, sex and short/long term

Annex 7: French Selectivity Trials with Flexible Grids

Trials with flexible grids have been carried out by IFREMER in France (Bay of Biscay) to improve size selectivity in *Nephrops* trawls in 2003 and 2004. Over 800 days at sea and 2000 hauls were observed. These trials were conducted with the backing of the Industry (18 associations or producer organizations at local to national level). All these experiments have been carried out on a catch comparison basis on over 50 different commercial vessels. The goal was to assess improvement in the reduction of discards when compared with the standard trawls commonly used in the fishery. The flexible grid used was fitted in the extension of the trawl and different ranges of bars spacings (square section of the bars) were tested to optimise escapement of small *Nephrops* (<25 mm cephalothoracic length before 2006, < 28 mm from 2006) and commercial losses for higher sizes. This work has shown average escape rates of 36% to 57% for undersize *Nephrops* using the grid with commercial losses of approximately 0.1kg of *Nephrops* per trawl.

In 2006, further work was carried out on *Nephrops* selectivity with the flexible grid using a new design of grid with circular cross-sectional bars. SMP in the bottom of the extension (70 and 55 mm) and increased codend mesh size of 80 mm PE were also compared with standard mesh size of 70 mm. Nearly 100 days at sea on 16 different vessels (from 12 to 19 m long) were completed and over 200 hauls were sampled. The results are as follows:

- The results obtained with the grids confirm the findings of 2004 but the escapement seems to be even easier with circular section of the bars. *Nephrops* discards (< 28 mm) were reduced by 25 to 35% (13 mm bars spacing). There were no recorded commercial losses (> 28 mm).
- With SMP in the bottom of the extension, the results on escapement were between 20 and 40% for a 70 mm mesh size; but commercial losses were high on small boats (12 m). With a smaller mesh size (55 mm), the variability of the results is very high; losses seem to disappear.
- Only 3 trials were carried out with larger meshes in the codend (80 mm PE instead of 70 mm PE) ; escapement on small *Nephrops* (<9 cm) is around 30% and no losses are recorded on commercial sizes. A few hauls tried also to compare two kinds of PE.

Annex 8: Gear Specifications

Country	Denmark	Denmark	Denmark	Denmark	England	England	England
Unique Gear Identifier	89.01PE52N92	92.48PE52N92	68.39PA31N100	90.55PE52N92	84PE41Y100	80PE41y 100	82PE41Y100
Institute	DIFRES	DIFRES	DIFRES	DIFRES	CEFAS	CEFAS	CEFAS
Date Month/Year	Sep-05	Sep-05	Sep-06	Sep-06	Nov-Dec/07	Dec-07	Nov-07
Number of Hauls	17	17	18	18	3	5	3
Number of Cruises	1	1	1	1	1	1	1
Fishing Area	IIIa	IIIa	IIIa	IIIa	6	6	6
Vessel LOA (m)	20.8	20.8	20.8	20.8	11.9	12	10
Vessel Type							
Vessel Engine Power kw or HP							
Tide state							
Av. Fishing Depth (m)							
Av. Haul Duration (min)	102.35	114.71	88.33	88.33	60.00	60.00	60.00
Av. Towing Speed (knots or m/s*)	1.30*	1.30*	1.33*	1.33	2.60	2.62	2.50
Av. Nephrops	18.62	11.18	14.75	37.78			
Av. Roundfish	291.30	147.15	22.68	32.76			
Av. Flatfish	32.74	27.13	10.12	9.33			
Gear Information							
Codend Mesh Size (mm)	89.01	92.48	68.39	90.55	84	80	82
Twine Type	PE	PE	PA	PE	PE	PE	PE
No of Twines	2	2	1	2	1	1	1
Nom Twine Value (mm)	5	5	3	5	4	4	4
Rtex							
Lifting Bag Present	N	N	N	N	Y	Y	Y
Open Meshes Round	92	92	100	92	100	100	100
Length of Extension and Codend (m)	9	9	8	8			
Total (m)	45	45	45	45			
Cover or Small Mesh Codend	SM	SM	C	C			
Description (Cover=0, Twin Exp=1)	1	1	0	0	1	1	1
Mesh size of Control Codend or Cover (mm)	44.2	43.6	35.84	36.12	40	40	40
Mesh Shape	DIA	DIA	SQ	DIA	DIA	DIA	DIA
Mesh Gauge Type	I	I	I	I	W	W	W

Country	France	Ireland	Ireland	Ireland	Italy	Italy	Italy
Unique Gear Identifier	70PEbreizline42N108	103PE61Y100	94PE61Y100	74PE61Y100	45.2PA1Y275	43.3PA1Y70	46.4PA1Y326
Institute	IFR	BIM	BIM	BIM	SC007-06	SC019-06	SC018-06
Date Month/Year	Jun-02	Nov-07	Nov-07	Nov-07	May-05,Sept-07	May-05,Sept-07	May-05,Sept-07
Number of Hauls	9	9	9	10	19	20	13
Number of Cruises	1	1	1	1	2	2	2
Fishing Area	8A	VIIb	VIIb	VIIb	GFCM-17	GFCM-17	GFCM-17
Vessel LOA (m)	24.5	26	26	26	35	35	35
Vessel Type	R	C	C	C	R	R	R
Vessel Engine Power kw or HP	442	317	317	317	810 kw	810 kw	810 kw
Tide state	S				N	N	N
Av. Fishing Depth (m)	93	118	120	118	210	210	210
Av. Haul Duration (min)	155.41	21.11	27.70	38.11	58.16	60.25	57.15
Av. Towing Speed (knots or m/s*)	1.61	2.70	2.70	2.82	3.54	3.54	3.55
Av. Nephrops	7.23	N/A	N/A	N/A	20.33	20.60	20.89
Av. Roundfish	20.43	N/A	N/A	N/A	15.59	15.24	14.90
Av. Flatfish	2.34	N/A	N/A	N/A	4.23	3.88	4.82
Gear Information							
Codend Mesh Size (mm)	70	103	94	74	45.2	43.3	46.4
Twine Type	PE	PE	PE	PE	PA	PA	PA
No of Twines	2	1	1	1	1	1	1
Nom Twine Value (mm)	4	6	6	6	2.45	2.45	2.41
Rtex	2500				3839	3839	3733
Lifting Bag Present	N	Y	Y	Y	Y	Y	Y
Open Meshes Round	108	100	100	100	275	70	326
Length of Extension and Codend (m)	8				13	13	13
Total (m)	41.5						
Cover or Small Mesh Codend	SM	SM	SM	SM	C	C	C
Description (Cover=0, Twin Exp=1)	1	1	1	1	0	0	0
Mesh size of Control Codend or Cover (mm)	20	40	40	40	20	20	20
Mesh Shape	DIA	DIA	DIA	DIA	DIA	SQ	DIA
Mesh Gauge Type	W	O	O	O	I	I	I

Country	Portugal	Portugal	Portugal	Portugal	Portugal	Portugal	Portugal
Unique Gear Identifier	55PE2.51N109	70PE2.51N85	55PE21N65	60PE2.51N100	70PE4.51N123	55PE4.51N156	80PE4.51N107
Institute	IPIMAR	IPIMAR	IPIMAR	IPIMAR	IPIMAR	IPIMAR	IPIMAR
Date Month/Year	Mar/April-04	Mar-04	Mar-04	May-93	17/05/1999	20/05/1999	22/05/1999
Number of Hauls	17+17	13+18	14+6	33	5+5	2+7	4+1
Number of Cruises	2	2	2	1	2	2	2
Fishing Area	29	29	29	29	29	29	29
Vessel LOA (m)	47.5	47.5	47.5	47.5	31.5	31.5	31.5
Vessel Type	R	R	R	R	C	C	C
Vessel Engine Power kw or HP	1500 hp	1500 hp	1500 hp	1500 hp	589 kW	589 kW	589 kW
Tide state	S (25)	S (22)	N (16)	N	N	N (7)	N
Av. Fishing Depth (m)	429.4411765	395.3870968	362	398.030303	473.339	501.8927778	523.746
Av. Haul Duration (min)	61.18	61.68	60.00	60.76	193.50	194.44	274.00
Av. Towing Speed (knots or m/s*)	2.92	2.98	2.95	2.86	3.09	3.10	3.10
Av. Nephrops	3.68	2.37	2.65	4.53	11.24	7.91	25.46
Av. Roundfish							
Av. Flatfish	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Gear Information							
Codend Mesh Size (mm)	55	70	55	60	70	55	80
Twine Type	PE	PE	PE	PE	PE	PE	PE
No of Twines	1	1	1	1	1	1	1
Nom Twine Value (mm)	2.5	2.5	2	2.5	4.5	4.5	4.5
Rtex							
Lifting Bag Present	N	N	N	N	N	N	N
Open Meshes Round	109	85	65	100	123	156	107
Length of Extension and Codend (m)	6	6	6	6	8	8	8
Total (m)	65.2	65.2	65.2	65.2	70	70	70
Cover or Small Mesh Codend							
Description (Cover=0, Twin Exp=1)	0	0	0	0	0	0	0
Mesh size of Control Codend or Cover (mm)	20	20	20	20	20	20	20
Mesh Shape	DIA	DIA	SQ	DIA	DIA	DIA	DIA
Mesh Gauge Type	W	W	W	W	I	I	I

Country	Portugal	Portugal	Portugal	Portugal	Scotland	Scotland
Unique Gear Identifier	70PA31N123	80PA31N107	55PA31N156	60PE3.52N120	100PE52n100	120PE52n100
Institute	IPIMAR	IPIMAR	IPIMAR	IPIMAR	FRS	FRS
Date Month/Year	23/10/1998	26/10/1998	29/10/1998	August 2006	27/11/2003	22/11/2003
Number of Hauls	7	2	2	22	12	7
Number of Cruises	1	1	1	1	2	1
Fishing Area	29	29	29	29	9	7
Vessel LOA (m)	31.5	31.5	31.5	24.8	21	21
Vessel Type	C	C	C	C		
Vessel Engine Power kw or HP	589 kW	589 kW	589 kW	600hp	482kW	554kW
Tide state	N (6)	N	N	N	S	S
Av. Fishing Depth (m)	504.165	530.7	528.87	347.3181818	120	104
Av. Haul Duration (min)	222.00	187.50	190.00	182.45	158.33	240.00
Av. Towing Speed (knots or m/s*)	3.10	3.10	3.10	1.47	1.35	1.21
Av. Nephrops	3.09	11.75	4.50	17.70	59.58	52.00
Av. Roundfish				34.18	149.17	138.29
Av. Flatfish	n.s.	n.s.	n.s.	n.s.	22.58	11.57
Gear Information						
Codend Mesh Size (mm)	70	80	55	60	100	120
Twine Type	PA	PA	PA	PE	PE	PE
No of Twines	1	1	1	2	2	2
Nom Twine Value (mm)	3	3	3	3.5	5	5
Rtex						
Lifting Bag Present	N	N	N	N	N	N
Open Meshes Round	123	107	156	120	100	100
Length of Extension and Codend (m)	8	8	8	6	16.8	22.1
Total (m)	70	70	70	90	119	119
Cover or Small Mesh Codend						
Description (Cover=0, Twin Exp=1)	0	0	0	0	1	1
Mesh size of Control Codend or Cover (mm)	20	20	20	30	40	40
Mesh Shape	DIA	DIA	DIA	SQ	DIA	DIA
Mesh Gauge Type	I	I	I	I	W	w

Country	Scotland	Scotland	Scotland	Scotland	Scotland	Scotland	Scotland
Unique Gear Identifier	81PE41Y116	80PE41y 100	82.9PE41Y120	104.1PE41Y102	113PE41Y101	93.2PE41Y100	95.1PE52Y100
Institute	FRS	FRS	FRS	FRS	FRS	FRS	FRS
Date Month/Year	31/05/05	25/09/04	17/03/2005	19/03/2005	21/03/2005	26/03/2005	24/09/2006
Number of Hauls	19	20	5	5	5	2	8
Number of Cruises	1	1	1	1	1	1	1
Fishing Area	12	7	12	12	12	12	7
Vessel LOA (m)	18	9.9	18.8	18.8	18.8	18.8	19.9
Vessel Type							C
Vessel Engine Power kw or HP	387kW	194kW	466kW	466kW	466kW	466kW	620kW
Tide state	S	S	S	S	S	N	S
Av. Fishing Depth (m)	121	97	143	143	143	143	139
Av. Haul Duration (min)	178.68	158.10	127.80	134.20	144.00	125.00	201.25
Av. Towing Speed (knots or m/s*)	1.39	1.20	1.19	1.10	1.10	1.10	1.40
Av. Nephrops	25.68	13.88	49.90	40.10	37.40	41.00	32.75
Av. Roundfish	65.34	21.45	17.76	17.60	16.66	13.50	117.75
Av. Flatfish	6.47	26.45	9.40	5.60	3.30	8.50	44.00
Gear Information							
Codend Mesh Size (mm)	81	80	82.9	104.1	113	93.2	95.1
Twine Type	PE	PE	PE	PE	PE	PE	PE
No of Twines	1	1	1	1	1	1	2
Nom Twine Value (mm)	4	4	4	4	4	4	5
Rtex							
Lifting Bag Present	Y	Y	Y	Y	Y	Y	Y
Open Meshes Round	116	100	120	102	101	100	100
Length of Extension and Codend (m)	17.3	14	17.7	17.7	18.6	18	18
Total (m)	61	82	106	106	106	106	61
Cover or Small Mesh Codend							SM
Description (Cover=0, Twin Exp=1)	1	1	1	1	1	1	1
Mesh size of Control Codend or Cover (mm)	40	40	40	40	40	40	40
Mesh Shape	DIA	DIA	DIA	DIA	DIA	DIA	DIA
Mesh Gauge Type	I	I	W	W	W	W	W

Country	Scotland	Scotland	Scotland	Scotland	Scotland	Sweden	Sweden
Unique Gear Identifier	82.5PE52Y120	83PE51Y100	106PE52N100	111PE52N100	95PE41Y100	63.9PA31N95	69,3PE31N100
Institute	FRS	FRS	FRS	FRS	FRS	IMR-SE	IMR-SE
Date Month/Year	23/09/06	15/10/2002	18/10/2002	13/01/2003	21/01/2003		
Number of Hauls	5	7	9	9	8	5	7
Number of Cruises	1	1	1	1	1	1	1
Fishing Area	7	7	7	7	7	20	20
Vessel LOA (m)	19.9	21	21	21	21	16.59	16.59
Vessel Type							
Vessel Engine Power kw or HP	620kW	500kW	500kW	500kW	500kW		
Tide state	S	N	S	N	S		
Av. Fishing Depth (m)	132	126	126	104	104		
Av. Haul Duration (min)	200.00	148.71	121.33	176.22	184.50	112.60	112.17
Av. Towing Speed (knots or m/s*)	1.40	1.31	1.34	1.30	1.30	2.32	2.40
Av. Nephrops	37.40	74.00	118.11	14.39	3.00	27.24	27.48
Av. Roundfish	239.20	43.29	37.33	74.67	25.00	17.38	48.02
Av. Flatfish	62.60	4.86	10.22	43.22	37.00		
Gear Information							
Codend Mesh Size (mm)	82.5	83	106	111	95	63.9	69.3
Twine Type	PE	PE	PE	PE	PE	PA	PE
No of Twines	2	1	2	2	1	1	1
Nom Twine Value (mm)	5	5	5	5	4	3	3
Rtex		2300	2300	2300	2300		
Lifting Bag Present	Y	Y	N	N	Y	N	N
Open Meshes Round	120	100	100	100	100	95	100
Length of Extension and Codend (m)	18	14.5	14.5	14.5	14.5	8	8
Total (m)	61	102	102	102	102	72	72
Cover or Small Mesh Codend							
Description (Cover=0, Twin Exp=1)	1	1	1	1	1	0	0
Mesh size of Control Codend or Cover (mm)	40	40	40	40	40	16	16
Mesh Shape	DIA	SQ	DIA	DIA	SQ	SQ	DIA
Mesh Gauge Type	W	W	W	W	W	I	I